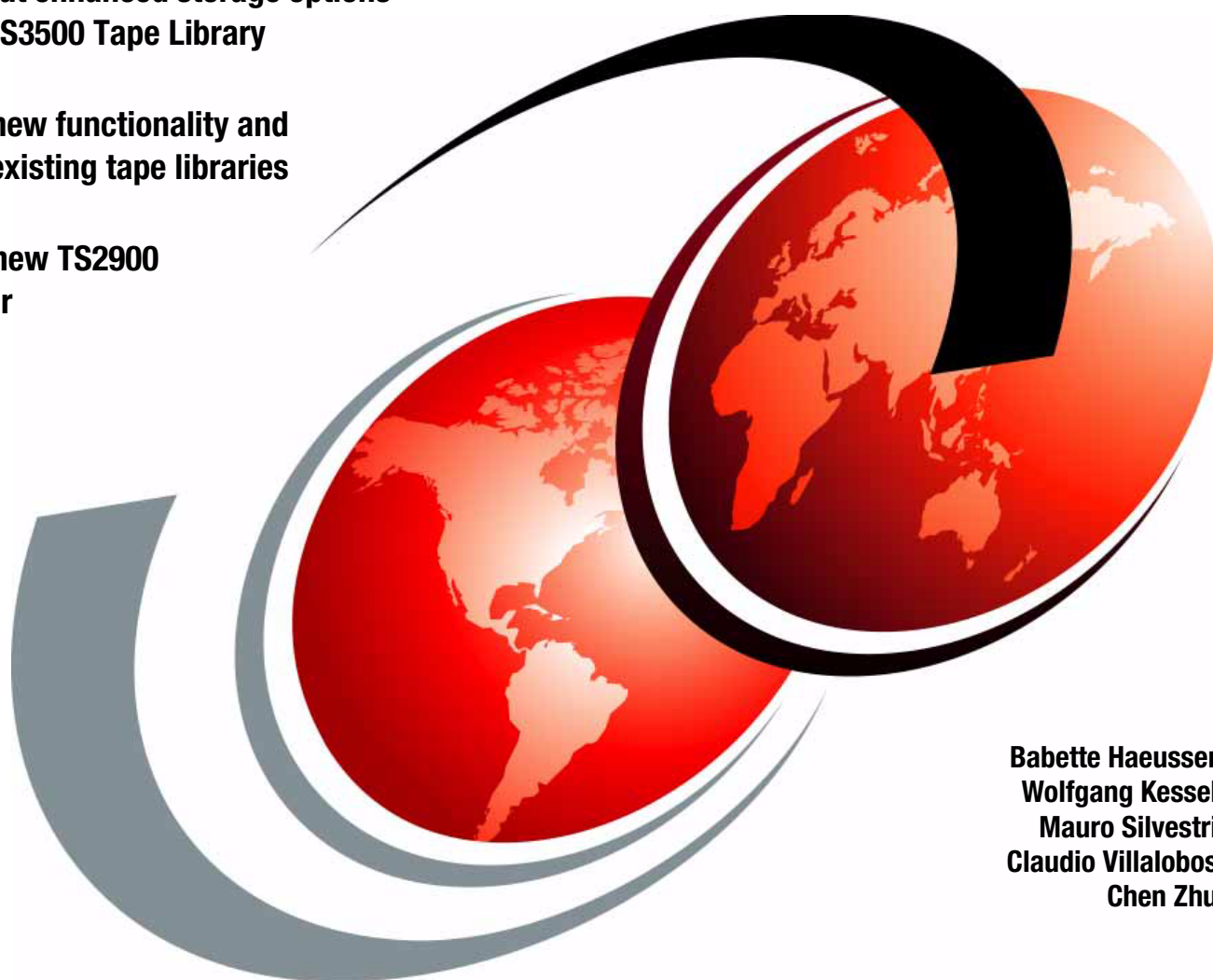


IBM System Storage Tape Library Guide for Open Systems

Learn about enhanced storage options
with the TS3500 Tape Library

Discover new functionality and
drives in existing tape libraries

Meet the new TS2900
Autoloader



Babette Haeusser
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Redbooks



International Technical Support Organization

IBM System Storage Tape Library Guide for Open Systems

September 2008

Note: Before using this information and the product it supports, read the information in “Notices” on page xv.

Seventh Edition (September 2008)

This edition of the book applies to those versions of the IBM TSxxxx tape drive and tape library products current at the time of publishing. For reference purposes, it also contains information about tape drives and libraries that have been withdrawn from marketing.

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Preface

This IBM Redbooks publication presents a general introduction to Linear Tape-Open (LTO) technology and the implementation of corresponding IBM® products. It describes both general LTO technology specifications and specific details of the unique design of IBM Ultrium tape drives and libraries.

This seventh edition of the book includes information about the latest enhancements to the IBM Ultrium family of tape drives and tape libraries. In addition, we have included a brief description of the new IBM TS1130 Tape Drive, which can be installed in the IBM TS3500 Tape Library for Open Systems hosts. You will find technical information about each of the IBM tape products for Open Systems, including generalized sections about Small Computer System Interface (SCSI) and Fibre Channel connections, Multi-Path Architecture configurations, and new IBM System Storage™ TS3500 features, such as the Advanced Library Management System (ALMS) and virtual I/O. The book also includes a detailed discussion of tools and techniques for library management.

This book is intended for anyone who wants to understand more about the general LTO technology specification and how it came about, as well as the IBM implementation of that specification. It is suitable for IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists. If you do not have a background in computer tape storage products, you might need to reference other sources of information. In the interest of being concise, topics that are generally understood are not covered in detail.

The team that wrote this book

This book was produced by a team of specialists from around the world working at the International Technical Support Organization, San Jose Center.

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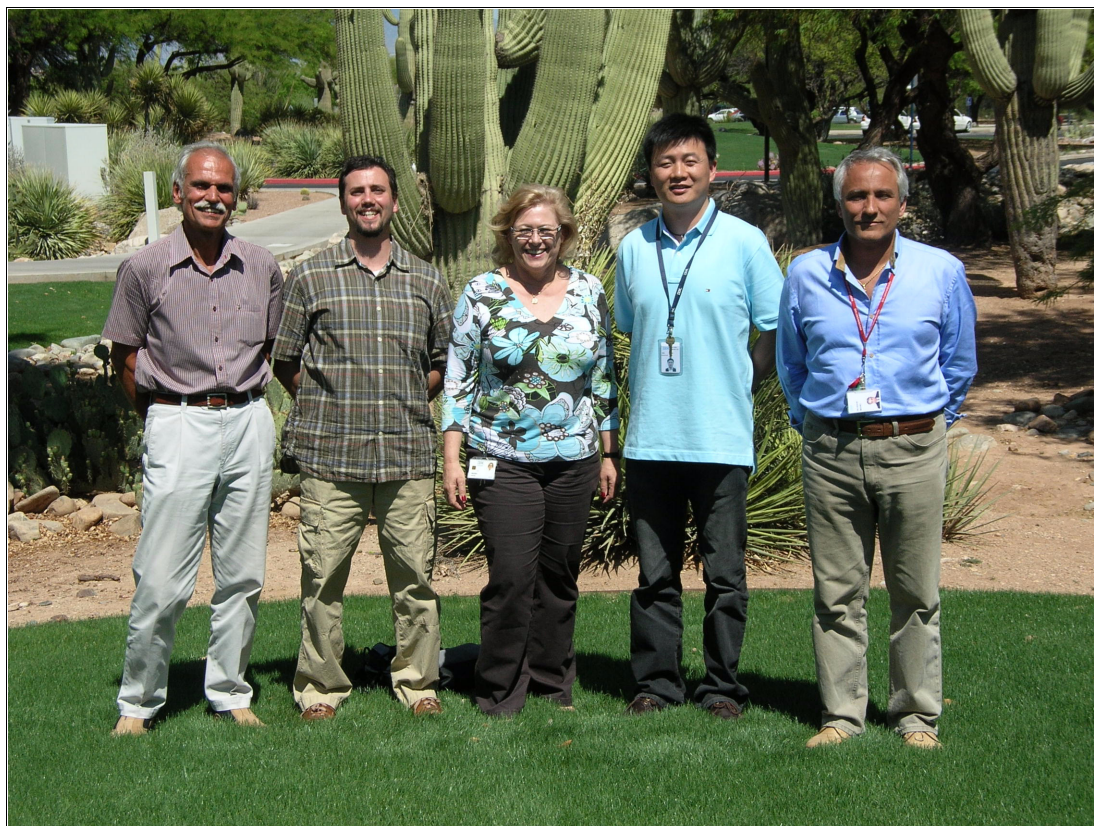
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Summary of changes

This section describes the technical changes made in this edition of the book and in previous editions. This edition might also include minor corrections and editorial changes that are not identified.

Summary of Changes
for SG24-5946-06
for IBM System Storage Tape Library Guide for Open Systems
as created or updated on September 26, 2008.

September 2008, Seventh Edition

This revision reflects the addition, deletion, or modification of new and changed information.

New information

The book includes the following new information:

- ▶ TS1130 Tape Drive
- ▶ TS2240 Tape Drive
- ▶ TS2900 Tape Autoloader
- ▶ TS3310 Advanced Reporting
- ▶ IPV6 Protocol
- ▶ ITDT Graphical Edition
- ▶ TS3500 High Density

Changed information

This book includes the following changed information:

- ▶ TS3100
- ▶ TS3200
- ▶ TS3310
- ▶ TS3400
- ▶ TS3500
- ▶ Tivoli Productivity Center (TPC) Version 3.3
- ▶ Library management

October 2007, Sixth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- ▶ TS2230 Tape Drive
- ▶ TS2340 Tape Drive

- ▶ IBM Linear Tape-Open Ultrium 4 Tape Drive
- ▶ IBM System Storage TS3400 Tape Library
- ▶ Tape Encryption

Changed information

The book includes the following changed information:

- ▶ IBM TS3310 Tape Library
- ▶ IBM TS3500 Tape Library

April 2007, Fifth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- ▶ IBM TS3100 Tape Library
- ▶ IBM TS3200 Tape Library
- ▶ IBM TS3310 Tape Library
- ▶ Library management

Changed information

The book includes the following changed information:

- ▶ IBM TS1020 Tape Drive
- ▶ IBM TS1120 Tape Drive
- ▶ IBM TS3500 Tape Library

September 2005, Fourth Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- ▶ WORM media for Ultrium 3 drives
- ▶ Ultrium 3 drives and libraries
- ▶ Virtual I/O for IBM TotalStorage 3584 Tape Library

June 2004, Third Edition

This revision reflects the addition, deletion, or modification of the following new and changed information.

New information

The book includes the following new information:

- ▶ Description of WORM technology
- ▶ New models IBM TotalStorage 3581 2U Tape Autoloader L28 and F28

- ▶ New frames and features for the IBM TotalStorage 3584 Tape Library, including support for IBM TotalStorage 3592 Tape Drive with WORM media
- ▶ Advanced Library Management System (ALMS) for the IBM TotalStorage 3584 Tape Library



Part 1

Open Systems Tape Basics

In this part, we discuss Open Systems tape technologies and introduce the IBM tape drives that can be installed inside IBM tape libraries for Open System hosts.



Tape technology perspective

Tape systems traditionally have been associated with the mainframe computer market, because they have represented an essential element in mainframe systems architectures since the early 1950s as a cost-effective way to store large amounts of data. The midrange and client/server computer market has, in contrast, made limited use of tape technology until quite recently.

Over the past few years, however, the growth in the demand for data storage and reliable backup and archiving solutions has greatly increased the need to provide manageable and cost-effective tape library products. The value of using tape for backup purposes has only gradually become obvious and important in these environments.

In this chapter, we will review the history of tape technology, including technologies, formats, and standards that you will see for tape products in today's market. We discuss a number of products from non-IBM vendors and, although we have reviewed the material carefully, we remind you that the vendors of those products are the definitive source of information.

1.1 Tape products and technologies

Two basic tape technologies have been utilized. Until the middle of the 1980s, all computer tape systems utilized linear recording technology, a technology that uses a stationary head writing data in a longitudinal way. (Refer to Figure 1-3 on page 6 for an example of longitudinal technology.)

In the middle of the 1980s, helical tape technology (which had been developed for video applications) became available for computer data storage. This technology uses heads rotating on a drum and writing data in an angle. Helical tape systems found natural applications in backing up magnetic disk systems where their cost advantages substantially outweighed their operational disadvantages. (refer to Figure 1-4 on page 7 for an example of helical-scan technology.)

1.1.1 Helical compared to longitudinal

The first computer tape systems used linear recording technology. This technology provides excellent data integrity, rapid access to data records, and reasonable storage density.

The first implementation of linear recording technology used magnetic tapes on open reels. Later, the tape was protected inside cartridges, using one or two reels. Linear technology drives write each data track on the entire length of the tape. Data is first written onto a track along the entire length of the tape, and when the end is reached, the heads are repositioned to record a new track again, along the entire length of the tape, now travelling in the opposite direction. This method continues back and forth until the tape is full. On linear drives, the tape is guided around a static head.

On helical scan systems, by contrast, the tape is wrapped around a rotating drum containing Read/Write heads. Due to the more complicated path, mechanical stress is placed on the tape. When contrasted with linear tape systems, helical tape systems have higher density (and, therefore, lower media cost), but lower data transfer rates (due to the smaller number of active Read/Write heads), less effective access to random data records, increased maintenance requirements, and reduced data integrity.

Both linear and helical tape systems have advanced substantially over the past decade. Linear systems have improved significantly in the areas of storage density (and, therefore, cost) and operational convenience (with a variety of removable cartridge systems, such as 3590, QIC, digital linear tape (DLT), and now Linear Tape-Open (LTO) replacing reel-to-reel systems). Helical systems have improved in the areas of transfer rate and data integrity with the implementation of both channel and error correction coding technologies.

Over the past few years, one of the most significant advances in tape technology for computer applications has been the maturation of serpentine linear recording systems, which, for the first time, has permitted linear recording systems to provide recording density that is comparable with that of helical systems. The first commercially successful serpentine linear tape system for professional applications was DLT. Another important improvement is the use of servo tracks, first introduced by IBM on the Magstar® 3590 tape. Servo tracks on the tape cartridge are recorded at the time of manufacture. These tracks enable the tape drive to position the Read/Write head accurately with respect to the media while the tape is in motion.

Most linear media is manufactured using metal particle (MP) technology. As with most tape products, metal particle media comprises several layers: a substrate that provides the base for other layers, the magnetic layer where data is stored, and a back coat that controls the media's frictional characteristics.

The most advanced implementations of 8 mm format (VXA and AIT) use Advanced Metal Evaporative (AME) media. The AME magnetic layer is 100% cobalt and is a much thinner, pure magnetic layer that contains no binders or lubricants. These qualities give AME tapes greater potential data density so that more information can be stored on less tape surface.

We think that the fundamental difference between linear recording and helical scan technologies is so important that it is worthwhile to summarize all of the available current technologies (refer to Table 1-1).

Table 1-1 Tape technology overview

Name	Recording technology	Media width	Type
1/2-inch reels	Linear	1/2 inch	Single hub
QIC	Linear	1/4 inch and 8 mm	Dual hub
DDS/DAT	Helical-scan	4 mm	Dual hub
8 mm	Helical-scan	8 mm	Dual hub
Mammoth	Helical-scan	8 mm	Dual hub
AIT	Helical-scan	8 mm	Dual hub
VXA	Helical-scan	8 mm	Dual hub
DLT/SDLT	Linear	1/2 inch	Single hub
IBM 3480/90	Linear	1/2 inch	Single hub
IBM Magstar MP 3570	Linear	8 mm	Dual hub
IBM 3590	Linear	1/2 inch	Single hub
Sun™ StorageTek™ T9840 and T9940	Linear	1/2 inch	Dual hub
LTO Ultrium	Linear	1/2 inch	Single hub
IBM 3592	Linear	1/2 inch	Single hub
Sun StorageTek T10000	Linear	1/2 inch	Single hub

1.1.2 Tape reels (1/2-inch)

The first data backup device (and the ancestor of magnetic tape devices with a 1/2-inch-wide tape format) used magnetic tape reels, shown in Figure 1-1. Reel tapes have been around for many years. They can support densities from 800 bpi to 6250 bpi (bits per inch) and were manufactured and sold in many different lengths and brands. The most common densities used were 1600 and 6250 bpi, but most of these devices have since been replaced.



Figure 1-1 Tape reels, 1/2-inch

1.1.3 Quarter-inch tape

The quarter-inch tape cartridge (QIC) was first introduced in 1972 by the 3M company as a means to store data from telecommunications and data acquisition applications. As time passed, the comparatively inexpensive QIC drive became an accepted data storage system, especially for standalone PCs.

A QIC cartridge (shown in Figure 1-2) looks much like an audio tape cassette with two reels inside, one with tape and the other for take-up. The reels are driven by a belt built into the cartridge. A metal rod, known as a *capstan*, projects from the drive motor and pinches the tape against a rubber drive wheel.

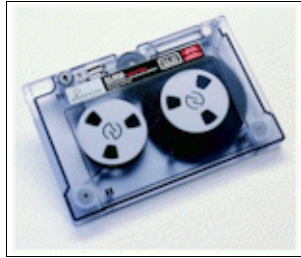


Figure 1-2 QIC cartridge

The QIC format employs a linear (or longitudinal) recording technique in which data is written to parallel tracks that run along the length of the tape. The number of tracks is the principal determinant of capacity. The cartridges come in two varieties, DC600 cartridge and DC2000 mini-cartridge, the latter being the more popular. The encoding method used is either Modified Frequency Modulation (MFM) or Run Length Limited (RLL) and is similar to the way that a hard drive encodes data.

QIC uses a linear Read/Write head similar to those found in domestic cassette recorders (Figure 1-3). The head contains a single write head flanked on either side by a read head, which allows the tape drive to verify data just written when the tape is running in either direction. If the data just written is verified by the read head, the buffer is flushed out and new data is acquired from the system memory.

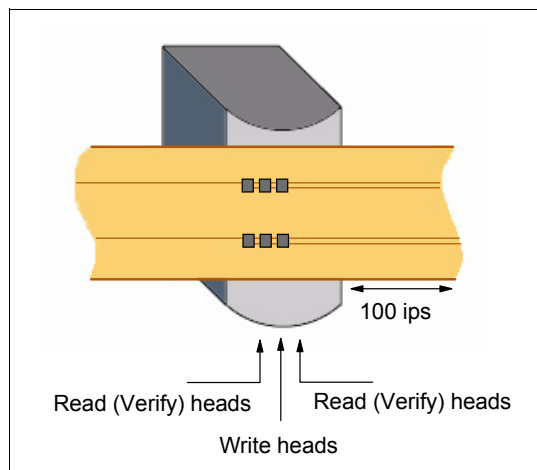


Figure 1-3 QIC head diagram

QIC standards

As the QIC standards of the time failed to keep up with the storage media explosion of the mid-1990s, the QIC cartridge underwent an evolution that increased capacities by both

lengthening and widening the tape. The Sony-inspired move to a wider format tape was a noteworthy development.

One of the drawbacks with QIC is incompatibility. The format has suffered from an overabundance of standards over the years. There are more than 120 standards currently, and not all QIC drives are compatible with all standards.

Tandberg Data manufactures QIC drives with its Scalable Linear Recording (SLR) technology. Their most recent drive, the SLR140, provides 70 GB (native) and 100 GB (with 2:1 compression) capacity on a single data cartridge. The maximum data transfer rates are 6 MB/s uncompressed and 12 MB/s (with 2:1 compression).

1.1.4 Digital Data Standard (4 mm)

The Digital Audio Tape (DAT) standard was created in 1987 and, as its name implies, was originally conceived as a CD-quality audio format offering three hours of digital sound on a single tape. The Digital Data Standard (DDS) is based on DAT and uses a similar technology. The cartridge design is common, but different tape formulations have been developed. In 1988, Sony and Hewlett-Packard (HP) defined the DDS standard, transforming the format into a format that can be used for digital data storage.

DAT technology is a 4 mm tape that uses helical scan recording technology. This is the same type of recording as that used in videocassette recorders and is inherently slower than the linear type. The tape in a helical scan system is pulled from a two-reel cartridge and wrapped around a cylindrical drum containing two read heads and two write heads, arranged alternately. The read heads verify the data written by the write heads. The cylinder head is tilted slightly in relation to the tape and spins at 2000 revolutions per minute. The tape moves in the opposite direction to the cylindrical spin, at less than one inch per second, but because it is recording more than one line at a time, it has an effective speed of 150 inches per second. (Refer to Figure 1-4.)

Short diagonal tracks, about eight times longer than the width, are written across the width of the tape. These tracks each contain about 128 KB of data and an error correction code.

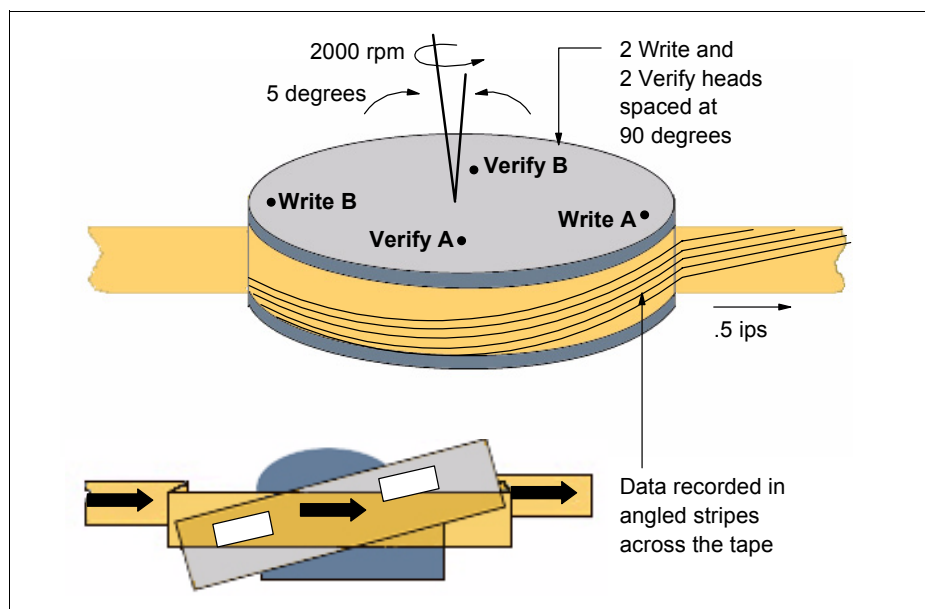


Figure 1-4 Helical-scan recording diagram

A read head verifies the data. If errors are present the data is rewritten; otherwise, the controller buffer is flushed ready for the next segment. The second write head writes data at a 40-degree angle to the first one.

Even though the first and second writes overlap, they are magnetically encoded with different polarities so that they are read only by the correct read head. The “criss-cross” pattern packs more data onto the tape, enabling helical scan systems to achieve very high data densities. A directory of files is stored in a partition at the front of the tape.

Just as with linear recording, the performance would be greatly improved if additional Read/Write heads were added, but this is difficult with helical scan devices because of the design of the rotating head. The fact that the heads can only be added in pairs makes it difficult to fit the wiring inside a single cylinder, and this limits the potential performance of helical scan devices. Because of the wide wrap angle of the tape and the consequent degree of physical contact, both the head and the media are prone to wear and tear.

Table 1-2 shows the various DDS standards, all of which are backward-compatible.

Table 1-2 DDS standards

Standard	Capacity	Maximum data transmission rate
DDS	2 GB	0.55 MB/s
DDS-1	2/4 GB	0.55/1.1 MB/s
DDS-2	4/8 GB	0.55/1.1 MB/s
DDS-3	12/24 GB	1.1/2.2 MB/s
DDS-4	20/40 GB	2.4/4.8 MB/s
DAT72 DDS-5	36/72 GB	3.0/6.0 MB/s

1.1.5 The 8 mm format

Designed for the video industry, 8 mm tape technology was created to transfer high-quality color images to tape for storage and retrieval and now has been adopted by the computer industry. Similar to DAT, but with greater capacities, 8 mm drives are also based on the helical scan technology. A drawback to the helical scan system is the complicated tape path. Because the tape must be pulled from a cartridge and wrapped tightly around the spinning Read/Write cylinder (Figure 1-5), a great deal of stress is placed on the tape.

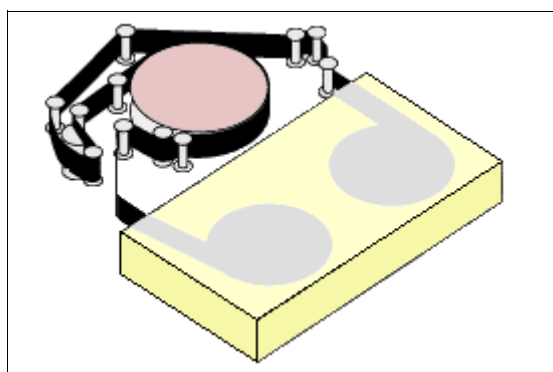


Figure 1-5 An 8 mm tape path

There are two major protocols that use different compression algorithms and drive technologies, but the basic function is the same. Exabyte Corporation sponsors standard 8 mm and VXA formats, while Seagate and Sony represent a new 8 mm technology known as Advanced Intelligent Tape (AIT).

Mammoth tape format

This Small Computer System Interface (SCSI)-based 8 mm tape technology is designed for Open Systems applications. It is a proprietary implementation of the 8 mm original format available since 1987 and uses Advanced Metal Evaporative (AME) media. This media has a coating over the recording surface that seals and protects the recording surface.

The Exabyte Mammoth drives have a 5.25-inch form factor. The first generation provided 20 GB (native) and 40 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MB/s uncompressed and 6 MB/s (with 2:1 compression).

With the Mammoth-2 technology, the capacity and data rate have been increased to 60 GB (120 GB with 2:1 compression) and 12 MB/s uncompressed (24 MB/s with 2:1 compression). Mammoth-2 drives are read compatible with the previous models.

VXA tape format

This is an 8 mm tape technology designed for Open Systems applications. It is a proprietary implementation of an 8 mm packet format available since 2001 and uses Advanced Metal Evaporative (AME) media. This media has a coating over the recording surface that seals and protects the recording surface.

The Exabyte VXA drives have a 5.25-inch form factor. The first generation provided 32 GB (native) and 64 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rates were 3 MB/s uncompressed and 6 MB/s (with 2:1 compression).

With the VXA-2 technology, the capacity and data rate have been increased to 80 GB (160 GB with 2:1 compression) and 6 MB/s uncompressed (12 MB/s with 2:1 compression). VXA-2 drives are read compatible with the previous model.

With the VXA-3 technology, the capacity and data rate have been increased to 160 GB (320 GB with 2:1 compression) and 12 MB/s uncompressed (24 MB/s with 2:1 compression). VXA-3 drives are read compatible with the previous model.

Advanced Intelligent Tape (AIT) format

The AIT format was developed by Sony. Available in a 3.5-inch form factor, Sony AIT-1 drives and media provide 25 GB (native) and 50 GB (with 2:1 compression) capacity on a single 8 mm data cartridge. The maximum data transfer rate is 3 MB/s native.

Sony's latest AIT-4 format, made available in 2004, has capacity and performance of 100 GB (200 GB with 2:1 compression) and 12 MB/s native. AIT-4 drives are backward-Read/Write compatible with AIT-3 and backward-read compatible with AIT-2 and AIT-1.

AIT drives feature an Auto Tracking Following (ATF) system, which provides a closed-loop, self-adjusting path for tape tracking. This servo tracking system adjusts for tape flutter, so that data tracks can be written much closer together for high-density recording. AIT uses the Adaptive Lossless Data Compression technology (ALDC) compression algorithm. The 8 mm original format has various drive generations, and all generations are backward-compatible (Table 1-3 on page 10).

Table 1-3 Standards for 8 mm

Standard	Capacity	Maximum data transmission rate (compressed)
Original 8 mm	3.5/7 GB	0.53 MB/s
Original 8 mm	5/10 GB	1 MB/s
Original 8 mm	7/14 GB	1 MB/s
Original 8 mm	7/14 GB	2 MB/s
Mammoth	20/40 GB	6 MB/s
Mammoth-2	60/120 GB	24 MB/s
VXA-1	32/64 GB	6 MB/s
VXA-2	80/160 GB	12 MB/s
VXA-3	160/320 GB	24 MB/s
AIT-1	25/50 GB	6 MB/s
AIT-2	50/100 GB	12 MB/s
AIT-3	100/200 GB	24 MB/s
AIT-4	200/520 GB	48 MB/s

1.1.6 Digital Linear Tape (DLT)

DLT drives appeared in 1985 when Digital Equipment Corporation needed a backup system for their MicroVAX systems.

The system uses a square cartridge that contains tape media but no take-up reel. The take-up reel was built into the drive itself. This design eliminated the additional space typically associated with cassette and cartridge drives, such as QIC or 8 mm. The drive itself had to be made larger than most to accommodate the internal take-up reel. Called the TK50, the new tape drive was capable of storing 94 MB per cartridge.

Using a ferrite Read/Write head, the TK50 recorded data in linear blocks along 22 tracks. Its Read/Write head actually contained two sets of Read/Write elements. One set was used when reading and writing forward, and the other set was used when reading and writing backward.

The TK50 started recording at the beginning of the tape, recording on one track. When it reached the end, the system recorded back to the beginning along a new track. After every two tracks that were written, the system moved the head up the width of one track and began the process again. The read-after-write capability of the system ensured basic data accuracy. The drive fit into a full-height, 5.25 inch drive bay.

In 1987, Digital released the TK70. This tape drive offered 294 MB of storage on the same square tape cartridge, a threefold improvement over the TK50. Digital accomplished this by increasing the number of tracks to 48 and by increasing density on the same 1/2-inch tape.

In 1989, Digital introduced the TF85, the first true DLT system. The TF85 (later called the DLT 260) incorporated a new feature that enabled the system to pack 2.6 GB onto a 1200 foot tape (CompacTape III, now known as DLTtape III).

The DLT Tape Head Guide Assembly was incorporated for the first time in the TF85 drive. Six precision rollers provided long tape life. The six-roller head guide assembly gave the TF85 a much shorter tape path than helical-scan systems (Figure 1-6).

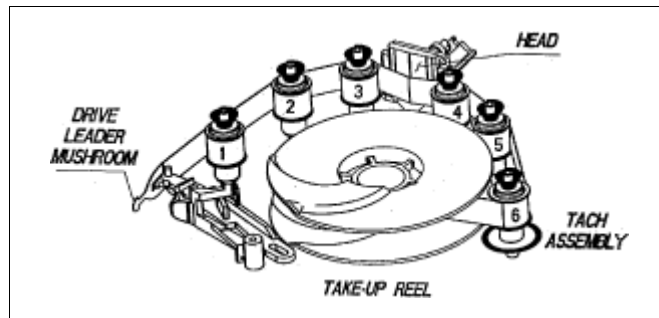


Figure 1-6 DLT tape path mechanism

The Read/Write head was equipped with an additional write element. The elements now were arranged in a write/Read/Write pattern. This pattern enabled the TF85 to read after writing on two channels and in both forward and reverse directions. This is the multi-channel serpentine recording depicted in Figure 1-7.

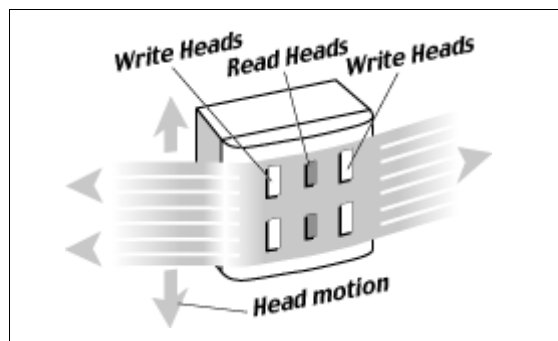


Figure 1-7 DLT 2000 recording head design

Two years later, Digital introduced the TZ87, now known as the DLT 2000 tape drive. This system offered 10 GB of native capacity on a single CompacTape III cartridge (shown in Figure 1-8) and now known as DLTtape III, 2 MB of Read/Write data cache memory, and a data transfer rate of 1.25 MB/s. This was the first generation of DLT.

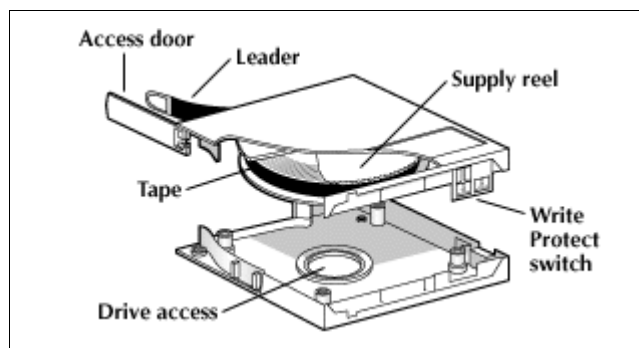


Figure 1-8 DLT cartridge

In 1994, Quantum acquired the Storage division of Digital Equipment Corporation (DEC). In late 1994, Quantum released the DLT 4000. By increasing real density (bits per inch) from 62 500 to 82 000 and tape length by 600 additional feet (DLTtape IV), the capacity of the DLT

4000 grew up to 20 GB (40 GB compressed) on a single 1/2-inch DLTtape IV cartridge. The new DLTtape system provided data transfer at 1.5 MB/s (3 MB/s compressed) and was fully Read/Write compatible with previous generations of DLTtape drives.

DLT 2000 and DLT 4000 drives write data on two channels simultaneously in linear tracks that run the length of the tape, as shown in Figure 1-9.

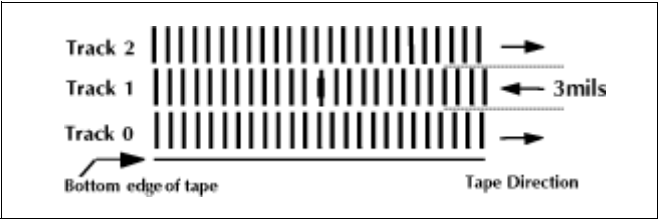


Figure 1-9 DLT 2000/4000 linear recording format

The DLT 7000 appeared in 1996. This drive offered a total storage capacity of 35 GB native, 70 GB compressed on the 1800 foot DLTtape IV cartridge. The DLT 7000 incorporated a 4-channel head that gives the drive a transfer rate of 5 MB/s of data in native mode (Figure 1-10).

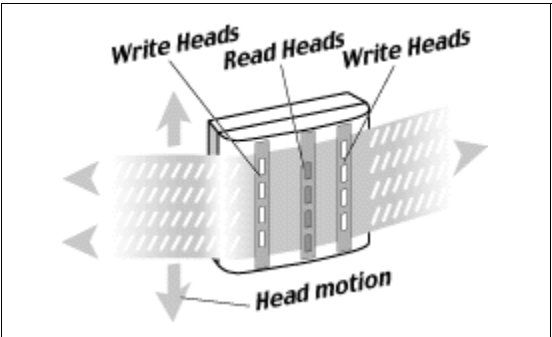


Figure 1-10 DLT 7000/8000 tape head

Quantum’s latest DLT product is their DLT 8000 drive. This tape drive features a native transfer rate of up to 6 MB/s, with a native capacity of 40 GB. The DLT 7000/8000 drives incorporate the Symmetric Phase Recording technology that writes data in an angled pattern (Figure 1-11).

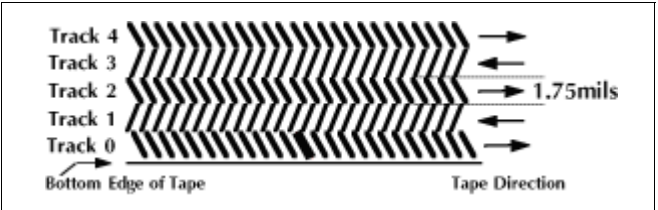


Figure 1-11 Symmetric Phase Recording technology

The DLT standard has various generations of tape drives, all of which are backward-compatible. We have summarized the specifications in Table 1-4 on page 13.

Table 1-4 DLT drive standards

DLT drive generation	Capacity	Maximum data transmission rate
DLT2000	10/20 GB	1.25 MB/s
DLT2000XT	15/30 GB	1.25 MB/s
DLT4000	20/40 GB	1.5 MB/s
DLT7000	35/70 GB	5 MB/s
DLT8000	40/80 GB	6 MB/s

1.1.7 SuperDLT (SDLT)

SuperDLT (SDLT) is a new format specification designed by Quantum Corporation as an evolution of the DLT standard. It uses Laser Guided Magnetic Recording (LGMR) technology. This technology includes the Pivoting Optical Servo (POS). This optically assisted servo system is implemented on the unused reverse side of the media and uses a laser to read the servo guide. SDLT uses 100% of the media for data recording.

SDLT uses Advanced Metal Powder (AMP) media containing embedded information for the Pivoting Optical Servo system.

The recording mechanism is made of Magneto-Resistive Cluster (MRC) heads, a cluster of small magneto-resistive tape heads.

The first SDLT drive, the SDLT 220, was introduced in late 2000. It provides a capacity of 110 GB (native) and 220 GB (with 2:1 compression). The native data transfer rate is 11 MB/s. This first drive was not backward-read compatible with earlier models. In 2001, Quantum released a version of the SDLT 220 drive that was backward-read compatible with the DLTtape IV cartridge.

Quantum's second SDLT 320 drive became available in 2002. It increased the native capacity to 160 GB (320 GB with 2:1 compression) and the native transfer rate to 16 MB/s. (32 MB/s with 2:1 compression). The SDLT 320 is backward read compatible with DLTtape IV cartridges and uses Super DLTtape I media.

The SDLT 600 is the third generation of Quantum's SDLT product range. It provides a capacity of 300 GB (native) and 600 GB (with 2:1 compression) and the native transfer rate increased to 36 MB/s (72 MB/s with 2:1 compression). The SDLT660 comes with an LVD 160 Small Computer System Interface (SCSI) or with a 2 GB Fibre Channel interface. The SDLT 600 is backward-compatible with the SDLT 320 and the DLT VS 160.

The media format compatibility includes:

- ▶ Super DLTtape II (Read/Write) 300 GB native capacity
- ▶ Super DLTtape I (read only) 160 GB native capacity
- ▶ DLTtape VS1 (read only) 80 GB native capacity

1.1.8 IBM 3480

The second generation of IBM magnetic tapes and the first one to use an enclosed cartridge containing 1/2-inch tape, the IBM 3480, was announced on 22 March 1984. The tape was stored in a now-familiar cartridge, which was smaller, much more robust, and easier to handle than tape reels. The cartridge capacity was 200 MB, and the channel data rate was 3 MB/s, writing 18 tracks in one direction.

1.1.9 IBM 3490

The 3490 replaced the 3480 tape technology, using the same tape cartridge media. The IBM 3490E, with a tape capacity of 800 MB uncompact (2.4 GB compacted) and a channel data rate of 3 MB/s, increased the capacity of the 3480 fourfold by using a double-length tape and by writing data in both directions: 18 tracks to the end of tape, and 18 tracks back to the start of the tape.

During this second generation, several steps were taken to automate tape processing and to reduce or eliminate human intervention. Automatic cartridge loaders and automated tape libraries, such as the StorageTek Silos and the IBM 3495 and 3494 libraries, were introduced to reduce or eliminate the need for tape operators. Software packages, such as CA-1, TLMS, and the DFSMS Removable Media Manager (DFSMSRmm™), were implemented to manage the tape volumes automatically.

The IBM 3490 and compatible drives were probably the first family of tape products that was mostly used with automatic tape libraries rather than being installed as stand-alone drives operated manually.

Applications still used tapes directly, and the Improved Data Recording Capability (IDRC), which compacts the data, reduced the number of tape volumes used.

Magnetic disks were now widely used for online data, and these second-generation tape systems therefore became primarily a medium for backup and were introduced as an archive medium. The process of archiving was also automated with products, such as Hierarchical Storage Manager (HSM) and DFSMSHsm™ (a component of DFSMS/MVS™) using tape as the lowest level in a storage hierarchy. Of course, tape was still used as an interchange medium, but networks were also used for that purpose.

1.1.10 IBM 3590

The IBM TotalStorage® Drive 3590 was previously called the IBM Magstar 3590. The IBM Magstar tape technology was first introduced in July 1995. The original cartridge maintained the external form factor of the 3490 (Figure 1-12), had a capacity of 10 GB uncompact (30 GB compressed), and the data rate was 9 MB/s. Later drive models and new media increased these figures. The data format is incompatible with the 3490.

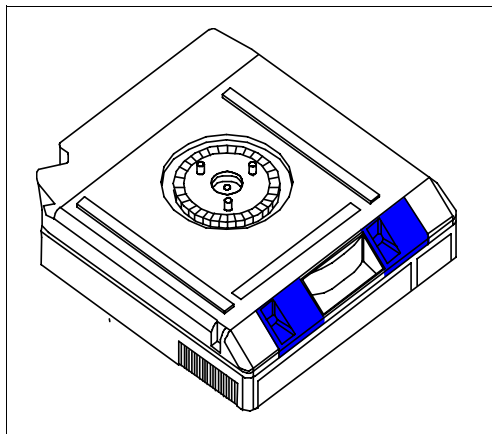


Figure 1-12 Magstar 3590 tape cartridge

The 3590 drive (Figure 1-13 on page 15) incorporates a new longitudinal technology, Serpentine Interleaved Longitudinal Recording. Data is written in each direction in turn, and to increase capacity further by providing multiple sets of tracks in parallel, the concept of *head*

indexing is introduced. The entire set of heads is slightly shifted after one pass, and all subsequent passes (for a total of eight) are used to write data tracks adjacent to the existing ones. This means a significant improvement in the tape capacity and transfer rates without changing the tape speed (2 m/s) and media length (600 m). The 3590 drive uses a buffer and compresses the data before it writes the data to tape. In addition, the drive can complete a stop-start cycle in approximately 100 ms. The performance is significantly improved for both start-stop and streaming applications.

With the IBM TotalStorage 3590 Model H and the Extended Length Cartridges made available in 2002, the capacity and data rate increased to 60 GB (180 GB assuming 3:1 compression) and 14 MB/s native respectively, while maintaining backward compatibility for reading with the base models.

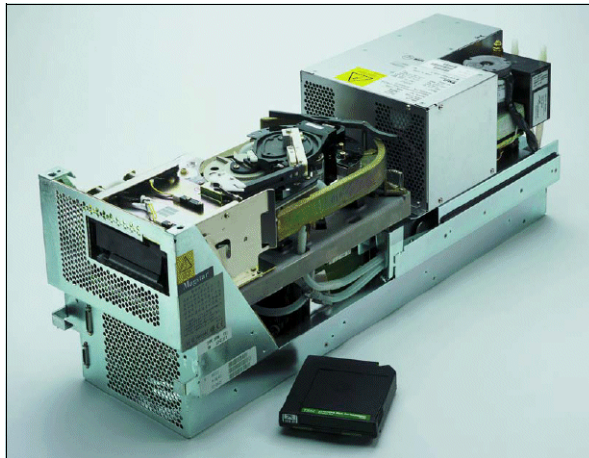


Figure 1-13 Magstar 3590 tape drive

This design incorporates innovations, such as servo tracks on the tape to guide the Read/Write heads along the data tracks and the implementation of an improved error correcting code (ECC). A portion of the tape within each cartridge is reserved for statistical information; it is continually updated after each read or write, providing statistics that you can use to obtain drive and media information and identify problems with a particular tape or drive as early as possible.

Technology

The IBM 3590 provides high capacity, performance, reliability, and a wide range of host connectivity. This technology exploits a fourth generation magneto resistive (MR) head, a 16 MB buffer, predictive failure analysis, and state-of-the-art electronic packaging.

While reading or writing 16 tracks at a time, the 3590 models use serpentine, interleaved, longitudinal recording technology for a total of four, eight, or twelve round trips from the physical beginning to the physical end of the tape and back again. The tape Read/Write head indexes, or moves vertically, when it completes each round trip so that the recorded tracks are interleaved across the width of the tape.

Figure 1-14 on page 16 shows the recording element of the IBM TotalStorage Enterprise 3590 tape drives. It also shows the way in which the Read/Write heads are moved over the width of the tape medium.

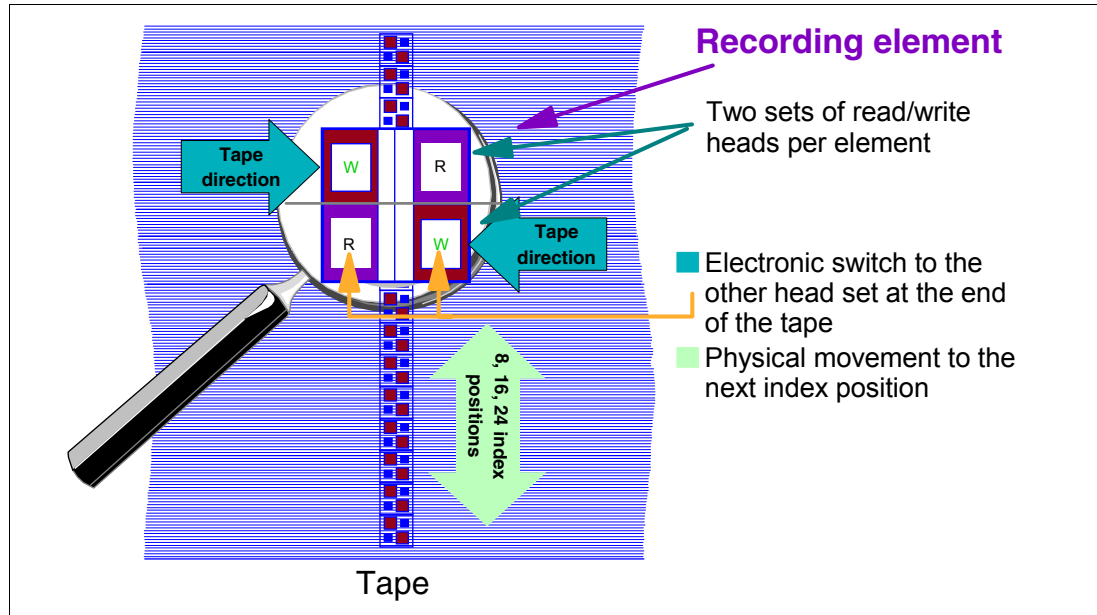


Figure 1-14 IBM 3590 recording

The 3590 tape drives use a metal particle medium in the tape cartridge that can store 10, 20, 30, 40, or 60 GB of uncompact data, depending on the cartridge type and the drive model. The integrated control unit uses a compaction algorithm that can increase the storage capacity of these cartridges. Assuming a compression ratio of three to one (3:1), the cartridge capacity increases to 60 GB on E models and to 90 GB on H models.

The 3590E and 3590H models have a 14 MB/s device data rate, and 3590B models have a 9 MB/s device data rate. With data compression, the 3590 Tape Drive can more effectively use the full capability of the Ultra™ SCSI data rate, the Enterprise Systems Connection (ESCON®) data rate, or the Fibre Connection (FICON®) data rate. The Ultra/wide SCSI data rate is up to 40 MB per second and the Fibre Channel data rate is up to 100 MB per second.

High-speed data access

The 3590 longitudinal serpentine recording technique allows for high performance read operations. The 3590 Model E Tape Drive makes eight round-trip passes over the tape, where the Model H Tape Drive makes 12 passes. If a required block of data is, logically, one-eighth or one-twelfth of the way along the length of the tape, the read head only needs to index upward by one position to access this data, which requires no tape movement.

Unlike any previous tape product, the IBM Magstar 3590 tape subsystem uses a volume control region, inaccessible to user applications, to locate data on the tape. When a read request takes place, the tape drive uses a high-speed block search to position the tape directly at the required data block. It indexes the head to the correct set of tracks to allow for high-speed access to blocks or files. The tape drive performs this work while it is logically disconnected from the channel. This enables the channel to do other work.

This facility allows for access speeds that are significantly faster than previous generations of tape technology. The 3590 can search for data at up to 332 MB/s, compared to the 3490 rate.

Data integrity with the 3590 tape system

A unique feature of the IBM TotalStorage Enterprise 3590 Tape System is the way data is *striped* horizontally and vertically (Figure 1-15 on page 17). If a media error occurs, even one that covers several tracks, the error correction code can reconstruct the data for the

application. The 3590 E and H tape drives have enhanced error correction code for improved data reliability compared to the Model B drives.

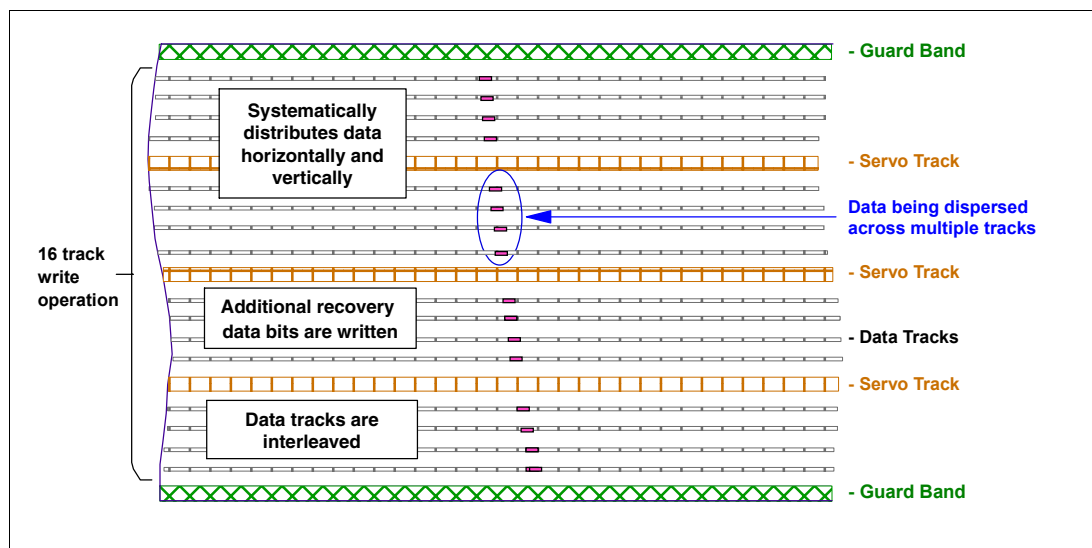


Figure 1-15 IBM TotalStorage 3590 tape data integrity

Considering the way the 3590 Tape Drive writes data onto the tape, we achieve RAID-like tape storage:

- ▶ Multiple write elements are used for improved performance.
- ▶ Data is spread across multiple tracks to achieve improved availability.
- ▶ Recovery bits are written for improved error recovery.

Metal particle media

A chromium dioxide medium was used in the IBM 3480 and 3490 cartridges. The IBM 3590 High Performance Tape Cartridge uses a metal particle medium, which has a significantly increased coercivity and therefore permits a much higher data recording density in comparison with chromium dioxide media. The linear density is proportional to the medium's coercivity, and therefore, the linear density of the IBM 3590 tape is approximately three times that of the IBM 3480 and 3490. The track density is also improved approximately fourfold. Advances in the metal particle coatings and media binders afford reliability and magnetic stability equal or superior to chrome media.

1.1.11 LTO Ultrium

The Linear Tape-Open (LTO) standard was released as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. As result of this initiative, two LTO formats (Ultrium and Accelis) were defined. The consortium now consists of IBM, Hewlett-Packard, and Quantum/Certance.

The consortium of these companies is known as the Technology Provider Companies. The new technology specifications are detailed at an LTO Web site:

<http://www.lto-technology.com>

The IBM LTO Ultrium 1 drive provides a single-media capacity of up to 100 GB (200 GB with 2:1 compression) data storage per cartridge and a sustained data rate of up to 15 MB/s (uncompressed). IBM LTO Ultrium 2 doubled the media capacity to 200 GB (400 GB with 2:1 compression) data storage per cartridge and more than doubled the sustained data rate to

35 MB/s (uncompressed). IBM LTO Ultrium 3 doubled the capacity to 400 GB (800 GB with 2:1 compression) and more than doubled the sustained data rate to 80 MB/s (uncompressed). IBM LTO Ultrium 4 doubled the capacity to 800 GB (1.6 TB with 2:1 compression) and more than doubled the sustained data rate to 120 MB/s.

For a detailed description of the LTO Ultrium tape format specification, refer to 2.1.2, “LTO standards” on page 32.

For a detailed description of the IBM LTO Ultrium drive, refer to 2.1.5, “IBM LTO Ultrium common subassembly” on page 52.

1.1.12 LTO WORM

The IBM Ultrium Write Once Read Many (WORM) cartridges (machine type 3589) were designed for applications, such as archiving and data retention, as well as those applications requiring an audit trail. The IBM Ultrium 3 and Ultrium 4 tape drives provide WORM support for these types of applications. The IBM Ultrium WORM cartridges work with the IBM System Storage LTO Ultrium Tape Drive to help prevent the alteration or deletion of user data. In addition, IBM has taken several steps to reduce the possibility of tampering with the information:

- ▶ The bottom of the cartridge is molded in a different color than rewritable cartridges.
- ▶ The special cartridge memory helps protect the WORM nature of the media.
- ▶ A unique format is factory-written on each WORM cartridge.

New models of the 3589 are now available. To order the IBM TotalStorage Ultrium WORM Data Cartridges, refer to Table A-1 on page 499. The Ultrium 400 GB WORM format, based on LTO specifications, provides a tape cartridge capacity of up to 400 GB native physical capacity (800 GB with 2:1 compression). You can use these cartridges in IBM TotalStorage Ultrium 3 Tape Drives, the third generation LTO Ultrium Tape Drive in the IBM TotalStorage LTO Ultrium family of products. The WORM 800 GB data cartridge provides a capacity of up to 800 GB native physical (1600 GB with 2:1 compression). The 800 GB WORM can only be used in the IBM Ultrium 4 tape drives.

For currently installed 358x products with IBM TotalStorage LTO Ultrium 3 Tape Drives, you might need a drive microcode and library firmware update. However, no hardware additions or features are necessary to enable this LTO WORM capability.

1.1.13 IBM System Storage TS1100 Tape Drive family

The IBM System Storage TS1100 Tape Drive family offers a design that is focused on high capacity, performance, and high reliability for storing mission critical data. Introduced in October 2003, the 3592-J1A Tape Drive had 300 GB of native capacity in a half-inch format tape cartridge. It was also a foundation for future generations of this new tape drive family based on the concept of media reuse. This design helps protect the client’s investment in tape cartridges.

In October 2005, the second generation of the 3592 drive, the IBM System Storage TS1120 Tape Drive Model E05, was introduced. The IBM 3592-E05 has the same physical measurements as the 3592-J1A Tape Drive, but the capacity increased 1.6 times from 300 GB to 500 GB native capacity on one cartridge. It has a 4 GB Fibre Channel attachment and a native data rate of up to 100 MB/s.

Now, the achievable capacity characteristics of the two generations of 3592 tape drives have increased again for the IBM System Storage TS1130 Model E06 Tape Drive, the third

generation of the 3592 family, which provides the unprecedented capacity of 1 TB of uncompressed data.

Figure 1-16 shows the TS1130 Tape Drive, the IBM 3592-E06.

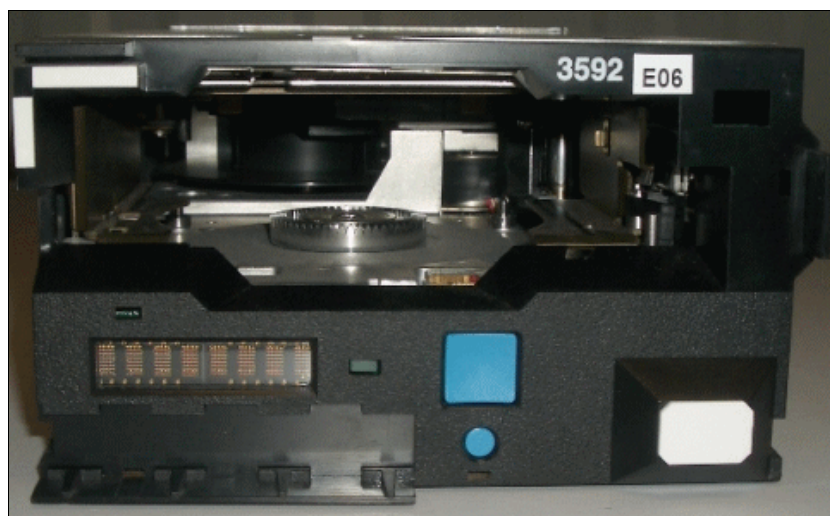


Figure 1-16 IBM System Storage TS1130 Tape Drive Model E06

For more specifications regarding the IBM 3592 J1A Tape Drive, the TS1120 Tape Drive, and the TS1130 Tape Drive, refer to Chapter 3, “Overview of IBM System Storage TS1100 Tape Drives” on page 91.

The key technology enhancements that are common for all three generations of the 3592 Tape Drive family in terms of technology enhancements, reliability and availability improvements, and features for performance and capacity include:

- ▶ Virtual backhitch, which is the optimum adaptive format and algorithm designed for improved start/stop write synchronize performance (refer to “Virtual backhitch (nonvolatile caching)” on page 100).
- ▶ High performance and robust dual microprocessor architecture. One microprocessor operates the host attachment interface (running what is essentially proven 3590 host attach microcode), while the other microprocessor is allowed to focus strictly on writing data and reading data from tape. Each microprocessor is designed to reset the other microprocessor to act as a fail-safe.
- ▶ Attachment to all well-established Open Systems platforms.
- ▶ S/390® and System z attachment through ESCON and FICON by means of the existing 3592 Model J70 controller or the TS1120 Tape Controller.
- ▶ Statistical Analysis Recording System (SARS) algorithm with extended mount count.
- ▶ Fast random access performance when operating on any of the two Short Length Cartridge (SLC™) types.
- ▶ Support of an enhanced capacity scaling and segmentation format when operating on the full length Read/Write (R/W) cartridge type JA and JB, enabling very fast locate and read times.
- ▶ Streaming Lossless Data Compression (SLDC) algorithm (enhancement of the Lempel-Ziv class 1 (LZ-1) data compression algorithm).
- ▶ Cartridge memory of 4 K is designed for the 3592 to support advanced features.

- ▶ An advanced interleaved bidirectional serpentine recording technique that writes 16 data tracks at a time on a 3592 cartridge.
- ▶ The timing-based servo technique guarantees the most accurate positioning of the Read/Write heads.
- ▶ Improved reliability and availability are achieved by:
 - Single Field Replaceable Unit (FRU)
 - Redundant, hot-pluggable power supplies
 - Retention of Fibre Channel Worldwide Name ID during service action
- ▶ Advanced technology by:
 - Robust loader mechanism
 - Elimination of drive pneumatics and mechanical adjustments
 - Straighter and shorter tape path for better tape tracking
 - Speed matching to reduce backhitching. Refer to 3.2.4, “Features designed for capacity and performance” on page 99 for further details.
 - Channel calibration to optimize performance and data integrity
- ▶ The drive has a large data buffer with read-ahead buffer management.
- ▶ Speed matching for medium data rates when operating from a host that cannot sustain the maximum 3592 data rate.
- ▶ Cartridge memory chip, which holds information about that specific cartridge, the media in the cartridge, and the data on the media.
- ▶ High-resolution tape directory for improved nominal and average access times for locate operations.
- ▶ Virtual backhitch (nonvolatile caching) helps greatly improve write performance through backhitch reduction.
- ▶ Performance/Capacity scaling to allow clients to trade off capacity for improved access times.

1.1.14 Libraries

System administrators are clamoring for technologies that enable them to efficiently and economically manage the explosive growth in stored data. As the amount of data increases, the backup process takes longer and longer.

The solution to this problem is to use a device that integrates the tape drive with a level of automation. The challenge is to choose the right solution in terms of size and automation level.

System administrators industry-wide have recognized the need for automating the backup-and-restore process to the extent that it requires little or no human intervention. This method has become known as *lights-out backup*. This process can be done off-shift or concurrently with other applications during normal operations. Multi-drive tape libraries are the only available technology to offer both the reliability and low cost to make lights-out backup practical.

The hardware options for automation are autoloaders and a range of multi-drive automated tape libraries. We distinguish among them in the following descriptions.

Autoloaders

Autoloaders have one tape drive, and clients typically use autoloaders to access a small number of tapes once a day. Most autoloaders are designed for purely sequential operations. These units place no emphasis on performance.

Automated tape libraries

Automated tape libraries have one or more tape drives, but clients typically use them with at least two tape drives. All tape cartridges are accessible to all drives, therefore making concurrent reading and writing operations possible.

You can increase throughput by adding additional drives. Libraries can exchange tapes in a few seconds, substantially improving file-restore response times. Tape libraries are mandatory for lights-out operations and other higher performance tape storage applications. Tape libraries also offer the security of knowing that other drives take over if one fails.

Multi-drive automated tape libraries and ultra-scalable tape libraries combined with storage-management software, including concurrent backup, archive, and hierarchical storage management (HSM), offer the most robust solution to manage and protect huge amounts of corporate data. Automated tape libraries allow random access to large numbers of tape cartridges and the concurrent use of two or more drives, rather than manually loading one tape after another or using a single-drive sequential autoloader.

Enterprise tape libraries

Enterprise tape libraries are automated tape libraries that provide enhanced levels of automation, scalability, reliability, availability, and serviceability. They typically have the capacity to house dozens of drives and hundreds of tapes. Equipped with high-performance robotic mechanisms, barcode scanners, and support for cartridge I/O ports, these libraries often offer redundant components and a high degree of flexibility through a modular design. Certain models add support for multiple SCSI, Fibre Channel-Arbitrated Loop (FC-AL), FCP, and ESCON or FICON connections to allow connection to more than one host platform. The top of the line of the enterprise tape library products, such as the IBM TotalStorage Enterprise Tape Library 3494 and the IBM System Storage TS3500 Tape Library, are designed to be shared between two or more heterogeneous host systems. All the hosts have access to the control functions of the tape library robotics. Simply put, the library is shared in a physical way, with each system thinking it really owns the entire library.

1.1.15 Sun StorageTek tape products

In the following sections, we briefly describe the tape products of Sun StorageTek.

Sun/STK T9840

Introduced in late 1998, the STK T9840 Tape Drive (dubbed “Eagle”) is based on linear technology and targeted at the high-end, enterprise server market. The dual-hub cartridge (shown in Figure 1-17 on page 22) has a native capacity of 20 GB and a maximum data rate of 10 MB/s with T9840A. To maintain compatibility with existing enterprise system automation products (mainly the STK silos), the cartridge maintains the external form factor of the 3490/3590 cartridge.

In 2001, StorageTek introduced a second-generation T9840 drive, the T9840B, which increased the data rate to 19 MB/s and provided the same capacity as T9840A. The latest T9840 drive, introduced in 2003, is the T9840C, which doubled the capacity to 40 GB and increased the data rate to 30 MB/s.

Data on all T9840 drives is written 16 tracks at a time in a total of 18 passes for a total of 288 tracks. In addition to the data tracks, the tape contains five bands of five servo tracks each (25 tracks total) that are pre-written on the tape.

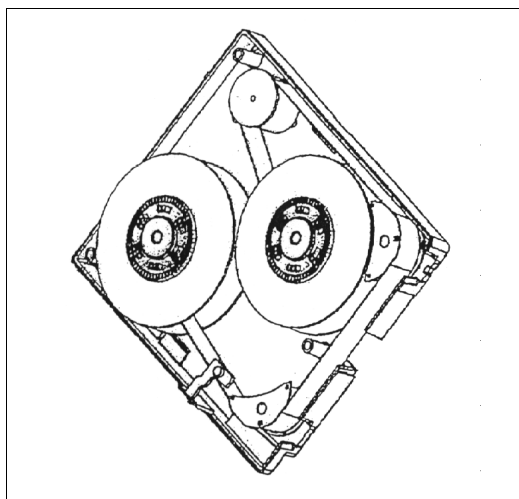


Figure 1-17 STK T9840 tape cartridge

Sun/STK T9940

The STK T9940 is based on T9840 technology. The biggest differences between these two drives are the data cartridge and the loader mechanism for the cartridge. The T9940 cartridge has the same form factor and dimensions as the T9840 cartridge, but the T9940 cartridge contains a single reel of media, and the tape path, take-up reel, and tape guidance system are located inside the drive. The first-generation T9940A drive has a capacity of 60 GB (native) and 120 GB (with 2:1 compression). The native data transfer rate is 10 MB/s.

The StorageTek T9940B format, made available at the end of 2002, increased the capacity and data transfer rate of the prior generation to 200 GB (400 GB with 2:1 compression) and 30 MB/s native. The T9940B drive is backward-read compatible with the T9940A model.

Sun/STK T10000 Tape Drive

The new generation of tape drives and media are incompatible with their predecessors. It offers a capacity of 500 GB uncompressed data and throughput of 120 MB/s. Media can be reused using the same StorageTek T10000 tape cartridges for at least two generations by reformatting and reusing tape cartridges with next-generation drives. The T10000 Tape Drive uses VolSafe secure media technology for WORM storage. Reliability is provided with the StorageTek SafeGuide system for tape guiding. With dual-head, 32-channel technology, the number of tape passes is reduced, and head and media life can be extended. Speed-matching functionality supports high throughput rates. The T10000 design includes two motor speeds, a 256 MB buffer, and dual error correction code to reduce data errors. The long tape path that has been maintained from previous generations is used to guide the media and to reduce tape tension. The airflow design cools the electronics by pulling air under, not across, the tape path.

The 4 Gb crypto-ready T10000 Tape Drive is designed to simplify data security and provide device-level encryption. The T10000 works with the latest Sun StorageTek enterprise automation, such as the StorageTek StreamLine SL8500 modular library system from Sun, with the StorageTek PowderHorn 9310 tape library, and with most third-party solutions.

The StreamLine SL8500 modular library system

The SL8500 supports the T10000, T9840, and T9940 lines of tape drives, and midrange LTO, SDLT, and DLT-S4 drives, as well as VolSafe secure media technology. Drives can be upgraded without disruption to normal operations, and tape drives and other components are hot-swappable.

1.2 SAN technologies

A *Storage Area Network (SAN)* is a high-speed network that enables the establishment of direct connections between storage devices and processors (servers) within the distance supported by Fibre Channel. View the SAN as an extension to the storage bus concept that enables storage devices and servers to be interconnected using elements similar to Local Area Networks (LANs) and Wide Area Networks (WANs): routers, hubs, switches, directors, and gateways. You can share a SAN between servers or dedicate a SAN to one server. A SAN can be local or extended over geographical distances.

1.2.1 Tiered overview

In today's SAN environment, the storage devices in the bottom tier are centralized and interconnected, which represents, in effect, a move back to the central storage model of the host or mainframe.

Figure 1-18 shows a tiered overview of a SAN connecting multiple servers to multiple storage systems.

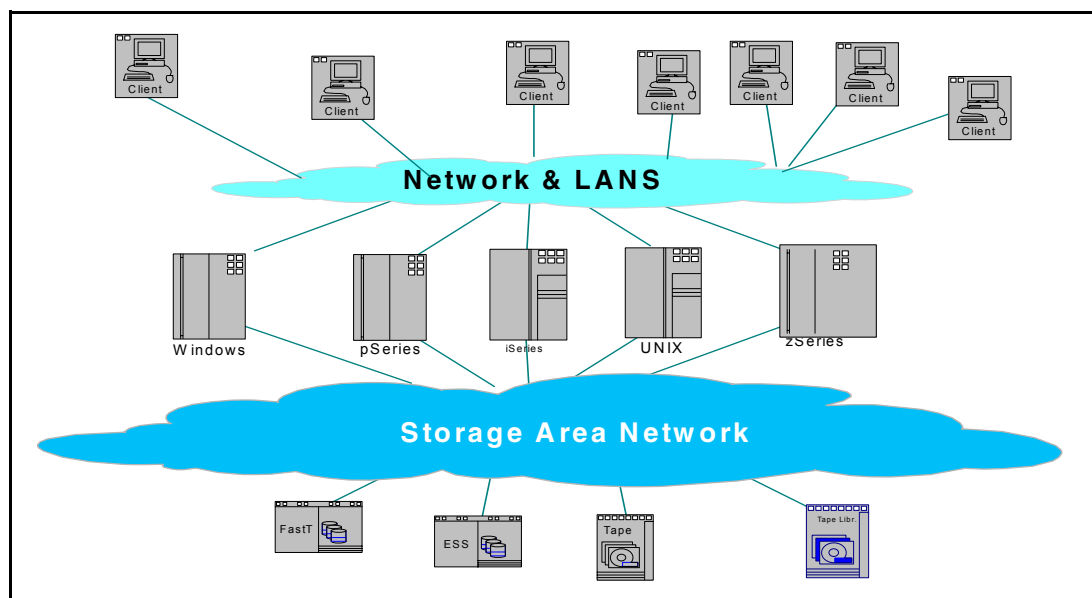


Figure 1-18 Overview of a SAN

A SAN facilitates direct, high-speed data transfers between servers and storage devices, potentially in any of the following ways:

- **Server to storage:** This is the traditional model of interaction with storage devices. The advantage is that the same storage device can be accessed serially or concurrently by multiple servers.

- ▶ **Server to server:** A client can use a SAN for high-speed, high-volume communications between servers.
- ▶ **Storage to storage:** This outboard data movement capability enables the movement of data without server intervention, thereby freeing up server processor cycles for other activities such as application processing. Examples include a disk device backing up its data to a tape device without server intervention or a remote device mirroring across the SAN.

1.2.2 Tape solutions in a SAN environment

Connectivity to tape is essential for most backup processes. However, manual tape operations and tape handling are expensive. Studies show that automation of tape processing saves money and increases reliability. Enterprises have long had to utilize staff to remove these tapes, transport them to a storage site, and then return them to the tape drive for mounting when necessary. Client tape planning initiatives are directed at more efficient utilization of drives and libraries, as well as minimization of manual labor associated with tape processing.

The biggest challenges with SCSI tape implementations are the limited cable length and the limited possibilities to share drives between several systems. For LVD SCSI, the total cable length is limited to 25 m (82 ft.) using point-to-point interconnection (such as one host connected to only one tape drive). With multi-drop interconnection (one host connected to more than one tape drive on the same SCSI bus), the total cable length is 12 m (39.4 ft.) for LVD SCSI and 25 m (82 ft.) for High Voltage Differential (HVD) SCSI. Most SCSI tape drives currently have only one SCSI port and therefore can only be attached on one SCSI bus. This severely limits the number of hosts that can physically allocate the drive without recabling.

SANs enable greater connectivity of the tape libraries and tape drives, as well as tape sharing, which we discuss later in this chapter. With Fibre Channel, the distance between the server (or *data point*) and the connected tape node can be up to 10 km. Fibre Channel enables multiple host scenarios without recabling.

If software to manage tape-drive sharing is unavailable, we have to isolate (or *zone*) the drives to unique hosts using functions commonly available on SAN gateways or switches. With the proper management software, each drive can talk to each host, and connections can be dynamic without recabling.

Backup solutions can utilize SAN technology in a number of ways to reduce the costs of their implementation and at the same time increase their performance.

Sharing tape devices on a SAN environment

The tape world has three distinct means of sharing:

- ▶ Library sharing
- ▶ Drive sharing
- ▶ Media sharing

Library sharing

Library sharing occurs when multiple servers attached to a tape library share both the library and the robotics. Tape drives within the library might or might not be shared (*pooled*) among the attached servers. Tape library sharing is a prerequisite for tape-drive sharing.

Drive sharing

The sharing of one or more tape drives among multiple servers is called *drive sharing*. To share drives between heterogeneous applications within a tape library, the tape library must

provide multiple paths to the robotics and also must have the capability to define the library's drives and slots as multiple logical libraries. The server attached to each partition has no knowledge of any drives or slots outside the partition.

Media sharing

Media sharing today is possible only in a homogeneous environment between servers that use the same backup server and the same library to back up their data. For systems that are not backed up by the same backup server, it is only possible to share a tape scratch pool.

Figure 1-19 shows the Multi-Path Architecture of the 3584 LTO tape library. Every drive can have a path defined to the SCSI Medium Changer (SMC).

The library on the left has been partitioned into three logical libraries. In the AIX® and Windows® partitions, only the first drive has a defined library control path.

The iSeries® is unique in that every IOP/IOA must have a library control path defined. That is true for V5R1. When you install V5R2, one FC adapter can support up to 16 LUNs. The System i attached to the library on the left has two SCSI buses and, therefore, two library control paths defined. These three servers share the IBM 3584 but not the drives.

The library on the right has not been partitioned and has only one logical library. Every System i SCSI bus has a library control path defined to allow control of the TS3500 robotics.

The System i servers attached to the right library also share the library even though it has not been partitioned. Through Backup Recovery Media Services (BRMS), the System i servers share the library and media; they are not performing tape-drive pooling.

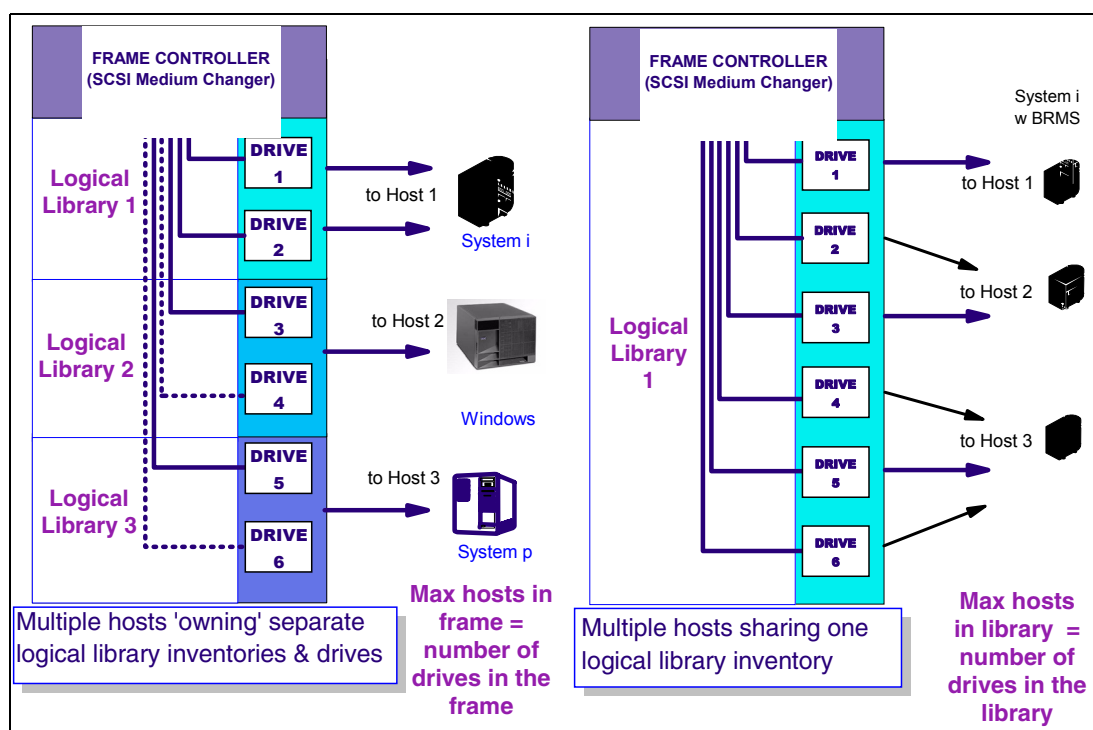


Figure 1-19 IBM 3584 Multi-Path Architecture

IBM LTO in SAN environment

The IBM LTO Ultrium 2 and 3 Tape Drives are available with a Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop (FC-AL) attachment. These options

remove the need to use a SAN data gateway. The device can be attached directly to SAN switches or FC-AL hubs.

In each case, the server requires a supported Fibre Channel host bus adapter (HBA).

Backup software for SAN environments

Implementing backup solutions in a SAN topology requires software developed to enable sharing tape drives at a logical level. The major benefits of this software are:

- ▶ Direct connection of the tape drive to the server for high speed
- ▶ Sharing the drive with another server to save money

All you need is the proper traffic control feature at a software level.

The development of backup software solutions supporting tape sharing on SAN is an ongoing process, and many of the backup software vendors have already delivered products or plan to deliver this type of product. IBM has made tape sharing available for IBM Tivoli® Storage Manager since Version 3.7 (October 1999).

Using electronic vaulting for disaster recovery

Another important aspect of using tape in a SAN is the opportunity to exploit tape connectivity for disaster recovery enhancements. Today, most enterprises take their tape backups off-site for disaster recovery. The tape is actually created in a locally attached tape library, then ejected from the library, and finally removed to an off-site location. All of this requires manual intervention and is error-prone. A major reason for failed recoveries is a misplaced tape or tapes.

Fibre Channel SANs enable the backup server to create tapes easily and safely in a remotely attached tape library. This is called *electronic vaulting*. It removes all of the manual effort, because the tape is already off-site and prevents a major cause of disaster-recovery failure. Currently, most enterprises staff tape operations to handle the tapes as they come and go from off-site storage. Fibre Channel allows for greater distances, so it becomes much easier to put a remote tape library at another location to create the backup tape copy. With this method, outlined in Figure 1-20, no manual handling is necessary.

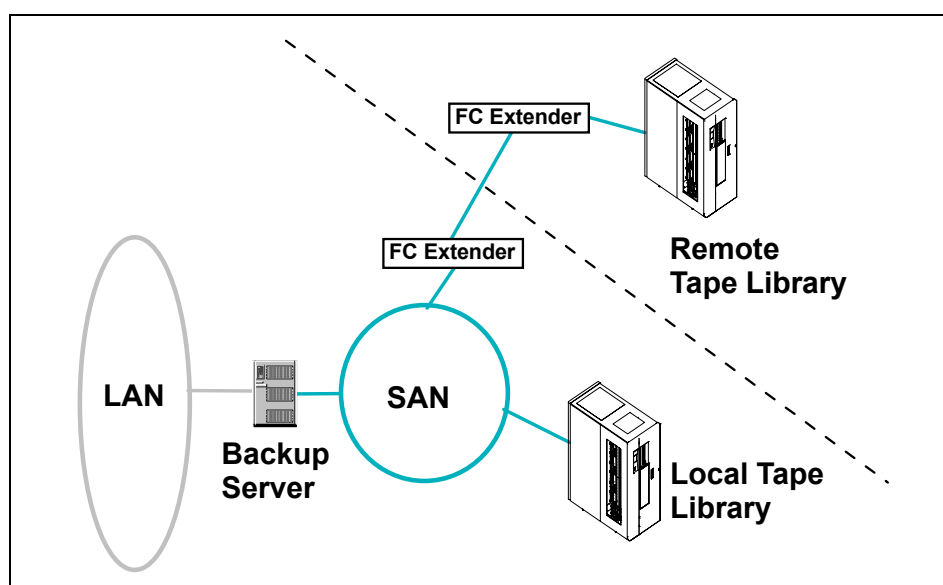


Figure 1-20 Electronic vaulting

LAN-free backup

SAN technology provides an alternative path for data movement between the backup client and the server. Shared storage resources, such as disk and tape, are accessible to both the client and the server through the SAN. Data movement is off-loaded from the LAN and from the server processor and allows for greater scalability. LAN-free backups decrease the load on the LAN.

Managed System for SAN is a feature of IBM Tivoli Storage Manager that enables LAN-free data movement. The Tivoli Storage Manager client data moves directly to and from a storage device attached to a SAN. A Tivoli Storage Manager Storage Agent is installed on the client machine and shares storage resources with the Tivoli Storage Manager server. The Storage Agent can write directly to storage media in a format that is consistent with that used by the server. The Tivoli Storage Manager server or servers control the storage devices and keep track of the data that the client has stored. Tivoli Storage Manager continues to use a LAN connection to exchange control information, such as policy information and data about the backed up objects. Using the SAN for client data movement decreases the load on the Tivoli Storage Manager server and allows the server to support a greater number of simultaneous client connections. Refer to Figure 1-21.

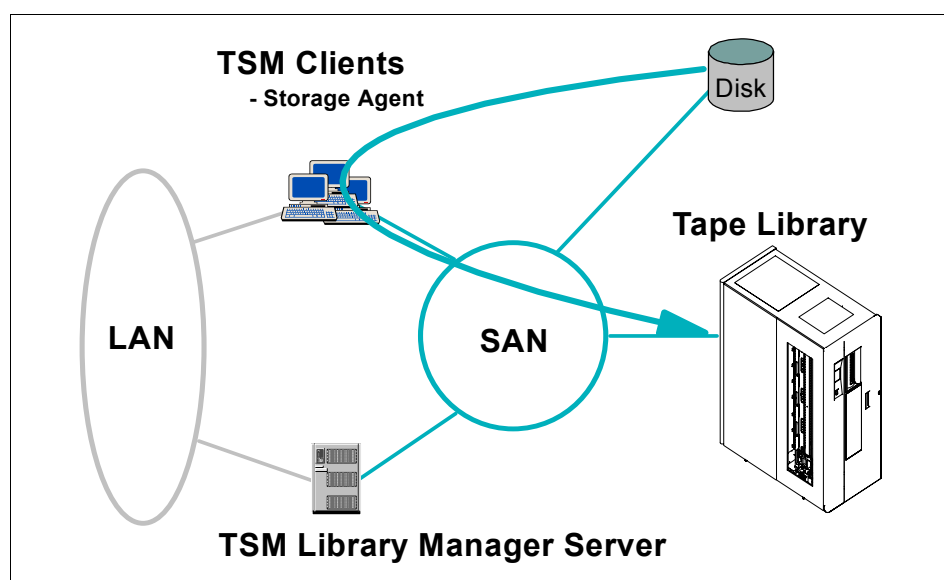


Figure 1-21 Tivoli Storage Manager LAN-free backup

The Storage Agent communicates with the server via the LAN to obtain and store database information and to coordinate device and volume access. The server determines whether the client is requesting access to storage for which the client has a defined SAN path. If a SAN path is defined, the client (by means of the Storage Agent) transfers data on that path. If a failure occurs on the SAN path, failover occurs and the client uses its LAN connection to the Tivoli Storage Manager server and moves the client data over the LAN.

1.3 Tape Virtualization for Open Systems

In order to reduce the Total Customer Ownership of the IT infrastructure, data centers have been adopting virtualization strategies in a number of areas, most notably in servers, with virtualization solutions, such as VMware, and in disk storage, with solutions, such as IBM SAN Volume Controller. Now, starting from a base of over 3000 early adopters of the 3494 VTS subsystem, IBM is extending that technology with the TS7500 Virtualization Engine™.

The storage industry refers to the IBM TS7500 Virtualization Engine as a virtual tape library. A *virtual tape library* provides high performance backup and restore by using disk arrays and virtualization software. IBM has taken an IBM System x™ server running Linux® and attached it to an IBM TotalStorage DS4000™ disk subsystem, running tape virtualization software, to form a Virtualization Engine.

A virtual tape library is a unique blend of several storage tiers. The life cycle of data from its creation at the server level migrates by backup software to a virtual tape library. There is no better place for the data to be, because the virtual tape library is a combination of high performance SAN-attached disk and high performance servers running Linux, emulating a tape storage device. At this level, you have many options for the data. For example, the data can remain on the virtual tape library indefinitely, as long as there is enough space, or it can be migrated to tape for off-site storage, archive, or both.

Any business that has a need for high performance backup and restore might need Virtualization solutions. Instant access backups and restores are capabilities that only the disk storage tier can provide. All backup software products were designed to back data up to tape drives and libraries, and virtual tape library emulates tape. You can go directly to a virtual tape library and have your backups completed quickly.

Virtual tape libraries fill a void in the backup infrastructure for data that needs to be restored at a certain moment. Most restores that need to occur happen often within six weeks of the data being backed up. Backup software can be configured to back up data to a virtual tape library and then create a virtual tape-to-tape copy for off-site deployment. It is no longer necessary to call the tapes back from an off-site location, unless data is required from years past.

Refer to Appendix D, “IBM Virtualization solutions” on page 521 for additional description of the IBM TS7500 Virtualization Engines.



Overview of IBM LTO Ultrium Tape Drives

The Linear Tape-Open (LTO) program was conceived as a joint initiative of IBM, Hewlett-Packard, and Seagate Technology. In 1997, the three technology provider companies set out to enable the development of best-of-breed tape storage products by consolidating state-of-the-art technologies from numerous sources. In November of that year, they produced a joint press release about LTO. The three technology provider companies for LTO are Hewlett-Packard (HP), IBM Corporation, and Certance LLC¹.

In the tape storage industry, the member companies saw a common set of problems affecting clients in the midrange and network server areas. Multiple tape options were available, each offering certain strengths in terms of capacity, performance, data integrity, reliability, and cost, but no single option appeared to meet all of these client needs effectively. The LTO technology objective, therefore, was to establish new open-format specifications for high-capacity, high-performance tape storage products for use in the midrange and network server computing environments and to enable superior tape product options.

We discuss the LTO format specifications in general terms, including first, second, third, and fourth generation Ultrium. The documented LTO specification includes all of this information: information referring to the data cartridge, the format in which data is written, elements of the drive specification relating to that format, and the compression algorithm description. This kind of information is applicable to all LTO manufacturers' product offerings to ensure cartridge interchangeability.

Information in this chapter that relates to the LTO Ultrium drive relates to the IBM LTO Ultrium drive. It might differ from information from other manufacturers in regard to features, such as data rate and reliability.

In this chapter, we also present the IBM 3592 technology, introduced by IBM in October 2003.

¹ Seagate RRS became Certance and is now owned by Quantum.

2.1 The LTO organization

The two principal Web sites for marketing, technical, and licensing details for the Linear Tape-Open program are:

<http://www.lto-technology.com>

<http://www.ultrium.com>

2.1.1 Overview

Two LTO formats (Ultrium and Accelis) were originally introduced in 1997, and licenses for the new technology were made available. Since then, the Accelis format has not been actively pursued by manufacturers, because it is apparent that the Ultrium format meets market needs. The three LTO sponsoring companies also took steps to protect client investment by providing a six-generation roadmap that illustrates native capacity as shown in Figure 2-1 and establishing an infrastructure to enable compatibility between products. At the time of writing this book, four generations were available.

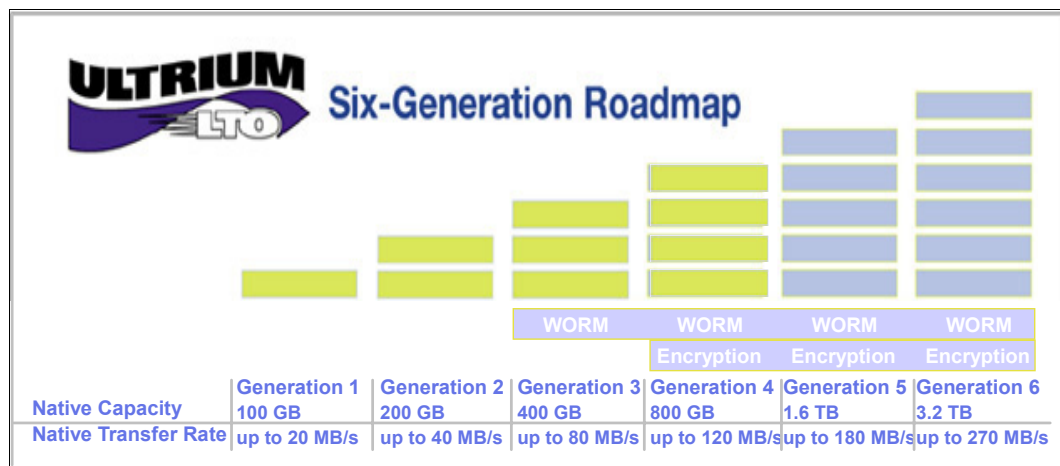


Figure 2-1 LTO Ultrium native capacity roadmap

Important: Hewlett-Packard, IBM, and Quantum reserve the right to change the information in this migration path without notice.

The LTO Ultrium compatibility investment protection is provided based on the following principles:

- ▶ An Ultrium drive is expected to read data from a cartridge in its own generation and at least the two prior generations.
- ▶ An Ultrium drive is expected to write data to a cartridge in its own generation and to a cartridge from the immediately prior generation in the prior generation format.

We discuss compatibility among the available Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 media in 2.5.1, “IBM Ultrium 1, 2, 3, and 4 compatibility” on page 78.

The three technology provider companies (HP, IBM, and Quantum) have all made significant contributions of time and expertise to the definition of the LTO format specifications. All three companies have deep knowledge of client needs and have provided expert knowledge and engineering skill in the critical areas of magnetic recording technology, mechanism design, media materials, and cartridge design. This cooperative process has created stronger LTO format definitions than any of the individual companies might have developed working alone.

Open licensing and manufacturing

To answer industry calls for open tape format specifications, LTO format specifications have been made available to all who want to participate through standard licensing provisions. More than 25 companies, including HP, IBM, and Quantum, have become LTO technology licensees. The licensees include an impressive array of worldwide storage industry leaders, such as:

- ▶ Accutronics Incorporated
- ▶ ADIC
- ▶ Advanced Research Corporation
- ▶ Alps Electric Company Limited
- ▶ Certance
- ▶ EDP/Colorflex
- ▶ EMag Solutions
- ▶ EMTEC Magnetix GmbH
- ▶ Exabyte Corporation
- ▶ Fuji Photo Film Company Limited
- ▶ Fujitsu Limited/FCPA Intellistor
- ▶ Hewlett-Packard Company
- ▶ Hi/fn
- ▶ IBM Corporation
- ▶ Imation Corporation
- ▶ M4 Data Limited
- ▶ Matsushita Electric Industry
- ▶ Maxwell
- ▶ Mitsumi Electric Company Limited
- ▶ Mountain Engineering II Incorporated
- ▶ NEC Corporation
- ▶ Otari Incorporated
- ▶ Ontrack Data International
- ▶ Overland Data, Incorporated
- ▶ Phillips Semiconductor Gratkorn
- ▶ Plasmon IDE Incorporated
- ▶ Quantegy Incorporated
- ▶ Sony Corporation
- ▶ Tandberg Data
- ▶ TDK Corporation
- ▶ Verbatim Corporation

In attracting these other industry-leading companies, LTO program technology and LTO specified products (tape drives and tape storage cartridges) can reach the market from multiple manufacturers, not just the technology provider companies. This availability is critical to meeting an open market objective and is accomplished through open licensing of the technology.

License packages

Three combinations of packages are available for potential licensees:

- ▶ *Ultrium Specification Document* provides the opportunity to review the Ultrium format specification with a minimal investment and is suitable for those companies interested in a feasibility investigation.
- ▶ *Ultrium Tape Cartridge License Package* is for those companies that are interested only in designing Ultrium tape cartridges.
- ▶ *Ultrium Tape Mechanism License Package* enables the licensee to design Ultrium Tape Drive mechanisms.

Each license package contains one or all of the following types of documents:

- ▶ *Format specification documentation*, which provides the technical information about the format that is necessary to develop mechanisms and cartridges that interchange between products of the same format
- ▶ *License documentation*, which provides additional technical information about tolerance interdependencies and interchange verification testing, and which also presents a conceptual overview of the design
- ▶ The *trademark style guide*, which describes the use of the Ultrium trademarks and logos (Figure 2-2)



Figure 2-2 LTO trademarks

Compliance verification

The technical strategy for accomplishing format compliance verification among the licensees has been defined, and an independent Compliance Verification Entity (CVE) has been selected. In an effort to promote interchangeability of tape cartridges, a third-party verification test company has been enlisted to perform specification compliance verification testing. These tests will be required annually for all companies that use the logo.

The objective of the compliance testing is to test only the ability to produce, read, or write Ultrium cartridges that meet the format specifications. It is not an objective of this format compliance testing to evaluate Ultrium drive quality, mean time before failure (MTBF), physical form factor, or other parameters that are not directly related to the LTO program formats and interchangeability. LTO program licensees have wide latitude to establish their own mechanical, electrical, and logical designs to meet the format specifications. These factors will not be tested as part of the compliance verification process.

For more details about the packages, documentation, or licensing, refer to the LTO Web site:

<http://www.lto-technology.com>

2.1.2 LTO standards

LTO technology was originally developed for two open tape format specifications: Accelis and Ultrium. The Accelis format (fast-access) is not being developed, because the Ultrium format provides adequate fast-access performance.

LTO core technology

Multi-channel linear serpentine recording is at the core of the LTO formats. It enables an optimum balance of reliability and data integrity, performance, and high capacity. In the LTO recording format, data is written in tracks that run down the length of the tape.

The Ultrium format records either 384 (Ultrium 1), 512 (Ultrium 2), or 704 (Ultrium 3) tracks across the half-inch tape width. This linear recording format has a *serpentine* characteristic. The drive mechanism makes multiple passes from the beginning of the tape to the end of the tape and back to read or write the full capacity of the cartridge. In the Ultrium 1 format, the 384 tracks are split into four bands of 96 tracks each. In Ultrium 2 format, the 512 tracks are split into four bands of 128 tracks each. In Ultrium 3 format, the 704 tracks are split into four bands of 176 tracks each. In Ultrium 4 format, the 896 tracks are split into four bands of 224 tracks each.

Data is written to the innermost bands first to provide protection to the data recorded earliest in the process, by writing it in the center, which is the most physically stable area on the tape. Data is also verified as it is written. On pass one of a round-trip down the length of the tape and back, eight tracks are read or written, concurrently. At the end of the tape, pass two of the round-trip starts. The Read/Write heads are indexed and positioned over eight new tracks, and the tape reverses direction back toward the beginning of the tape to complete the round-trip. For the next round-trip, the heads are again indexed to a new position over a new group of eight tracks. With Ultrium 3 and 4, 16 tracks are read/written on each pass of a round-trip.

Because track densities are high, and because the tape is subject to lateral movement as it is moved, it is critical for performance and data integrity that the Read/Write heads are always positioned precisely over the correct tracks. This is accomplished through a technique called *timing-based servo*. This technique makes it possible to use high track densities, now and in the future, without changing the format of the media, and it provides the ability to read data, even with media imperfections.

In the LTO system, electronic signals are generated through the real-time reading of servo data bands that are prerecorded on the LTO tape. These signals enable the servo system to dynamically control the positioning of the Read/Write heads across the width of the tape. Similar magnetically based, track-following servo systems are used successfully in tens of thousands of tape drives that are in use today, such as the IBM TotalStorage 3590 Tape Drive (IBM 3590) and IBM TotalStorage 3592 Tape Drive (IBM 3592).

The LTO formats also utilize advanced error correction codes for data integrity. These systems are designed to automatically correct most cross-track errors and provide data correction even if a full track is lost. Data is further protected by the demarcation of bad areas of the tape (for example, where servo signals are unreliable) and through dynamically rewriting bad blocks. Cartridge memory is embedded in the LTO cartridges. A non-contacting radio frequency module, with non-volatile memory capacity of 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4, provides for storage and retrieval.

Ultrium tape formats

Figure 2-3 on page 34 and Figure 2-4 on page 35 show the IBM Ultrium cartridges, which you can distinguish by color: The first generation IBM cartridge is black, the second generation (Ultrium 2) cartridge is purple, the third generation (Ultrium 3) is slate blue, and the fourth generation (Ultrium 4) is green. The third generation IBM Write Once Read Many (WORM) cartridge is a two-tone cartridge with a slate-blue top and a platinum (silver) bottom, and the fourth generation WORM cartridge is a two-tone cartridge with a green top and a platinum (silver) bottom.

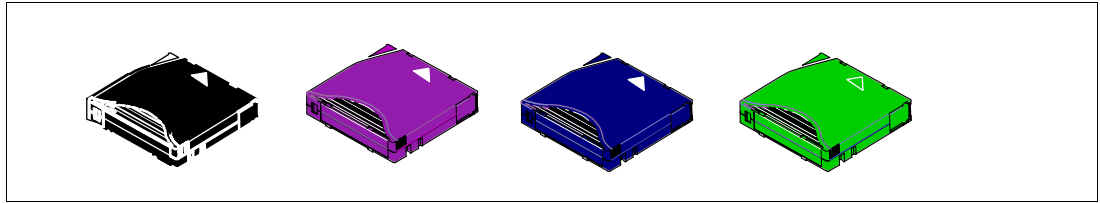


Figure 2-3 IBM LTO Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 tape cartridges

The Ultrium tape format specification is the implementation of LTO optimized for high capacity and performance with outstanding reliability, in either a stand-alone or an automated environment. The Ultrium cartridge uses a larger single-reel design (Figure 2-3 and Figure 2-4 on page 35) and 1/2-inch tape to provide ultra-high storage capacity. The tape is extracted from the cartridge by the tape drive through a leader pin and wound onto a take-up reel contained within the drive itself. This design is focused on client requirements for very high capacity and performance, and is ideally suited for backup, restore, and archive applications. Ultrium drive technology is intended to meet the needs of the enterprise on a roadmap, or migration path, that extends well into the future. The Ultrium tape format establishes a new benchmark for large volume backup and archive.

WORM tape format

Beginning with LTO Ultrium format generation 3, Write Once Read Many (WORM) functionality provides for non-erasable, non-rewritable operation with tape media and is designed for long-term, tamper-resistant record retention. LTO4 drives provide the same WORM capability.

The format specification for WORM for LTO Ultrium generation 3 and 4 includes low-level encoding in the Cartridge Memory (CM) and also is mastered into the servo pattern as part of the manufacturing process. This encoding is designed to prevent tampering.

Data can be appended at the end of a WORM cartridge to which data was previously written allowing the full use of the high-capacity tape media.

LTO Ultrium format generation 3 non-WORM and WORM as well as LTO4 drives can coexist.



Figure 2-4 IBM LTO Ultrium 3 WORM tape cartridges

Interleaved recording

The LTO drive uses an interleaved, serpentine, longitudinal recording format. The first set of 8 or 16 data tracks is written from near the physical beginning of the tape to near the physical end of the tape. The head then repositions to the next set of tracks for the return. This process continues until all tracks are written and the tape is full.

The format of the recording of the data and servo tracks is defined as part of the LTO specification in order to meet the requirement for interchange among different manufacturers' implementations.

Servo tracks

Servo tracks (also called *servo bands*) enable accurate positioning of the tape drive head over the data track, ensuring that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo bands are written when the cartridge is manufactured, before the cartridge is usable for data storage and retrieval. If the servo bands are erased, the tape becomes unusable.

Servo tracks are similar to lane markings on a multi-lane highway. Imagine how difficult it is to drive on the highway without any lane markings. Lane markings help by positioning you on the lane, just as servo tracks support the drive recording head to position it on the data tracks. Refer to Figure 2-5 on page 36.

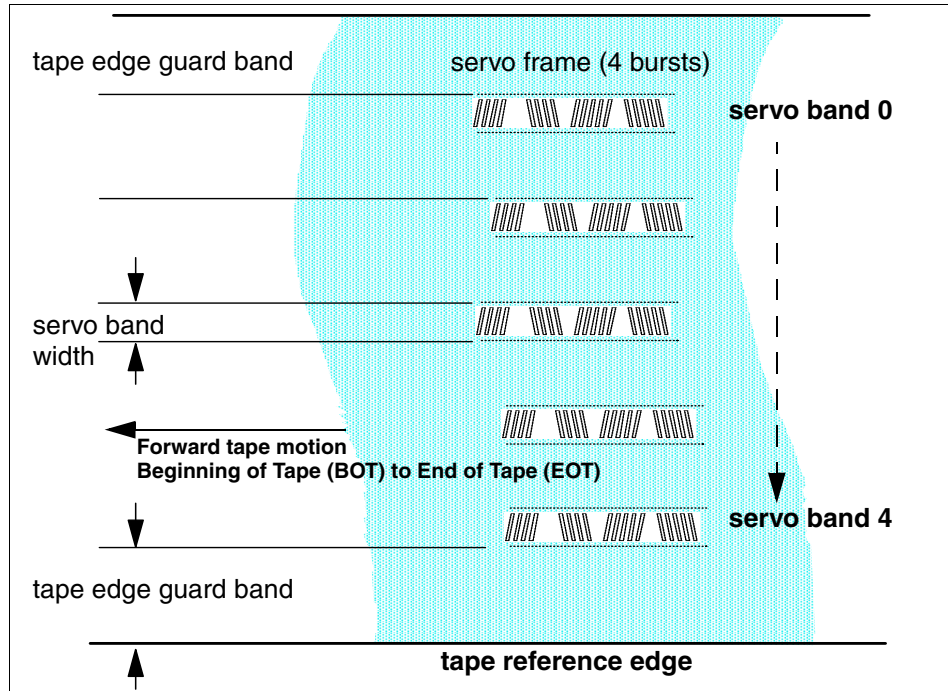


Figure 2-5 Servo band position and nomenclature

As shown in Figure 2-5, five servo bands, numbered 0 through 4, make up the servo tracking mechanism on the LTO Ultrium tape. They are each located at specific distances from the tape reference edge². Within the servo bands are *servo stripes*, groups of which make up *servo bursts*. Four servo bursts make up a servo frame; the first two bursts (as written in the forward tape-motion direction) contain five servo stripes, and the second two bursts contain four servo stripes.

Track following

Each pair of servo bursts is at an angle to each other, and the servo heads move such that they keep a constant value for the distance between the bursts. In this way, the servo is able to follow a straight line within the servo band; any small deviation away from the correct path causes a variation (plus or minus) in the gap between the bursts (see Figure 2-6 on page 37). Provided that the servo head element follows a straight line along the servo band, then the distance “x” shown in the figure remains constant. IBM LTO drives use two servo bands simultaneously during write operations to provide two sources of servo information and therefore increased accuracy.

² The reference edge of the tape is the bottom edge when viewing the recording side of the tape with the hub of the tape to the observer's right, as shown in Figure 2-5.

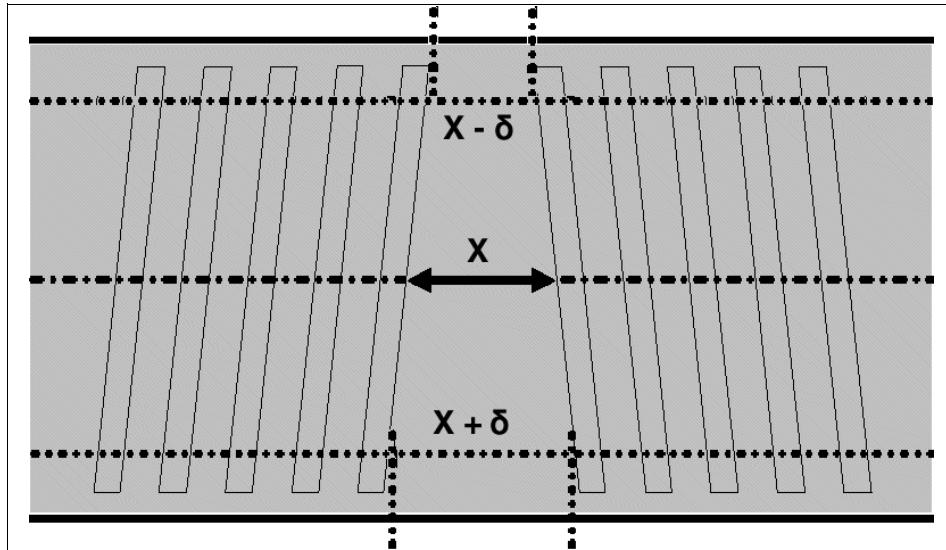


Figure 2-6 Magnified servo band showing a pair of servo bursts

The format specifies six nominal servo positions for Ultrium 1, eight servo positions for Ultrium 2, and eleven servo positions for Ultrium 3 within each servo band. In addition, the servo head is made up of two servo head elements to address a single servo band. This design means that, using the two elements, the servo head is able to reposition within the servo band for the six (Ultrium 1) or eight (Ultrium 2) forward and reverse data wraps within each data band (Figure 2-9 on page 40). The distance between each servo position corresponds to the distance apart that the data tracks are written. For further information about the drive head and elements, refer to “Drive head” on page 53 and Figure 2-20 on page 53.

This technology can be extremely fine-tuned and is capable of supporting very high track densities using the same servo tracks, because the Ultrium 1 and Ultrium 2 six/eight nominal positions are basically definitions of six/eight different “x distances” between servo bursts (see Figure 2-6) and not a fixed servo track. By defining additional “x distance” positions, it is possible to increase the number of tracks on an LTO Ultrium while still using the same technology. With this technology, LTO is also able to satisfy the compatibility aspects as described in 2.1, “The LTO organization” on page 30. The Ultrium 2 drives have to use the six defined “x distances” on the Server tracks to read and write in Ultrium 1 Format.

With Ultrium 3, the concept is still the same, but increases the number of servo positions to eleven. Compatibility with the previous generations is achieved by using their six/eight servo positions. Refer to “Data tracks” on page 38 also for further details.

Longitudinal positioning

The LTO servo band is designed not only for track following, but also for recording the longitudinal position (LPOS). The absolute location down the length of the tape and the manufacturer data are recorded in LPOS *words* approximately every quarter-inch (.7 cm) along the tape. The LPOS word consists of symbols constructed from bit sequences (ones and zeros); these bits are encoded within the servo frames. Refer to Figure 2-7 on page 38.

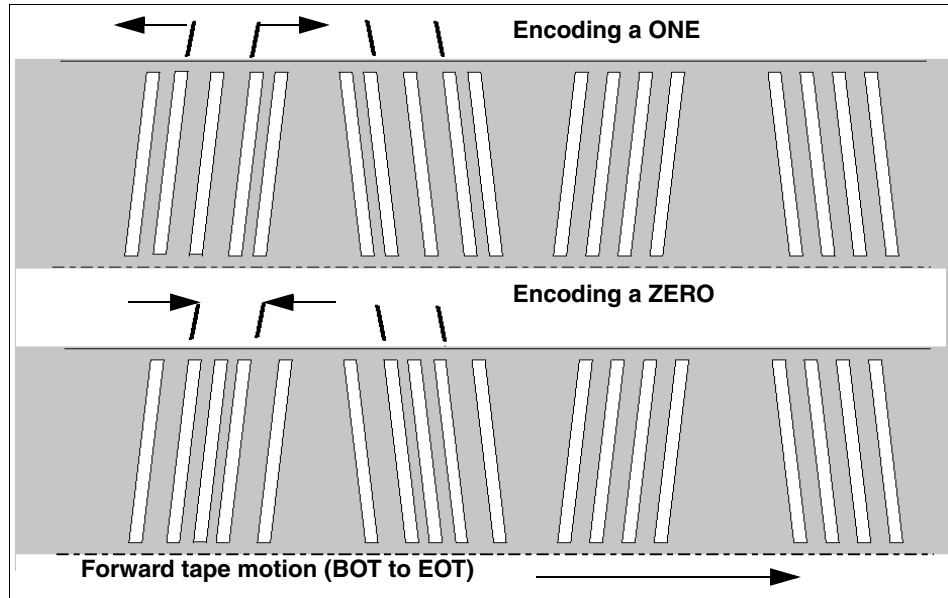


Figure 2-7 Encoding bits using the servo stripes within the servo bursts

Each servo frame encodes one bit using the first pair of servo bursts. When servo stripes 2 and 3 (out of the five) are shifted inward (see Figure 2-7), this encodes a zero; when servo stripes 2 and 3 are shifted outward, this encodes a one. The LPOS word contains 36 bits and therefore has a length of 36 servo frames.

Each of the 5 servo bands on the tape can be uniquely identified by the relative positions of the frames down the tape, in adjacent servo bands. The offset of the frames between servo band n and servo band $n+1$ are specific to each servo band (0 and 1, 1 and 2, 2 and 3, or 3 and 4). Therefore, the drive can move the head directly from the physical beginning of the tape to a specific logical position for reading or writing.

Data tracks

The area between adjacent servo bands is a *data band*. There are four data bands numbered 2, 0, 1, and 3, where data band number 2 is nearest to the reference edge of the tape and data band 3 is farthest away, as in Figure 2-8 on page 39. The data bands are written in sequence beginning with 0 (in the center of the tape) and ending with 3.

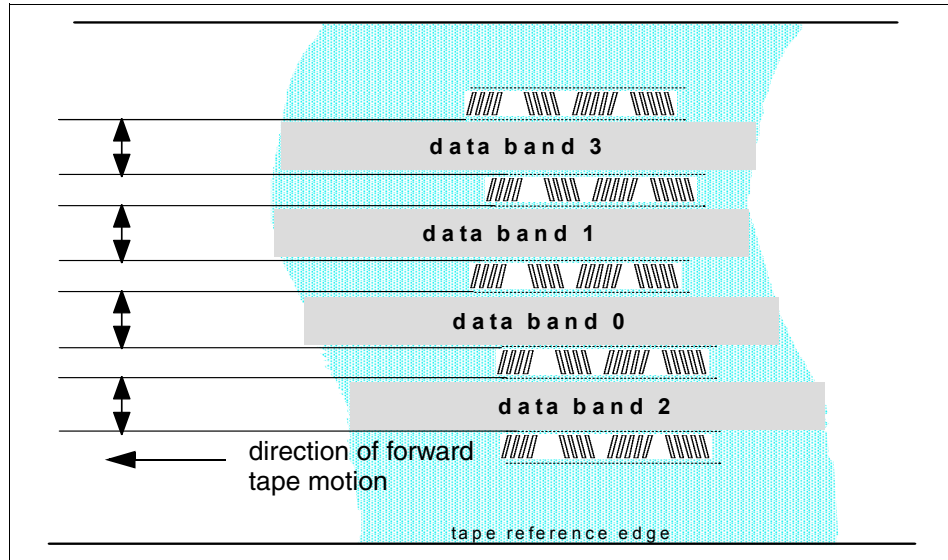


Figure 2-8 Four data bands written between the servo tracks

Each data band consists of numbers of tracks that are recorded eight tracks at a time (for Ultrium 1 and Ultrium 2) from one end of the tape to the other end. For Ultrium 3 and Ultrium 4, the tracks are recorded 16 tracks at a time. The process is:

1. The head is positioned over data band 0, and the first set of eight (16) tracks is written from the physical beginning of the tape (BOT) to the physical end of the tape (EOT).
2. The head physically repositions (using a different servo position within the same servo bands) and switches electronically³ to a second set of eight (16) write elements in order to write eight (16) tracks in the reverse direction back to the physical beginning of the tape.
3. The head physically repositions again, and, switching back to the first set of write elements, writes another set of tracks to the physical end of the tape.
4. The head continues to switch and index in this manner until all the tracks are written, and the head is back at the physical beginning of the tape (Ultrium 1 and 2) or at the end of the tape for Ultrium 3.
5. The head moves to data band 1 to continue writing the data.

For Ultrium 1, 96 data tracks (8 tracks times 6 forward and backward writes) coexist in one data band. For Ultrium 2, there are 128 data tracks in one data band (8 tracks times 8 forward and backward writes), and for Ultrium 3 there are 176 tracks in one data band (16 tracks times 6+5 forward or backward writes). For Ultrium 4, 224 data tracks (16 tracks times 14 forward and backward writes) are in one data band.

A group of tracks recorded concurrently in the physical forward or the physical backward direction is called a *wrap*. Wraps recorded while the tape is moving from BOT to EOT are *forward wraps*; wraps recorded while the tape is moving from EOT to BOT are *reverse wraps*. The wraps are recorded in a serpentine fashion, as described: a forward wrap, then a reverse wrap. They are numbered sequentially in the order that they are processed, starting with wrap 0. Therefore, for Ultrium 1 six forward wraps and six reverse wraps make up a data band. For Ultrium 2, eight forward and eight reverse wraps make up a data band. The individual tracks within a wrap are interleaved with tracks from other wraps; in other words, adjacent tracks are not part of the same wrap. Refer to Figure 2-9 on page 40.

³ See "Drive head" on page 53 for more information about electronic head switching.

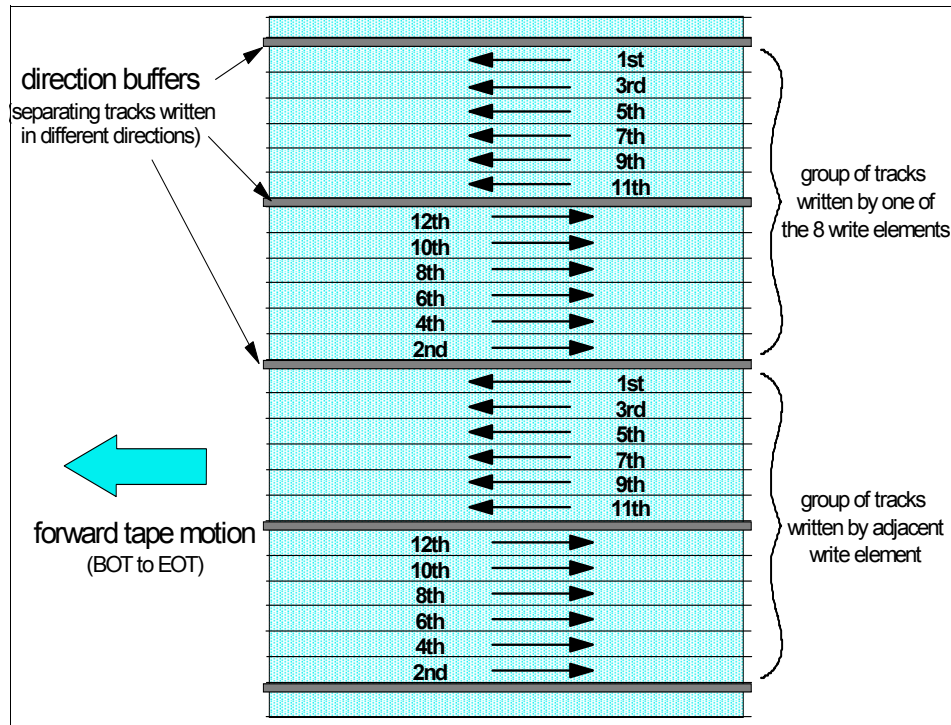


Figure 2-9 Portion of data band showing Ultrium 1 track-writing sequence

This figure expands on Figure 2-8 on page 39 to illustrate the sequence in which the tracks are written. One data band is magnified⁴ to show an area written by two adjacent write head elements (from the total of eight); this is one quarter of the width of the data band. You can see that the tracks are written in an inward spiral (serpentine) manner; the first and second tracks are farthest away from one another while the 11th and 12th tracks are adjacent to one another. In Ultrium 2, there will be 16 serpentine tracks for each of the eight write elements.

Ultrium 3 is conceptually the same, but technically different. Within each data band, there are 16 write elements that will write a total of 11 serpentine tracks. For example, in data bands 0 and 2, there are six forward wraps but only five reverse wraps. The data bands 1 and 3 are complementary to this and will contain five forward wraps and six reverse wraps. Thus with Ultrium 3, the Read/Write head is moved from data band 0 to data band 1 while the tape is at the EOT position.

The space between tracks written in opposing directions is called a *direction buffer*. This space is designed to minimize magnetic interference between tracks written in opposite directions (cross-track interference).

Read/verify elements are built into the tape head in the drive. The data is written by the write elements and then immediately passes the read/verify elements and is checked for errors. If any errors are found, the block of data is rewritten farther down the tape.

The total number of data tracks across the width of the tape is 384 for Ultrium 1, numbered 0 through 383. For Ultrium 2, 512 tracks are used, for Ultrium 3 there is a total of 704 tracks, and for Ultrium 4, there are 896 tracks. Track numbering is unrelated to the sequence in which the tracks are written: data track 383/511/703 is the closest to the reference edge of the tape, and data track 0 is farthest away.

⁴ Refer to "Drive head" on page 53 and Figure 2-20 on page 53 to see the structure of the eight-element head.

Backwards compatibility

The LTO standard specifies a backwards compatibility of writing one generation backwards and reading two generations backwards. To make this possible, LTO uses a technique called *shingling*. When using shingling, a write track might overlap the bottom of a previously written track. LTO Generation 2 uses shingling when writing data to an LTO Generation 2 Cartridge. The very first two passes write to the tape in the normal way. The following passes can partially overwrite previously written data tracks. The IBM LTO Generation 2 write head width is that of the LTO Generation 1. Therefore, the LTO Generation 2 drives can write an LTO1 cartridge in full track width, and when writing to an LTO2 cartridge, it uses the shingling write function. To read the residual LTO Generation 2 data tracks, the read head must of course be narrower than the LTO Generation 1 read head (Figure 2-10).

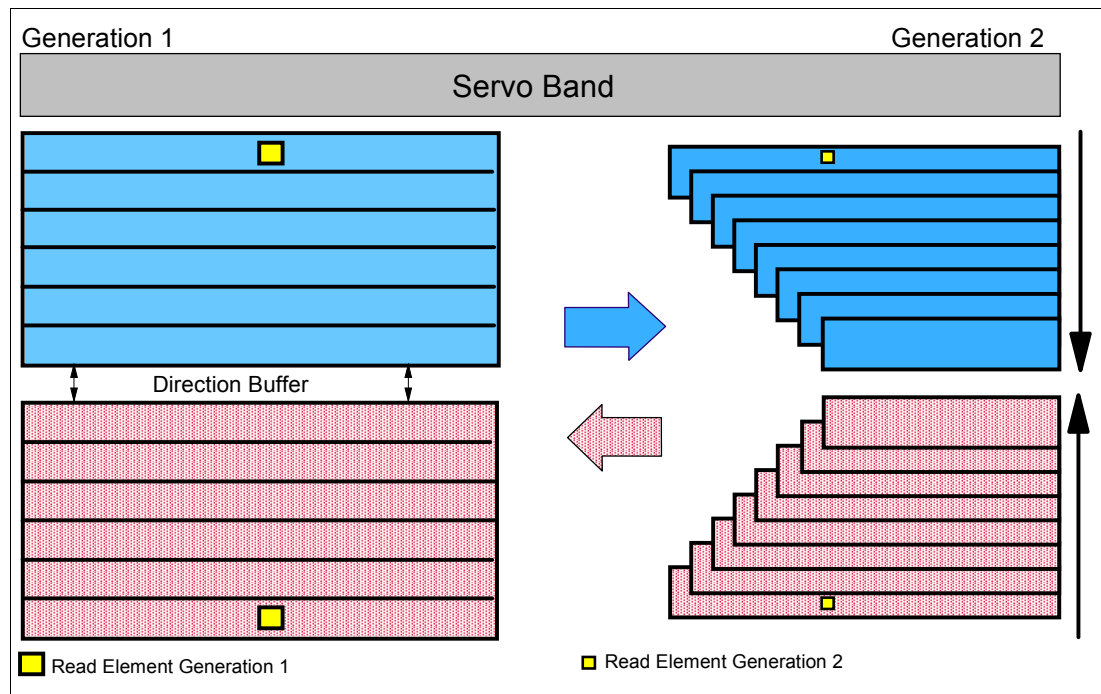


Figure 2-10 Shingling: Writing to tape Generation 1 compared to Generation 2

Again, LTO Generation 3 and 4 are conceptually the same, but technically different. The Ultrium 3 and 4 data is written 16 tracks at a time utilizing the shingling technique. To achieve compatibility, the write heads of LTO3 drives are equal to the residual track width of the Generation 2 format, and the spacing between alternate (every second) Generation 3 write heads is the same as between the Generation 2 write heads. Thus, Generation 3 data is written using the shingling method, but Generation 2 data is written using only every second write head and writing the full Generation 2 data width. Generation 1 data can similarly be read by every other read head.

Linear density

The linear density for LTO1 is 4880 bits per mm. The linear density was improved for LTO2 to 7398 bits per mm and for LTO3 to 9638 bits per mm.

Both LTO1 and LTO2 cartridges are of the same length, 610 m (2000 ft.). To achieve the required doubling of capacity, the LTO3 tape is slightly longer, 680 m (2231 ft.) and LTO4 is 864 m (2703 ft.).

2.1.3 Data compression

The LTO Consortium created a superior data compression technique known as *LTO Data Compression (LTO-DC)*. Though an excellent data compression algorithm, adaptive lossless data compression (ALDC) already existed, and it is not optimized for incompressible data such as encrypted or previously compressed data. For incompressible data, it is usually best not to apply any data compression algorithm, but rather to simply pass the input data directly out to the compressed data stream (pass-through). Given the variations in data, there are times when ALDC is desirable and times when a simple pass-through is better. For instance, if using ALDC-based data compression, it is best if all segments of incompressible data are recorded without expansion by using a pass-through technique instead. Figure 2-11 is a block diagram illustration of the LTO-DC data compression technique using the two schemes.

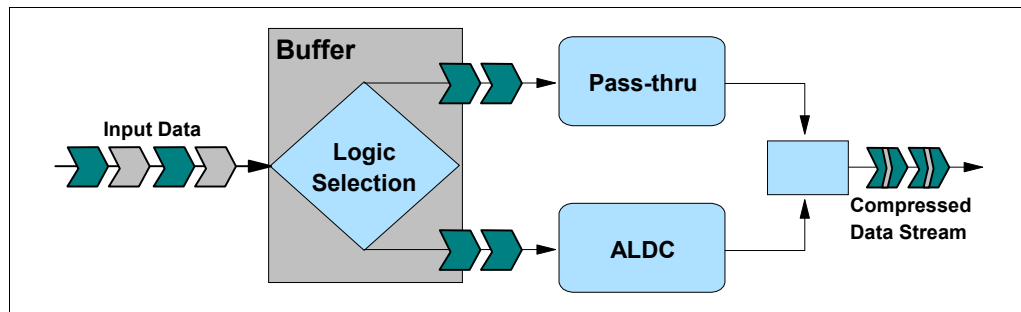


Figure 2-11 LTO-DC block diagram

Note that no standardization of when to scheme swap when compressing data was specified by LTO-DC. LTO-DC was approved by ECMA as the Streaming Lossless Data Compression (SLDC) standard, as explained at:

<http://www.ecma-international.org/publications/standards/ECMA-321.htm>

Note: The LTO compression technique is called SLDC.

Because no standardization is specified, all vendor implementations might perform scheme swapping differently. What is specified and tested is that the resultant compressed data stream is decompressible by the defined set of LTO-DC rules. This capability enables interchange between drives from multiple vendors. Each vendor's Ultrium drive has been shown to be able to read and decompress the LTO-DC streams of the other vendors' Ultrium drives.

Embedded codewords

LTO-DC uses embedded codewords to enable swapping between the two schemes. ALDC is referred to as Scheme 1, and pass-through is referred to as Scheme 2. Both methods are used. However, only one method is used to output any given data byte, although, different bytes in a record might be output in different schemes. Therefore, if a given record begins with compressible data, it can be output in Scheme 1, and if the nature of the data changes inside of the record and it becomes incompressible (as embedded control data or an array of incompressible data), a scheme swap can be performed to allow outputting the incompressible data in Scheme 2. Similarly, a scheme swap can be performed to revert to Scheme 1 if the data becomes compressible again. A scheme swap is denoted in the compressed data stream via one of four embedded codewords.

As an example, one 13-bit codeword basically means all following data is to be decompressed as Scheme 1 until another scheme swapping codeword is encountered. Embedded codewords are also used to delineate record boundaries and file marks. Having

record boundaries demarked within the output compressed data stream, rather than by pointers maintained in a separate directory table, has a number of advantages. First, from a storage point of view, it is more efficient because it enables greater capacity. Second, the insertion of these codewords enables higher-speed data streaming because they can be managed by the compression engine without microprocessor involvement. Both of these features are especially useful for small records. Typically, backup applications will send 512-byte, 4-KB, 32-KB, or 256-KB records to a backup tape drive. For small records such as 512 bytes, the improved format efficiency of the embedded control is substantial. By reducing required microprocessor involvement, it allows superior transfer rates to the drives. This is why LTO tape drives offer high capacity tape backup, as well as drive transfer rates far better than other midrange backup tape drives and are superior even to some more expensive, high-end tape drives.

The ability to swap between ALDC and a pass-through mode gives a tape drive the power to automatically adapt to the incoming data stream.

Note: The IBM 3592 Tape Drive uses the same compression technique: SLDC.

2.1.4 Tape cartridge

The Ultrium cartridge is a single-reel cartridge. This means that the whole tape is wrapped around a single reel when the cartridge is not loaded in a drive. During the loading process, the threader of the drive catches the leader pin of the tape and threads it through the drive and the machine reel. During the Read/Write process, the tape is stored on the machine reel and the cartridge.

Two views of the tape cartridge are shown in Figure 2-12 and Figure 2-13 on page 44.

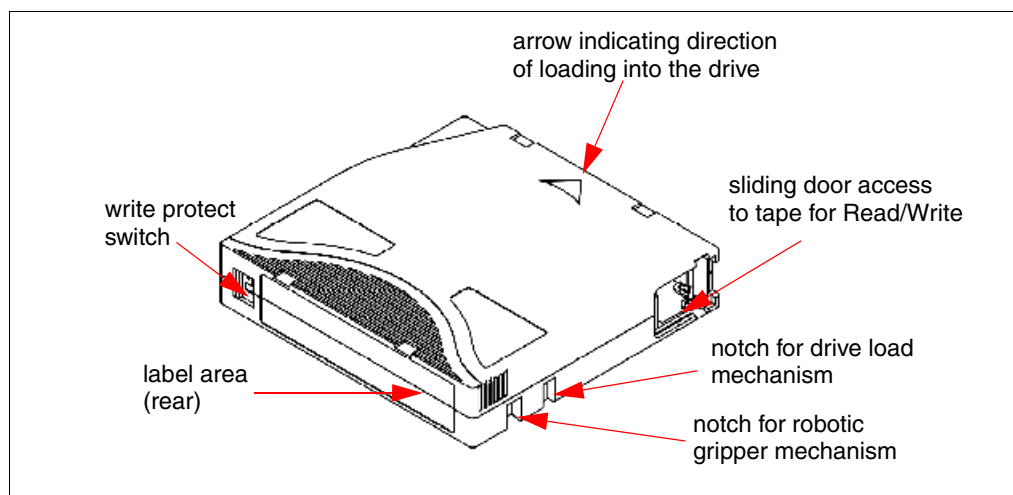


Figure 2-12 Ultrium cartridge view from top and rear

The cartridge is approximately 10.2 cm long, 10.5 cm wide, and 2.2 cm high (approximately 4 x 4.16 x 0.87 inches). The cartridge contains 12.6 mm (1/2-inch), metal-particle tape with a high density recording area. The Ultrium 1 specification describes four types of cartridges, each with a different tape length and, therefore, capacity. At this time, only one cartridge type is generally available, with a tape length of 610 m (2000 ft.) providing 100 GB of native data and 200 GB of compressed data (assuming 2:1 compression). There is only one standard Ultrium 2 cartridge type and therefore only one tape length of 610 m (2000 ft.). The native capacity of the Ultrium 2 cartridge is 200 GB (400 GB compressed assuming 2:1 compression).

With Ultrium 3 and 4, there are both regular rewritable tapes and Write Once Read Many (WORM) tapes. To achieve the 400 GB (LTO3) or 800 GB (LTO4) native data, this tape is slightly longer at 680 m (2231 ft.).

Figure 2-13 shows several of the components of the cartridge.

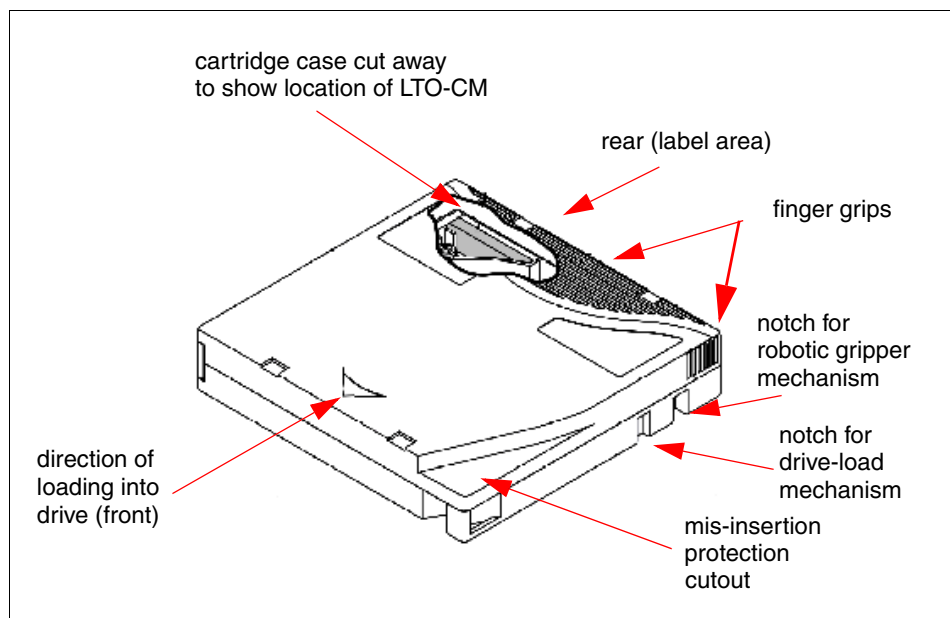


Figure 2-13 Ultrium cartridge view from top and front

The labeled parts are:

- ▶ Grips: Molded areas on the cartridge casing designed as finger grips for manual loading.
- ▶ Label area: Located at the designated area at the rear of the cartridge where the adhesive barcode label is applied.
- ▶ Sliding door: Cartridge door (shown in Figure 2-12 on page 43) that protects the tape from contamination whenever the cartridge is out of the drive. Behind the door, the tape is threaded onto a leader pin (shown in detail in Figure 2-14 on page 45), which is used to pull the tape from the cartridge for use. A locking mechanism prevents the media from unwinding when the cartridge is not located in the drive.
- ▶ Notches: Two sets of molded notches in the cartridge casing are located on the sides near the rear. The first pair enables the robotic gripper to pull the cartridge out of the drive mouth after the cartridge has been unloaded; the second pair enables the drive to grip the cartridge and pull it into the loading position inside the drive.
- ▶ Mis-insertion protection: A cutout in the front side of the cartridge casing that prevents the cartridge from being inserted into the drive in the wrong orientation. This feature prevents the use of unsuitable cartridges of similar, but not identical, construction.

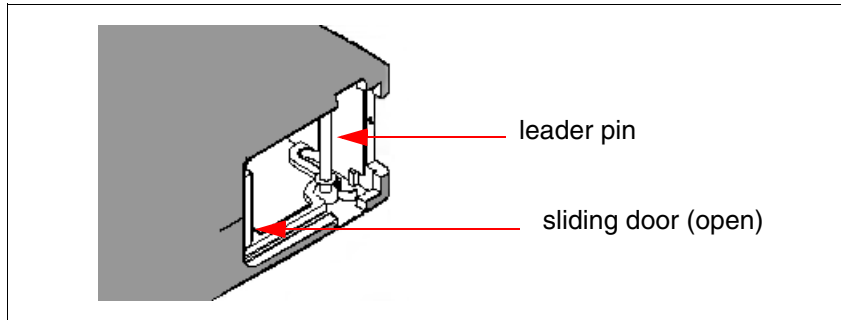


Figure 2-14 Leader pin attached to the tape medium

The various cartridges are color-coded for easy visual distinction (refer also to “Ultrium tape formats” on page 33). Refer to Table 2-1 for reference.

Table 2-1 Data cartridge identification by case color

Data cartridge	Case color
Ultrium 4 WORM	Slate green top, platinum (silver gray bottom)
Ultrium 3 WORM	Slate blue top, platinum (silver gray bottom)
Ultrium 4	Green
Ultrium 3	Slate blue
Ultrium 2	Purple
Ultrium 1	Black

Even though the servo tracks are similar on Ultrium 1 and Ultrium 2 cartridges, Ultrium 2 cartridges are required with an Ultrium 2 drive to achieve Ultrium 2 capability. Similarly, an Ultrium 3 cartridge is required to achieve Ultrium 3 capacity, and an Ultrium 4 cartridge is required to achieve Ultrium 4 capacity. Refer to 2.5.1, “IBM Ultrium 1, 2, 3, and 4 compatibility” on page 78 for more about media compatibility among the generations.

LTO data cartridge capacity

When processing the Ultrium Tape Cartridge, the Ultrium Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time, and the Ultrium 4 drive writes data on 896 tracks. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB and 800 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

The native data capacity of Ultrium data cartridges is listed in Table 2-2 on page 46.

Table 2-2 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

Metal particle medium

The metal particle tape medium consists of a transparent polyethylene base material with two coatings. On one side, the base has two fine coats of a strong yet flexible ferromagnetic material, dispersed in a suitable binder; this side is the surface on which the data is written. The back surface is coated with a non-ferromagnetic conductive coating.

Metal particle media have high coercivity, which is a measure of their ability to retain their magnetic properties after the data is written to the tape; this is one of the factors in enabling a potentially longer shelf life than other media.

Cartridge memory (LTO-CM)

Information about the cartridge and the tape is written to the LTO-CM, which is a serial Electronically Erasable Programmable Read-Only Memory (EEPROM) with both read-only and rewritable areas. It is housed inside the cartridge casing at the left rear (label side) corner as illustrated in Figure 2-13 on page 44, which shows the interior of the cartridge casing.

The LTO-CM has a capacity of 4096 bytes for Ultrium 3 or 8192 bytes with Ultrium 4. It is used to hold information about that specific cartridge, the media in that cartridge, and the data on the media. A copy of this information is also kept in the first data set within the user data area and is given the data set number zero.

Communication between the drive and the LTO-CM uses a contactless low-level radio frequency (RF) field generated (in the IBM implementation) by the drive. The LTO-CM is non-volatile storage that is updated using the RF field; it requires no additional power source. This type of technology has an expected shelf life of more than 30 years.

There are a number of distinct data fields within the LTO-CM, shown in Table 2-3 on page 47. The fields align to 32-byte boundaries, because this is the defined block access size.

Table 2-3 Data fields stored in the LTO-CM

LTO-CM information	Read/Write
LTO-CM manufacturer's data	Read-only
Tape label ^a	
Media manufacturer information	
Initialization data ^b	Restricted write capability
Cartridge status and tape alert flags	Read or write
Usage information	
Tape write pass	
Tape directory	
End-of-data information	
Mechanism-related	
Application-specific data ^c	
Vendor-unique data	

a. This field contains information about the tape, including a 10-byte field with the tape serial number; it is a read-only area and does not contain the volume label, which can be changed if the tape is reinitialized.

b. This is a restricted-write field that is updated with changes when the tape is reinitialized.

c. This is a field for application data (such as the volume label) to be stored in the CM. However, currently there is no SCSI function available to support writing to that area.

Although transparent to the user, keeping this type of information enhances the efficiency of the drive and the cartridge. Data and block locations are stored in memory; for example, the end-of-data location is stored, so that when the tape is next loaded, the drive can use the fast locate function to move directly to the recording area and begin recording. Storing data about the age of the cartridge, how many times it has been loaded, and how many errors it has accumulated aids in determining the reliability of the cartridge. It is of particular value if this data is stored with the cartridge itself, so that whenever the cartridge is mounted on any host system, the history is accessible.

This is not the first tape product where information has been kept on the cartridge; however, previously it has been written onto the tape medium itself in a non-user-accessible portion of the tape before the BOT marker, for example, as in the IBM 3590 Tape Drive.

Barcode label

Each data and cleaning cartridge processed by an Ultrium tape library needs to have a barcode label. (This barcode label is mandatory for libraries that have an installed barcode reader.)

The label, as shown in Figure 2-15 on page 48, contains a human-readable volume serial number or volume label and the corresponding machine-readable barcode.



Figure 2-15 Barcode label example

The barcode format is:

- ▶ Quiet zones (at each end of the barcode).
- ▶ A start character (indicating the beginning of the label).
- ▶ A six-character volume label.
- ▶ A two-character cartridge media-type identifier (L1, L2, L3, or L4), which identifies the cartridge as an LTO cartridge (“L”) and indicates the LTO generation: 1, 2, 3, or 4. Other identifiers are also specified by the LTO standard; thus, the LTO3 WORM cartridge is identified by LT and the LTO4 WORM cartridge is identified by LU.
- ▶ A stop character (indicating the end of the label).

When read by the library’s barcode reader, the barcode identifies the cartridge’s volume label to the tape library. The barcode volume label also indicates to the library whether the cartridge is a data, cleaning, or diagnostic cartridge.

Tape cartridges are often supplied with the labels already attached, or you can attach a label yourself. Operators must handle the cartridges and barcode labels in accordance with the instructions in the operator guides that are supplied with the products. You must ensure that labels are removed cleanly, reapplied carefully, in good condition, and not obscured or damaged. The Ultrium cartridge features a recessed area for the label (see Figure 2-12 on page 43). The label must be applied only in the recessed label area; if the label extends outside of the recessed label area, it can cause loading problems in the drive.

Volume label format

The LTO cartridge label uses the Uniform Symbol Specification-39 barcode symbols. A description and a definition are available from the Automatic Identification Manufacturers (AIM) specification document *Uniform Symbol Specification-39* and *ANSI MH10.8M-1993 ANSI Barcode Specification*.

A cartridge’s volume label consists of exactly six characters, starting from the left. Except for cleaning and diagnostic cartridges, these six characters are limited to the following ASCII characters:

- ▶ Uppercase A-Z (ASCII character code: 41h-5Ah)
- ▶ 0-9 (ASCII character code: 30h-39h)

The volume label must consist of exactly six, all uppercase alphabetical, all numeric, or alphanumeric characters, such as ABCGVE, 123621, or F8H5N9. It cannot consist of fewer than six characters.

A volume label format of CLN*U**nn* represents a universal cleaning cartridge. A volume label of the form CLN*v**nn* is used for a unique cleaning cartridge, where *v* is an alphanumeric identifier that represents the vendor of a drive-unique cleaning cartridge. (An IBM-unique cleaner cartridge uses the label format CLN/*nn*.) This identifier is logged in the vendor information pages in the Ultrium Tape Drive.

A volume label of the form DG(space)*v**nn* is used for diagnostic and service cartridges. The drive uses the *v* to determine whether the drive-unique diagnostic cartridge is loaded. The *nn* represents a specific cartridge and is logged in the vendor information pages in the Ultrium Tape Drive.

The internal and external labels on a cartridge do not need to match; therefore, the volume label on the barcode label does not need to match the volume label recorded on the tape in the tape label area when it is initialized. However, it is generally preferable for them to match to avoid confusion.

You can find more detailed information in the LTO Label Specification at:

<http://www.ibm.com/servers/storage/media/lto/index.html>

Ordering barcode labels

For ordering barcode labels, refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497.

Write protect switch

The write protect switch is located at the front of the cartridge to the left of the barcode label (see Figure 2-12 on page 43). The position of the write-protect switch on the tape cartridge determines whether you can write to the tape; you cannot write to the tape when the switch is pushed to the right. When the write protect switch is set to inhibit writing, a visual lock mark, such as a padlock, is visible.

In most cases, backup and recovery host application software is used to achieve the most benefit from using an LTO system. It is better to rely on the host application software to write protect your cartridges rather than manually setting the write protect switch. This enables the host software to identify a cartridge that no longer contains current data and is eligible to become a scratch cartridge. If the switch is set and the host application sets the cartridge to scratch status, the tape drive will not be able to write new data to the tape.

Cleaning the cartridge

Cartridges that are physically dirty on the outside of the casing can reduce the reliability of an Ultrium tape library as well as cause the loss of recorded data. If dirt appears on the cartridge, you can wipe the outside surfaces with a lint-free cloth, which can be lightly moistened with the manufacturer's recommended tape unit cleaner or equivalent.

When cleaning a tape cartridge, do not allow anything wet (including the cleaning fluid) to contact the tape inside the casing. Make sure that all cartridge surfaces are dry before the cartridge is inserted into a drive.

Cartridge life

The magnetic tape inside the cartridge is made of highly durable materials. However, the tape wears after repeated cycles. Eventually, such wear can cause an increase in tape errors,

records of which are stored in the LTO-CM. This means that cartridge performance can be tracked and monitored, enabling predictive failure analysis and enhancing data integrity. This tracking is done automatically, and the drive issues a message when errors on the tape exceed a certain threshold.

The IBM Ultrium Data Cartridge has a usable life of 5000 load and unload cycles in a typical office computer environment.

The data recorded on the cartridge has an archive storage life of 30 years minimum with less than 5% loss in demagnetization, when the cartridge is stored at 16° C (60° F) to 25° C (77° F), 20% to 50% non-condensing humidity, and wet bulb temperature of 26° C (79° F) maximum.

Cleaning cartridge

To support client and application requirements and expectations for cleaning, each LTO drive vendor used to provide its own cleaning cartridge specifically for its Ultrium drives. To avoid potential interoperability problems, the LTO consortium decided to introduce a universal cleaning cartridge. IBM offers only the universal cleaning cartridge.

The IBM Ultrium LTO Tape Drive was intentionally designed to be self-monitoring and self-cleaning. Therefore, the IBM recommendation is not to manually clean the tape drive, but rather to use the automatic cleaning function provided with the library or by your application.

Each drive determines when it needs to be cleaned and alerts the library or your application.

In order to prevent recontamination of drive surfaces, you are limited to using a specific cleaner cartridge a maximum of 50 times.

Cartridge handling

Tape cartridges are tough packages made of inexpensive materials capable of storing tremendous amounts of data and approaching data densities of hard disks. They can survive for years in library environments where they are being gripped, poked, loaded, and unloaded. But we recommend treating tape cartridges in a similar fashion to hard disk drives. Here are several suggestions to protect your data on tape cartridges.

Ensure that proper procedures are in place to cover media handling, and make sure that anyone who handles cartridges has been trained in those procedures.

Media shipping and handling: Procedures

Ship cartridges in their original packaging or, preferably, ship and store in jewel cases. Use only recommended shipping cases that securely hold the cartridges in their jewel cases for transportation. Turtle Cases from Perm-A-Store, shown in Figure 2-16 on page 51, have been tested and found to be satisfactory. Turtle Cases are available at:

<http://www.turtlecase.com>



Figure 2-16 Turtle case

Never ship a cartridge in a commercial shipping envelope without boxing or packaging. If shipping in cardboard or similar boxes:

- ▶ Double-box the cartridges with padding between the boxes, as shown in Figure 2-17.
- ▶ Pack snugly so cartridges do not rattle around.
- ▶ If possible, place cartridges in polyethylene plastic wrap or bags to help seal out dust, moisture, and other contaminants.



Figure 2-17 Double box

Media shipping and handling: Inspecting

If you receive media, inspect it before use:

- ▶ Inspect packaging for evidence of potential rough handling.
- ▶ Inspect cartridge for damage before using and storing.
- ▶ Check leader pin for correct seating.
- ▶ When there is evidence of poor handling or shipping, ensure that the cartridge leader pin (Figure 2-18 on page 52) is undamaged before inserting the cartridge in a drive or library, because a bad cartridge can damage a drive.

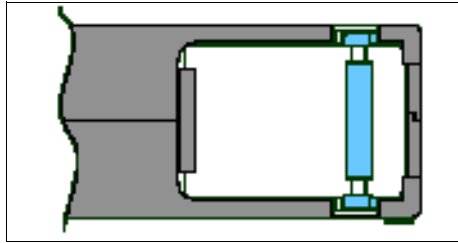


Figure 2-18 Correct leader pin placement

If the pin is loose or bent, look for cartridge damage and use the IBM Leader Pin Re-Attachment Kit, part number 08L9129, to correctly seat the pin.

Shipping summary

Important considerations include:

- ▶ Package appropriately for shipping.
- ▶ Inspect for damage or rough handling and take appropriate action.
- ▶ Do not put damaged media in drives or libraries; use data recovery services.
- ▶ For specific media types, check your product's Planning and Operator Guide.
- ▶ With simple care and handling, you can get the most out of your tape media.

2.1.5 IBM LTO Ultrium common subassembly

Certain elements of the Ultrium drive design are covered by the LTO format specification, such as anything related to writing the specified data format that enables tape interchange. However, there is no strict LTO definition in terms of how the drive module is constructed, so in this area, manufacturer's drives might differ from each other in performance and specification, such as the data rate or quality design points. This section therefore relates specifically to the IBM LTO implementation. However, we emphasize again that the IBM LTO Ultrium cartridges are compatible with those of all other licensed manufacturers.

The IBM LTO Ultrium common subassembly drive (Figure 2-19) is a high-performance, high-capacity tape drive. The drive records data using the specified linear serpentine recording format on 1/2-inch tape housed within the LTO Ultrium cartridge. The data tracks are located using preformatted servo tracks, as outlined in "Servo tracks" on page 35.

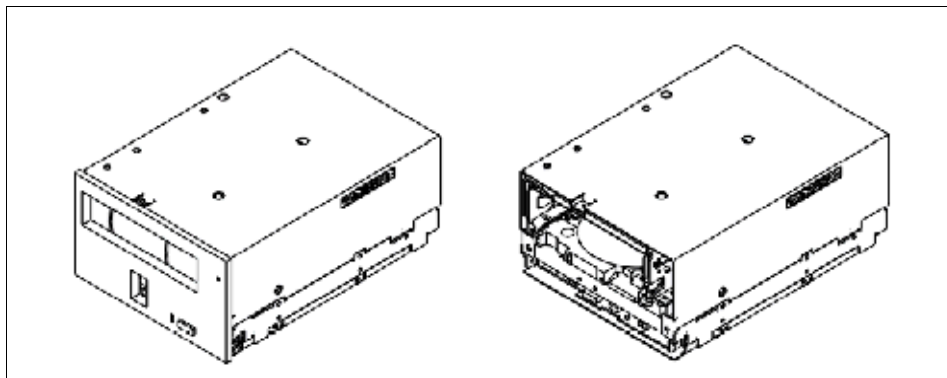


Figure 2-19 IBM LTO Ultrium common subassembly

The original basic unit was the first-generation IBM LTO series of products. Subsequent generations of IBM LTO exploit extensive reuse, making the IBM Ultrium drives extremely reliable. Especially in LTO3, there have been a number of reliability improvements to tape path and internal tape handling. These units are a common subassembly and so do not have

an IBM machine type. The subassembly is not available for clients to purchase directly, but only as a part number used in the assembly of other IBM machine types. The subassembly does not have its own power supply but is powered by the library, frame, or casing into which it is integrated.

The IBM machine types that integrate the subassembly are described in 2.5.6, “The IBM LTO Ultrium family of tape drives and libraries” on page 86 and in more detail in later chapters. The subassembly is sold on the other equipment manufacture (OEM) market to other LTO library manufacturers. The common subassembly is a single field-replaceable unit (FRU); that is, if it fails, the whole unit is replaced and no parts or subassemblies within the unit are replaced when the drive is maintained by an IBM service support representative (SSR).

Drive head

When the cartridge is inserted into the drive, a threading mechanism pulls the leader pin and attached tape (see Figure 2-14 on page 45) out of the cartridge, across the Read/Write head, and onto a non-removable take-up (machine) reel. The head can then read or write data from or to the tape.

In generations 1 and 2, the drive has a 2 x 8 element head, reading or writing data eight tracks at a time (see Figure 2-20). The head is sized to cover the width of a data recording band (approximately a quarter of the tape width; refer to Figure 2-8 on page 39). Unlike the IBM 3590, for example, it does not cover the whole width of the tape.

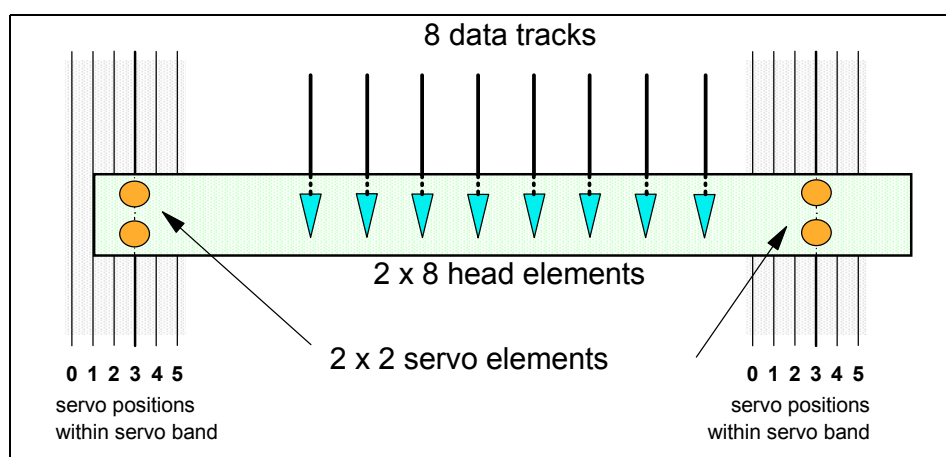


Figure 2-20 Generation 1 and 2: One of eight element heads shown, with servo elements

The write elements are immediately followed by read/verify elements, so there are in fact two sets of eight head elements (eight write elements and eight read elements) to allow the tape to write in the forward and reverse directions down the length of the tape. The head switches electronically from one set to another as the tape changes direction, as in Figure 2-21 on page 54, which shows two enlarged pairs of head elements and the direction indicators. Two sets of heads (Read/Write (R/W) and Write/Read (W/R)) are required because the tape is written and read in both directions.

The LTO3 and LTO4 drive has a 2 x 16 element head, reading or writing data at 16 tracks at a time. Conceptually, they are similar to the 8 element head, except they have elements of a smaller size. The 16 R/W heads are side by side similar to the sum of R/W and W/R heads in Figure 2-21 on page 54. The corresponding 16th W/R head element (for writing the reverse wrap) is located immediately face-to-face with the R/W element. Thus, only every second R/W head corresponds to the LTO1 or LTO2 formats. Note that LTO4 drives cannot read LTO1 cartridges.

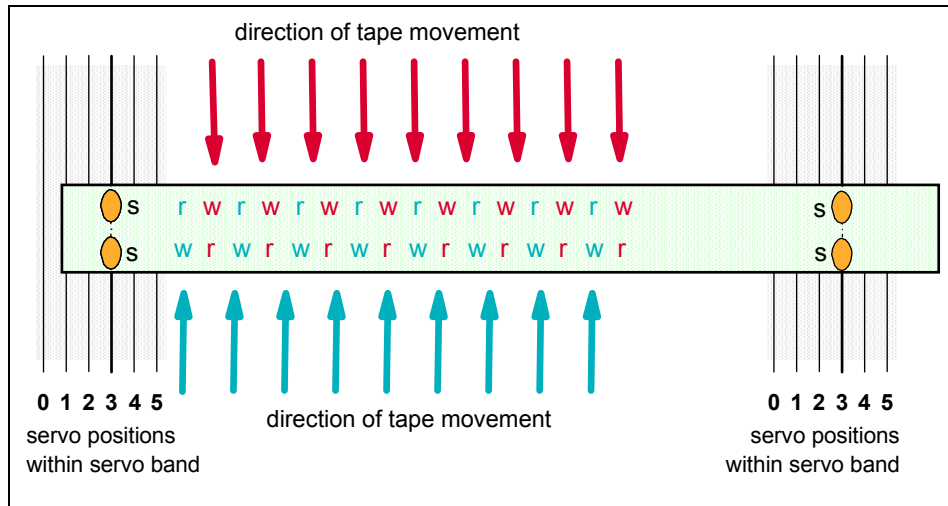


Figure 2-21 Conceptual allocation of read and write heads for forward and reverse wrap

We explain the mechanism for writing data in “Data tracks” on page 38.

Four servo elements are used: two for each set of Read/Write elements. The head actually uses both servo tracks at each edge of the data band it writes for increased accuracy in track-following, so there are two servo elements at each end of the head. As an example, Figure 2-20 on page 53 shows a diagram of the top servo element 1 following servo position 3, used for the sixth wrap (a reverse wrap) in a data band. Note that the diagram is not to scale. If you need more information about this topic, an animated conceptual explanation is in the LTO Ultrium technology primers on the LTO Web site at:

http://www.lto-technology.com/newsite/html/about_tech.html

Note that the animation is designed to provide a basic understanding of LTO technology and does not provide the same level of detail outlined here. Nor does it detail the actual implementation in the IBM Ultrium drives.

Data compression

As described in 2.1.3, “Data compression” on page 42, data compression implementation can differ from vendor to vendor. However, they all conform to the basic rules, and the data written can be read by any other vendor’s tape reader.

One implementation appears to only perform scheme swapping on a record basis. For example, if the compressed data stream output for a given record is larger for Scheme 1 than for Scheme 2, the entire record is output in Scheme 2. A second implementation seems to react to data on an ongoing basis so that if the drive perceives that the nature of the data in a record has changed from compressible to incompressible, then a Scheme 2 swap is enabled and the incompressible data from there on is output in Scheme 2. This is not always advantageous because the incompressible data might again transition to compressible even before that scheme swap occurs. Each scheme swap codeword output is 13 bits long. Therefore, to swap to a scheme and swap back costs 26 bits. The compression gain following the first scheme swap might benefit more than 26 bits over the previous scheme; if so, the swap was well-advised. If not, the scheme swap actually increased the size of the output compressed data stream and reduced the compression rather than increase it. This can occur if data compressibility is inferred by having the data compression engine observe how

data that has already been output from the compression engine was compressed, that is, only by viewing data in the past.

The only way to adapt via scheme swapping within records, without being susceptible to inadvertent data expansion, is to use the IBM-patented scheme swapping technique. This method is preferred, because it effectively looks at data ahead, rather than behind. In the IBM implementation, a scheme swap is not automatically generated unless there appears to be more compression gain within the look ahead buffer than it costs to scheme swap, and then swap back. This is advantageous because small bursts of compressible data within an otherwise incompressible file might not make it worthwhile to scheme swap. If a scheme swap is optimal, the IBM implementation puts the scheme swap out where the change in data compressibility occurs, giving maximum advantage. For more information, refer to the white paper at:

http://www.ibm.com/servers/storage/tape/whitepapers/pdf/whitepaper_compression.pdf

This paper shows how the IBM LTO-DC embodiment achieved superior data compression to another vendor's LTO drives by performing scheme swapping simultaneously with changes in the compressibility of the data, enabled by effectively looking 64 bytes ahead in the input data stream.

The LTO consortium decided, as many other vendors also do in the open environment, to indicate characteristics of LTO products for both native data and when assuming a data compression ratio of 2:1. For enterprise-related (mainframe) tape products, IBM and other manufacturers assume a compression ratio of 3:1, even though the IBM LTO and IBM 3592 use the same compression algorithm (SLDC). In any case, remember that the real compression reached by the drive depends on the nature of the data and that you need to base all sizings on the native value.

Interfaces

The IBM LTO Ultrium drive is available with a choice of the following interfaces:

- ▶ Small Computer System Interface (SCSI):
 - Low Voltage Differential (LVD)
 - High Voltage Differential (HVD (LTO1 and 2 only)
- ▶ Fibre Channel (FC)
- ▶ Serial-Attached SCSI (SAS)

When ordering an IBM product offering, you choose the drive interface. You cannot change the interface on the drive; if you want a different interface, you must replace the drive assembly.

Historically, SCSI connections were used for attachment of tape drives and libraries to Open Systems. Fibre Channel connections using SANs are becoming increasingly common.

SCSI single-ended

This was the most common form of SCSI signaling. Many removable drives, scanners, and almost all 50-pin SCSI devices fit into this category. Often you do not see "SE" or "single-ended" written on the documentation; if a device does not specifically say LVD, Ultra2 Wide, differential, or a similar definition, it is probably single-ended. Typically, single-ended devices support a total bus length of 1.5 meters (5 ft.) or less.

IBM high-performance SCSI tape drives (IBM 3590, IBM 3570, and LTO Ultrium drives) are all differential-attached drives, not single-ended.

SCSI differential (HVD)

HVD (often referred to as just *differential*) uses differential signaling. The idea behind differential signals is that each bus signal is carried on a pair of wires. The first wire of the pair carries the same type of signal as single-ended SCSI. However, the second wire of the pair carries its logical inversion. The receiver of the signals takes the difference of the pair (therefore, the name), which makes it less susceptible to noise and capable of supporting greater cable lengths. HVD and single-ended SCSI are completely incompatible with each other.

In general, IBM HVD tape devices support an overall bus length of 25 m (82 ft.), using point-to-point or multi-drop interconnection (*daisy-chaining*). For each daisy-chain device, you have to reduce the maximum cable length by 0.5 m (1.6 ft.).

SCSI differential (LVD)

This newer differential interface implementation, LVD, uses less power than the HVD differential interface and allows the higher speeds of Ultra2 SCSI. LVD requires 3.3 V dc instead of 5 V dc for HVD.

LVD is sometimes referred to as Ultra2 Wide SCSI, which is a general marketing term for 16-bit Fast-40 or 80 MB/s. Only LVD and HVD can potentially run in Ultra2 Wide mode and only LVD in current commercially available products.

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point, and 12 m (39.4 ft.) using multi-drop interconnection (*daisy-chaining*). For each daisy-chain device, you have to reduce the maximum cable length by 0.5 m (1.6 ft.).

The terms “fast”, “wide”, and “ultra” indicate characteristics that are separate from those implied by differential, single-ended, and high or low voltage. Table 2-4 shows the SCSI terms used to describe different host and device adapters and what they imply in terms of bus width and speed.

Table 2-4 SCSI terms and characteristics

SCSI term	Bus width (bits)	Speed (MB/s)	Maximum length	Maximum number of devices
SCSI	8	5	6 m	7
Fast SCSI	8	10	3 m	7
Fast Wide SCSI	16	20	3 m	15
Ultra (Wide) SCSI HVD	16	40	25 m	15
Ultra (Wide) SCSI 2 LVD	16	80	25 m/12 m	15
Ultra 160 SCSI LVD	16	160	12 m	15

Note that a faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at that maximum speed. For a detailed table of SCSI terms and related specifications, refer to the SCSI Trade Association Web site at:

<http://www.scsita.org/terms/scsiterms.html>

To ensure best performance, if possible, avoid daisy-chaining.

Serial-Attached SCSI

Serial-Attached SCSI (SAS) was introduced because parallel SCSI has a maximum bandwidth of 320 MB/s. There was a need for a faster interface to attach tapes and disks on a host bus adapter (HBA). Parallel SCSI started in the beginning of the IBM 360 Mainframe period back in the early sixties. That IBM 360 mainframe was able to communicate with more devices using the same I/O bus. This I/O bus was known later as the OEM channel, and IBM wanted to make this OEM channel the Industrial Standard for parallel devices. IBM went to the American National Standards Institute (ANSI), but ANSI refused because it was not standardized enough. In 1981, Adaptec designed a standardized bus that ANSI approved. From that time forward, it was called Small Computer System Interface (SCSI).

SCSI was designed in the first place to attach hard disks on a I/O bus but over the years all types of devices were able to connect to the SCSI bus, such as tape drives, scanners, plotters, printers, and optical devices. Over the years, the bandwidth increased from 5 MB/s up to 320 MB/s, better known as Ultra320 SCSI.

In 2003, the SCSI bus speed was increased up to 640 MB/s but that never became a new standard for the SCSI speed. One problem when the SCSI speed increases is a phenomenon called *clock skew*. Clock skew is a phenomenon in synchronous circuits in which the clock signal (sent from the clock circuit) arrives at different components at different times. This is typically due to two causes. The first is material variability, which causes a signal to travel faster or slower than expected. The second is distance: The further a signal has to travel the longer it takes to arrive; therefore, signals arrive at different points at different times. As the clock rate of a circuit increases, timing becomes more critical and there is less variation that can be tolerated while still functioning properly.

The industry was looking for a new, faster interface and a serial version of SCSI was designed and approved in 2002 by the SCSI Trade Association and by the International Committee for Information Technology Standards. In 2005, the first devices came on the market with a SAS interface. The first generation of SAS has a native speed of 3 GB/s, and future generations will be at 6 GB/s and 12 GB/s.

One of the benefits of SAS is that it can communicate with *Advanced Technology Attachment* (ATA) devices. SAS has a point-to-point architecture and a bandwidth of 300 MB/s. Because of its point-to-point architecture, more devices can be handled in the same time on the bus with an maximum of 128 targets. Another advantage of SAS is that the connection cables between the HBA and the devices are much thinner and thus more scalable. SAS devices do not need external terminators. The I/O bus is electronically terminated.

The total cable length from the device to the HBA is limited to 5.5 m (18.04 ft.). The total cable length in an LVD configuration is 25 m (82 ft.) when a point-to-point connection is used or 12.5 m (39 ft.) when a multi-drop connection is used.

Figure 2-22 on page 58 shows you an IBM SAS HBA, part number 25R8060.

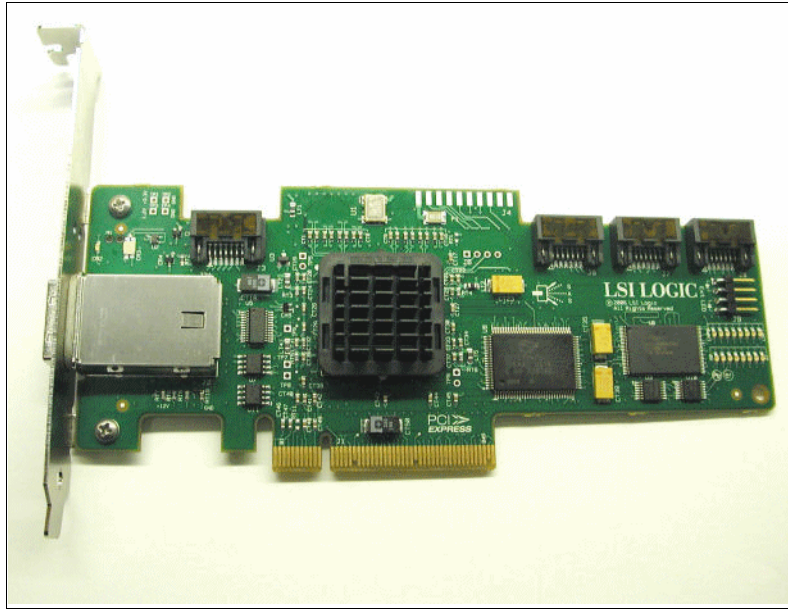


Figure 2-22 SAS HBA with IBM part number 25R8060

The PCI small form factor IBM SAS HBA Controller is based on the LSI 1068E SAS processor. It can handle medium to large capacity server storage applications by connecting an eight lane PCI-Express adapter with one external x4 Small Form Factor Committee (SFF)-8088 connector and four x1 internal 7 pin connectors.

Two connecting interfaces are used for connecting the external devices: SFF-8088 and SFF-8470. Figure 2-23 shows an SFF-8088 connector.

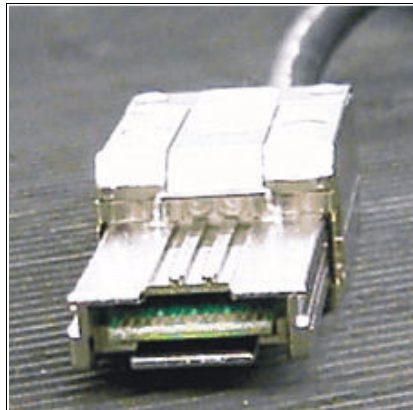


Figure 2-23 SFF-8088 connector

All IBM SAS tape drives have an SFF-8088 interface. SAS cables are available in several lengths with a maximum length of 5.5 m (18.04 ft.) and in any combination of the SFF-8470 and SFF-8088 connectors.

Figure 2-24 on page 59 shows the SFF-8470 connector.



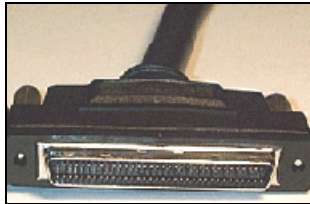
Figure 2-24 SFF-8470 connector

At the time of writing this publication, IBM SAS Tape Drives only support a point-to-point connection, and there is no support to connect the SAS Tape Drive on an Expander Box. Two IBM LTO tape drives are available with the SAS interface:

- ▶ IBM LTO Ultrium 3 Half-High Tape Drive
- ▶ IBM LTO Ultrium 4 Full-High Tape Drive

Connector types

When ordering cables, pay careful attention to the type of connector on both the cable and device, so that everything correctly plug ins together. These are the major connector types.



SCSI HD68

The HD68 connector is the normal 68-pin SCSI connector. All IBM LTO SCSI drives, except the drives in the 3584, have an HD68 connector. Before 12 June 2001, all LTO tape drives in the IBM 3584 used HD68 connectors.

Figure 2-25 HD68 connector



SCSI VHDCI

The Very High Density connector (VHDCI) is a mini-SCSI connector, about half the width of the HD68 connector. The IBM LTO drives in the IBM 3584 have a VHDCI connector.

Figure 2-26 VHDCI connector

FC SC

The duplex SC connector is a low-loss, push/pull fitting connector. The two fibers each have their own part of the connector. The connector is keyed to ensure correct polarization (transmit to receive and receive to transmit) when connected. Most 1 Gb SAN devices, including IBM Ultrium 1 FC drives, use SC connectors.

FC LC

Connectors that plug into SFF or SFP devices are called *LC connectors*. There is also a duplex version used so that the transmit and receive are connected in one step. The primary advantage of these LC connectors compared to SC connectors is that the LC connectors use a smaller form factor. Therefore, manufacturers of Fibre Channel components can provide more connections in the same amount of space.

Most 2 Gbit SAN devices, including IBM Ultrium 2 and 3 FC drives, use LC connectors.

Available interfaces for IBM Ultrium 1

IBM Ultrium 1 drives offer these connection types:

- ▶ Ultra2 Wide LVD SCSI using HD68 connector
- ▶ Ultra/Wide HVD SCSI using HD68 connector
- ▶ FC-AL, 1 Gbit using SC connector
- ▶ SCSI drives installed in the 3584 use VHDCI connector

Available interfaces for IBM Ultrium 2

IBM Ultrium 2 drives offer these connection types:

- ▶ Ultra 160 LVD SCSI using HD68 connector
- ▶ Ultra/Wide HVD SCSI using HD68 connector
- ▶ Switched fabric 2 Gbit using LC connector
- ▶ SCSI drives installed in the TS3500 use VHDCI connectors

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log on as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit or with 2 Gbit.

With the IBM 3584, you have the capability to set the FC port speed and the FC protocol mode.

Available interfaces for IBM Ultrium 3

IBM Ultrium 3 drives offer these connection types:

- ▶ Ultra 160 LVD SCSI using HD68 connector
- ▶ 3 Gbps SAS
- ▶ Switched fabric 2 or 4 Gbit using LC connector
- ▶ SCSI drives installed in the 3584 use the VHDCI connector

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log in as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit, 2 Gbit, or with 4 Gbit.

With the IBM 3584, you have the capability to set the FC port speed and the FC protocol mode.

Available interfaces for IBM Ultrium 4

IBM Ultrium 4 drives offer these connection types:

- ▶ Ultra160 SCSI LVD using HD68 connector
- ▶ 3 Gbps dual port SAS
- ▶ 4 Gbps native Fibre Channel

The drive can work in fabric or FC-AL mode. Per the SNIA standard, it tries first to connect as FC_AL, and if this fails, it tries to log in as a fabric device. It does an autosensing on the speed and connects with either 1 Gbit, 2 Gbit, or with 4 Gbit.

With the IBM 3584, you have the capability to set the FC port speed and the FC protocol mode.

2.2 Tape Encryption overview

Data is one of the most highly valued resources in a competitive business environment. Protecting this data, controlling access to it, and verifying its authenticity while maintaining its availability are priorities in our security-conscious world. Tape Encryption is a process that answers many of these needs.

The IBM System Storage TS1120 (3592-E05), TS1130 (E06), and TS1040 (3588-F4A) tape drives are capable of encrypting data as it is written to tape. The TS1120 and TS1130 support any type of IBM TotalStorage Enterprise Tape Cartridge, including WORM cartridges, and the TS1040 supports IBM Ultrium 4 Data Cartridges for data encryption, including WORM cartridges. Encryption is performed at full line speed in the tape drive after compression. (Compression is more efficiently done before encryption.) The encryption process is less than one percent of the performance impact on the Read/Write throughput.

Encryption for the TS1120 and TS1130 tape drives is available at no charge. The TS1120 and TS1130 can be installed in the TS3400 and TS3500 Tape Libraries.

For the TS1040, the Application-Managed Encryption method is available at no charge. However, a billable Feature Code (FC) must be installed, FC5900 or, for the TS3500, FC1604, to support Transparent LTO Encryption. You must also order FC9900 (Encryption Configuration). Supported Tape Libraries for the TS1040 Tape Drive are: TS3100, TS3200, TS3310, and TS3500.

Encryption adds significant strength to the security of your stored data without the processing overhead and the performance degradation associated with encryption performed on the server or the expense of a dedicated appliance.

Note: TS1120 drives produced before 8 September 2006, do not have the encryption capability. However, there is a chargeable upgrade available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware, as well as microcode additions and changes.

Encryption keys are used to encrypt data when data is being written and decrypt the data when being read from a data cartridge. The IBM Encryption Key Manager (EKM) is the component that assists the TS1120 and TS1130 tape drives and the TS1040 in generating, protecting, storing, and maintaining encryption keys. The EKM R2 must be used when using a TS1040 Tape Drive in a tape library or as a stand-alone tape drive (TS2340 Tape Drive).

2.2.1 IBM Encryption Key Manager (EKM)

The EKM is installed on a server in the network and communicates through TCP/IP with the tape library or the tape drive. The EKM operates on z/OS®, i5/OS®, AIX, Linux, HP-UX, SUN Solaris™, and Windows. The EKM is capable of serving numerous IBM encrypting tape drives, regardless of where those tape drives reside.

The EKM is part of the IBM Java™ environment and uses the IBM Java Security components for its cryptographic capabilities. The EKM and three other major components, shown in Figure 2-27 on page 62, control Tape Encryption.

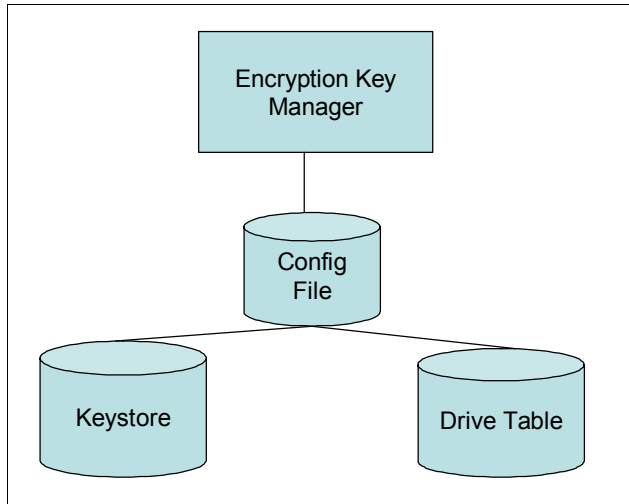


Figure 2-27 Encryption major components

These components are:

- Encryption Key Manager

The EKM obtains encryption keys and manages their transfer to and from the tape devices.

- Configuration file

The configuration file records the keystore location and defines the EKM behavior. The EKM configuration file allows you to tailor the behavior of the EKM to meet the needs of your organization.

- Java security keystore

The keystore is defined as part of the Java Cryptography Extension (JCE) and is an element of the Java Security components, which are, in turn, part of the Java Runtime Environment™ (JRE). A *keystore* holds the certificates and keys (or pointers to the certificates and keys) used by the EKM to perform cryptographic operations. The EKM supports several types of Java keystores offering various operational characteristics to meet your needs.

- Tape drive table

The tape drive table is used by the EKM to keep track of the tape devices it supports. The tape drive table is a non-editable, binary file whose location is specified in the configuration file.

Important: Due to the critical nature of keys in your keystore, we highly recommend that you back up your keystore on a regular basis so that you can recover it as needed and be able to read the data cartridges that were encrypted using the certificate with that drive or library. *Do not encrypt your backups.*

The EKM is a process awaiting a key generation or key retrieval request that a tape drive or library sends over a TCP/IP communication path between the EKM and the tape library or tape drive. When a tape drive writes encrypted data, it first requests an encryption key from the EKM. Upon receipt of the request, the EKM generates an Advanced Encryption Standard (AES) key and sends it to the tape drive.

An AES encryption key is typically a random string of bits generated specifically to scramble and unscramble data. Encryption keys are created using algorithms designed to ensure that each key is unique and unpredictable. The longer the key string, the harder it is to break the encryption code. TS1120 and TS1130 tape drives and TS1040 Tape Drive Encryption use 256-bit AES algorithm keys to encrypt data.

2.2.2 Tivoli Key Lifecycle Manager

In addition to the Encryption Key Manager, IBM plans to provide a new Tivoli Key Lifecycle Manager (TKLM) that can be used to encrypt your data with the TS1130 and TS1120 tape drives.

Like the Encryption Key Manager, the TKLM serves data keys to the tape drive. The first release of TKLM focuses on ease of use and provides a new graphical interface (GUI) to help with the installation and configuration of the key manager. It also allows for the creation and management of the key encrypting keys (certificates). If you already are using the existing Encryption Key Manager, you easily can migrate to the new TKLM.

Host software including the IOS proxy has no direct knowledge of which key manager is being used. Specification of either key manager is handled the same way, using the EKM keyword on existing IOS commands. For additional information about the TKLM, refer to the IBM Tivoli Key Lifecycle Manager Information Center.

2.2.3 Encryption methods

The encryption methods for the TS1120 and TS1130 and the TS1040 tape drives differ slightly. In the following sections, we explain those differences.

Symmetric key encryption

Encryption of data using a symmetric key and algorithm is sometimes called *private key encryption* or *secret key*, which is not to be confused with the private key in an asymmetric key system. In a symmetric key system, the cipher key that is used for encrypting data is the same as the cipher key used for decryption.

The encryption and decryption ciphers can be related by a simple transform on the key, or the encryption key and the decryption key can be identical. In the IBM Tape Encryption solution, the same encryption key is used for both encryption of data and decryption of data; this key is protected by an asymmetric key algorithm and never available in the clear.

Symmetric key encryption is several orders of magnitude faster than asymmetric key encryption; in addition, the comparable key sizes for symmetric key as opposed to asymmetric key are an order of magnitude different. A 128-bit secret key is considered safe, while Rivest-Shamir-Adleman (RSA) suggests a 1024-bit key length. The IBM Tape Encryption solution utilizes an AES algorithm with a key length of 256 bits. The AES algorithm is based on the Rijndael algorithm. AES is an accepted standard that supports a subset of the key sizes and block sizes that the Rijndael algorithms support.

Secret key algorithms can be architected to support encryption one bit at a time, or by specified blocks of bits. The AES standard supports 128-bit block sizes and key sizes of 128, 192, and 256. The IBM Tape Encryption solution uses an AES-256 bit key. Other well-known symmetric key examples include Twofish, Blowfish, Serpent, Cast5, DES, TDES, and IDEA.

Figure 2-28 on page 64 shows the process of symmetric encryption data flow.

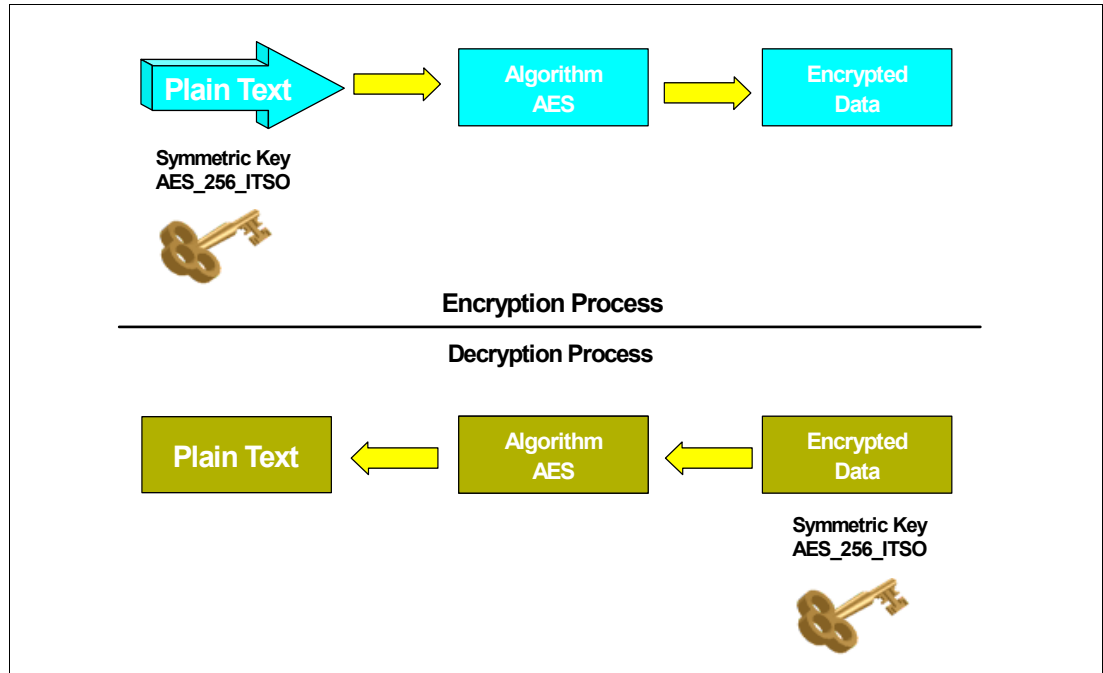


Figure 2-28 Symmetric key encryption data flow

Asymmetric key encryption

Another important method of encryption that is widely used today is referred to as *public/private key encryption* or *asymmetric encryption*. Using this encryption methodology, ciphers are generated in pairs. The first key is used to encrypt the data, and the second key is used to decrypt the data.

This technique was pioneered in the 1970s and represented a significant breakthrough in cryptography. The Rivest-Shamir-Adleman (RSA) algorithm is the most widely used public key technique. The power of this approach is a public key, which is used to encrypt the data. This public key can be widely shared, and anyone who wants to send secure data to an organization can use its public key. The receiving organization then uses its private key to decrypt the data, which makes public/private key encryption very useful for sharing information between organizations. This methodology is widely used on the Internet today to secure transactions, including Secure Sockets Layer (SSL).

Asymmetric key encryption is much slower and more computationally intensive than symmetric key encryption. The advantage of asymmetric key encryption is the ability to share secret data without sharing the same encryption key. Figure 2-29 on page 65 shows an encryption and decryption data path when using public key encryption algorithms. In the diagram, the plain text is enciphered using the public key and an RSA encryption algorithm, which yields the encrypted data. Starting with the enciphered text, a private key is used, with the RSA algorithm to decrypt the data back to plain text.

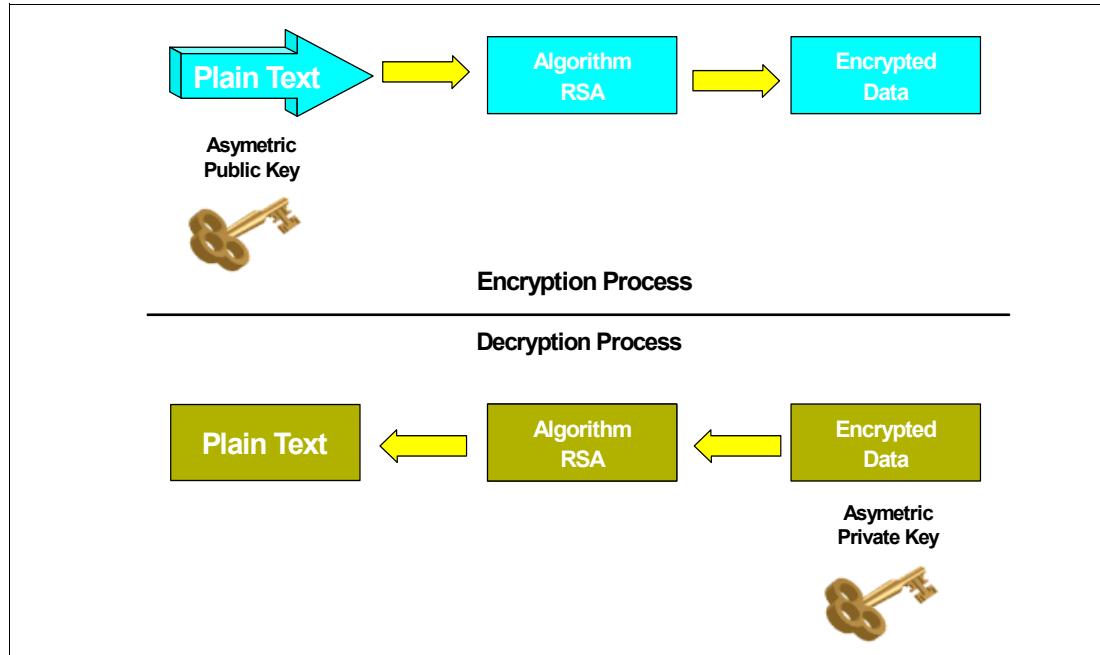


Figure 2-29 Asymmetric key encryption data flow

Managing encryption

There are three methods of encryption management from which to choose. These methods differ in where you choose to locate your EKM application. Your operating environment determines which is the best for you, with the result that key management and the encryption policy engine can be located in any one of the following environmental layers.

Application-Managed Tape Encryption (AME)

This method is best where operating environments run an application already capable of generating and managing encryption policies and keys, such as Tivoli Storage Manager (TSM). Policies specifying when encryption is to be used are defined through the application interface. The policies and keys pass through the data path between the application layer and the TS1120 and TS1130 and TS1040 tape drives. Encryption is the result of interaction between the application and the encryption-enabled tape drive and is transparent to the system and library layers. Because the application manages the encryption keys, volumes written and encrypted using the application method can only be read using the Application-Managed Encryption method.

System-Managed Tape Encryption (SME)

This method can be used for Open Systems operating environments where no application that is capable of key management runs. Encryption policies specifying when to use encryption are set up through each instance of the IBM device driver. Key generation and management are performed by the Encryption Key Manager (EKM), a Java application running on the host or externally on another host. Policy controls and keys pass through the data path between the system layer and the TS1120 and TS1130 and TS1040 tape drives. Encryption is transparent to the applications. System-Managed Tape Encryption and Library-Managed Tape Encryption are transparent to one another. In other words, a tape encrypted using System-Managed Encryption can be decrypted using Library-Managed Encryption, and the reverse is also true, provided they both have access to the same EKM keystore.

Library-Managed Tape Encryption (LME)

This method is supported on the following IBM Tape Libraries:

- ▶ TS2900 with Ultrium 4 Half-High Tape Drive
- ▶ TS3100 with the TS1040 Tape Drive
- ▶ TS3200 with the TS1040 Tape Drive
- ▶ TS3310 with the TS1040 Tape Drive
- ▶ TS3400 with the TS1120 and TS1130 Tape Drives
- ▶ TS3500 with the TS1040, TS1120, and TS1130 tape drives. Those tape drives can be installed in the TS3500, but TS1120 and TS1130 and LTO tape drives cannot be intermixed within the same logical library. You can, however, have TS1120 and TS1130 tape drives in the same logical library.

Key generation and management are performed by the EKM, a Java application running on a library-attached host. The keys pass through the library-to-drive interface; therefore, encryption is transparent to the applications. Library-Managed Encryption, when used with certain applications, such as Symantec Netbackup, includes support for an internal label option. When the internal label option is configured, the TS1120 and TS1130 and TS1040 tape drives automatically derive the encryption policy and key information from the metadata that is written on the tape volume by the application.

System-Managed Tape Encryption and Library-Managed Tape Encryption are transparent to one another. In other words, a tape that is encrypted using System-Managed Encryption can be decrypted using Library-Managed Encryption, and the reverse is also true, provided they both have access to the same EKM keystore and both use AIX and the IBM device driver. Otherwise, this capability might not be feasible.

2.2.4 TS1120 and TS1130 Tape Encryption

The TS1120 and TS1130 tape drives use an AES encryption key, which is a random string of bits generated specifically to scramble and unscramble data. Encryption keys are created using algorithms designed to ensure that each key is unique and unpredictable. The longer the key string, the harder it is to break the encryption code. TS1120 and TS1130 encryption uses 256-bit AES algorithm keys to encrypt data.

Two types of encryption algorithms are used by the EKM for encryption on the TS1120 and TS1130 tape drives:

- ▶ **Symmetric algorithms**
Symmetric, or secret key encryption, uses a single key for both encryption and decryption. Symmetric key encryption is generally used for encrypting large amounts of data in an efficient manner.
- ▶ **Asymmetric algorithms**
Asymmetric encryption uses a pair of keys. Data encrypted using one key can only be decrypted using the other key in the asymmetric key pair.

When an asymmetric, or public/private key pair, is generated, the public key is typically used to encrypt, and the private key is typically used to decrypt. TS1120 and TS1130 encryption uses both types: symmetric encryption for high-speed encryption of user or host data, and asymmetric encryption (which is necessarily slower) for protecting the symmetric key used to encrypt the data (key wrapping). We show the TS1120 and TS1130 Tape Encryption process flow in Figure 2-30 on page 67.

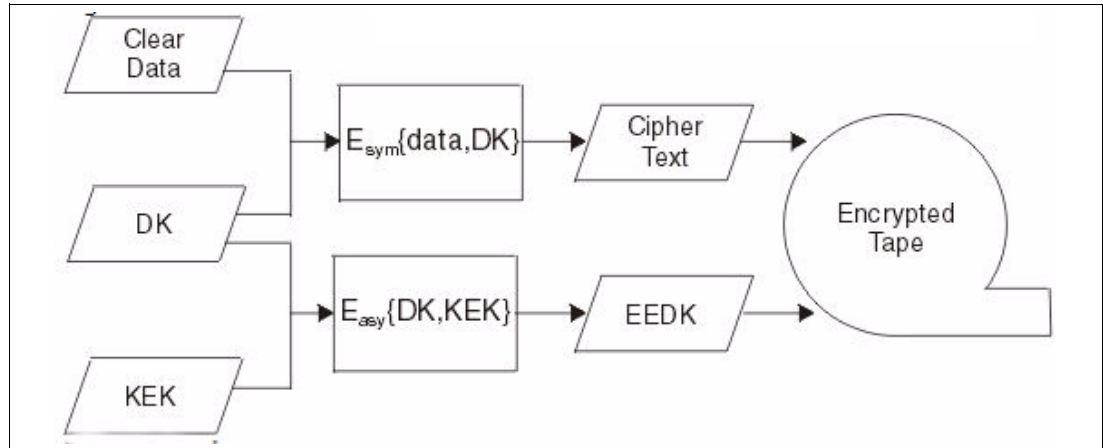


Figure 2-30 Tape Encryption process flow of the TS1120 and TS1130 tape drives

When unencrypted data (*clear text*) is sent to the TS1120 or TS1130 tape drive for encryption, it is converted to ciphertext (encrypted data) through AES encryption, which is a symmetric (or secret) key type of encryption requiring a symmetric Data Key (DK), and is then written to tape. The 256-bit AES Data Key is also encrypted, or wrapped, using the public key from an asymmetric Key Encrypting Key (KEK) pair to create an Externally Encrypted Data Key (EEDK).

This EEDK is written to the cartridge memory and to three additional places on the 3592 Tape Cartridge. The tape cartridge now has both the encrypted data and the means to decrypt it for anyone who holds the private KEK. The DK can also be wrapped a second time, using the public key of another party, to create an additional EEDK. Both EEDKs can be stored on the tape cartridge. In this way, the tape cartridge can be shipped to a business partner holding the corresponding private key that allows the DK to be unwrapped and the tape decrypted on another TS1120 or TS1130 tape drive.

In Figure 2-31 on page 68 and Figure 2-32 on page 69, we explain the tape encryption and decryption processes in a more detailed way. We start first with the encryption process.

Figure 2-31 on page 68 describes the flow of encrypted data to tape, and how keys are communicated to the tape drive and then stored on the data cartridge. In our example, we assume that an EKM is running on one server and that the tape library and tape drives are connected to another server.

We assume that a *certificate*, which is a way to bind public key information with an identity, from a Business Partner had been imported into this keystore. It has only a public key associated with it; the Business Partner has the corresponding private key.

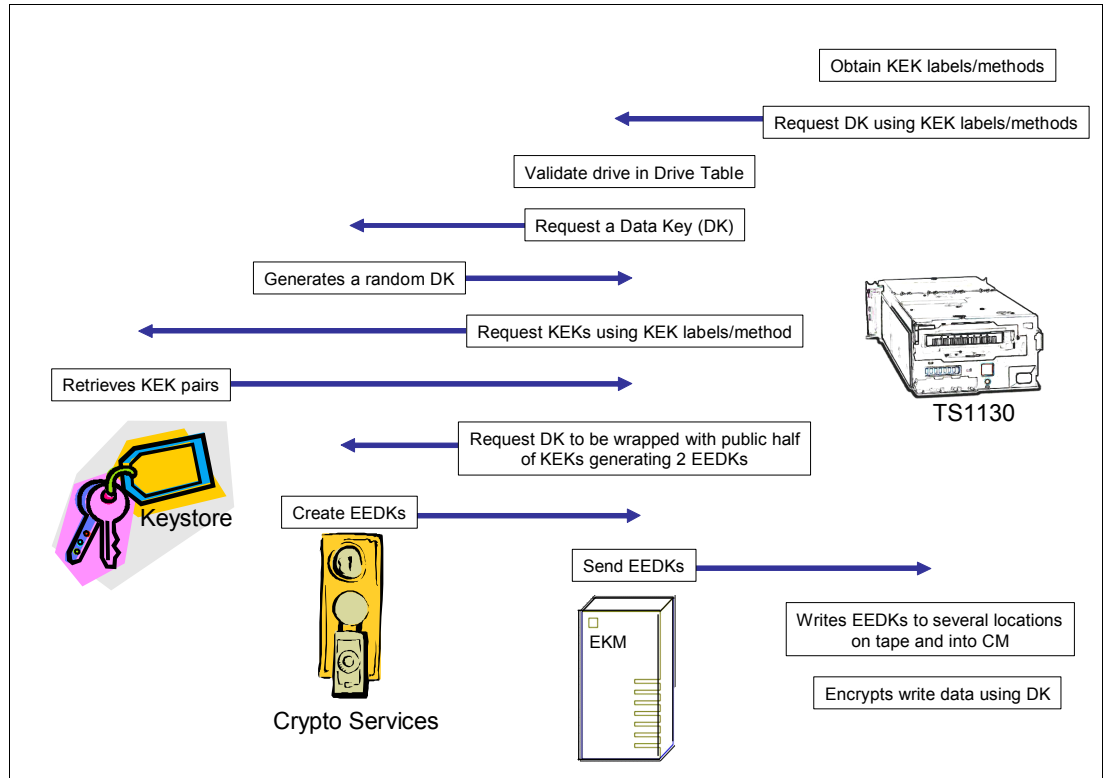


Figure 2-31 Encryption process TS1120

Now, our abstract server sends a write request to the drive. Our drive is encryption-capable, and the host has requested encryption. As part of this initial write, the drive obtains two Key Encrypting Key (KEK) labels from the host or a proxy, which are aliases for two Rivest-Shamir-Adleman (RSA) algorithm KEKs. The drive requests that the EKM send it a data key (DK) and encrypt the DK using the public KEKs aliased by the two KEK labels.

The EKM validates that the drive is in its list of valid drives. After validation, the EKM obtains a random DK from cryptographic services. The EKM then retrieves the public halves of the KEKs aliased by the two KEK labels. The EKM then requests that cryptographic services create two encrypted instances of the DK using the public halves of the KEKs, therefore, creating two Externally Encrypted Data Keys (EEDKs).

The EKM sends both EEDKs to the tape drive. The drive stores the EEDKs to several locations on the tape and in the cartridge memory. The EKM also sends the DK to the drive in a secure manner. The drive uses the separately secured DK to encrypt the data.

Figure 2-32 on page 69 is the decryption data path. In this example, we decrypt data that was encrypted at another site, as outlined in Figure 2-31. For the decryption process, the tape has two EEDKs stored in its cartridge memory. We call these EEDK1 and EEDK2.

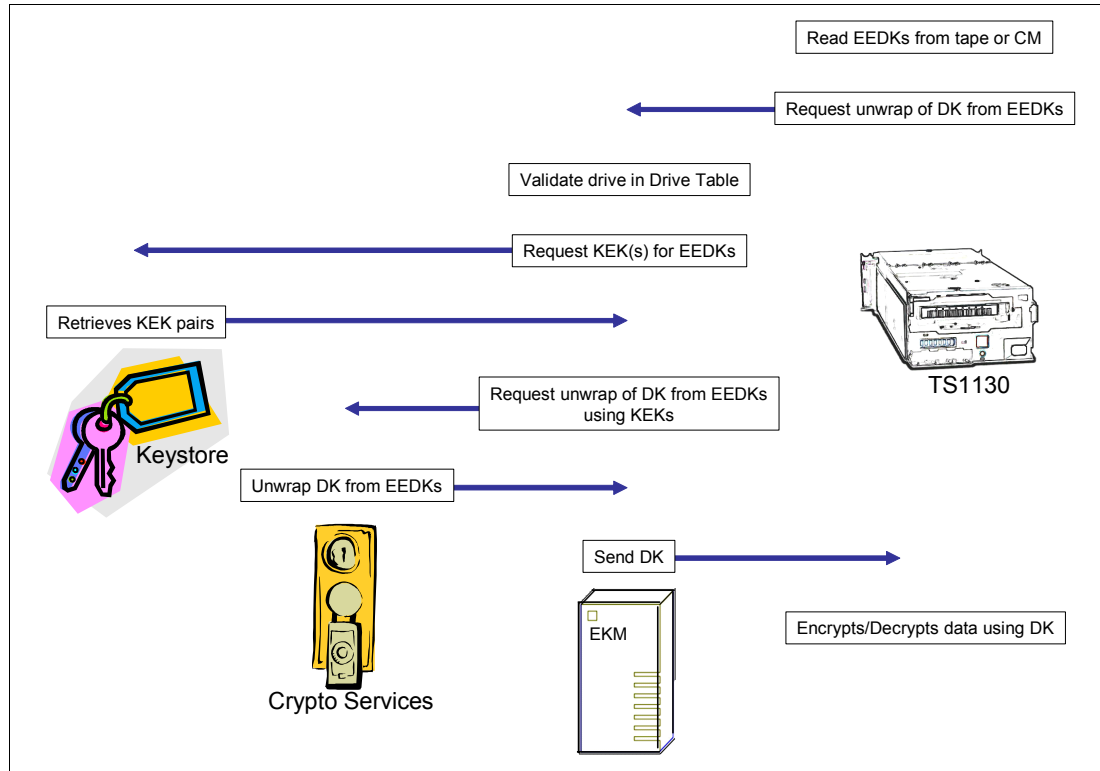


Figure 2-32 Decryption process TS1120

An encrypted tape is mounted for a read or a write append. The two EEDKs are read from the tape. The drive asks the EKM to decrypt the DK from the EEDKs. The EKM validates that the drive is in its list of valid drives. After validation, the EKM requests the keystore to provide the private halves of each KEK used to create the EEDKs. The KEK label associated with EEDK1 cannot be found in the keystore, but the HASH of the public key for EEDK2 is found in the keystore.

The EKM asks cryptographic services to decrypt the DK from EEDK2 using the private half of the KEK associated with EEDK2. The EKM then sends the DK to the drive in a secure manner. The drive either decrypts the data for a read operation or uses the DK to encrypt data for a write-append.

2.2.5 TS1040 Tape Encryption

TS1040 Tape Encryption differs from the TS1120 and TS1130 Encryption. Unlike the TS1120 and TS1130 tape drives, the TS1040 cannot store a wrapped form of the symmetric encryption key on the tape cartridge. The symmetric encryption key is stored in the keystore attached to the EKM. An associated *Key Identifier* or *alias* maps to the Data Key in the keystore. This alias is stored with each block of data on the tape. AES 256-bit encryption is used, as with the TS1120 and TS1130E tape drives, to encrypt and decrypt the data on the data cartridge.

Write Request

The process for a Write Request to the TS1040 with encryption includes these steps:

1. The TS1040 Tape Drive receives a mount request for write with Beginning Of Tape (BOT) with encryption.
2. The TS1040 initiates a session with the EKM. The TS1040 communicates through the library using TCP/IP. The TS1040 requests a data key and passes an optional key label.
3. The EKM authenticates the TS1040 in its drive table.
4. The EKM retrieves a pre-generated AES-256 Data Key from the TS1040.
5. The EKM sends a data key and key identifier to the TS1040 in a secure manner.
6. The TS1040 receives the key structures and embeds the key identifier in the data and encrypts and writes the data to the tape.

Read or Write-Append Request

When an encrypted cartridge is mounted in the TS1040 in response to a specific mount request, the following steps are taken:

1. The TS1040 receives a mount request for a read or an append operation.
2. The TS1040 begins reading and finds an encrypted record. The key identifier is retrieved.
3. The TS1040 initiates a session with the EKM. The TS1040 communicates through the library using TCP/IP. The key identifier is passed for decryption.
4. The EKM authenticates the TS1040 in the drive table.
5. The EKM retrieves the pre-generated data key referenced by the key identifier.
6. The EKM passes the data key to the TS1040 in a secure manner.
7. The TS1040 reads the data from or write-appends data to the data cartridge.

2.3 IBM System Storage TS1030 Tape Drive

The TS1030 Tape Drive offers high capacity, performance, and technology designed for the midrange Open Systems environment. The TS1030 Tape Drive has a 4 Gbit Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop attachment.

The native data transfer rate is 80 MB/s, and it uses the IBM TotalStorage LTO Ultrium 400 GB data cartridge, which provides up to 800 GB of storage with 2:1 compression.

The TS1030 Tape Drive uses the new dual-stage 16 head actuator for more precise head alignment to help support higher track density, improved data integrity, a new independent tape loader, and threader motors with positive pin retention. The new pin retention mechanism helps prevent loose tape wraps and stretching or breaking the tape. Also, the tape loader and threader motors are designed to help improve the reliability of loading and unloading a cartridge and to help retain the pin even if the tension drops. The TS1030 Tape Drive has a 128 MB internal buffer.

We describe highlights of The TS1030 Tape Drive in the following sections.

Servo and track layout technology

The TS1030 Tape Drive uses 704 data tracks to read and write to tape in Ultrium 3, compared to 512 data tracks in Ultrium 2. These tracks are grouped in five servo bands as explained in “Servo tracks” on page 35. The high-bandwidth servo system features a

low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Surface Control Guiding Mechanism

The Surface Control Guiding Mechanism is designed to guide the tape along the tape path in The TS1030 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Magneto resistive head design

Magneto resistive (MR) head design using flat lap head technology in MR heads for Ultrium 3 helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the LTO3 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Dynamic speed matching

The Ultrium 3 Tape Drives are designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). Speed matching reduces the number of backhitch repositions and improves throughput performance. Speed matching on the Ultrium 3 model ranges from 30 to 60 MB/s compared to 17.5 to 35 MB/s on Ultrium 2 Tape Drives. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

Separate writing of multiple file marks

Separate writing of multiple file marks is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark. This feature has two advantages:

- ▶ It helps improve performance if a subsequent append overwrites somewhere after the first file mark.
- ▶ Writing multiple file marks typically indicates a point where an append operation might occur after the first of these file marks.

This change helps prevent having to rewrite data sets containing client data and the first file mark if such an append occurs.

Dynamic braking

The TS1030 Tape Drive uses *dynamic braking*. In the event of a power failure, reel motors are designed to maintain tension and gradually decelerate instead of stopping abruptly, reducing the potential for tape breakage, stretching, or loose tape wraps during a sudden power down.

Power management

The Ultrium 3 Tape Drive power management function is designed to control the drive electronics to be either completely turned off or stay in a low-power mode when the circuit functions are not needed for drive operations.

Statistical Analysis and Reporting System (SARS)

The Ultrium 3 Tape Drives uses SARS to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the Cartridge Memory (CM) module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive dump is taken from the drive, the Support Center can determine if the failure is in the Tape Drive itself or on the Data Cartridge.

Dynamic Amplitude Asymmetry Compensation

This design helps to dynamically optimize readback signals for linear readback response from magneto resistive read head transducers.

Cartridge compatibility

The drive (Generation 3) uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge and is compatible with the cartridges of its predecessor, the IBM Ultrium Internal Tape Drive (Generation 2).

The drive performs the following functions:

- ▶ Reads and writes Generation 3 cartridges to Generation 3 format
- ▶ Reads and writes Generation 2 cartridges to Generation 2 format
- ▶ Reads Generation 1 cartridges
- ▶ Does not write Generation 3 cartridges to Generation 2 format
- ▶ Does not write Generation 2 cartridges to Generation 3 format
- ▶ Does not write Generation 1 cartridges.
- ▶ The drive reads tapes that have been written by other licensed Ultrium 3 drives.

It also writes to tapes that can be read by other licensed Ultrium 3 drives. In addition to using the IBM TotalStorage LTO Ultrium Data Cartridge with up to 400 GB capacity, the drive also offers Read/Write capability for certified LTO Ultrium tape cartridges.

Data cartridge capacity scaling

The SET CAPACITY SCSI command enables a client to capacity scale a data cartridge to enable faster random access. As an example, a client can capacity scale a data cartridge to 20% of its normal length, which improves the average access time by almost a factor of 5; however, it also reduces the native capacity of the tape to 80 GB.

Note: The SET CAPACITY command can only be accepted at the beginning of tape.

2.3.1 IBM LTO3 Full-High (FH) Tape Drive

LTO Generation 3 Full-High Tape Drive is a high-performance, high-capacity data storage device that is designed to back up and restore Open Systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library. The characteristics of the LTO3 FH Tape Drive are similar to the IBM TS1030 LTO Tape Drive that was described in the previous section.

Drive features

The LTO3 FH Tape Drive characteristics are:

- ▶ The Ultrium 3 Full-High Tape Drive supports:
 - Two HD-68 LVD Ultra160 interfaces
 - One Fibre Channel interface
- ▶ Greater performance:
 - Up to 80 MB/s native transfer rate (Up to 160 MB/s with 2:1 compression)
 - We have a 129% increase in the transfer rate of LTO Generation 2 Drives (35 MB/s native up to 70 MB/s compressed)
- ▶ Higher cartridge capacity:
 - 400 GB native (800 GB with 2:1 compression)
 - We have a 100% cartridge capacity increase from LTO Generation 2 Drives (200 GB native and 400 GB compressed)
- ▶ Backward compatibility:
 - Reads and writes LTO Generation 2 data cartridges
 - Reads LTO Generation 1 data cartridges
- ▶ Dual-stage 16-channel head actuator:

The actuator is designed to provide precision head alignment to help support higher track density (704 data tracks as opposed to 512 data tracks in LTO Generation 2) and improved data integrity
- ▶ Larger internal data buffer:

128 MB internal data buffer as opposed to the 64 MB internal data buffer of the LTO2 Generation

2.3.2 IBM LTO3 Half-High (HH) Tape Drive

The IBM LTO Ultrium 3 Half-High Tape Drive is a high-performance, high-capacity data storage device that is designed to back up and restore Open Systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library. The characteristics of this drive are similar to the LTO3 Full-High Tape Drive described in the previous section. We summarize them in the next section.

Drive features

The LTO3 HH Tape Drive does not support Fibre Channel interfaces. It has the following features:

- ▶ Host interface connections:
 - Two HD-68 Ultra 160 Low Voltage Differential (LVD) Small Computer System Interface (parallel SCSI) interfaces
 - One SFF-8088 Serial Attached SCSI (SAS) interface
- ▶ Half-height form factor
- ▶ 68-pin, D-shell connector for SCSI signals
- ▶ Power connection
- ▶ Native storage capacity of 400 GB per cartridge (800 GB at 2:1 compression) on the Ultrium 3 Data Cartridge
- ▶ Maximum native data transfer rate of up to 60 MB/s
- ▶ Burst data transfer rate of 120 MB/s

- ▶ Dual stage 16 channel head actuator for precision head alignment to help support higher track density with improved data integrity and backwards compatibility with previous LTO generations
- ▶ Internal buffer size of 128 MB
- ▶ Independent tape loader and threader motors designed to help with cartridge insertion in the tape drive
- ▶ Cartridge Auto-Eject on over-temperature function to safely unload a cartridge when an over-temperature condition is detected in the drive, and after cooling down, to safely resume normal drive operations
- ▶ Four Light Emitting Diodes (LEDs) operator panel configuration

2.4 IBM System Storage TS1040 Tape Drive

The TS1040 LTO Tape Drive offers high capacity, performance, and technology that are designed for the midrange Open Systems environment. The TS1040 LTO Tape Drive has a 4 Gbit Fibre Channel interface for either point-to-point or Fibre Channel-Arbitrated Loop attachment, a Ultra160 LVD SCSI attachment, or a 3 Gbps dual-ported SAS interface.

The TS1040 is the first tape drive within the IBM LTO tape family that supports Tape Encryption. Tape Encryption is supported on the SAS and Fibre Channel tape drives. The Ultra160 LVD SCSI interface does not support Tape Encryption.

AME is available at no charge. For SME and LME, Feature Codes (FC) 5900 or 1604 (Transparent LTO Encryption) and FC9900 (Encryption Configuration) must be ordered if you are planning to implement Tape Encryption in your environment. If you want to learn more about Tape Encryption, we recommend that you read the following interesting topic, 2.2, "Tape Encryption overview" on page 61.

The internal Read/Write buffer size is 256 MB, and the total amount of data tracks is 896.

The native storage capacity is 800 GB and 1600 GB with a 2:1 compression. Table 2-5 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-5 Native data transfer rate with various media

	Generation 4 media	Generation 3 media	Generation 2 media
Supported methods of operating	Read/Write	Read/Write	Read only
Native data rate SCSI (MB/s)	120	80	35
Native data rate SAS (MB/s)	120	80	35
Native data rate Fibre Channel (MB/s)	120	80	35

Basic points to consider

The Ultrium 4 drive can operate either as an NL port (FCAL support, or connection to an FL port on a fabric) or as an N port ((supporting direct connection to an F port (for example, a McData switch), also known as point-to-point to a fabric)). The Ultrium 4 drive auto-configures to either an N or an NL port depending on whether it sees a loop or an F-port connection when the drive boots unless it has been set to force an explicit setting of these configurations.

The drive can be forced to an explicit setting by serial port (LDI/ADI) and library port (LUN 1) commands, which write the vital product data (VPD). The Ultrium 4 drive will attempt to connect at 4 Gb, but will auto-negotiate down to 2 Gb or 1 Gb if the system or switch to which it is connected cannot support 4 Gb.

SAS drives will auto-negotiate speed. The SAS drives are dual-ported and use the SAS Drive Plug Connector, which supplies power to the drive.

Speed matching

To improve the performance of the LTO4 Tape Drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's HBA. The LTO4 Tape Drive is negotiating with the server's HBA to set up a speed with the best performance. Six speeds are available when reading or writing the prior generation of data cartridges. Native rates are:

- ▶ Generation 2: 30, 26, 22, 19, and 15 MB/s
- ▶ Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- ▶ Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces backhitching. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

There is a 256 MB internal data buffer in the Ultrium 4 Tape Drive as compared to a 128 MB internal data buffer in the Ultrium 3 Tape Drive.

Servo and track layout technology

There are 896 data tracks in Ultrium 4 compared to 704 data tracks in Ultrium 3, which are used to read and write data to the data cartridge. These tracks are grouped in five servo bands as explained in "Servo tracks" on page 35. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and to improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Magneto resistive head design

Magneto resistive (MR) head design using flat lap head technology in MR heads for Ultrium 4 helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the LTO4 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Separate writing of multiple file marks

Separate writing of multiple file marks is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark.

This feature has two advantages:

- ▶ It helps improve performance if a subsequent append overwrites somewhere after the first file mark.
- ▶ Writing multiple file marks typically indicates a point where an append operation might occur after the first of these file marks.

This change helps prevent having to rewrite data sets containing client data and the first file mark if this type of an append occurs.

Power management

The Ultrium 4 Half-High Tape Drive power management function is designed to control the drive electronics to be either completely turned off or stay in a low-power mode when the circuit functions are not needed for drive operations.

Channel calibration

The performance of the LTO4 Tape Drive is further optimized by a feature called *channel calibration*. Channel calibration is the process by which the drive automatically customizes each Read/Write data channel to compensate for variations in the recording channel's transfer function, the media, and characteristics of the drive head.

Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 Tape Drive must be inactive for a minimum of 30 seconds. The LTO4 Tape Drive goes out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI or RS-422), or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

Customer Centric Statistical Analysis Reporting System

Customer Centric Statistical Analysis Reporting System (ccSARS) provides information reflecting the current and overall health of the drive and any media recently used within the TS1040. The ccSARS can be used either directly by the host or a subsystem to monitor the systemic operational characteristics of the TS1040 and media. At the time of writing this publication, the TS3500 Tape Library is the only library that supports ccSARS.

2.4.1 IBM LTO4 Full-High (FH) Tape Drive

The IBM LTO Ultrium 4 Full-High Tape Drive is a high-performance, high-capacity data-storage device that is designed to back up and restore Open Systems applications. The drive can be integrated into an enclosure, such as a desktop unit, tape autoloader, or tape library. The characteristics of this drive are similar to the IBM TS1040 Tape Drive described in the previous section. We summarize them in the next section.

Drive features

LTO Generation 4 Full-High Tape Drive characteristics are:

- ▶ Host interface connections are:
 - Two SFF-8088 3 Gb SAS interfaces to align with new systems
 - Two HD-68 Ultra160 Low Voltage Differential (LVD) Small Computer Systems Interface (SCSI) connections
 - 4 Gb Fibre Channel interface

- ▶ Greater performance:
 - Up to 120 MB/s native transfer rate (Up to 240 MB/s with 2:1 compression)
 - Burst data transfer rate of 160 MB/s for the SCSI interface and 300 MB/s for the SAS interface. Transfer rate increases 50% from LTO Generation 3 Tape Drives (80 MB/s native up to 160 MB/s compressed)
- ▶ Higher cartridge capacity:
 - 800 GB native (1.6 TB with 2:1 compression) using Ultrium 4 cartridge
 - Per cartridge 100% capacity increase from LTO Generation 2 Tape Drives (400 GB native/800 GB Compressed)
- ▶ Backward compatibility:
 - Reads and writes LTO Generation 3 Data Cartridges
 - Reads LTO Generation 2 Data Cartridges
- ▶ WORM support:

Leverages WORM cartridges so that you can store data in a non-erasable, non-rewritable format
- ▶ New 256 AES Encryption:

Addresses security and compliance concerns by enabling the writing of encrypted data to LTO Ultrium 4 tape cartridges. Unable to read encrypted data without access to the “key”

2.4.2 IBM LTO4 Half-High (HH) Tape Drive

IBM LTO Ultrium tape technology is designed for the heavy demands of backup tape storage and archiving in the Open Systems environment. LTO Ultrium proven tape technology has been enhanced in the new IBM Ultrium 4 Half-High Tape Drive to help provide increased capacity, enhanced performance, and reliability compared to LTO Ultrium 3. Drive data transfer rates are up to 120 MB/s compared to 80 MB/s native for LTO Ultrium 3. The single-reel IBM LTO Ultrium 800 GB Tape Cartridge features a physical capacity of up to 1600 GB with 2:1 compression (800 GB native). Features of the Half-High Tape Drive are similar to the TS1040 Tape Drive described in the previous section.

Drive features

The Ultrium 4 Tape Drive also includes the following characteristics as compared to the Ultrium 3 Tape Drive:

- ▶ Half height form factor
- ▶ Native data transfer rate of up to 120 MB/s
- ▶ Ultrium 4 tape cartridge native physical capacity of 800 GB (1.6 TB at 2:1 compression)
- ▶ Burst data transfer rate of 300 MB/s
- ▶ Gbps SAS attachment
- ▶ Larger 256 MB internal buffer
- ▶ Ultrium 4 tape cartridges drive encryption support
- ▶ 8 KB cartridge memory with Ultrium 4 media
- ▶ Integrated electronics using IBM-engineered copper technology

The IBM Ultrium 4 technology is designed to support encryption of data. The hardware encryption and decryption core and control core reside in the IBM Ultrium 4 Tape Drive (available to the TS3100 and TS3200 with the 3 Gbps SAS interface). A larger internal data

buffer helps improve data access rates and reduce cartridge fill and rewind times along with dynamic channel calibration that is designed to help increase data throughput. In addition to reading and writing to LTO Ultrium 4 tape cartridges, the LTO 4 Half-High Tape Drive can read and write to LTO Ultrium 3 cartridges and read LTO Ultrium 2 cartridges.

2.5 IBM Ultrium 1, 2, 3, and 4 highlights

In this section, we show you highlights of the IBM Ultrium 1, 2, 3, and 4 Tape Drives, such as drive and cartridge compatibility, LTO drive performance, drive operations, reliability, and cleaning the drive. We also illustrate the IBM LTO Ultrium family of tape drives and libraries and an overview of the Multi-Path Architecture.

2.5.1 IBM Ultrium 1, 2, 3, and 4 compatibility

Table 2-6 shows the compatibility among the four generations of LTO data cartridges. The following rules describe the compatibility among the various LTO cartridge generations:

- ▶ Data cartridges one generation prior are Read/Write compatible.
- ▶ Data cartridges two generations prior are read only.
- ▶ Data cartridges three generations prior are not supported.

However, the Ultrium 4 drive only allows an Ultrium 3 cartridge to be written at the LTO Generation 3 operating point (400 GB). More specifically, the Ultrium 4 drive does not allow an Ultrium 3 cartridge (400 GB) to be reformatted to the Ultrium 4 format (800 GB), which is generally true when a data cartridge is used in a higher generation Ultrium tape drive.

Table 2-6, Figure 2-33 on page 79, and Figure 2-34 on page 80 provide an overview of the compatibility of the four generations of data cartridges.

Table 2-6 shows the Read/Write compatibility among the four generations of data cartridges.

Table 2-6 *Ultrium data cartridge compatibility*

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (Ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

Figure 2-33 on page 79 shows the Read/Write compatibility, the native sustained data rate, and the native physical data cartridge capacity. You can recognize the various generations of data cartridges quickly by the color or barcode label. The color represents the following generation LTO data cartridges:

- ▶ Black LTO1 data cartridge
- ▶ Purple LTO2 data cartridge
- ▶ Slate blue LTO3 data cartridge
- ▶ Green LTO4 data cartridge

Every data cartridge has an external label, and the generation shows on the right side of the label: L1 for the first generation, L2 for the second generation, L3 for the third generation, and L4 for the fourth generation. WORM data cartridges use LT for identification.

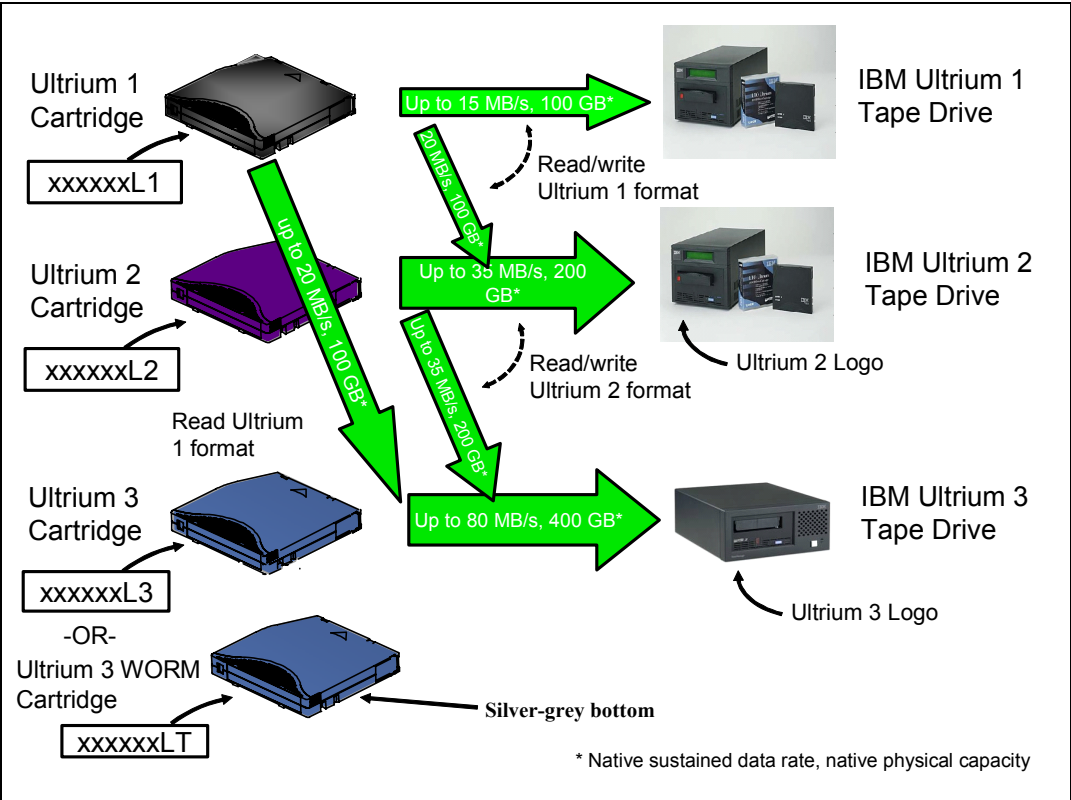


Figure 2-33 IBM Ultrium 1, 2, and 3 compatibility

Figure 2-34 on page 80 shows the compatibility among Ultrium 2, 3, and 4 data cartridges.

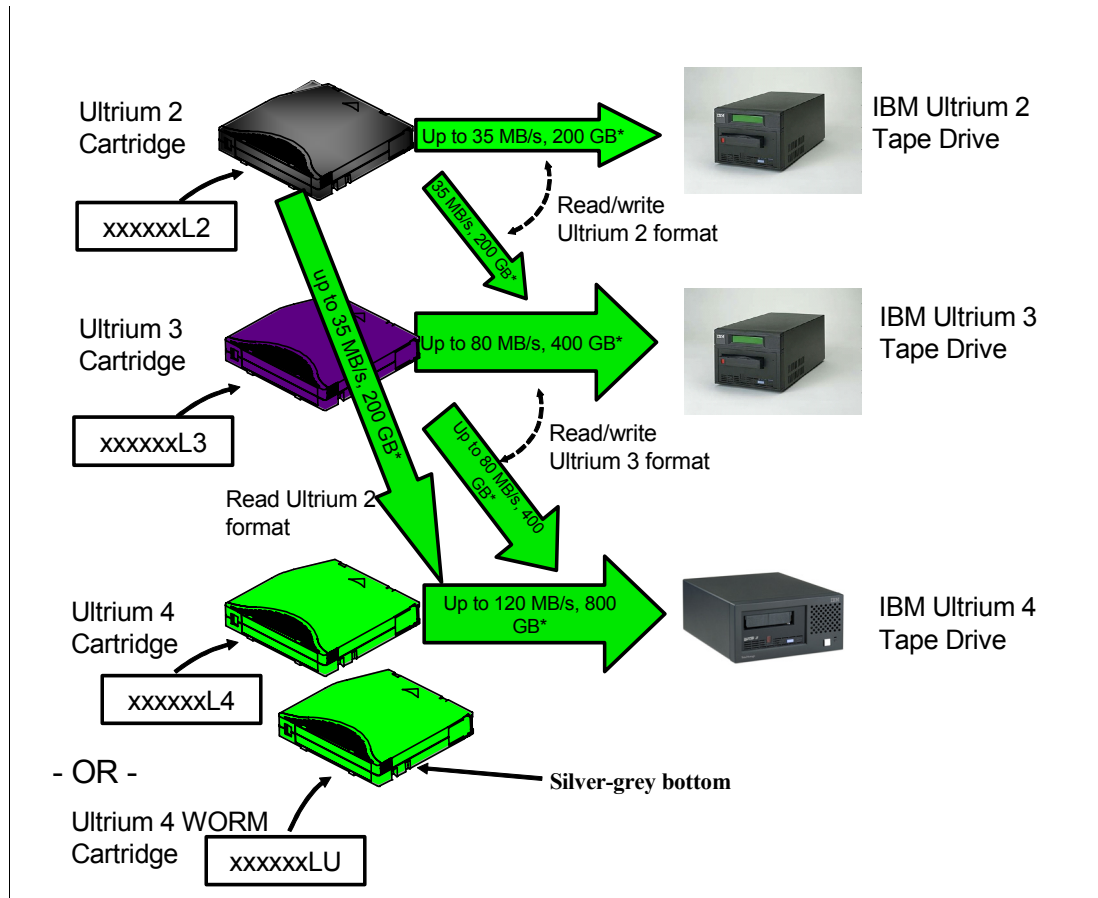


Figure 2-34 IBM Ultrium 2, 3, and 4 compatibility

2.5.2 LTO performance

IBM LTO drives provide high performance and will continue to improve with each new generation of products. If you run applications that are highly dependent on tape-processing speed, you can exploit the significant performance that is provided by the Ultrium tape drives.

IBM LTO Ultrium drives provide efficient tape operations and relief to users who have difficulty completing tape activities in the time available. If you have limited system backup windows, or if you have large amounts of disk data to back up, Ultrium tape drives are ideal.

By using the built-in data-compression capability of the Ultrium drive, you can potentially achieve greater data rates than the uncompressed data rate. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, SCSI bus capabilities, and system or application software. Installing multiple tape drives in general (or more than two in the case of IBM LTO) on a single SCSI bus can adversely affect data transfer rates.

IBM Ultrium 1

The IBM LTO Ultrium 1 Tape Drive has these performance characteristics:

- ▶ 15 MB/s native sustained data transfer rate
- ▶ 30 MB/s sustained data transfer rate at 2:1 compression
- ▶ 60 MB/s maximum sustained data rate (at maximum compression)
- ▶ 100 MB/s burst data transfer rate for Fibre Channel

- ▶ 80 MB/s burst data transfer rate for Ultra2 SCSI LVD drives
- ▶ 40 MB/s burst data transfer rate for Ultra SCSI HVD drives
- ▶ 20 s nominal load-to-ready time
- ▶ 18 s nominal unload time
- ▶ 73 s average search time to first byte of data
- ▶ 110 s maximum rewind time
- ▶ 4 m/s Read/Write speed
- ▶ 6 m/s search/rewind speed
- ▶ 32 MB buffer

IBM Ultrium 2

The IBM LTO Ultrium 2 drives provide more than twice the performance of IBM Ultrium 1 with sustained data rates of 35 MB/s native and 70 MB/s with 2:1 compression. IBM Ultrium 2 has faster load and unload time, faster data access time, faster rewind time, and faster cartridge fill time compared with IBM Ultrium 1. The Ultrium 2 drive provides speed matching with five speeds for the Ultrium 2 cartridge. The Ultrium 2 drive also reads and writes to an Ultrium 1 cartridge at a higher speed than the Ultrium 1 drive.

The IBM LTO Ultrium 2 Tape Drive has these performance characteristics:

- ▶ 35 MB/s native sustained data transfer rate
- ▶ 70 MB/s sustained data transfer rate at 2:1 compression
- ▶ 110 MB/s maximum sustained data rate (at maximum compression)
- ▶ 200 MB/s burst data transfer rate for Fibre Channel
- ▶ 160 MB/s burst data transfer rate for Ultra 160 SCSI LVD drives
- ▶ 40 MB/s burst data transfer rate for Ultra SCSI HVD drives
- ▶ 15 s nominal load-to-ready time
- ▶ 15 s nominal unload time
- ▶ 49 s average search time to first byte of data
- ▶ 80 s maximum rewind time
- ▶ 6.2 m/s Read/Write speed
- ▶ 8 m/s search/rewind speed
- ▶ 64 MB buffer

IBM Ultrium 3

The IBM LTO Ultrium 3 drives offer more than double the performance of IBM Ultrium 2 with sustained data rates of 80 MB/s native and 160 MB/s with 2:1 compression. IBM Ultrium 3 provides speed matching with five speeds for both Ultrium 3 and Ultrium 2 cartridges and reads and writes an Ultrium 2 cartridge at the speed of the Ultrium 2 drive.

The IBM LTO Ultrium 3 Tape Drive has these performance characteristics:

- ▶ 80 MB/s native sustained data transfer rate
- ▶ 160 MB/s sustained data transfer rate at 2:1 compression
- ▶ Over 200 MB/s maximum sustained data rate (at maximum compression)
- ▶ 200 MB/s burst data transfer rate for Fibre Channel
- ▶ 160 MB/s burst data transfer rate for Ultra 160 SCSI LVD drives
- ▶ 15 s nominal load-to-ready time
- ▶ 15 s nominal unload time
- ▶ 54 s average search time to first byte of data
- ▶ 88 s maximum rewind time
- ▶ 6.2 m/s Read/Write speed
- ▶ 8 m/s search/rewind speed
- ▶ 128 MB buffer

IBM Ultrium 4

The IBM LTO Ultrium 4 Tape Drive has these performance characteristics:

- ▶ 120 MB/s native sustained data transfer rate
- ▶ Sustained data transfer rate at 2:1 compression:
 - For SCSI: 140 MB/s
 - For SAS: 240 MB/s
 - For FC: 240 MB/s
- ▶ 12 s nominal load-to-ready time
- ▶ 17 s nominal unload time
- ▶ 57 s average search time to first byte of data
- ▶ 54 s average rewind time
- ▶ 8 m/s Read/Write speed
- ▶ 8m/s rewind speed
- ▶ 256 MB buffer

Partial Response Maximum Likelihood (PRML)

The IBM patented linear tape implementation of a Partial Response Maximum Likelihood (PRML) channel technology increases linear densities up to 33% and, consequently, data throughput. The key to PRML's space-saving capability is that on a read-back operation, the magnetic flux transitions are sampled and the sampling feeds logic algorithms that reconstruct the user's data stream, rather than using the flux transitions themselves. The previous method of data encoding was Run Length Limited (RLL) encoding, which was also patented by IBM for use in earlier tape drives. Figure 2-35 compares both methods.

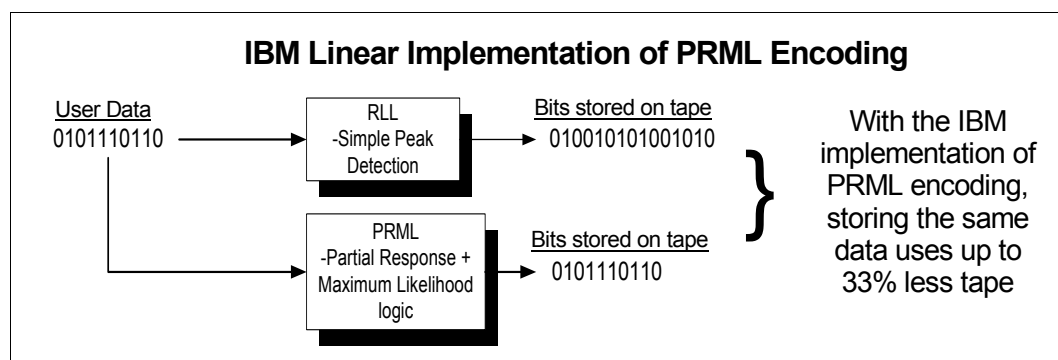


Figure 2-35 IBM linear implementation of PRML encoding

2.5.3 Operating the Ultrium drive

The IBM subassembly itself has a simple status LED indicator, an unload push button, and a single-character display (refer to Figure 2-36).

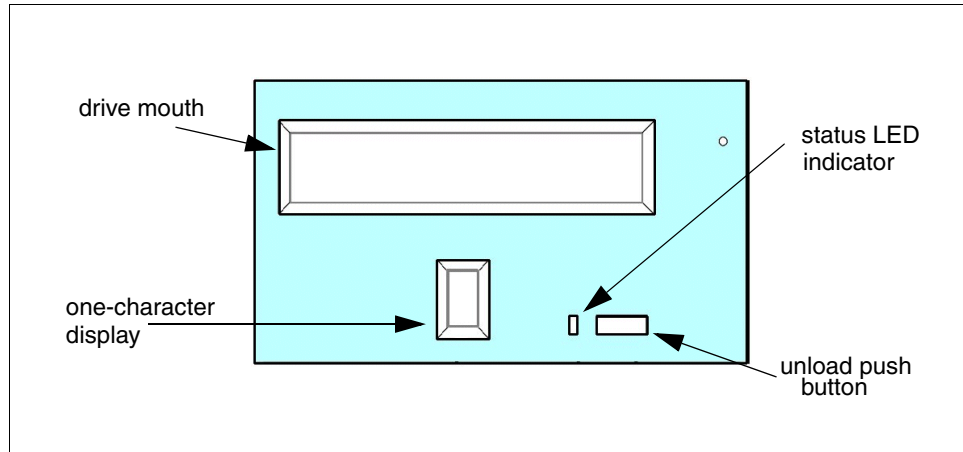


Figure 2-36 Front of subassembly showing Operator Panel indicators

The status LED indicator uses color and lighting to indicate that:

- ▶ The tape is in motion for reading or writing.
- ▶ The drive is rewinding, locating, or unloading the cartridge.
- ▶ The drive is in maintenance mode.
- ▶ A failure occurred, and the drive or media requires service.
- ▶ A microcode update is occurring.

The unload push button enables the operator to:

- ▶ Unload a cartridge
- ▶ Enter maintenance mode and execute maintenance operations
- ▶ Force a drive dump operation

The single-character display indicates errors and communicates messages, such as requests for cleaner tapes. The operator uses the single-character display for diagnostic and maintenance functions.

2.5.4 Reliability

The IBM LTO Ultrium tape format differs from earlier IBM products. Reliability and availability features include:

- ▶ Data integrity

The drive performs a read after write for verification. Incorrectly written data, such as the result of a tape defect, is automatically rewritten by the drive in a new location. Data rewritten as the result of media defects is not counted against the drive error performance.

The drive never records incorrect data to the tape media without posting an error condition.

- ▶ Power loss

No recorded data is lost as a result of normal or abnormal power loss while the drive is reading or writing data. If power is lost while writing data, only the data block currently being written might be in error. Any previously written data is not destroyed.

- ▶ Error correction

Data integrity features include two levels of error correction that can provide recovery from longitudinal media scratches.

- ▶ Integrated head cleaner

The head of the drive must be kept clean to prevent errors that are caused by contamination. During the load process, a brush integrated into the drive mechanism cleans the head before it is used with the tape. This keeps the head and media free of debris on a continuing basis and is designed to require fewer drive-cleaning operations.

- ▶ Surface control guiding

The Surface Control Guiding Mechanism, which is patented by IBM, guides the tape along the tape path using the surface of the tape rather than the edges to control tape motion. Using grooved rollers (refer to Figure 2-37), an air cushion builds between the tape and the rollers that keeps the tape in the right position. This results in less tape damage (especially to the edges of the tape) and less debris from damaged edges that can accumulate in the head area, which helps minimize the chance of physical damage to the tape media.

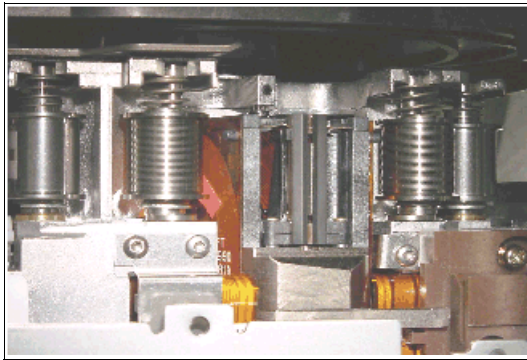


Figure 2-37 Surface control guiding

- ▶ Flat lap head

The flat lap head, which is shown in Figure 2-38, improves contact between the read and write recording elements and the tape, giving higher quality recording and readback of data.

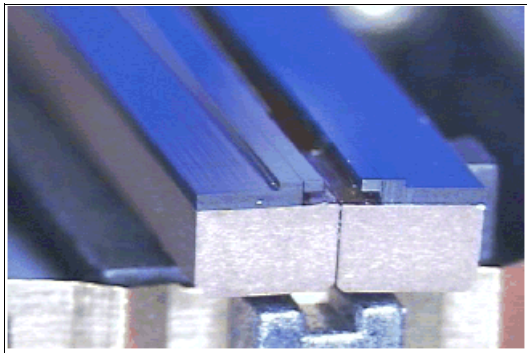


Figure 2-38 Flat lap head

Surface control guiding and the flat lap head are designed to help minimize debris generated as the tape moves through its path, resulting in increased reliability in reading and writing data. This also potentially increases the life expectancy of the media by not

using the edges of the tape to guide it over the Read/Write head. Historically, this also was a major source of debris on the tape path.

► Statistical Analysis and Reporting System

Statistical Analysis and Reporting System (SARS) is another IBM exclusive. Only IBM LTO drives provide this level of preventive diagnostic reporting. The Ultrium drive uses this reporting system to assist in isolating failures between media and hardware. SARS uses the cartridge performance history saved in the CM module and the drive performance history kept in the drive flash EEPROM to determine the most likely cause of failure. It then can cause the drive to request a cleaner tape, to mark the media as degraded, and to indicate that the hardware has degraded. SARS reports the results of its analysis in the form of a Tape Alert if necessary (refer to Figure 2-39).

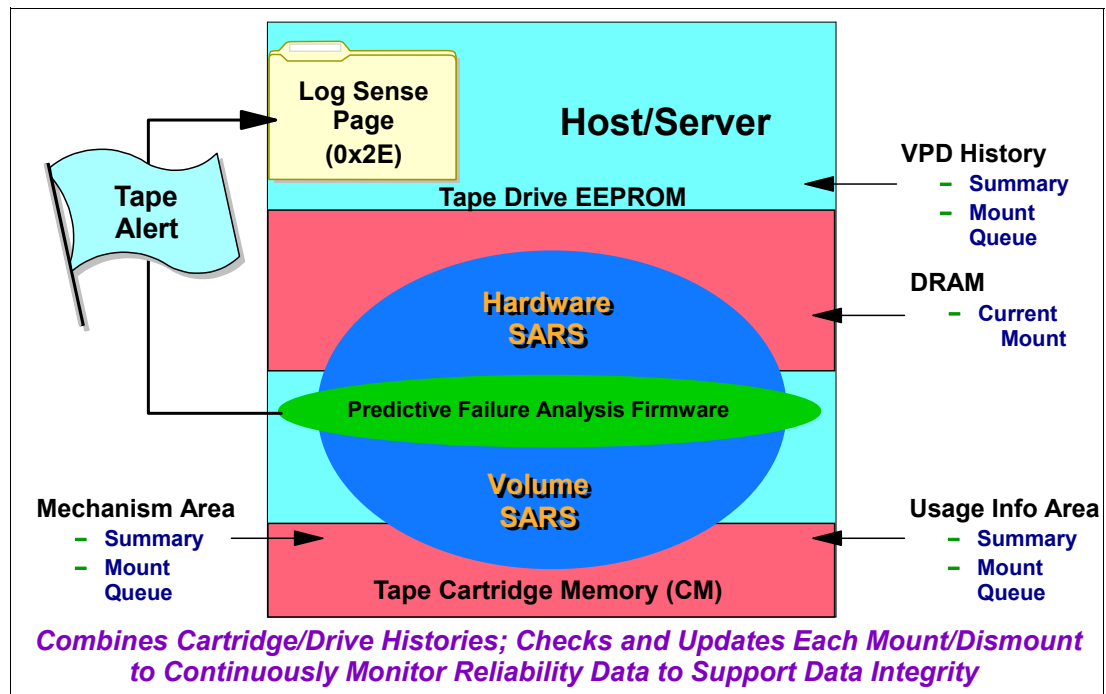


Figure 2-39 Statistical Analysis and Reporting System

2.5.5 Cleaning the drive

In addition to the integrated head-cleaning mechanism, IBM recommends that you clean the drive regularly, with automatic cleaning enabled where supported in the libraries. The automatic cleaning prevents drive shutdowns because of improper maintenance or contaminants that cause the drive to fail.

In the unusual event that the drive head becomes clogged, it *might* be necessary to use the specially labeled IBM LTO Ultrium cleaning cartridge supplied with each Ultrium tape drive product. The cleaning cartridge is good for 50 cleaning operations. If cleaning proves necessary, the LTO-CM memory in a cleaning cartridge is used to track the number of times that the cartridge has been used. After the cartridge has been used 50 times, the drive marks the cleaning cartridge as expired, which also protects you from accidentally reinserting a cleaning cartridge that has been used 50 times.

Note: The use of cleaning cartridges other than when automatically required (that is, a manual or user-initiated cleaning) is unnecessary. Using cleaning cartridges other than when automatically required is discouraged for normal operation of Ultrium tape drives.

2.5.6 The IBM LTO Ultrium family of tape drives and libraries

The IBM LTO Ultrium family of tape drives and libraries (pictured in Figure 2-40) is comprised of five product offerings, ranging from a stand-alone unit to a highly scalable automated library.



Figure 2-40 The IBM Ultrium family of tape drives and libraries

They are all based on a common tape drive subassembly packaged in various robotic and stand-alone environments. The tape drives and libraries that are shown in Figure 2-40 are:

- ▶ The *IBM TotalStorage 3580 Tape Drive* is a stand-alone desktop single-drive unit without an autoloader. You mount tapes manually one at a time.
- ▶ The *IBM TotalStorage 3581 Tape Autoloader* is also a single-drive unit, but it has a seven-cartridge or eight-cartridge autoloader within the device. It is either a stand-alone desktop, an external 2U stand-alone, or a rack-mountable unit. This unit is no longer available (as of 1 October 2004), and the existing units only support LTO1 or LTO2 drives.
- ▶ The *IBM TotalStorage 3581 2U Tape Autoloader* is a desktop or rack-mountable unit that comes equipped with a robotic interface that moves tape cartridges to and from the drive and an eight-cartridge carousel. It occupies two units of the rack when it is rack-mounted.
- ▶ The *IBM TotalStorage 3582 Tape Library* is a small robotic library, accommodating one to two drives and providing space for up to 23 Ultrium cartridges. The IBM 3582 can be stand-alone or, with an optional feature, housed in a rack.

- ▶ The *IBM TotalStorage 3583 Tape Library* is a small robotic library, accommodating from one to six drives and providing space for up to 72 Ultrium cartridges. The IBM 3583 can be stand-alone or, with an optional feature, housed in a rack.
- ▶ The *IBM System Storage TS3500 Tape Library* (previously known as IBM TotalStorage 3584 Tape Library) is a larger modular enterprise class library with the potential to house a maximum of 192 IBM LTO or IBM 3592 tape drives in as many as 16 frames. There is a trade-off between cartridge capacity and installed drives: a fully configured library with 192 drives and a cartridge I/O station has a cartridge capacity of 6201; in a minimal drive configuration, the cartridge capacity can reach a maximum of 6887.

Note: The IBM 3580 Tape Drive and the IBM 3581, 3582, and 3583 Tape Libraries have been withdrawn from Marketing.

Replacement tape drives and tape libraries are available. We show them in Figure 2-41.



Figure 2-41 IBM 3580 Tape Drive, TS2900 Autoloader TS3100, TS3200, and TS3310 Tape Libraries

The tape drives and libraries shown on the left side of Figure 2-41 are (listed from top to bottom):

- ▶ The *IBM System Storage TS2340 Tape Drive* is an external stand-alone or rack-mountable (optional) unit for the family of IBM Ultrium Tape products. It features the LTO4 Tape Drive.
- ▶ The *IBM System Storage TS3100 Tape Library* is a desktop or rack-mountable single drive unit that can hold up to 24 cartridges. A robotic system moves the cartridges to and from the drive. When it is mounted in a rack, it occupies two units of the rack.

- ▶ The *IBM System Storage TS3200 Tape Library* is a desktop or rack-mountable single or dual drive unit that can hold up to 48 cartridges. It has a three slot I/O station that must be shared when logical libraries are configured. When it is mounted in a rack, it occupies four units of the rack.
- ▶ The *IBM System Storage TS3310 Tape Library* is highly modular and vertically expandable. The smallest configuration includes a base module with one to two LTO3 or LTO4 tape drives, 12 TB of native tape storage (30 slots), and 6 I/O slots. This will be upgradeable in the future to a fully configured rack-mounted library 41U high with up to 18 LTO3 or LTO4 tape drives, over 320 TB of native tape storage (402 slots), and up to 48 I/O slots.

On the right side of Figure 2-41 on page 87, you see (from top to bottom):

- ▶ The *IBM System Storage TS2900 Tape Autoloader* is an external stand-alone or rack-mountable unit in the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. It features the LTO3 Half-High Tape Drive and the LTO4 Half-High Tape Drive.
- ▶ The *IBM System Storage TS2230 Tape Drive* is an external stand-alone or rack-mountable unit and is the entry point to the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. It features the LTO3 Half-High Tape Drive.
- ▶ The *IBM System Storage TS2240 Tape Drive* is an external stand-alone or rack-mountable unit in the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. It features the LTO4 Half-High Tape Drive.
- ▶ The *IBM System Storage TS3400 Tape Library* is a tape library based on the TS1120 and TS1130 Tape Drives. The TS3400 provides 18 storage slots, including a three slot I/O station. The total native capacity is 12.6 TB with the TS1120 Tape Drive and 18 TB with the TS1130 Tape Drive.

2.5.7 Multi-path architecture

The patented Multi-Path Architecture was introduced with the IBM Magstar MP 3575 library. It provides a way to share a tape library among a number of servers without the need to implement application software to control and serialize tape drives and media. It is presently implemented in the IBM TS3100, TS3200, TS3310, TS3400, 3582, 3583, TS3500, and 3584 libraries.

Multi-path architecture is an IBM unique feature. The IBM TS3100, TS3200, TS3310, TS3400, TS3310, 3582, 3583, TS3500, and 3584 LTO libraries feature the second generation of the architecture. It uses the SCSI-3 Move Media command set that is featured in midrange and open libraries. The key benefit is that Multi-Path Architecture removes the need for a dedicated server plus middleware to control the use of a library by multiple hosts utilizing various operating systems, because each drive has its own path to the control unit.

Conventional tape libraries use a dedicated host port to communicate with the library, for example, for sending mount request commands. IBM LTO tape libraries use the same path to communicate with both the drives and the library controller, as shown in Figure 2-42 on page 89. This is not one dedicated path, but it might be any path to any tape drive.

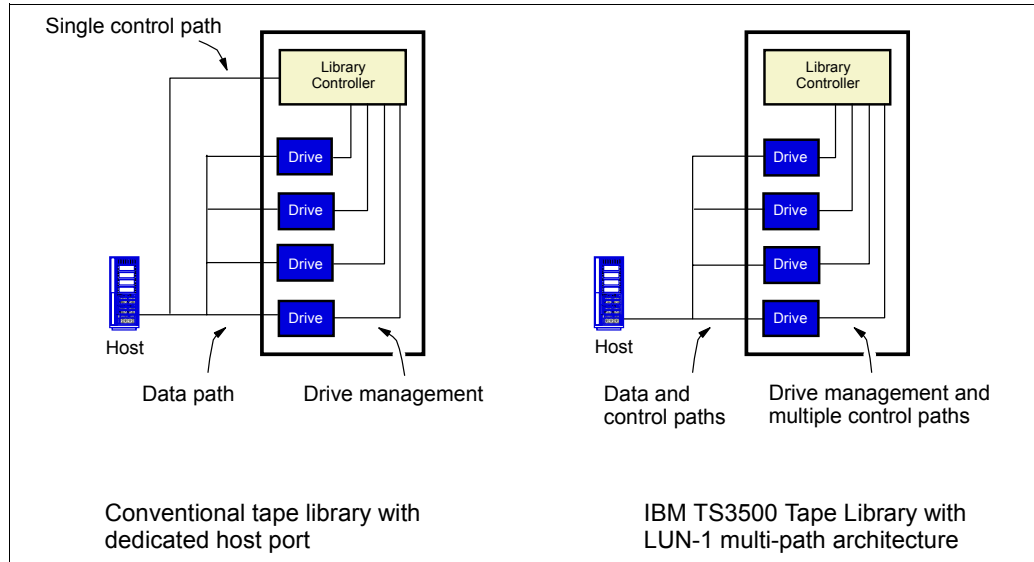


Figure 2-42 Conventional tape library compared to Multi-Path Architecture

For conventional tape libraries, the control path is a single point of failure. In contrast, the IBM LTO tape libraries offer as many control paths as there are drives installed in the library, so in the event of individual control path failure, you can communicate with your library over different, redundant control paths. As shown in Figure 2-43, if one path to a drive is broken because of a defective switch port, cable, or HBA, communication to the library controller can still occur using one of the other available paths. In conjunction with automatic control path failover, this design constitutes a unique high-availability option.

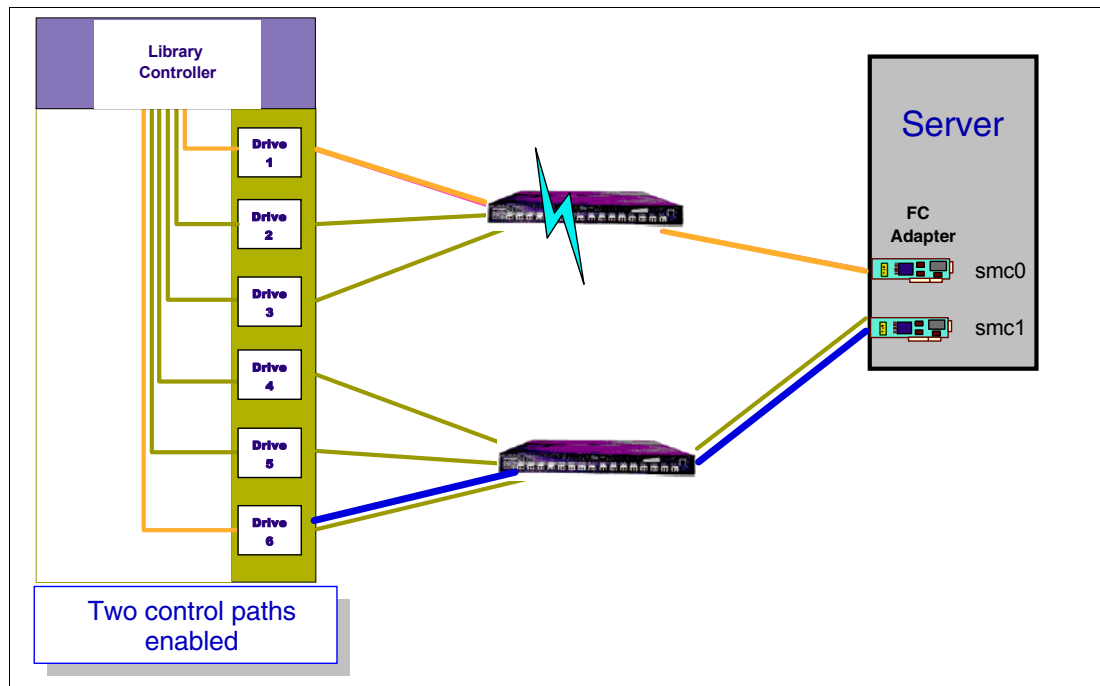


Figure 2-43 Redundant control paths to the library controller

As well as the redundant control path, Multi-Path Architecture offers the additional benefit of built-in partitioning. With the partitioning feature of the IBM LTO libraries, you can divide the physical library into several smaller logical libraries, which are independent from each other.

The maximum number of logical libraries varies by model type. A logical library must contain at least one tape drive and cartridge cell and can comprise more than one tape drive sharing the same cartridge cells.

Multiple heterogeneous hosts can share the library with this partitioning option. Each logical library has its own drives, cartridges, and control paths. Because of barriers between the logical libraries, cartridges cannot be moved from one logical library to another. Figure 2-44 shows three logical libraries with two drives each and several cartridge storage slots dedicated to each of the heterogeneous servers.

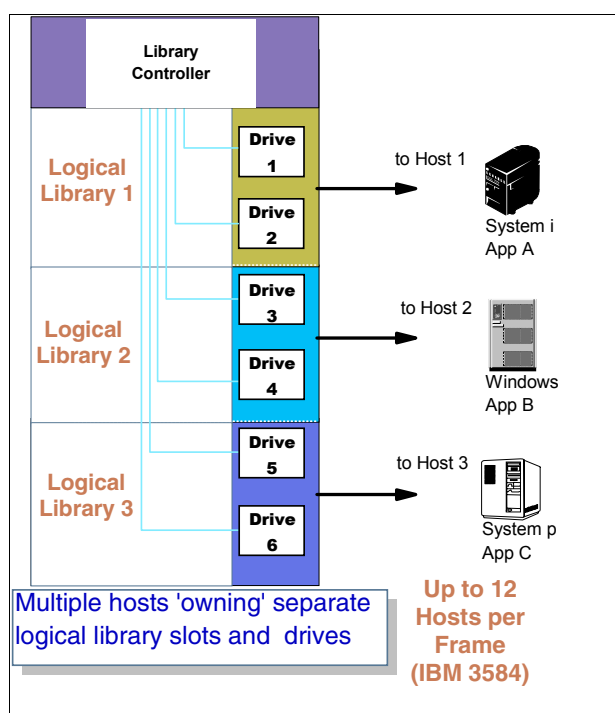


Figure 2-44 IBM LTO tape library partitioned into three logical libraries

2.5.8 Next generation Multi-Path Architecture

The Advanced Library Management System (ALMS) is an optional extension to the IBM patented Multi-Path Architecture. The Multi-Path Architecture itself virtualized the library accessor. This enabled a library to be partitioned into multiple logical libraries and allowed a single library accessor to be used by multiple host computers in a transparent manner. The ALMS virtualizes the SCSI element address for storage slots, I/O slots, and drives. ALMS provides enhanced automation functionality, such as dynamic partitioning, including storage slot pooling and flexible drive assignment. Tape drives can be assigned to any logical library and to multiple logical libraries using a Web browser-based user interface. Logical libraries can be added, deleted, or easily changed non-disruptively. Storage capacity can be changed without any impact to host applications.

ALMS is a feature with the IBM TS3500 Tape Library and is described in detail in 12.5, “ALMS” on page 355.



Overview of IBM System Storage TS1100 Tape Drives

This chapter describes the TS1100 Tape Drive family, their common characteristics, the differences of the three generations, and the 3592 media characteristics.

We describe these models:

- ▶ IBM System Storage TS1130 Model E06/EU6 Tape Drive
- ▶ IBM System Storage TS1120 Model E05 Tape Drive
- ▶ IBM TotalStorage Enterprise 3592 Model J1A Tape Drive

Note: The 3592 Model J70 and the 3592-J1A are no longer marketed but are still currently supported in various subsystems, so we describe them briefly in this chapter.

3.1 IBM System Storage TS1100 Tape Drive family

The IBM System Storage TS1120 and TS1130 tape drives (machine types 3592-E05 and 3592-E06/EU6) offer a design focused on high capacity, performance, and high reliability for storing mission critical data. With the September 2003 introduction of the first generation of the new family of tape drives, IBM advanced its high-end half-inch cartridge tape technology to a new level. The second generation of the 3592 family enhanced the capacity and performance characteristics, which have now become increased by the IBM System Storage TS1130 Model E06/EU6 Tape Drive, the third generation of the 3592 family, which provides the unprecedented capacity of 1 TB of uncompressed data.

3.1.1 The 1 TB background

On 5 April 2002, IBM achieved an unprecedented feat - 1 TB of data was recorded, without compression, to a tape containable in a half-inch format tape cartridge. This was a technological accomplishment that set the foundation for the 3592 Tape Drive family. By using the evolutionary progression of technology building blocks that IBM had set in place over the preceding five years, an enterprise tape drive roadmap was laid out which can ultimately reach and exceed 1 TB in native cartridge capacity over several tape drive generations. The 3592 Model J1A became the first tape drive generation of the Enterprise Tape family. It enabled storage of 300 GB of data to a cartridge even if it is incompressible (900 GB with 3:1 compressible data). An even more innovative achievement was that these same cartridges are designed to be reused by the second generation of 3592 tape drives, the TS1120 Model E05 to store significantly more data; using the JA media, we can store 500 GB and with the high capacity cartridge, 700 GB without compression. Now, with the third generation of IBM 3592 Tape Drive, IBM kept its promise documented in the roadmap for 3592 tape drives. The TS1130 Tape Drive is not just a new drive but the IBM commitment to further tape technology development.

Note: The 3592 Model J1A is no longer being marketed, but it is still currently supported in the TS3500 Tape Library, so we describe it in this chapter.

3.1.2 Nomenclature

The TS1130 Tape Drive actually has several naming attributes similar to the TS1120:

- ▶ Machine Type/Model

3592 Model E06 and 3592 Model EU6 are the device models:

- The Model E06 is the factory-built model.
- The Model EU6 is the field miscellaneous equipment specification (MES) upgrade model for E05 to E06 conversions.

The 3592 Model E06 and EU6 drives display as a 3592-3E, which indicates that this is the third generation 3592 drive and has the encryption feature enabled.

- ▶ Product name

TS1130 is the product name.

Because of so many common considerations for the TS1120 and the TS1130 tape drives, and in order to make reading more convenient, we will use the name *3592-J1A* for the first 3592 generation and *3592 models E* for the IBM System Storage TS1120 Tape Drive and IBM System Storage TS1130 Tape Drives in the following chapters.

3.2 Common characteristics of the 3592 tape drive family

Next, we discuss the common characteristics of the 3592 tape drive family in terms of technology enhancements, reliability and availability improvements, features for performance and capacity, and the media, which is reusable by all three generations.

3.2.1 Technology enhancements

The key features of the 3592 tape drive family include:

- ▶ *Virtual backhitch*, which is the optimum adaptive format and algorithm designed for improved start/stop write synchronize performance (see “Virtual backhitch (nonvolatile caching)” on page 100).
- ▶ High performance and robust dual microprocessor architecture. One microprocessor operates the host attachment interface (running what is essentially proven 3590 host attach microcode), while the other microprocessor is allowed to focus strictly on writing data and reading data from tape. Each microprocessor is designed to reset the other microprocessor to act as a fail-safe.
- ▶ S/390 and System z attachment through ESCON and FICON by means of the existing J70 controller, as well as the TS1120 Tape Controller.
- ▶ Statistical Analysis Recording System (SARS) algorithm with extended mount count.
- ▶ Fast random access performance when operating on any of the Short Length Cartridge (SLC) types.
- ▶ Support of an enhanced capacity scaling and segmentation format when operating on the full length Read/Write (R/W) cartridge type JA and JB, enabling very fast locate and read times.
- ▶ Streaming Lossless Data Compression (SLDC) algorithm (enhancement of the Lempel-Ziv class 1 (LZ-1) data compression algorithm).
- ▶ Cartridge memory of 4 K designed for the 3592 to support advanced features.

3.2.2 Recording format

The IBM 3592 Tape Drive uses an advanced interleaved bidirectional serpentine recording technique that writes eight or 16 (depending on the drive) data tracks at a time on a 3592 cartridge. The 3592 cartridge is a half-inch, advanced metal particle, dual layer tape, and the tape layout consists of five servo bands (which are prerecorded on the tape) and four data bands where the data is written. Refer to Figure 3-1 on page 94. The servo bands provide location information to control the positioning of the head as it writes and reads data within the data band. This design is explained in detail in “Servo tracks” on page 96.

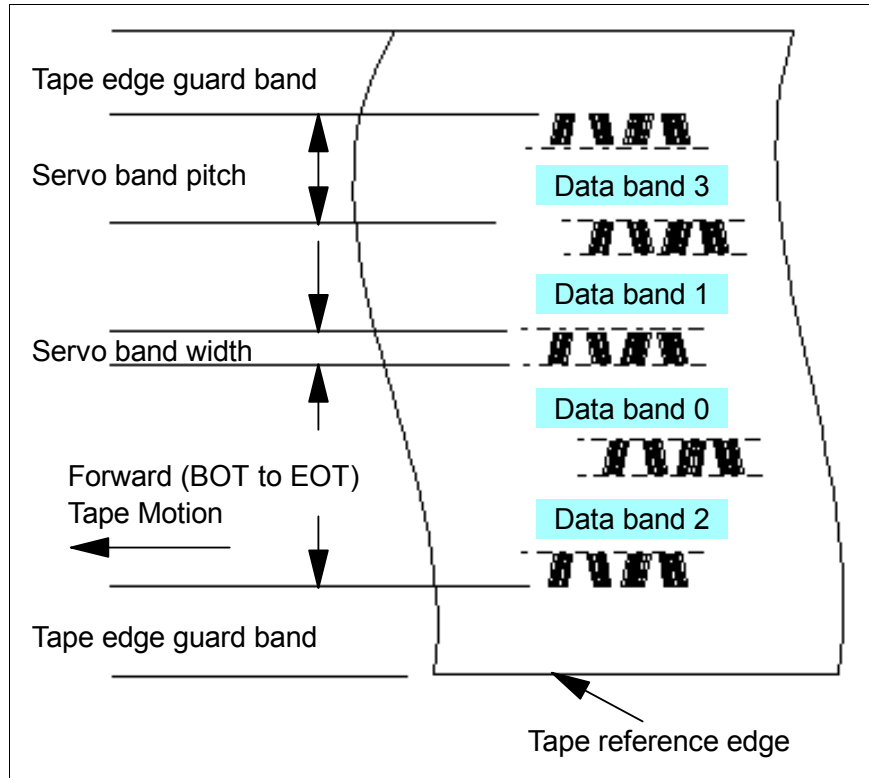


Figure 3-1 The layout of the servo and data bands on the 3592 media

As shown in Figure 3-1, the area between adjacent servo bands is a *data band*. There are four data bands, each with a number of data tracks (128 - 288, which is different for each model), on the 3592 media. The data bands are numbered 2, 0, 1, and 3, with data band 2 nearest the Tape Reference Edge and data band 3 farthest from the Tape Reference Edge.

As Figure 3-2 on page 95 shows (here, for example, is a J1A written cartridge), each data band is actually composed of eight data sub-bands, one for each of the eight write heads. Each sub-band is written by a given write-head position in a technique called a *linear serpentine*, which means that the tape moves back and forth longitudinally while the head is indexed up or down laterally at each pass. This technique makes it possible to write multiple distinct tracks in a given data sub-band.

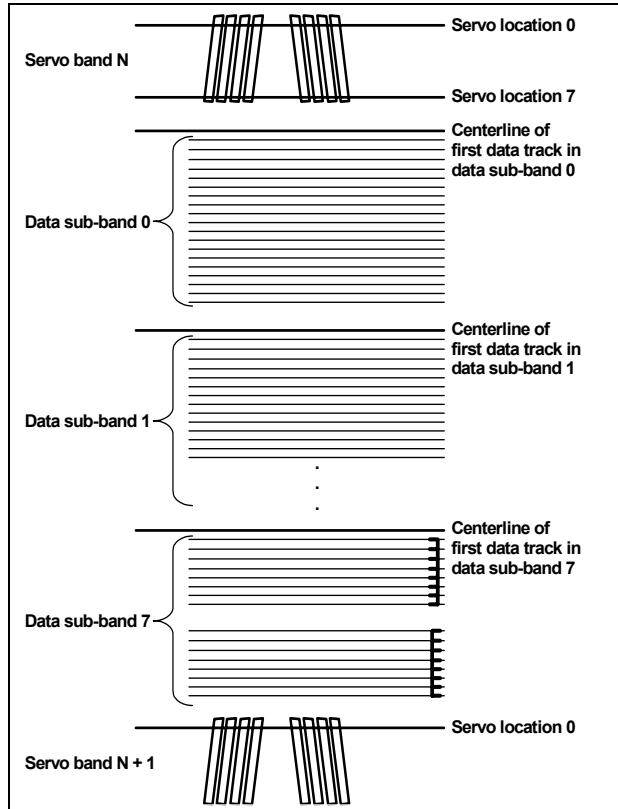


Figure 3-2 Section of tape showing one data band and its surrounding servo bands

Figure 3-3 on page 96 shows an even closer look at a data band. It demonstrates the serpentine method that is used to write data. The numbers on the right indicate the tracks, which are written simultaneously on each data sub-band in a converging spiral in 16 passes for J1A, 14 passes for E05, and 18 passes for E06: down (tape outbound from cartridge) and back (tape inbound to cartridge), each at a different lateral offset. Given the eight or 16 channel heads, eight or 16 tracks of data are written simultaneously in this linear serpentine pattern, each track in separate data sub-bands. After a given data band is full, a coarse-actuator motor moves the head to another quarter of the tape. This process continues until all four data bands are filled.

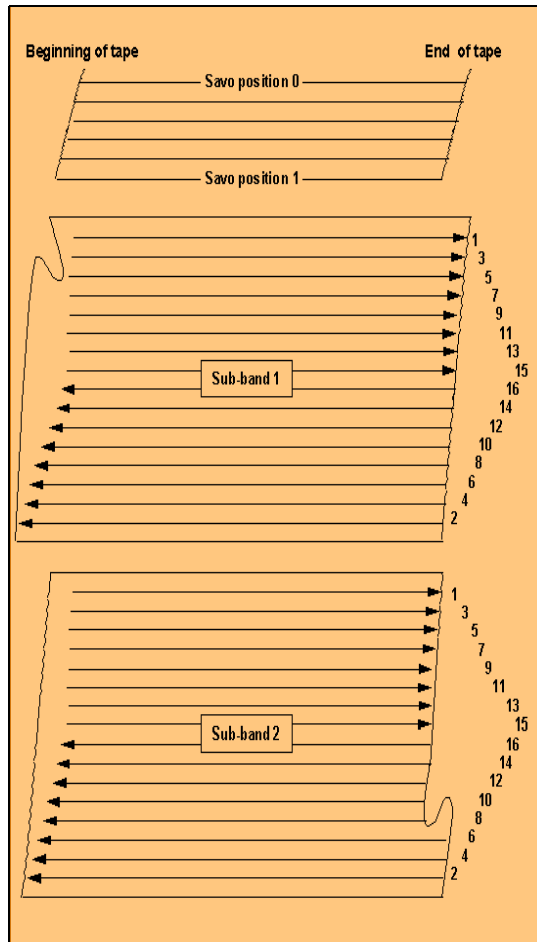


Figure 3-3 Close-up view of two data sub-bands for J1A with 8 tracks and one servo band

Servo tracks

Servo tracks enable accurate positioning of the tape drive head over the data track, ensuring that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo tracks are written at the time of cartridge manufacture, before the cartridge is usable for data storage and retrieval. Each tape write head has two *servo heads*, one servo head for each of the two *servo bands* that it spans. As shown in Figure 3-1 on page 94, five servo bands numbered 0 through 4 make up the servo tracking mechanism on the 3592 tape. They are each located at specific distances from the tape reference edge¹. Within the servo bands are *servo stripes*, groups of which make up *servo bursts*. Four servo bursts make up a *servo frame*; the first two bursts (as written in the forward tape-motion direction) contain five servo stripes, and the second two bursts contain four servo stripes.

Track following

Each pair of servo bursts is at an angle to each other, and the servo heads move so that they keep a constant value for the distance between the bursts by measuring the time taken between each burst (*timing-based servo (TBS)*). In this way, the servo is able to follow a straight line within the servo band; any small deviation away from the correct path causes a variation (plus or minus) in the gap between the bursts (refer to Figure 3-4 on page 97). Provided that the servo head element follows a straight line along the servo band, then the distance “x” shown in the figure remains constant.

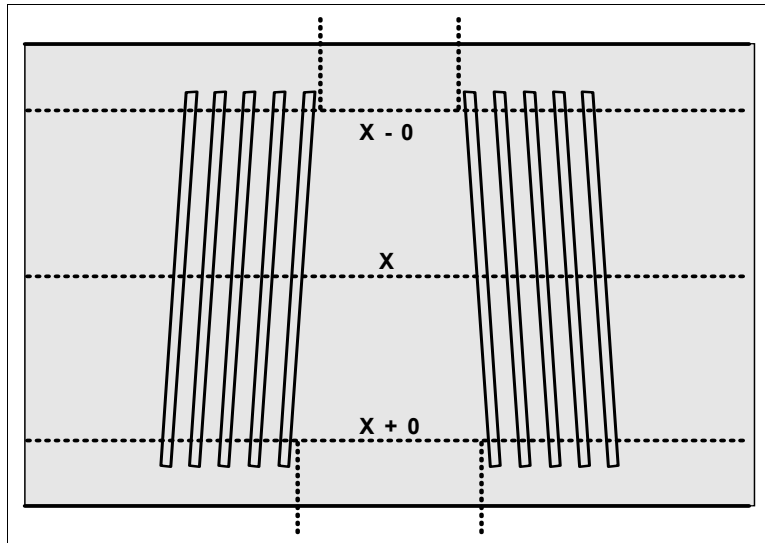


Figure 3-4 Diagram of the timing-based servo track

Two servo bands are used simultaneously to provide two sources of servo information for increased accuracy. For this format, there are control positions within the servo band used to reposition the head in order to write forward and reverse wraps, within each of the four data bands. This timing-based servo technology can be finely tuned and is capable of supporting extremely high-track densities for future 3592 generations, because more than eight positions can be defined within the same servo band, thus expanding the potential track densities. In addition to the significant advances in the tape coating process using the high-quality metal particle media, this means that we can confidently fulfill the road map design for reformatting this same media at higher densities.

3.2.3 Reliability and availability

The 3592 drive incorporates and expands on the high reliability and function of previous IBM drives developed over many years of experience. It builds on proven technologies to both enhance, as well as apply new techniques, to ensure high reliability and availability.

Improved availability

Improved availability characteristics include:

- ▶ **Single Field Replaceable Unit (FRU)**

When you place a service call, the IBM service support representative (IBM SSR) does not replace any parts or subassemblies inside the canister. The new smaller drive unit means that for any failure within the drive, the IBM SSR quickly exchanges the entire unit rather than perform lengthy diagnostics or component replacement in the field.

- ▶ **Redundant, hot-pluggable power supplies**

In all configurations, the drives are seated in *cradles* that contain two power supplies. Each pair of power supplies can be used by one or two drives. One of these power supplies is sufficient to run both drives, and the second power supply is provided for redundancy.

- ▶ **Retention of Fibre Channel Worldwide Name ID during service action**

This means that when a failed drive is exchanged; you do not have to reconfigure the attached hosts to recognize a replacement drive. This function also eliminates any issues with SAN hosts finding incorrect addresses during a system reboot.

Advanced technology

Advanced technology characteristics include:

- ▶ **Robust loader mechanism**

The loader mechanism has been designed to be suitable for the heavy duty cycle usage in mainframe systems. The leader block on the tape cartridge is replaced by a metal pin, which is enhanced over previous drive implementations for increased robustness.

- ▶ **Elimination of drive pneumatics and mechanical adjustments**

The aerodynamic movement of the tape over the flat lap head pulls the tape very close to the head while the tape is moving and provides maximum efficiency in reading and writing. Because of the shape of the head, particles do not accumulate on the tape, eliminating the possibility of debris contaminating the tape surface. Air-bearing heads effectively cushion the tape moving across the head, but whenever the tape stops, it relaxes toward the head surface. The head has a two stage actuator: one mechanism for moving to the required tape wrap and another finer actuator for adjustments to the track-following servo.

- ▶ **Straighter and shorter tape path for better tape tracking**

Tape tracking is improved by using grooved rollers to provide surface-controlled guiding. This not only decreases potential wear or damage on the edges of the tape, but in conjunction with the shorter tape path, lateral movement is decreased.

- ▶ **Speed matching to reduce backhitching.** Refer to 3.2.4, “Features designed for capacity and performance” on page 99 for further details.

Buffering, speed matching, and virtual backhitch algorithms all serve to eliminate physical backhitching, which not only improves performance, but reduces the wear on the drive mechanics caused by continually braking and reversing direction.

- ▶ **Channel calibration to optimize performance and data integrity**

The drive uses individual R/W data channel calibration, exploiting sophisticated techniques that were originally implemented in disk technology.

Enhanced service functions

These service functions include:

- ▶ **Enhanced Statistical Analysis Recording System (SARS) recording.** The tape drive uses the SARS to assist in isolating failures between media and hardware. The SARS uses the cartridge performance history saved in the cartridge memory (CM) module and the drive performance history kept in the drive flash, which is a serial Electronically Erasable Programmable Read-Only Memory (EEPROM) with both read-only and rewritable areas, to determine the more likely cause of failure. The SARS can cause the drive to request a cleaner cartridge (based on usage) to mark the media as degraded and to indicate that the hardware is degraded. SARS information is reported through the TapeAlert flags and through media information messages (MIMs) and Service Information Messages (SIMs).

- ▶ **Diagnostic information**

The drive maintains logs to assist engineering or service personnel. The logs are included in drive dumps and are accessible to service personnel in a number of ways, including through the new hot-pluggable service panel. Dumps are maintained over Power On Reset (POR).

- ▶ Additional temperature and voltage sensors to improve error isolation

The drive contains sensors and circuits to detect errors. A temperature sensor monitors the temperature of the drive electronics. Voltage sensors detect when the power supply is out of tolerance. Other error checks, such as tape velocity checks, Read/Write data integrity checks, and servo checks, are performed using circuitry and sensors. The drive microcode is designed to check for logic errors to handle hardware-detected errors and to detect and report microcode-related errors.
- ▶ Drive status indicators and reliability, availability, and serviceability (RAS) functions on the library drive interface

The drive provides indicators for Fibre Channel status, whether the power is good, and faults. However, the drive hot-pluggable service panel is the key service tool to perform test procedures and interpret results. You can now access many functions and information that was previously available only from this panel from the 3494 Library Manager interface, which is more convenient and accessible to clients, as well as service personnel.
- ▶ Concurrent microcode update, switch new/old copy of drive code
- ▶ Backup drive Vital Product Data (VPD card) stored from the drive

When a drive is replaced, you can quickly download the VPD to the drive using the backup, which reduces the time taken for repair.
- ▶ Functional microcode updates through the Library Manager broadcast

You can update the firmware (microcode) in the 3592 Tape Drive in several ways, and the update no longer requires a Field Microcode Replacement (FMR) tape. You can update the firmware by using the:

 - FMR cartridge that contains the updated code
 - Host attachment (FC bus) using the write buffer command
 - RS-422 port to the drive if supported by the library automation
- ▶ Preventive maintenance

The 3592 Tape Drive requires no preventive maintenance beyond the use of the cleaning cartridge. The 3592 media cartridges require proper care and appropriate handling and shipping procedures.

3.2.4 Features designed for capacity and performance

As we have mentioned previously, the unique features and specifications of the 3592 make it a true enterprise tape drive in both performance and reliability. We describe these industry leading features in detail in the following sections.

Data buffer

The drive has a large data buffer with read-ahead buffer management, which addresses the lowest band of data rates, effectively collecting more blocks of data together in the buffer before writing to the drive at a higher speed. As a result of this data buffer, the drive stops and starts less often, which in general improves the overall performance and reliability of the drive and tape.

Speed matching

For medium data rates when operating from a host that cannot sustain the maximum 3592 data rate, the drive performs dynamic *speed matching*. The drive adjusts the native data rate of the drive as closely as possible to the net host data rate (after data compressibility has been factored out). The 3592 drive operates at various speeds (between six and seven speeds depending on the drive used) when reading or writing the 3592 format in an attempt

to match the effective host data rates. If the net host data rate is between two of the speed matching native data rates, the drive calculates at which of the two data rates to operate. Speed matching reduces the number of required backhitches. In some environments, the drive's backhitch is completely masked by the drive's data buffer, and thus, the system throughput is not improved or reduced by speed matching.

Cartridge memory (CM)

Contained within the cartridge is the *cartridge memory (CM)*, which is a passive, canticles silicon storage device (4096 bytes) that is physically a part of the cartridge. The CM holds information about that specific cartridge, the media in the cartridge, and the data on the media. It is designed to support the high resolution tape directory feature (see "High resolution tape directory" on page 100). Communication between the drive and the CM occurs through a non-contact passive radio frequency interface, which eliminates the need for physical connections to the cartridge for power or signals.

High resolution tape directory

The 3592 drive maintains a tape directory structure with a higher granularity of information about the physical position of data blocks and file marks on the media. This feature gives the 3592 drive improved nominal and average access times for locate operations. Locate times are therefore uniform; they are based on the position of the block or file mark on the tape independent of the uniformity of the block size or file mark distribution along the length of the tape. The 3592 locate and space performance therefore is targeted to be completely and singly dependent upon the longitudinal position on tape of the target block or file mark. This might be specified as:

- ▶ Locate time to any block or file mark on tape = longitudinal position/locate speed.
- ▶ A block located at physical end-of-tape (EOT) on a J1A Tape Drive requires less than 82 seconds to retrieve. No block must exceed this locate time.
- ▶ A block closer to beginning-of-tape (BOT) takes a linear proportionately shorter time to retrieve.

Virtual backhitch (nonvolatile caching)

The 3592 stages write data through an intermediate DRAM buffer on its way to tape. This buffer is volatile, because it does not retain what is stored in it if power is lost. For streamed writes (or reads), this buffer yields considerably improved performance. When a pre-3592 drive performs a streamed write to tape and the buffer empties, or if a synchronizing command is received that forces the buffer to be written to tape, the streamed writing ceases for want of data. Any non-immediate write-type command (such as how file marks are typically written) is considered a synchronizing command. Non-immediate write-type commands require the drive to store data to tape before returning command complete (with good status) in response to that command. This, by definition, forces all the data in the volatile buffer to be written to tape.

When streaming writes cease, a pre-3592 Tape Drive halts the tape and repositions it upstream of where the writing ended. This action allows subsequently received data to be written immediately following the previously written data to eliminate the waste of the considerable length of tape from the point at which good status is returned to the host, to the point at which the host has subsequently sent enough data to resume writing. For example, if tape is streaming at 4.74 m/s when the buffered data falls below the threshold, an entire meter of tape can pass unwritten in about 210 milliseconds. Substantial lengths of unwritten tape can significantly reduce capacity. Here, a backhitch has been used by typical tape drives to eliminate this capacity loss following a synchronizing write to tape.

Nonvolatile Caching (NVC) is a 3592 feature that can help greatly improve write performance through backhitch reduction. This system temporarily reserves portions of physical tape for cache areas. Data received from the host is written to the volatile buffer as usual and also to nonvolatile tape cache areas with the exception that no backhitch is typically necessary when writing temporary copies to cache areas of tape. This temporary capacity loss is easily recouped. The data is written to temporary cache areas and is not released in the volatile buffer, but instead it accumulates. This accumulation typically continues until the buffer is nearly full. At this time, the accumulated data in the buffer is rewritten through a streamed write to the standard area of tape. When the rewrite is complete, the temporary cache areas of tape are released so that they can be overwritten. Writing temporary copies to the cache areas of tape without backhitching until the buffer is nearly full and then streaming a rewrite of the data to the standard area of tape can help significantly improve the average write throughput to tape.

As an example, if a synchronizing event occurs after every 256 KB of data, the best that the 3590 can average is about 0.4 MB/s; basically, 256 KB divided by the backhitch time plus system overhead. The 3592-J1A, for example, can average about 2.9 MB/s under the same conditions, which is more than a factor of eight better in write throughput because of the backhitches eliminated by NVC writing. Aside from the potentially improved write throughput performance, the second effect of NVC writing is to recover the capacity lost by the standard writing technique. Data received between synchronization events fills containers of data to be written to tape called *device blocks* or *datasets*. The standard writing technique calls for padding out the last partially filled dataset. This padding on average typically amounts to half the size of the last dataset. Given the large dataset sizes of modern tape drives, this loss can be substantial.

For example, certain systems write as little as 64 KB of data between synchronizations. The minimum dataset size that the 3592 Tape Drive can hold is about 400 KB of data. The 64 KB of data might compress to about 20 KB of data. If so, the dataset containing this 20 KB of compressed data is going to be written with 380 KB of unused space, which amounts to a 95% capacity loss in that dataset. The streaming rewrite of the data that is accumulated in a buffer causes nearly all the datasets written to a standard area of tape to be written out in full, which can be thought of as *dataset packing*. For example, NVC written data might allow in excess of 900 GB of 3:1 compressible data to be written to JA media on a J1A drive, even if the data written is synchronized every 64 KB.

Writing in NVC mode is automatically invoked by the drive when host writing behaviors are detected that get better performance when in NVC writing mode. Similarly, NVC writing is discontinued when host commands are received that do not benefit from NVC writing, or when commands, such as rewind, are received. When NVC writing is exited, the drive writes any packed datasets that are accumulated in its buffer before beginning execution of the command that caused NVC mode to be exited. Because it is automatically invoked and exited, NVC writing is designed to be transparent to host applications. The only indication that NVC writing occurs is the improved capacity and performance that can result from this new mode of writing.

The two components of nonvolatile caching, backhitch reduction and dataset packing, are designed to provide major performance and capacity improvements over standard tape drive, such as 3590, or Linear Tape-Open (LTO) writing of synchronized data. Dataset packing improves overall tape capacity. Backhitch reduction decreases the frequency of mechanical repositions. Nonvolatile caching provides an innovative approach to increasing both capacity and write performance in a way that is designed to be transparent to host applications.

3.2.5 Performance/Capacity scaling

The 3592 drives support scaling and segmentation modes on the Read/Write (R/W) (JA/JB) cartridges (3592-J1A supports JA only) to allow clients to trade off capacity for improved access times. While 256 settings of capacity are supported on the 3592 drive, there are typically three primary settings used:

- ▶ Full capacity default mode
- ▶ 20% scaled fast access mode (capacity scaled, front of tape through a x'35' setting)
- ▶ Performance scaling for 87% capacity (segmented format, capacity scaling setting x'E0')

Performance scaling, also known as *capacity scaling*, is a function that allows you to contain data in a specified fraction of the tape, yielding faster locate and read times. This function is made possible through the action of modifying internal formatting indicators in the medium (and in the CM chip), so that the normal serpentine track format is altered in such a way as to limit the recorded portion of the tape to a specified fraction of the linear dimension of the medium (illustrated for 3592-J1A in Figure 3-5). The 3592 allows an application to issue a command to scale an individual cartridge (**Mode Select** command). It pertains only to the cartridge that is currently loaded; it is not persistent.

The result of performance scaling a tape to a percentage value (for example, 20%) is that the maximum number of recordable gigabytes is reduced to 20% of the normal value, and the average time to locate a random record on a full tape starting from load point is (very roughly) 20% of the time to locate a random record from load point for a full, unscaled tape. To compare, the average time to locate a random record on an unscaled (serpentine) tape that has only been filled to 20% capacity is nearly the same as the average time to locate a random record on an unscaled tape that has been filled to 100%. Scaling cuts the access time proportionately, and it also introduces normal end-of-tape programmatic warnings when approaching the scaled capacity limit in the same sense that those indicators are returned at end-of-tape when unscaled.

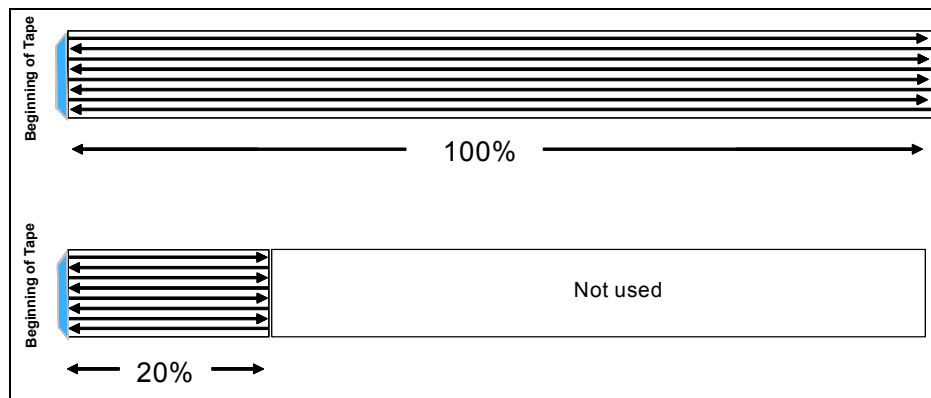


Figure 3-5 Examples for a 100% tape and scaled tape by 20%

Various capacities are set in the following ways:

- ▶ The 3592 drive does not change current cartridge scaling unless a SCSI **Mode Select** command (CDB) specifying Mode Page X'23' (with appropriate non-default parameter settings) is received while the cartridge is positioned at the beginning of tape. The drive can sense and report the scaling state of the current medium through a **Mode Sense** command specifying Mode Page X'23'.
- ▶ The cartridge can be rescaled from any current value to any supported new value. Tape is logically erased by this rescaling (the end of data mark is written at the beginning of the tape), but not physically erased as with the long erase command. Scaling or rescaling one

cartridge does not cause rescaling of the next cartridge; you must issue an explicit command for each cartridge to be scaled or rescaled.

- ▶ The drive provides the option of setting scaling values of $N/256$ ths of full capacity, where N ranges from x'16' (22 decimal equals about 8% capacity) to x'EB' (236 decimal equals about 92%). Refer to Table 3-1 on page 106 for a complete list of capacity scaling options.
- ▶ For scaling factors, N greater than x'4B', the drive scales to the specified amount and creates a fast access segment in the beginning of the scaled region.
- ▶ At all scaling factors, the drive supports early warning at the end of the scaled region (appropriate unit attention message to inform the software that it needs to flush the buffers and close the volume) and reports the physical end-of-tape check condition at the end of the scaled region just as it does at the real physical end-of-tape if the region is unscaled.

Performance segmentation

Performance segmentation provides fast access and capacity by allowing the tape to be divided into two segments: one segment as a fast access segment to be filled first and the other segment as additional capacity to be filled after the first segment. Therefore, it is high performance in two ways. It has segmentation so it has high performance random access in the first segment, as though it was a scaled cartridge, while still providing an additional larger capacity as shown in Figure 3-6.

The implications of performance capacity scaling and segmentation are:

- ▶ If host systems provide a means to limit the amount of data that a client places on the media, for example, with a % utilization construct, the user gets much faster average access time to the first data; also, additional locates on the same volume improve significantly.
- ▶ With segmentation, there is a small, less than 1% degradation in the data rate due to the increased number of wrap changes. Segmentation also reduces the nominal cartridge capacity by approximately 10%.

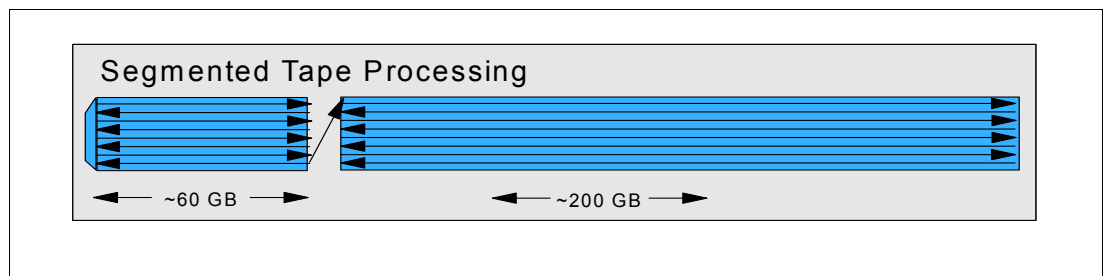


Figure 3-6 Example of a segmented tape on 3592-J1A

3.3 IBM 3592 Tape Drive attachment

The 3592 tape drives are supported in a wide range of environments, including selected IBM mainframes, System i, iSeries, AS/400, System p™, pSeries®, RS/6000®, System x, xSeries®, Sun, and Hewlett-Packard servers, as well as Intel®-compatible servers running Microsoft® Windows and Linux. The 3592 tape drives can also attach to System z and zSeries® servers with Fibre Channel Protocol (FCP) channels and Linux.

The TS1130 Tape Drive (IBM 3592-E06) and the TS1120 (IBM 3592-E05) have a dual-ported 4 Gbps native switched fabric Fibre Channel interface. The 3592-J1A Tape Drive provides as standard two switched fabric 2-Gbps Fibre Channel attachments. This offers attachment

flexibility in an Open Systems environment. The drive can be directly attached to Open Systems servers with Fibre Channels.

The IBM 3592 Model E tape drives attempt to connect at 4 Gbps (3592-J1A at 2 Gbps) but will auto-negotiate down to 2 or 1 Gbps if the system or switch to which they are connected cannot support higher bandwidth.

The 3592 tape drives can operate either as an NL port (Fibre Channel Arbitrated Loop (FC-AL) support) or as an N port (supporting direct connection to a McDATA switch, also known as *point-to-point*). The 3592 tape drives will auto-negotiate to either the N or NL port depending on whether it sees a loop or a point-to-point connection when the drive boots, unless it has been set to force an explicit setting of these configurations. Regardless of whether the 3592 tape drives connect as an NL port or an N port, they auto-negotiate to be a public device (attached to a switch) or a private device (attached to another N port, that is, directly to a host). If a library drive is replaced, an IBM service support representative (SSR) might select for the replacement unit to automatically inherit the configuration attributes of the failed unit. This way, a user can avoid having to reconfigure the zoning in the switches. Alternatively, the panels can be used to change these fields directly at any time.

For a detailed description of Fibre Channel attachment planning, refer to *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide*, GA32-0464.

For the latest information about applications and their levels that support 3592 tape drives, refer to the Independent Software Vendor (ISV) matrixes in this document:

http://www.ibm.com/servers/storage/tape/compatibility/pdf/3592_isv_matrix.pdf

You can find a list of host bus adapters (HBAs) supported for the 3592 drive at:

<http://knowledge.storage.ibm.com/servers/storage/support/hbasearch/interop/hbaSearch.do>

3.3.1 Multiple Fibre Channel ports

All 3592 models have two independent Fibre Channel interfaces or ports. Both ports run the SCSI protocol with Fibre Channel tape support. Two ports allow concurrent attachment of two independent Fibre Channel configurations to each drive. One or both ports can be attached to a variety of Open Systems servers, switches, hubs, and directors.

The 3592 tape drives support industry standard shortwave LC-Duplex fiber-optic cables. This allows cable lengths of up to 500 m (1640 ft.) with 50 micron core fiber.

3.3.2 Supported topologies

The 3592 tape drives support switched fabric and point-to-point loop topologies.

Switched fabric

Two or more Fibre Channel endpoints interconnect through a switch. The Fibre Channel architecture supports up to 256 ports through each switch. Switches include a function called *Zoning*. This function allows the user to partition the switch ports into port groups. It then assigns group access to other groups. This prevents group interference. Switched fabrics allow all of their ports simultaneous use of the full Fibre Channel architecture bandwidth.

Point-to-point loop

Point-to-point loop is similar to point-to-point topology. Both have two connected Fibre Channel endpoints. The difference is in the protocol. Therefore, when only two Fibre Channel endpoints are connected, either protocol is usable. Both endpoints must, however, use the

same protocol. The 3592 models supports point-to-point loop. SAN Data Gateway will utilize either protocol. Most Fibre Channel adapters default to the loop protocol when not directly connected to a fabric.

Address assignments

The 3592 tape drives must have a Fibre Channel address to communicate over the Fibre Channel interface. The tape drives allow both hard and soft addressing. Most Fibre Channel hosts (initiators) support hard addressing and do not support soft addressing. Refer to your device driver documentation for more information. Selecting the hard addressing option enables you to also select the drive's arbitrated loop physical address (AL_PA) where the higher the number, the lower the priority. Most hosts will attempt the lowest AL_PA number (highest priority).

The drive must have a higher AL_PA (lower priority). Multiple drives connected in an arbitrated loop require the drive closest to the host to have a lower AL_PA number (higher priority) than the next drive. Follow this protocol throughout the loop. The soft address feature allows the drive to arbitrate the AL_PA number with other Fibre Channel devices. When sharing a drive between systems, take caution to keep both hosts from attempting to use the drive at the same time.

Fibre Channel Worldwide ID

Each Fibre Channel card on the 3592 Tape Drive has four names (Node 0, Node 1, Port 0, and Port 1) that are hard-coded into the electronics of the card by IBM manufacturing. These names are similar to a serial number and are unique throughout the world.

3.4 IBM 3592 cartridges and media

Users need to cost-effectively store more digital information than ever before, often to meet growing regulatory and legal requirements. The 3592 tape drives are designed to help meet these needs with the IBM System Storage Tape Cartridge 3592. The 3592-J1A, 3592-E05, and 3592-E06 use the 3592 tape cartridge, which offers various capacity options depending on what drive and recording format you use or what cartridge model you order (Data, WORM, or Economy).

These capabilities expand the range of client data workloads that can be addressed with the 3592 tape drives. The economy cartridge can help lower the cartridge cost for users with smaller capacity needs and provide faster access to data. The WORM cartridges provide non-erasable, non-rewritable storage media. Users with regulatory or legal requirements to store electronic records for long periods of time might be able to use the 3592 tape drives to provide cost-effective storage.

The 3592 cartridges have a form factor similar to the 3590 tape cartridge. They are supported in the IBM TotalStorage 3494 Tape Library, IBM System Storage TS3500 Tape Library, IBM System Storage TS3400 Tape Library, and StorageTek Automated Cartridge System (ACS) automation environments.

The 3592 cartridge contains 0.5 inch tape media with a new dual-coat, advanced-particle media and has improved areal density capabilities that differ from the tape media in any previously shipped cartridge. The 3592 cartridge is designed to have the strength and durability of an enterprise cartridge. Enhanced assembly strengthens the cartridge at critical locations and helps make the 3592 cartridge less susceptible to damage, for example, if you drop it.

The tape is pulled from the cartridge by means of a leader pin rather than a leader block as in the 3590, and a sliding door covers the area formerly occupied by the leader block in a 3590 cartridge. A locking mechanism prevents the media from unwinding when the cartridge is not located within a drive. A special mechanical design provision prevents the 3592 cartridge types from being loaded into 3590 or 3490 drives; if inadvertently loaded into a 3590, the cartridge present sensor does not change state and the drive does not attempt to load.

3.4.1 Media types

The 3592-E05 and the 3592-E06 use six media cartridge types: JA, JJ, JW, JR, JB, and JX. The 3592-J1A uses four media cartridge types: JA, JJ, JW, and JR. All six cartridge types contain the same dual-coat, advanced-particle media. Capacity on these media types depends on whether the cartridge is used by model 3592-J1A, 3592-E05, or 3592-E06. Table 3-1 shows the media types and the capacity options that are available with 3592 tape drives.

Table 3-1 IBM TotalStorage Enterprise 3592 media types

Media type and description	Media type	Length	Native capacity 3592-J1A (E1 format)	Native capacity 3592-E05 emulating J1A (E1 format)	Native capacity 3592-E05 (E2 format)	Native capacity 3592-E06 (E3 format)	Native capacity 3592-E06 (writing in format E2)
MEDIA5 DATA	JA	609 m	300 GB	300 GB	500 GB	640 GB	500 GB
MEDIA6 ECONOMY	JJ	246 m	60 GB	60 GB	100 GB	128 GB	100 GB
MEDIA7 WORM	JW	609 m	300 GB	300 GB	500 GB	640 GB	500 GB
MEDIA8 ECONOMY WORM	JR	246 m	60 GB	60 GB	100 GB	128 GB	100 GB
MEDIA9 EXTENDED DATA	JB	820 m	N/A	N/A	700 GB	1 TB	700 GB
MEDIA10 EXTENDED WORM	JX	820 m	N/A	N/A	700 GB	1 TB	700 GB

Figure 3-7 on page 107 shows four of the media types. The WORM cartridges pictured on the left have a platinum color shell, and the R/W cartridges on the right have a black shell. The write protect tab, door, and label for the full length cartridges (both WORM and R/W) are dark blue. The write protect tab, door, and label for the extended length cartridges (both WORM and R/W) are dark green. The write protect tab, door, and label for the economy cartridges (short length) are light blue.



Figure 3-7 IBM TotalStorage Enterprise 3592 WORM and R/W cartridges

Figure 3-7 shows two WORM cartridges on the left and two R/W cartridges on the right.

Labels

The 3592 cartridges use a media label to describe the cartridge type. Figure 3-8 shows a 3592 cartridge with a JA label. In tape libraries, the library vision system identifies the types of cartridges during an inventory operation. The vision system reads a volume serial number (VOLSER), which appears on the label on the edge of the cartridge. The VOLSER contains from one to six characters, which are left-aligned on the label. If fewer than six characters are used, spaces are added. The media type is indicated by the seventh and eighth characters.

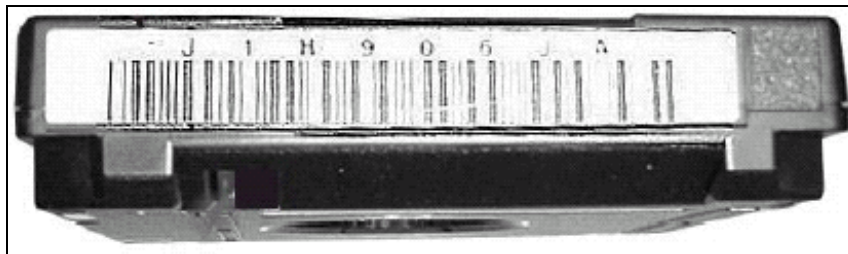


Figure 3-8 View of the 3592 cartridge label

Cleaning cartridges

There is one cleaning cartridge designed specifically for the 3592 drives. As with the data cartridges, the 3592 cleaning cartridges are not interchangeable with any other model cleaning cartridges (that is, LTO), so you must have both types of cleaning cartridges if you have both types of drives in your environment. The cleaning cartridge also contains a cartridge memory (CM) device, which automatically tracks the number of times that it has been used. Cleaning cartridges need to be replaced after 50 uses. The physical characteristics of the 3592 cleaning cartridge can be used to distinguish it from the 3592 data cartridges. The product label on the top of the cartridge is white with the word “cleaning” printed on it. Instead of the write-protect switch, there is a non-moveable light gray block. The cartridge door is also light gray. If you order cleaning cartridges with pre-attached labels, the first three characters of the volume serial number (VOLSER) are CLN.

3.4.2 3592 WORM functionality

The IBM TotalStorage Enterprise Tape Cartridge 3592 Write Once Read Many (WORM) data cartridges are designed to provide non-alterable, non-rewritable tape media for long-term records retention. WORM characteristics include:

- ▶ WORM cartridges are available as 300 GB or 60 GB native capacity for E1 format (3592-J1A), 700 GB, 500 GB, or 100 GB native capacity for E2 format (3592-E05), and 1000 GB, 640 GB, or 128 GB native capacity for E3 format (3592-E06).
- ▶ Non-reversible screws are used to secure the media housing.
- ▶ WORM and R/W cartridges can be intermixed within the same IBM TotalStorage Enterprise Automated Tape Library 3494, IBM System Storage TS3500 Tape Library, or StorageTek Automated Cartridge System (ACS) solutions.
- ▶ When the drive senses that a cartridge is a WORM cartridge, the microcode prohibits changing or altering user data already written on the tape. The microcode tracks the last appendable point on the tape by means of an overwrite-protection pointer stored in the cartridge memory (CM).
- ▶ Each WORM cartridge is identified using a Unique Cartridge Identifier (UCID).

Basic WORM

The 3592 tape drives support both the 3592 R/W cartridges, as well as 3592 WORM cartridges. The WORM cartridge is geometrically identical to a R/W cartridge and uses the same rewritable media formulation. The servo format, which is mastered onto the tape at manufacturing, is different for WORM cartridge types, however. The WORM function comes not from any inherent non-reversible media characteristic (such as permanent WORM on optical media, such as CD-R or ablative optical WORM), but rather by the way that the 3592 drive's microcode handles a WORM cartridge. The drive's microcode does not allow overwrite or erasure of previously written user data, such as records or file marks; however, the drive's microcode supports appending new data following existing data.

Unique cartridge identifier

Each IBM TotalStorage Enterprise 3592 Tape WORM cartridge is identifiable through a unique cartridge identifier (UCID). The intent of the UCID is that it is constructed to guarantee that it is unique worldwide. This identifier is derived from a concatenation of the 4 byte unique CM serial number of the CM chip in the 3592 WORM cartridge and the 8 byte unique tape serial number created from information mastered into the timing-based servo (TBS) at the time that the cartridge is manufactured. The parts of UCID that come from this serial number are written to a locked part of the CM. This additional level of security supports legal audit requirements. Furthermore, the UCID allows unique cartridge tracking and can be the differentiator to using other WORM tape providers.

Drive operation to prevent overwrite

A WORM drive handles a WORM cartridge differently than a R/W cartridge. In general, it responds to a subset of the SCSI commands that work on a R/W cartridge. For example, an **Erase** command is rejected with the appropriate error posted. Additionally, a WORM drive rejects certain command sequences of otherwise valid commands. For example, if a cartridge is not empty, a **Rewind** command followed by a **Write** command is rejected with the appropriate error posted. In general, the drive prevents overwrite. There are, however, exceptions, which the drive has to support to be flexible and "application software transparent." Specifically, the drive has to support certain overwrite cases.

WORM permits overwrite for the following scenarios:

- ▶ WORM permits overwrite in order to allow extending files.

- ▶ It permits overwrite to allow appending files.
- ▶ WORM permits overwrite in order to allow relabeling a new scratch tape. It then overwrites the VOL1 record if there are no subsequent records on the tape.
- ▶ WORM relies on known header/trailer constructs.
- ▶ Statistical Analysis and Reporting System (SARS) data can be written and updated on WORM tapes, because the SARS data is not in the user area of the tape.

Final destruction of WORM cartridges

You cannot reuse a WORM cartridge after you have written to it; therefore, you need to destroy it when it is no longer of use. If the WORM cartridge has sensitive data, you need to bulk-erase it, which erases everything on the tape including the mastered servo pattern, rendering it useless, before you send it to the landfill or the incinerator.

Compatibility when attached to Sun StorageTek Silo

You cannot move an IBM 3592 cartridge from a StorageTek ACS to an IBM 3584 without relabeling the cartridge. The ACS labels are unreadable in the IBM 3584, because they consist of two labels pasted together.

Also, you cannot move IBM 3592 cartridges into or from a StorageTek ACS or an IBM 3494 without changing the exterior labels.

When cartridges labeled with the standard media identification characters (JA, JJ, JR, JW, JB, or JX) or new cartridges are requested for temporary (or permanent) entry in an ACS, you must apply a new VOLSER label.

For IBM 3592 cartridges to be associated to various emulated drive types within an ACS, the standard media identification characters must be replaced. For more information regarding the silo attachment of 3592 tape drives, refer to *IBM TotalStorage 3592 Tape Frame Model C20 Introduction, Planning, and User's Guide*, GA32-0463-06, and contact your IBM marketing representative.

3.5 The IBM System Storage TS1130 Tape Drive

The IBM System Storage TS1130 Tape Drive (also referred to as the 3592 Model E06 and EU6) is the third tape drive generation of the IBM 3592 tape family. This generation provides higher capacity and performance compared to the predecessor 3592 Model E05. The TS1130 records in two recording formats supporting both encryption and non-encryption. Enterprise format 3 (EFMT3) is used to represent the non-encrypted recording format, and enterprise encrypted format 3 (EEFMT3) is used to denote the encrypted recording format. With these recording formats, the non-compressed capacity of the extended length MEDIA9 and MEDIA10 cartridges is increased from 700 GB to 1 TB. The 3592 Model E06 is downward read compatible ($n-2$) to the 3592 Model J1A format (EFMT1) and is downward write compatible ($n-1$) to the 3592 Model E05 formats (EFMT2/EEFMT2). All current media types are supported.

Host interfaces to System z and Open Systems platforms are maintained; the System Storage TS1130 Tape Drive is supported by IBM 3592 Model J70 Tape Controller, the System Storage TS1120 Tape Controller Model C06, and the TS7700 Virtual Engine using 4 Gb dual port fiber cards. It allows for the integration into the IBM TotalStorage 3494 library, the TS3500 library, the TS3400 library, stand-alone rack mounted, and the Sun/STK Silo. There is no support for the 3494 model B10/B20 Virtual Tape Server. Figure 3-9 on page 110 shows the front view of the IBM TS1130 Tape Drive.

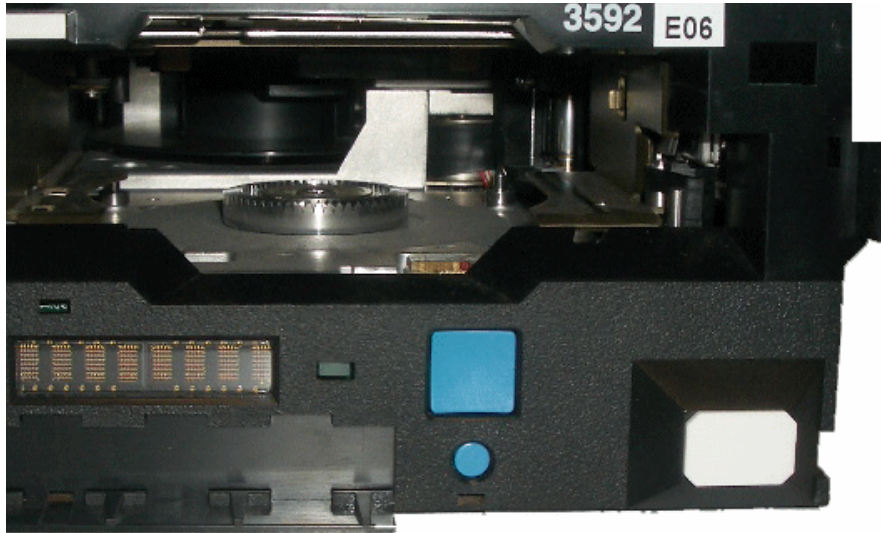


Figure 3-9 Front view of the TS1130 Tape Drive

The TS1130 Tape Drive maintains the same features and technology enhancements introduced with the 3592 Model J1A and extended by the TS1120. In addition, the TS1130 offers several enhancements over the predecessor models, which we explain in more detail on the following pages.

Features introduced with the 3592-J1A and 3592-E05 include:

- ▶ Digital speed matching
- ▶ Channel Calibration
- ▶ High resolution tape directory
- ▶ Recursive Accumulating Backhitchless Flush or Nonvolatile caching (NVC)
- ▶ Backhitchless backspace
- ▶ Streaming Lossless Data Compression (SLDC)
- ▶ Capacity scaling
- ▶ Single Field Replaceable Unit (FRU)
- ▶ Error detection and reporting
- ▶ Statistical Analysis and Reporting System (SARS)
- ▶ Encryption support
- ▶ Dual stage 16-head actuator
- ▶ Offboard data string searching
- ▶ Enhanced logic to report logical end-of-tape

3.5.1 Multiple subsystem and automation support

The 3592-E06 supports all of the same subsystems and automation environments as the previous models. The 3592-E06 and 3592 cartridges support multiple automation libraries and can be easily transported between environments (consider the compatibility requirements for silo-attached 3592 tape drives). These systems are summarized in Table 3-2 on page 111.

Table 3-2 Subsystem support summary

Subsystem	3592-E06	3592-E05	3592-J1A
3494-L22	Four drives per frame	Four drives per frame	Four drives per frame
3494-D22	12 drives per frame	12 drives per frame	12 drives per frame
3584-L23	12 drives per frame	12 drives per frame	12 drives per frame
3583-D23	12 drives per frame	12 drives per frame	12 drives per frame
Support within a frame	Full mix of all models allowed	Full mix of all models allowed	Full mix of all models allowed
SUN/STK Silo	Full mix of all models allowed (20 drives/C20)	Mix of E05 and J1A models allowed (20 drives/C20)	Mix of E05 and J1A models allowed (20 drives/C20)
ADIC Scalar 10000	Supported	Supported	Supported
TS3400	Supported (two drives/unit)	Supported (two drives/unit)	Not supported
Rack-mounted	Supported (12 drives/frame)	Supported (12 drives/frame)	Supported (12 drives/frame)

3.5.2 Media reuse

We provide the following TS1130 Tape Drive capacity and performance improvements on the existing media:

- ▶ The TS1130 Tape Drive reuses all TS1120-supported media types:
 - MEDIA5: IBM 3592 Enterprise Tape Cartridge
 - MEDIA6: IBM 3592 Enterprise WORM Tape Cartridge
 - MEDIA7: IBM 3592 Economy Tape Cartridge
 - MEDIA8: IBM 3592 Economy WORM Tape Cartridge
 - MEDIA9: IBM 3592 Extended Tape Cartridge
 - MEDIA10: IBM 3592 Extended WORM Tape Cartridge
- ▶ The TS1130 improves capacity and performance by writing and reading the E06 logical format by utilizing higher track density and higher linear density on the same media types.
- ▶ The TS1130 supports downward reading of 3592-J1A and TS1120 native formats and writing the TS1120 format:

$n-2$ for read and $n-1$ for R/W
- ▶ You have to apply the appropriate microcode levels available for 3592-J1A and TS1120 that enable the recognition of the E06 format and allow reuse of the media in the older formats. Thus, a model J1A or E05 drive is able to reformat media that was previously written in the E06 format and to write on it in the appropriate format.

Note: This design allows a common scratch pool by media type regardless of the last written format or allocation target drive.

3.5.3 Capacity and performance

Capacity and performance have been improved compared to the IBM TS1120 Tape Drive for all media types and for all formats that the TS1130 reads or writes.

Capacity improvement

We get a capacity improvement using the 3592-E06 logical format:

- ▶ There is a 42% capacity uplift for JB/JX (extended length media) from 700 GB to 1 TB.
- ▶ There is a 28% capacity uplift for JA/JW (standard length media) from 500 GB to 640 GB.
- ▶ There is a 28% capacity uplift for JJ/JR (economy short media) from 100 GB to 128 GB.

Note: Only JB/JX media get an additional 14% linear density improvement in the TS1130 format.

Performance improvement

The overall performance is increased by various improvements, such as:

- ▶ Data rate
- ▶ Larger buffer
- ▶ Better backhitching
- ▶ Improved speed matching
- ▶ Read Ahead
- ▶ Faster locate
- ▶ Improved communication links

Higher data rates

Performance is improved from the TS1120 up to 60% in TS1130 mode, 50% in TS1120 mode for read and writes, and 50% in 3592-J1A mode for reads only.

- ▶ The E06 format data rates go up to 160 MB/s maximum native and to 360 MB/s maximum compressed.
- ▶ The E05 format data rates go up to 150 MB/s maximum native and to 360 MB/s maximum compressed.
- ▶ The J1A mode for reads only goes up to 70 MB/s maximum native and to 360 MB/s maximum compressed.

The maximum compressed data rate numbers might be similar for all modes, but the capacity and performance characteristics are summarized in Table 3-3.

Table 3-3 Capacity and performance summary

Media	E06 format capacity data rate (minimum - maximum)	E05 format capacity data rate (minimum - maximum)	J1A format capacity data rate (minimum - maximum)
JB/JX	1 TB 40 MB/s - 160 MB/s	700 GB 40 MB/s - 150 MB/s	N/A
JA/JW	640 GB 40 MB/s - 140 MB/s	500 GB 40 MB/s - 140 MB/s	300 GB (read only) 30 MB/s - 70 MB/s
JJ/JR	128 GB 40 MB/s - 140 MB/s	100 GB 40 MB/s - 140 MB/s	60 GB 30 MB/s - 70 MB/s

Larger buffer

The main buffer size is increased to 1GB. This increase improves the drive agility, the file access, and small file handling, which might still be a requirement on z/OS platforms. Furthermore, the buffer reduces backhitches for all workloads and improves the overall write and read performance.

Speed matching

The speed matching function is improved on the TS1130 drive, because both the number of speeds and the range of supported data rates is improved. The data rate range depends on the logical format and the media typed used:

- ▶ Seven R/W speeds are supported for JB media:
 - For the EFMT3/EEFMT3 format, the range is 31 MB/s to 163 MB/s.
 - For the EFMT2/EEFMT2 format, the range is 29 MB/s to 150 MB/s.
- ▶ Seven R/W speeds are supported for JA media:
 - For EFMT3/EEFMT3 and EFMT2/EEFMT2, the range is 27 MB/s to 139 MB/s.
 - For EFMT1 format, the range is 14 MB/s to 70 MB/s.

Virtual backhitch

The small file write synchronize feature is improved, so we get a 30% - 50% net data rate improvement for the write synchronize workload. Learn more about write synchronize in “Virtual backhitch (nonvolatile caching)” on page 100.

Faster high speed space/locate

The load time and unload times have been slightly improved. The maximum locate/rewind speed is increased to 12.4 m/s. With these enhancements, average first file access time has improved. Refer to Table 3-4 on page 115.

Increased library interface link speed

For the TS3500 library attachment and for the TS3400 libraries, the LDI RS-422 interface speed has been increased to 922 KBAUD. This change allows faster code downloads and dump uploads from the library; in 3494 libraries, the BAUD rate remains at the current operating defaults.

Read Ahead

On sequential reads, we automatically Read Ahead and fill the buffer with data sequentially beyond the target block (N). If one of these blocks is a target of the next command (such as $N+200$), it is already in the buffer, and thus, transfer is very fast. And, we then automatically fill the buffer sequentially with past data ($N+200$). Due to the large data buffer, the 3592-E06 supports Read Ahead of approximately 1000 MB of compressed data from tape. So, for applications that issue many repeating sequential short-hop locates (skipping over files and reading the file headers, for example), we outperform competitive drives, which simply stop and wait for the next command, with this unique functionality.

Performance scaling and segmentation

As with the 3592 Model J1A and the 3592 Model E05, performance scaling and performance segmentation are supported with MEDIA5 and MEDIA9 cartridges on the TS1130. Using the recording formats EFMT3/EEFMT3, a MEDIA5 cartridge can be scaled to 128 GB, and a MEDIA9 cartridge can be performance scaled to 200 GB. Then using performance segmentation, a MEDIA5 cartridge can be segmented into a 128 GB fast access segment and a 426 GB slower access segment, and a MEDIA9 cartridge can be scaled to a 200 GB

fast access segment and a 666 GB slower access segment. Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity or to the performance segmentation format as indicated through the assigned data class.

Note: You might not want to make any scaling with JB media because of the higher waste of capacity, because there is still *no software available* to use any other segment except the first one.

3.5.4 Access performance specifications and drive characteristics

Table 3-4 on page 115 summarizes the improvements in the access performance, that is, time to first data, block locate time from load point, or random locate times, and the drive characteristics.

Table 3-4 Access performance specifications and drive characteristics

Parameter	3592-E06 EFMT3 or EEFMT3	3592-E05 EFMT2 or EEFMT2	3592-J1A EFMT1
Tape speed - locate/rewind	12.4 m/s	10 m/s	8 m/s
Drive load/ready time	12 s	13 s	19 s
Block locate time from load point average	27 s for JA/JW 11 s for 20% scaled JA/JW 11 s for JJ/JR 36 s for JB/JX 15 s for 20% scaled JB	33 s for JA/JW 11 s for 20% scaled JA/JW 11 s for JJ/JR 45 s for JB/JX 15 s for 20% scaled JB	39 s for JA 11 s for 20% scaled JA
Time to first data average (load/ready + locate)	39 s for JA/JW 24 s for 20% scaled JA/JW 24 s for JJ/JR 48 s for JB/JX 28 s for 20% scaled JB	46 s for JA/JW 24 s for 20% scaled JA/JW 24 s for JJ/JR 58 s for JB/JX 28 s for 20% scaled JB	39 s for JA 11 s for 20% scaled JA
Random block locate time	20s for JA/JW 9 s for 20% scaled JA 27 s for JB/JX 12 s for 20% scaled JB	23s for JA/JW 10 s for 20% scaled JA 31 s for JB/JX 12 s for 20% scaled JB	27 s for JA 9 s for 20% scaled JA
Unload time	23 s for JA/JW/JR/JJ/JB/JX	23 s for JA/JW/JR/JJ/JB/JX	21 s for JA
Rewind maximum	66 s for JA/JW 18 s for 20% scaled JA 18 s for JJ/JR 90 s for JB/JX 24 s for 20% scaled JB	66 s for JA/JW 18 s for 20% scaled JA 18 s for JJ/JR 90 s for JB/JX 24 s for 20% scaled JB	77 s for JA 18 s for 20% scaled JA
Read/Write speed maximum	8.551 m/s	6.21 m/s	4.74 m/s
Number of tracks	1152	896	512
Number of passes (from BOT to EOT)	72	56	64
Linear density	321 kbp	282 kbp	282 kbp
Servo regions	5	5	5
Data tracks recorded simultaneously	16	16	8
Buffer size	1 GB	512 MB	128 MB

3.5.5 Emulation mode

The 3592 model E06 does not support any emulation modes. Because the drive cannot write the J1A logical format, it cannot fully emulate all format behaviors of a TS1120 or 3592-J1A drive.

3.5.6 TS1130 physical characteristics

The TS1130 drive comes with the identical form factor and is plug-compatible with existing 3592 models. It maintains low power and improves power management. The maximum

continuous operating power has increased by 2 Watts from the TS1120 because of faster motor speeds:

- ▶ 39 Watts drive-only as compared to 37 Watts for the TS1120
- ▶ Standby power is less than 20 Watts

The TS1130 has a standby cooling management feature, which reduces the fan speed when idle to further reduce power and reduce airborne debris contaminants. The fan operating mode is controlled by a single input signal called “full speed mode” or “variable speed mode”. In full speed mode, the fan/blower runs at full speed. In variable speed mode, the blower adjusts its speed based on the ambient temperature down to a minimum of about 50% of its full speed:

- ▶ 3592-E06 drive code enables variable speed mode under the following conditions:
 - The drive has been unloaded and idle for five minutes.
 - The internal temperature is at least 3 degrees below the “Full speed required” temperature limit.
- ▶ The drive code reverts to full speed mode as soon as:
 - A cartridge is placed in the loader or loaded.
 - The internal temperature of the drive rises above the “Full speed required” temperature limit.

The internal temperature sensor is sampled at a five minute interval.

3592 packaging

As in previous models, the TS1130 is a canister with a drive packaged inside the canister. Unique markings on the front and rear of the canister allow the identification of an E06 from a E05 or J1A drive. The canister enclosure provides mounting, connections, fiducial labels for calibration, and status Light Emitting Diodes (LEDs) for the use in automation frames. The canister is mounted in various forms of mounting hardware for use in different automation systems. Inside of the canister is the drive unit. The 3592-E06 drive itself has the same physical form factor as the TS1120 and 3592-J1A drive. Thus, you can change the drive only instead of the complete canister.

The 3592-E06 canister no longer has an RS-232 serial port, which remains if you get a miscellaneous equipment specification (MES) to change an existing 3592-E05 model to a E06 model. An Ethernet service port has been added to the drive, which currently is used only for service. It is a single, standard RJ45 connector at the rear of the canister, supports only the IPv4 protocol, and supports online service and debug functions to a non-client network. Both features are not available on a TS1120 model that you have changed by using an MES.

3.5.7 Upgrade considerations

A drive field MES conversion feature is available to allow for a 3592-E05 model to 3592-EU6 model conversion to a TS1130. If you choose this way to replace your TS1120 drive, only the drive will be changed and the canister will remain. This model EU6 is identical to model E06 with the following exceptions:

- ▶ Standby fan speed control feature is not available.
- ▶ The drive Ethernet service port is not available.

The serial number of the original drive will be written by the library into the VPD of the replacement drive. The MES is valid for the TS3500, the IBM 3494 Tape Library, the C20 frame attached to a silo, and a rack-mounted drive.

3.5.8 Firmware updates

We describe the minimal changes to the firmware update mechanisms for the TS1130 that you can make as with the predecessor models:

- ▶ All four mechanisms currently supported for microcode updates on the 3592-E05 also provide support on the E06:
 - Host interface
 - Debug interface
 - Library interface
 - Field microcode replacement (FMR) cartridge
- ▶ The TS1130 continues to support concurrent microcode load with deferred activation.
- ▶ The TS1130 has a single microcode image unique from previous models. A unique LOAD ID and incremented RU name field is assigned for the 3592-E06 drive.

Unique microcode is required for the model E05 drives, because the LOAD ID differs from the LOAD ID that is required for the J1A drives. The firmware for the 3592-E06 drive can be updated in several ways, depending on where the drive is installed:

- ▶ Through the use of a FMR cartridge (which might not be supported on automation systems)
- ▶ Through the host attachment using the write buffer command
- ▶ Through the RS-422 port to the drive (which might not be supported on automation systems)
- ▶ Through the RS-232 debug port at the rear of the canister

3.5.9 RAS

With the TS1130 Tape Drive, the reliability, availability, and serviceability features are improved or maintained. Similar to its predecessor models, the TS1130 is a single Field Replaceable Unit (FRU), which is hot pluggable without a maintenance window and allows for nondisruptive code loading. There is fan speed management and unique device microcode file management through a LOAD ID. There is support for a larger service display panel. The end of life usage alert for media becomes activated on full file pass usage. Nearing Media Life (alert x13) is given at 19 900 mounts or 295 full-file passes, and media Life (alert x07) is given at 20 000 mounts or 300 full-file passes.

3.5.10 Improved media SARS

The media SARS function is improved for the TS1130:

- ▶ MIMs and tape alerts now are generated when media passes usage life, as determined by full-file passes, meters of tape proceeded, or write pass count, as well as the total number of mounts (which was already supported).
- ▶ A media SARS summary is maintained in the cartridge memory in a manner where it can be rebuilt on tape in the event that the SARS records on tape cannot be read and must be re-initialized. This CM copy is also readable on a down-level 3592-J1A drive to preserve SARS information between logical format conversions.

3.5.11 Encryption

The TS1130 Tape Drive is encryption-capable. There is no need to enable the drive explicitly as was the case with the TS1120 Tape Drive.

When installed behind a 3592-J70 or TS1120 Model C06 Tape Controller, the drive will be encryption-enabled as part of the installation, because this is a controller requirement.

3.5.12 Tracking data written

Today, an application can track in KBs:

- ▶ Number of logical bytes written
- ▶ Number of physical bytes written
- ▶ Amount of free space remaining on a volume
- ▶ Capacity of the volume
- ▶ Number of logical bytes deleted

Now with a 1000 GB tape (non-compressed), the 3592 Model E06 can allow part of the 4-byte fields that contain these values to overflow. Pay particular attention to the logical data-related fields that (with compression) might contain an amount of data that might be larger than the physical capacity of the tape. Applications that use, store, and display this type of information might need to account for and determine how best to handle an overflow situation.

3.6 The IBM System Storage TS1120 Model E05 Tape Drive

IBM System Storage TS1120 Tape Drive Model E05 is the second generation of the 3592 tape drives. It has the same machine type as the 3592-J1A with the model type of E05 and is designed for applications that require high capacity and fast access to data across a wide range of environments. The TS1120 Tape Drive provides you with the ability to encrypt your data at the drive. For more information about encryption, refer to 2.2, “Tape Encryption overview” on page 61. The TS1120 Tape Drive features dual 4 Gb Fibre Channel interfaces, a native data rate of up to 100 MB/s, and a native physical capacity of up to 500 GB on the JA cartridge or 700 GB on a JB cartridge. As with the previous 3592-J1A, the 3592-E05 includes an RS-422 library interface port for communication with the TS3500 Tape Library.

The 3592-E05 has support for attachment to ESCON and FICON channels on System z servers through the following tape subsystems:

- ▶ TS1120 Tape Controller
- ▶ 3592-J70 Tape Controller
- ▶ TS7700 Virtualization Engine¹
- ▶ B10 and B20 Virtual Tape Servers (VTSs) (in J1A Emulation mode)

Figure 3-10 shows the front view of the IBM TS1120 Tape Drive.



Figure 3-10 TS1120 Model E05

¹ You can configure TS1120 Model E05 in native E05 mode or J1A Emulation mode. All drives have to operate in the same mode behind a given tape subsystem. You must configure all drives in native E05 mode to enable the support of the 3592 Extended Data cartridge (JB media). You can intermix encryption-capable and non-encryption-capable drives. However, all drives must be encryption-capable to enable Encryption for the TS7700.

3.6.1 Features for reliability, availability, and performance

The TS1120 Tape Drive maintains the same form factor and reliability specification of the previous Model 3592-J1A, as well as the features and technology enhancements introduced with the 3592 Model J1A. In addition, the 3592-E05 offers several enhancements over the J1A Model.

Features introduced with the 3592-J1A and incorporated into the 3592-E05 include:

- ▶ Digital speed matching
- ▶ Channel Calibration
- ▶ High resolution tape directory
- ▶ Recursive Accumulating Backhitchless Flush or Nonvolatile caching (NVC)
- ▶ Streaming Lossless Data Compression (SLDC)
- ▶ Capacity scaling
- ▶ Single Field Replaceable Unit (FRU)
- ▶ Error detection and reporting
- ▶ Statistical Analysis and Reporting System (SARS)

These features are described in detail in 3.2.4, “Features designed for capacity and performance” on page 99.

To further improve performance and capacity, the TS1120 Tape Drive offers additional enhancements over the 3592 Model J1A. The following section describes these enhancements in detail. Table 3-4 on page 115 shows a comparison of the 3592-J1A, the TS1120, and the TS1130 tape drive characteristics.

Large internal buffer

The 3592-E05 has a 512 MB internal data buffer compared to the 128 MB maximum on the 3592-J1A. In addition to offering higher performance characteristics, the data buffer offers a Read Ahead feature of approximately 500 MB of compressed data from tape. When the drive processes a command to locate or read a block from tape, in parallel with returning the requested block or locate status to the host, the drive automatically continues to stream down the tape and Read Ahead until the buffer is full. This allows subsequent Locate or Read commands of relatively close proximity blocks to be fulfilled from the data buffer at higher speeds than if access to the tape is required.

Dual stage 16-head actuator

The 16-head actuator is designed to improve precision head alignment to help support higher track density. The 3592-E05 uses the Enterprise Format 2 (EFMT2 or E2) recording technology (896 tracks, 16 channels), which increases the data capacity of all four cartridge types to 500 GB for types JA and JW and 100 GB for types JR and JJ. When using the IBM Tape Cartridge 3592 Extended Data (JB and JX media type), the data capacity is 700 GB. The 3592-E05 can also read and write in Enterprise Format 1 (EFMT1 or E1) when emulating the 3592-J1A.

Offboard Data String Searching

The 3592-E05 can search the data content of host records for string matches. This function is called *Offboard Data String Searching*, because the data search might be performed off board from the host. This feature allows the tape drive to search for records on a tape that contains a particular ASCII or EBCDIC character string (1 to 16 bytes in length) at a maximum data rate of 100 MB/s. It takes longer if the host performs this function, because the host server needs to read the data, buffer the data to disk, and then parse the actual data stream with host software routines. You can program the compare string search content and options through the **Mode Select** or **Send Diagnostic** command. For information about these

commands and details of the programming fields, refer to *IBM System Storage TS1120 Tape Drive SCSI Reference*, GA32-0562.

Enhanced logic to report logical end-of-tape

The 3592-E05 uses enhanced logic to report the logical end-of-tape (LEOT), which is based on a combination of *capacity-based LEOT (CB-LEOT)* and *position-based LEOT (PB-LEOT)* indicators. Position-based LEOT is reported based on reaching a physical position on the tape. With capacity-based LEOT, the 3592-E05 monitors the total accumulated number of physical datasets written to the volume and reports LEOT when 505 GB of uncompressed data have been recorded. In the event that the 3592-E05 is unable to record the number of datasets before reaching the PB-LEOT physical landmark, LEOT is reported immediately upon reaching this physical position. A minimum capacity buffer of 5 GB is guaranteed between LEOT reporting and physical end-of-tape, beyond which no data can be recorded. The effect of this LEOT function is to reduce the variation in the amount of data recorded before LEOT is issued, and therefore for applications that use LEOT to stop the write process, a more consistent capacity is recorded to the media.

Encryption support

The IBM System Storage TS1120 Tape Drive provides you with an option to use drive-based data encryption, which is now standard on all TS1120 tape drives. A chargeable upgrade feature to enable your drive for encryption is available for existing installed TS1120 tape drives. All 3592 media, including Write Once Read Many (WORM) and extended cartridges, can be encrypted. Based on the Data Class that you have defined, the TS1120 Tape Drive can write in either encrypted or non-encrypted format.

Note: When using Tape Drive Encryption, all the TS1120 tape drives that are attached to a single 3592-J70 or TS1120 Tape Controller must be encryption-enabled.

J1A emulation

The 3592-E05 has an emulation mode that enables it to emulate the previous 3592-J1A Model. When attached to a TS7700 Virtualization Engine, a 3592-J70, or a TS1120 Model C06 Tape Controller in heterogeneous frames containing J1A drives, the 3592-E05 drives automatically operate in J1A Emulation mode in these subsystems, even when they are set to operate as native E05 drives. When attached to a VTS, the E05 tape drives always operate in J1A Emulation mode. In this mode, the 3592-E05 drives read and write only in E1 format at the J1A performance and capacity ratings. When removed from these subsystems, the drives automatically revert to native E05 operation, and no action is necessary to restore normal mode.

In J1A Emulation mode, the TS1120 cannot be enabled for Encryption. It can read and write in a format that is compatible with the 3592 Model J1A Tape Drive:

- ▶ The TS1120 Tape Drive can read and append to cartridges written by the 3592 Model J1A Tape Drive.
- ▶ The TS1120 Tape Drive can write cartridges in a 3592 Model J1A format that can be read and appended to by the 3592 Model J1A Tape Drive.
- ▶ The TS1120 Tape Drive cannot read cartridges written by the 3590 or 3490. Cartridges written by the TS1120 Tape Drive cannot be read by the 3590 or 3490. Even though the cartridges are similar in size, they contain different media and thus are not interchangeable.
- ▶ The 3592-J1A cannot read or append to cartridges that were created on a TS1120 Tape Drive in either EFMT2 or EEFMT2 mode.

- ▶ The TS1120 Tape Drive can be attached to the same 3592 Model J70 or C06 Controller, TS7700 Virtualization Engine, or 3494 VTS model B10 or B20 with 3592 Model J1A tape drives. This is only supported when the TS1120 is running in J1A Emulation mode. After TS1120 drives are set to run in E05 native mode, intermix is not supported.

3.6.2 Performance scaling and segmentation

The 3592-E05 provides the same support for performance scaling and segmentation on the JA and JB cartridge as the 3592-J1A does for the JA cartridge; however, the higher density E2 format used by the 3592-E05 results in different data capacity for scaled and segmented cartridges than the 3592-J1A.

For example, with the 3592-E05 and EFMT2 format, a JB cartridge can be segmented into a 140 GB fast access segment and a 466 GB slower access segment, and a JA cartridge can be scaled to a 100 GB fast access segment and a 330 GB slower access segment.

As with the 3592-J1A, 256 capacity settings are supported on the 3592-E05 drive. We recommend the following three primary settings for use; they are available as labeled and initialized part-numbered cartridges:

- ▶ Full capacity default mode - 500 GB
- ▶ 20% scaled fast access mode (capacity scaling setting x'35') - 100 GB
- ▶ Performance scaling for 87% capacity (segmented format, capacity scaling setting x'E0')

The tapes can subsequently be scaled back to full capacity as needed.

3.7 IBM TotalStorage Enterprise 3592 Model J1A Tape Drive

The 3592 Model J1A is the first offering in the 3592 tape drive family that was designed for enterprise applications. Introduced in 2003, it is designed to provide unprecedented levels of cartridge capacity, performance, and reliability. The 3592 surpasses the capabilities of its predecessors by providing up to five times the capacity and two and a half times the data transfer rates of the IBM 3590 series. It is capable of storing 300 GB of native capacity and a native data rate of up to 40 MB/s. Figure 3-11 shows an IBM TotalStorage Enterprise Tape Drive 3592 Model J1A.



Figure 3-11 IBM TotalStorage Enterprise Tape Drive 3592 Model J1A

For its high capacity capability, the 3592 uses the IBM TotalStorage Enterprise Tape Cartridge 3592 (Model 3599), which provides a native cartridge capacity of up to 300 GB. The 3599 media models include:

- ▶ Read/Write (R/W) 300 GB data cartridge
- ▶ R/W Economy 60 GB data cartridge

- ▶ Write Once Read Many (WORM) 300 GB data cartridge
- ▶ WORM Economy 60 GB data cartridge

3.7.1 3592-J1A characteristics

The first generation of the 3592 family of tape drives outperformed the IBM 3590 family with its performance and capacity characteristics:

- ▶ 40 MB/s native streaming data rate
- ▶ 300 GB native cartridge capacity
- ▶ Dual active Fibre Channel (FC)-2 ports to support enterprise environments that use dual paths for failover or load balancing
- ▶ Support of four cartridge types: JA, JJ, JW, and JR
- ▶ WORM functionality when operating on one of the two WORM cartridge types: JW or JR
- ▶ 128 MB data buffer

3.7.2 Performance scaling

The 3592-J1A drive introduced the support for scaling and segmentation modes on the 300 GB Read/Write (R/W) (JA) cartridge only. There are two primary settings used:

- ▶ 300 GB default mode
- ▶ 60 GB fast access mode (capacity scaled through a '0x35' setting to 20% capacity)

The result of performance scaling to a percentage value (for example, 20%) is that the maximum amount of recordable data is reduced to 60 GB, and the average time to locate a random record on a full tape starting from load point is (roughly) 20% of the time to locate a random record from load point for a full, unscaled tape.

Using segmentation results in the first segment of 60 GB and a slower access segment of 200 GB of capacity.



Part 2

IBM Open System Tape Libraries

In this part, we introduce the current IBM tape library models for the installation of Linear Tape-Open (LTO) tape drives.



IBM System Storage TS2230 Tape Drive

The IBM System Storage TS2230 Tape Drive (3580 models H3L and H3S) is an external stand-alone or rack-mountable unit and is the entry point to the family of IBM Linear Tape-Open (LTO) Ultrium Tape products. The IBM System Storage TS2230 Tape Drive is designed for backup and restore of midrange Open Systems applications and is part of the IBM System Storage TS2230 Tape Drive family. The IBM System Storage TS2230 Tape Drive incorporates the IBM System Storage Ultrium 3 Half-High T880V Tape Drive, which has a native physical capacity of 400 GB or 800 GB with 2:1 compression.

Additional important features of the TS2230 include:

- ▶ The TS2230 is the first member of the IBM LTO tape family that uses the new Half-High LTO3 Tape Drive. It has the same characteristics of the Full-High tape drive except that the native transfer rate is 60 MB/s compared to 80 MB/s for the Full-High LTO3 drive.
- ▶ The IBM System Storage TS2230 Model H3L Tape Drive is available with a Low Voltage Differential (LVD) Small Computer System Interface (SCSI).
- ▶ The IBM System Storage TS2230 Model H3S Tape Drive comes with a Serial-Attached SCSI (SAS) interface.
- ▶ It can be installed in an industry standard 19-inch rack using an optional rack mount kit.
- ▶ On the front side of the IBM System Storage TS2230 are four light-emitting diodes (LEDs) that indicate the status and errors for the tape drive.
- ▶ In addition to the LTO data cartridges, Write Once Read Many (WORM) cartridges are supported and recognized when loaded.
- ▶ The TS2230 is a client-replaceable unit (CRU). In case the IBM System Storage TS2230 Tape drive has a failure, IBM does not repair your unit, IBM replaces it. Products that are repaired by replacing them are called *CRUs*.

4.1 TS2230 description

The TS2230 can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard UNIX® (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest update of the supported servers, visit the Web at:

<http://www-03.ibm.com/servers/storage/tape/compatibility/pdf/>

Note: For the remainder of this chapter, we use the term TS2230 as an abbreviation for the IBM System Storage TS2230 Tape Drive.

Two models are available for the TS2230 Tape Drive:

- ▶ The *TS2230 Tape Drive Model H3L* has a SCSI Ultra160 LVD physical interface, which has a native data transfer rate of up to 60 MB/s. The physical interface is a high-density, 68-pin, D-shell receptacle connector (HD68).
- ▶ The *TS2230 Model Tape Drive H3S* has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The TS2230 SAS Tape Drive has an SFF-8088 interface.

The TS2230 uses the IBM TotalStorage LTO Ultrium 3 400 GB Data Cartridge and can write up to 400 GB or 800 GB using a compression ratio of 2:1. The TS2230 can read and write Ultrium 3 and Ultrium 2 cartridges and can read Ultrium 1 cartridges.

Figure 4-1 shows the front view of the TS2230.



Figure 4-1 Front view of the TS2230

4.1.1 Half-High Ultrium 3 Tape Drive

The TS2230 Tape Drive houses the Half-High Ultrium 3 Tape Drive. The TS2230 came available at the end of 2006 and might be an ideal tape drive for small clients who want a reliable tape drive with LTO technology.

The TS2230 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-inch, 4mm, or 8mm tape drives.

Performance highlights

The TS2230 Tape Drive Express Model incorporates third-generation IBM LTO Ultrium technology. It offers the following significant improvements over the Ultrium 2 Tape Drive in terms of performance. The maximum tape drive throughput data rate performance is up to 60 MB/s native data transfer rate. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and can read LTO Ultrium 1 Data Cartridges.

Note: Although the TS2230 Tape Drive provides the capability for excellent tape performance, other components of the system might limit the actual performance achieved. Also, although the compression technology used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

For additional details regarding the LTO3 Half-High Tape Drive, refer to 2.3.2, “IBM LTO3 Half-High (HH) Tape Drive” on page 73.

4.1.2 Data cartridges

When processing the Ultrium 3 tape cartridge, the TS2230 Tape Drive uses a linear, serpentine recording format. The TS2230 Tape Drive reads and writes data on 704 tracks, sixteen tracks at a time. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written.

To ensure that your IBM TS2230 Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

All three generations contain 1/2 inch, dual-coated, metal-particle tape. The native data capacity of Ultrium Data Cartridges is listed in Table 4-1.

Table 4-1 Native capacity

Data cartridge	Native data capacity
Ultrium WORM	400 GB (800 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

Cartridge compatibility

Table 4-2 shows the compatibility among the three types of Ultrium cartridges.

Table 4-2 Ultrium Data Cartridge compatibility with Ultrium 3 tape drive

	IBM Total Storage LTO Ultrium Data Cartridges		
IBM Ultrium Tape Drive	400 GB (Ultrium 3) 400 GB WORM	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 3	Read/Write	Read/Write	Read only

Drive cleaning

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive in your library. One cleaning cartridge is included in the shipping package of the TS2230.

You must clean the drive head whenever the Clean LED indicator is ON. We do not recommend that you clean the drive head on a periodic basis, only when the drive requests cleaning. The drive performs the cleaning automatically in less than two minutes and then ejects the cartridge.

The drive automatically ejects an expired cleaning cartridge. For additional details related to the cleaning cartridge, refer to “Cleaning cartridge” on page 50.

Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM), which is a passive contactless silicon storage device that is physically a part of the cartridge. The CM is a chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge’s use.

For additional details related to the Cartridge Memory chip, refer to “Cartridge memory (LTO-CM)” on page 46.

4.2 TS2230 setup

In the following sections, we provide an introduction to the necessary steps to implement and operate the TS2230. We describe a practical example of installing a TS2230 and provide background information about the steps that you perform. For a more detailed description, refer to the *IBM System Storage TS2230 Tape Drive Setup, Operator and Service Guide*, GC27-2099.

After unpacking and installing the TS2230, you must perform a few steps to connect it to your server. We show you how to attach your TS2230, which host bus adapters (HBAs) are supported, where you can find your device drivers, and how to install the latest firmware on your TS2230. We start with the physical attachment.

4.2.1 Physical attachment

The TS2230 is available with a SCSI Ultra Fast/Wide 160 LVD interface or with a Serial Attached SCSI (SAS) interface.

Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drive family, and the TS2230 comes with a single-port SFF-8088 interface on the back of the drive. For a more detailed description of SAS, refer to “Serial-Attached SCSI” on page 57.

At the time of writing this book, two HBAs were supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller Model 25R8060

The physical interface on the TS2230 is a single-port SFF-8088, and only a point-to-point connection to the server’s HBA is supported. There is no support (yet) for connecting to Expander Boxes. No terminator is needed, because the SCSI bus is automatically terminated. The SAS TS2230 has a single-port SFF-8088 port so that the TS2230 can be connected to only one server.

To install an adapter in your server, refer to the instructions that accompany it, as well as to the section about host adapter card installation in your server's documentation.

For a list of supported adapters and required interposers, visit the following Web site:

<http://www.ibm.com/storage/lto>

Figure 4-2 shows the back side of the TS2230 with a single-port SFF-8088 interface.

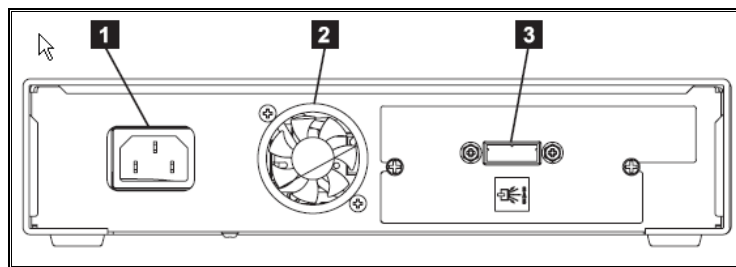


Figure 4-2 Back side of the TS2230 SAS interface

The numbers in Figure 4-2 represent:

- 1.** Power connector
- 2.** Air vents for fan
- 3.** Serial Attached SCSI Connector

SCSI interface

An LVD SCSI bus supports a length of 25 meters (82 ft.) point-to-point and 12 meters (39 ft.) using multi-drop interconnection (*daisy-chaining*). For each daisy-chained device, the maximum cable length must be reduced by 0.5 meters (1.6 ft.).

The Ultrium 3 drive uses shielded, HD68, 68-pin connectors and can attach directly to a 2 byte-wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer rate of 60 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

To connect your TS2230 to your server, make sure that the installed SCSI HBA is supported. To find out if your HBA is supported, visit this Web site and select the **TS2230**:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability>

If the HBA is supported, you can connect your TS2230 to the HBA of the server. Figure 4-3 on page 130 shows you the interoperability of all IBM tape drives and tape libraries.

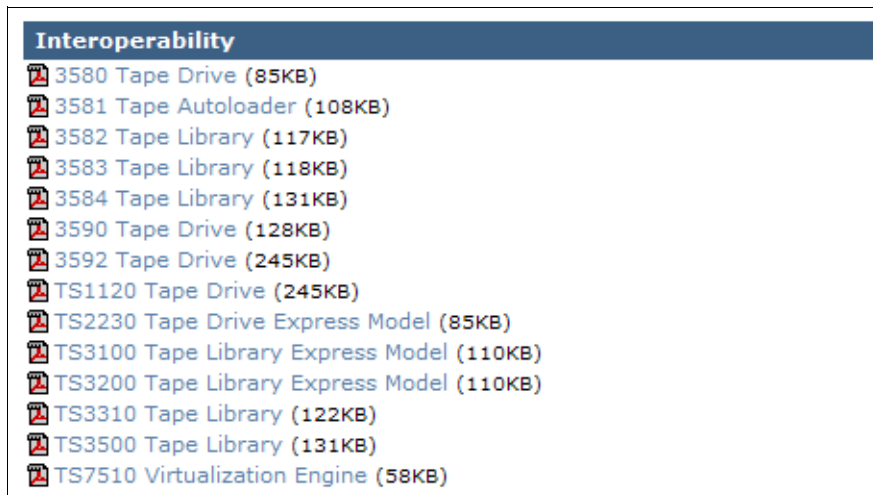


Figure 4-3 Interoperability window

By selecting the TS2230 Tape Drive Express Model, a document opens. Within this document, search for **Operating System**, and a list of all supported SCSI LVD HBAs appears. *Note that whenever a SCSI LVD HBA is used to connect the TS2230 to a host that is not in the list, no support can be given in case of a problem.* This operability list contains all of the HBAs that are tested in our test center in Tucson.

Note: SCSI adapters, which are part of the server's system board, are not supported.

When connecting the TS2230 to the HBA of the server, make sure that the TS2230 has a unique SCSI ID on the SCSI bus. The SCSI ID switch is located on the rear side of the TS2230. Use a small object to change the switch. The range of SCSI IDs is 0 through 15. Generally, the SCSI ID for the HBA is set to 7. Figure 4-4 shows the rear view of the TS2230.

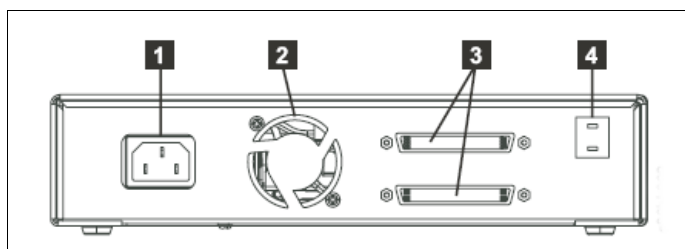


Figure 4-4 Back side of the TS2230 Ultra160 LVD SCSI interface

The numbers in Figure 4-4 represent:

1. Power connector
2. Air vents for fan
3. SCSI connector
4. SCSI ID switch

The IBM TS2230 can be attached as the only the tape drive on the HBA or can be daisy-chained with other SCSI LVD devices. We recommend that you do not use daisy-chaining because of performance reasons, and also because the total length of the SCSI cable is limited to 12 m (39.4 ft.) instead of 25 m (82 ft.) when using a point-to-point

connection. The more devices that you connect to the HBA, the smaller the actual bandwidth is for each connected device.

An LVD SCSI terminator must be installed on the last device of the SCSI bus. The LVD terminator is delivered with the TS2230.

Do not mix Low Voltage Differential (LVD) and High Voltage Differential (HVD) SCSI host adapters, tape drives, or terminators on the same bus, because they can become damaged.

Figure 4-5 shows a point-to-point configuration.

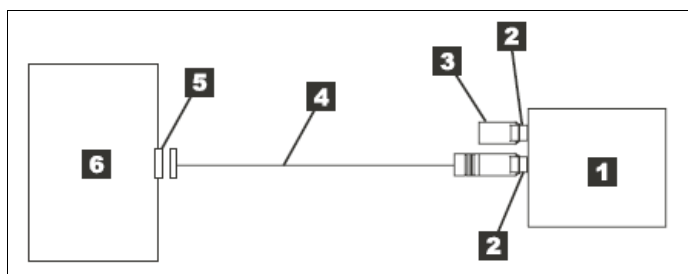


Figure 4-5 TS2230 in a point-to-point configuration

The numbers in Figure 4-5 represent:

- 1.** TS2230
- 2.** SCSI connectors
- 3.** SCSI LVD terminator
- 4.** SCSI cable
- 5.** SCSI HBA
- 6.** Server

Figure 4-6 shows a daisy-chained configuration with two TS2230 drives.

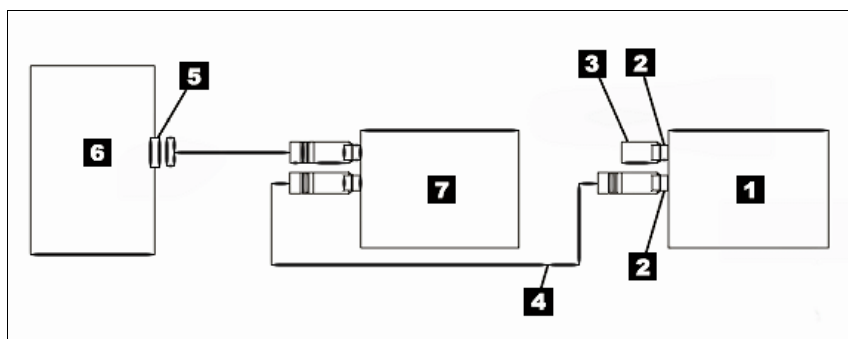


Figure 4-6 A daisy-chained configuration with two TS2230s

The numbers in Figure 4-6 represent:

- 1.** TS2230
- 2.** SCSI connectors
- 3.** SCSI LVD terminator
- 4.** SCSI cable
- 5.** SCSI HBA

6. Server

7. TS2230

In this example, we used two TS2230s, but it can be any other LVD tape drive. The last TS2230 must have a SCSI LVD terminator installed. Otherwise, the SCSI bus is open, which can result in unpredictable errors.

For maximum performance, the quantity of tape drives that can be attached to one SCSI bus is limited. It is based on the type of bus that you have and the amount of data compression achieved. Ultra SCSI buses have a bandwidth of 40 MB/s; Ultra2 SCSI buses have a bandwidth of 80 MB/s; Ultra160 SCSI buses have a bandwidth of 160 MB/s. The tape drive is capable of data transfer rates of up to 60 MB/s with no compression. For maximum performance, we recommend that you attach only one tape drive to an Ultra SCSI bus, an Ultra2 SCSI bus, or an Ultra160 SCSI bus.

Data transfer protocol time-outs for tape and disk drives are dissimilar. For that reason, we strongly recommend that you avoid running tape and disk drives on the same host bus adapter. A configuration with tape and disk on a single host bus adapter gives a slow and unreliable performance.

Note: Do not intermix LVD and HVD devices and HBAs on the same SCSI bus, because damage can occur on the devices.

4.2.2 Installing the tape device drivers

The next step is to install the tape device driver. For information about how to install the tape device driver on various platforms, refer to:

- ▶ *Implementing IBM TAPE in Unix Systems*, SG24-6502
- ▶ *Implementing IBM Tape in Linux and Windows*, SG24-6268
- ▶ *IBM Tape Device Drivers Installation and Users Guide*, GA27-2130

All publications are available and can be downloaded from the Web.

4.3 Firmware

At installation time, verify that the most current firmware is installed. Because the TS2230 does not have a display to show the firmware level, we recommend that you use an IBM tool called the IBM Total Storage Diagnostic Tool (ITDT). ITDT scans the SCSI bus for any attached tape drive and will reflect the firmware of the tape drive.

This tool can also be used for testing the drive and collecting a drive dump for error analyses by the IBM Support Centers. The big advantage of using ITDT is that it is device driver independent. Whatever device driver is installed (IBM or non-IBM device drivers), the TS2230 can be tested, the firmware can be updated, or a drive dump can be made.

This tool is supported on the following servers:

- ▶ Microsoft Windows Server® 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L™ 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)

- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium™)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and there are two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

In the readme file, you will find installation instructions, as well as instructions to use ITDT.

The latest firmware of the TS2230 can be found on the following Web site:

<http://www-03.ibm.com/servers/storage/tape/lto/>

Or, you can download the latest firmware from this FTP Web site:

<ftp://index.storsys.ibm.com/358x/3580>

4.4 Physical specifications

The TS2230 is small-sized with the following specifications:

Width	25 cm (9.85 in.)
Depth	27.5 cm (10.8 in.)
Height	6 cm (2.36 in.)
Maximum weight	4.08 kg (9.03 lbs.)

4.5 Feature codes

Table 4-3 on page 134 shows all feature codes and part numbers for the TS2230.

Table 4-3 Feature codes and part numbers for the TS2230

IBM Service part number	Client feature code	High volume part number	Product description
N/A	5402	N/A	2 m (6.6 ft.) SAS/Mini-SAS Cable (from HBA with SFF-8470 to drive with SFF-8088)
N/A	5406	N/A	5.5 m (18 ft.) SAS/Mini-SAS Cable (from HBA with SFF-8470 to drive with SFF-8088)
N/A	5502	N/A	2 m (6.6 ft.) Mini-SAS/Mini-SAS Cable (from HBA with SFF-8088 to drive with SFF-8088)
N/A	5506	N/A	5.5 m (18 ft.) Mini-SAS/Mini-SAS Cable (from HBA with SFF-8088 to drive with SFF-8088)
23R3841	5602	23R7133	VHDCI/HD 68 SCSI cable, 2.5 m (8.2 ft.)
23R3594	5604	23R7134	VHDCI/HD 68 SCSI cable, 4.5 m (14.8 ft.)
23R3593	5610	23R7135	VHDCI/HD 68 SCSI cable, 10 m (32 ft.)
35L1782	N/A	N/A	SCSI Y-cable
23R5841	N/A	N/A	SCSI LVD terminator
23R5840	N/A	N/A	SCSI LVD wrap plug
N/A	7003	96P1565	19-inch rack mount kit

Note: High Volume part numbers can be ordered using the High Volume Channel ordering system.



IBM System Storage TS2240 Tape Drive

The IBM System Storage TS2240 Tape Drive (3580 Model H4S) is an external stand-alone or rack-mountable shelf unit, designed for the family of IBM Ultrium Tape products. The TS2240 Tape Drive is a high-capacity data storage device that offers high performance and is designed for backup and restore by midrange Open Systems applications. The TS2240 Tape Drive incorporates the Linear Tape-Open (LTO) IBM System Storage Ultrium 4 Half-High Tape Drive, which writes cartridges with a native physical capacity of 800 GB.

The *TS2240 Tape Drive Model H4S* uses a 3 Gbps Serial-Attached SCSI (SAS) interface for connecting to the Open Systems servers. The TS2240 Model H4S has a single-port SFF-8088 interface for connecting to Open Systems servers.

Write Once Read Many (WORM) cartridges are supported and recognized when loaded.

The TS2240 Tape Drive Model H4S is encryption-capable and supports Application-Managed Encryption (AME). The TS2240 Tape Drive can use the T10 encryption method. Encryption is only supported with the LTO Ultrium 4 Data Cartridge.

The TS2240 is a client-replaceable unit (CRU). In case the TS2240 has a failure, IBM provides you a replacement rather than repairing the tape drive.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2240 Tape Drive.

5.1 TS2240 description

The TS2240 Tape Drive can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard UNIX (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest supported servers, visit the Web at:

<http://www-03.ibm.com/servers/storage/tape/compatibility/pdf/>

The only model available for the TS2240 Tape Drive is the *TS2240 Model Tape Drive H4S* that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The TS2240 SAS Tape Drive has a single-port SFF-8088 interface.

The TS2240 Tape Drive uses the LTO4 800 GB Data Cartridge and can write up to 800 GB or up to 1600 GB using a compression ratio of 2:1. The TS2240 Tape Drive can read and write Ultrium 4 cartridges, read and write Ultrium 3 cartridges, and read Ultrium 2 cartridges. Ultrium 1 cartridges cannot be used in the TS2240 Tape Drive. For Tape Encryption, only the LTO Ultrium 4 Data Cartridge is supported.

Figure 5-1 shows the front view of the TS2240 Tape Drive.



Figure 5-1 Front view of the TS2240

For the remainder of this chapter, we use the term TS2240 as a abbreviation for IBM System Storage TS2240 Tape Drive.

5.1.1 Half-High Ultrium 4 Tape Drive

The IBM TS2240 Tape Drive houses the Half-High Ultrium 4 Tape Drive. The TS2240 might be an ideal tape drive for small clients who want a reliable tape drive with LTO technology. For additional details, refer to 2.4.2, “IBM LTO4 Half-High (HH) Tape Drive” on page 77.

The TS2240 Tape Drive provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-inch, 4mm, or 8mm tape drives. It can be a cost-effective solution for backup, save-and-restore, and archiving functions as the entry point for the family of IBM Ultrium tape products.

Performance highlights

The TS2240 Tape Drive Express Model incorporates fourth-generation IBM LTO Ultrium technology. It offers the following significant improvements over the Ultrium 3 Tape Drive in terms of performance. The maximum tape drive throughput data rate performance is up to 120 MB/s native data transfer rate. Data tracks are written 16 at a time.

If you run applications that are highly dependent on tape processing speed, take advantage of the significant performance improvements provided by this tape drive. Table 5-1 on page 137 shows you the performance characteristics of the TS2240.

Table 5-1 TS2240 Performance characteristics

Performance characteristics	TS2240 Tape Drive
Native data rate	120 MB/s (with Ultrium 4 media)
Maximum sustained data rate (at maximum compression)	240 MB/s (SAS)
Burst data rate	300 MB/s (SAS)
Nominal load-to-ready time	12 seconds
Nominal unload time	15 seconds
Average rewind time	59 seconds

By using the built-in data compression capability of the tape drive, greater data rates than the native data transfer rate can be achieved.

Note: Although the TS2240 Tape Drive provides the capability for excellent tape performance, other components of the system might limit the actual performance that is achieved. Also, although the compression technology used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

5.1.2 Data cartridges

The TS2240 Tape Drive uses the Ultrium 4 Data Cartridge, has a native capacity of 800 GB, and uses a linear, serpentine recording format. The TS2240 Tape Drive reads and writes data on 896 tracks, 16 tracks at a time. The Cartridge Memory (CM) of the data cartridges has been doubled in comparison with the Ultrium 3 cartridge. The storage capacity of the Ultrium 4 Data Cartridge CM is 8192 bytes. LTO Generations 1, 2, and 3 have an LTO-CM of 4096 bytes.

The outside of the Ultrium 4 cartridges is green, and the cartridge has a nominal life of 20 000 load and unload cycles.

In Table 5-2, we show you the compatibility of the Ultrium 4 Data Cartridge and the generations. Ultrium 1 Data Cartridges are not supported.

Table 5-2 Ultrium compatibility among the generations

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

The generations of IBM TotalStorage data cartridges can be identified by color:

- ▶ The Ultrium 4 Data Cartridge is green.
- ▶ The Ultrium 3 Data Cartridge is slate blue.
- ▶ The Ultrium 2 Data Cartridge is purple.
- ▶ The Ultrium 1 Data Cartridge is black.

Write Once Read Many (WORM)

The TS2240 uses LTO4 WORM Cartridges. Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a new WORM feature is available on IBM TS2240 Tape Drive. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

Data security on WORM media

Certain built-in security measures help to ensure that the data written on a WORM cartridge does not become compromised, for example:

- ▶ The format of an IBM Ultrium 3 and Ultrium 4, 400 GB and 800 GB WORM Tape Cartridge, is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.
- ▶ When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

For additional information related to WORM media, refer to “WORM tape format” on page 34.

Cleaning cartridge

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive in your library. One cleaning cartridge is included within the shipping package of the TS2240.

You must clean the drive head whenever the Clean LED is ON. We do not recommend that you clean the drive head on a periodic basis, only when the drive requests to be cleaned. The drive performs the cleaning automatically in less than two minutes and then ejects the cartridge.

The drive automatically ejects an expired cleaning cartridge. For additional details related to the cleaning cartridge, refer to “Cleaning cartridge” on page 50.

Cartridge memory (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM), which is a passive contactless silicon storage device that is physically a part of the cartridge. The CM is a chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge’s use.

The LTO-CM also helps to determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the Ultrium 4 Tape Cartridge Memory Chip is 8192 bytes.

Communication between the TS2240 Tape Drive and the LTO-CM is via a low-level radio frequency field transmitted by the drive to the cartridge.

Data Encryption

IBM System Storage TS2240 is ordered with the SAS interface. The TS2240 Tape Drive supports host Application-Managed Encryption (AME) by using T10 encryption methods and also System-Managed Encryption (SME).

Data encryption is supported with LTO Ultrium 4 Data Cartridges only. The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. The Encryption policy and encryption keys are provided by the host application, and there is no encryption setup required (or available) for this drive. A drive digital certificate is installed at manufacturing time. Each drive receives a unique serial number and certificate. The T10 Application might validate each drive instance by checking the drive's digital certificate. AME is supported on Windows Server 2003 and Windows Server 2008, Linux, Solaris, and HP-UX.

SME is supported for the TS2240 on AIX, Windows Server 2003, Windows Server 2008, Linux, and Solaris.

Encryption requires the latest tape device drivers that are available on the FTP download site:
<ftp://ftp.software.ibm.com/storage/devdrv/>

At the time of writing this chapter, the only application that supports AME is Tivoli Storage Manager. Tivoli Storage Manager provides the key for the encryption, and then, the data is encrypted and transferred to the LTO4 tape drive. Encryption is only supported for LTO4 data cartridges.

5.2 Physical attachment

We provide a brief overview and the specifications for the physical attachment interface, SAS 3 Gbps.

The TS2240 Tape Drive provides a sustained native data transfer rate of 120 MB/s and can store up to 800 GB of uncompressed information on a single data cartridge.

5.2.1 Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drives family and the TS2240 comes with a single-port SFF-8088 interface on the back of the drive. For a more detailed description of SAS, refer to "Serial-Attached SCSI" on page 57.

At the time of writing this book, two HBAs were supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller model 25R8060

The physical interface on the TS2240 is a single-port SFF-8088, and only a point-to-point connection to the server's HBA is supported. There is no support (yet) for connecting to Expander Boxes. No terminator is needed, because the SCSI bus is automatically terminated. The SAS TS2240 has a single-port SFF-8088 port so the TS2240 can be connected to only one server.

To install an adapter in your server, refer to the instructions that accompany it, as well as to the section about host adapter card installation in your server's documentation.

For a list of supported adapters and required interposers, visit the following Web site:

<http://www.ibm.com/storage/lto>

Figure 5-2 shows the back side of the TS2240 with a single-port SFF-8088 interface.

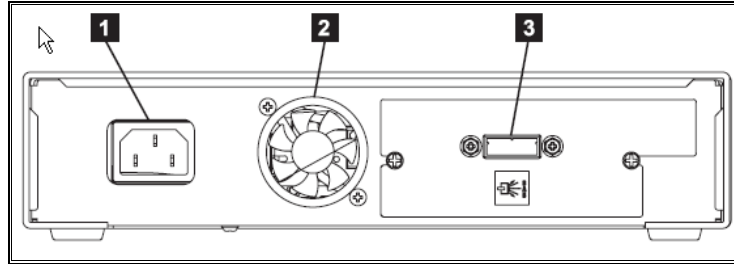


Figure 5-2 Back side of the TS2240

The numbers in Figure 5-2 represent:

- 1.** Power connector
- 2.** Air vents for fan
- 3.** Serial Attached SCSI Connector

5.3 IBM System Storage TS2240 setup

The following steps provide an introduction to the necessary steps to implement and operate the IBM TS2240 Tape Drive. For a more detailed description, refer to the *IBM System Storage Tape Drive Setup, Operator and Service Guide*, GC27-2151.

After unpacking and installing the TS2240, you need to perform a few steps to connect it to the host. We show you how to attach your TS2240. First, you need to set up your TS2240 with a SAS interface. And then, you need to update your TS2240 with the latest level of firmware.

5.3.1 SAS interface

Connecting the TS2240 to the HBA of the server is straightforward. The SAS interface of the TS2240 is always an SFF-8088, and the only supported HBAs in your server are:

- ▶ LSI Logic SAS3800
- ▶ IBM SAS HBA Controller model 25R8060

Connect one end of the SAS cable to the TS2240 and the other end of the cable to the HBA of the server. The only consideration is the physical connector on the cable. We included a list of all of the available features; refer to 5.5, “Feature codes” on page 142. Figure 5-3 on page 141 shows the connection to one server’s HBA.

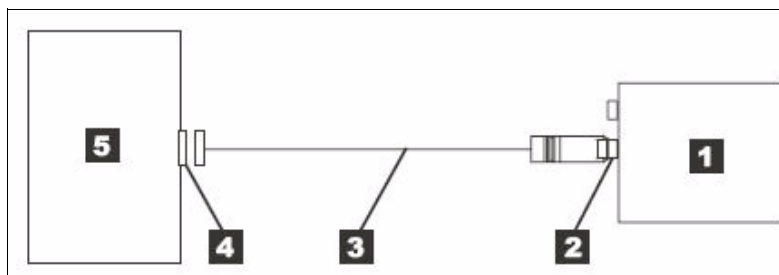


Figure 5-3 Point-to-point connection to one server

The numbers in Figure 5-3 represent:

- 1.** TS2240
- 2.** SAS connector
- 3.** SAS cable
- 4.** HBA of the server
- 5.** Server

The TS2240 has one SAS connector, so one server can be connected to the TS2240.

5.3.2 Firmware

At installation time, verify that the most current firmware is installed. Because the TS2240 does not have a display to show the firmware level, we recommend that you use an IBM tool called the *IBM Total Storage Diagnostic Tool (ITDT)*. ITDT scans the SCSI bus for any attached tape drive and will reflect the firmware of the tape drive. You can also use this tool for testing the drive and collecting a drive dump for error analysis by the IBM Support Centers. The advantage of using ITDT is that it works independently of the device driver. Whatever device driver is installed, whether it is an IBM device driver or a non-IBM device driver, the TS2240 can be tested, the firmware can be updated, or a drive dump can be performed.

This tool is supported on the following servers:

- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3 and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, which is available in two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

In the readme file, there are installation instructions, as well as instructions to use ITDT.

The latest firmware of the TS2240 can be found on the following Web site:

<http://www-03.ibm.com/servers/storage/tape/1to/>

Also, you can download the latest firmware from this FTP Web site:

<ftp://index.storsys.ibm.com/358x/3580>

5.4 Physical specifications

The TS2240 is a small-sized tape drive with the following specifications:

Width	25.02 cm (9.85 in.)
Length	29.21 cm (11.5 in.)
Height	12.06 cm (4.75 in.)
Weight	6.45 kg. (14.2 lbs.)

5.5 Feature codes

In this section, we summarize the feature codes for the TS2240 model. Table 5-3 on page 143 lists the feature codes and part numbers for SAS attachment.

Table 5-3 SAS feature codes

Feature code	Name	Description
5402 95P4711	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406 95P4712	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5502 95P4713	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506 95P4714	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405 95P4278	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2240.



IBM System Storage TS2340 Tape Drive

The IBM System Storage TS2340 Tape Drive (3580 Model X43) is an external stand-alone or rack-mountable (optional) unit and is the entry point for the family of IBM Ultrium Tape products. The TS2340 Tape Drive is designed for backup and restore by midrange Open Systems applications. The TS2340 Tape Drive incorporates the Linear Tape-Open (LTO) IBM System Storage Ultrium 4 Full-High Tape Drive, which writes cartridges with a native physical capacity of 800 GB.

With an optional rack mount kit, the TS2340 can be installed in an industry standard 19-inch rack.

The TS2340 Tape Drive is available in two models, which are determined by the attachment interfaces. The TS2340 Tape Drive Model L43 uses a Small Computer Systems Interface (SCSI) Ultra160 Low Voltage Differential (LVD) attachment, and Model S43 uses a 3 Gbps Serial-Attached SCSI (SAS) interface for connecting to Open Systems servers. The TS2340 Model S43 has two SFF-8088 interfaces for connecting to Open Systems servers.

Write Once Read Many (WORM) cartridges are supported and recognized when loaded.

The TS2340 Tape Drive Model S43 is encryption-capable and supports Application-Managed Encryption (AME). The TS2340 Tape Drive uses the T10 encryption method. Encryption is only supported with the LTO Ultrium 4 Data Cartridge.

The TS2340 is client-replaceable unit (CRU). In case the TS2340 has a failure, IBM provides you a replacement.

For error codes and messages, there is a Single Character Display (SCD) at the front of the TS2340 Tape Drive.

6.1 TS2340 description

The TS2340 Tape Drive can be attached to IBM System i, IBM System p, IBM System x, Microsoft Windows, Hewlett-Packard UNIX (HP-UX), Sun Solaris, UNIX, Linux, and PC servers. To determine the latest supported servers, visit the Web at:

<http://www-03.ibm.com/servers/storage/tape/compatibility/pdf/>

Two models are available for the TS2340 Tape Drive:

- ▶ The *TS2340 Tape Drive Model L43* has a SCSI Ultra160 LVD physical interface, which has a native data transfer rate of up to 120 MB/s. The physical interface is a high-density, 68-pin, D-shell receptacle connector (HD68).
- ▶ The *TS2340 Model Tape Drive S43* has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The TS2340 SAS Tape Drive has a dual-port SFF-8088 interface.

The TS2340 Tape Drive uses the IBM TotalStorage LTO Ultrium 4 800 GB Data Cartridge and can write up to 800 GB or 1600 GB (using a compression ratio of 2:1). The TS2340 Tape Drive can read and write Ultrium 4 cartridges, read and write Ultrium 3 cartridges, and can read Ultrium 2 cartridges. Ultrium 1 cartridges cannot be used in the TS2340 Tape Drive. For Tape Encryption, only the LTO Ultrium 4 Data Cartridge is supported.

Figure 6-1 shows the front view of the TS2340 Tape Drive.



Figure 6-1 TS2340

For the remainder of this chapter, we use the term TS2340 as a abbreviation for IBM System Storage TS2340 Tape Drive.

6.2 Physical attachment

We give a short overview and the specifications for the physical attachment interfaces:

- ▶ SCSI Ultra160 LVD
- ▶ The newly announced SAS 3 Gbps

6.2.1 SCSI interface

To communicate with a server, the TS2340 Tape Drive uses an Ultra160 LVD SCSI interface. The SCSI interface has a native data transfer rate of up to 120 Mb/s.

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) using multi-drop interconnection (daisy-chaining). For each daisy-chained device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

The TS2340 Ultra160 LVD Tape Drive drive uses shielded, HD68, 68-pin connectors and can attach directly to a 2 byte wide SCSI cable.

The TS2340 Tape Drive provides a sustained native data transfer rate of 120 MB/s and can store up to 800 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

6.2.2 Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drives family, and the TS2340 ships with two SFF-8088 interfaces on the back of the drive. For a more detailed description of SAS, refer to “Serial-Attached SCSI” on page 57.

At the time of writing this book, two HBAs were supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller Model 25R8060

The physical interface on the TS2340 is a dual-port SFF-8088, and only a point-to-point connection to the servers HBA is supported. There is no support (yet) for connecting to Expander Boxes. No terminator is needed, because the SCSI bus is automatically terminated. The SAS TS2340 has two SFF-8088 ports so the TS2340 can be connected to two servers.

Figure 6-2 shows the back side of the TS2340 with two SFF-8088 interfaces.



Figure 6-2 Back side of the TS2340

6.3 TS2340 data cartridges

The TS2340 uses the Ultrium 4 Data Cartridge that has a native capacity of 800 GB and uses a linear, serpentine recording format. The TS2340 Tape Drive reads and writes data on 896 tracks, sixteen tracks at a time. The Cartridge Memory (CM) of the data cartridges has been doubled in comparison with the Ultrium 3 cartridge. The storage capacity of the Ultrium 4 Data Cartridge CM is 8160 bytes. LTO Generations 1, 2, and 3 have an LTO-CM of 4096 bytes.

The outside of the Ultrium 4 cartridges is green, and the cartridge has a nominal life of 20 000 load and unload cycles. For additional details related to the data cartridge, refer to 2.1.4, “Tape cartridge” on page 43.

In Table 6-1, we show you the compatibility of the Ultrium 4 Data Cartridge and the other generations. Ultrium 1 Data Cartridges are not supported.

Table 6-1 Ultrium compatibility among the generations

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

6.4 Highlights of the TS2340 Tape Drive Full-High

The IBM System Storage TS2340 Tape Drive uses the IBM System Storage TS1040 LTO Ultrium 4 Tape Drive. For the remainder of this chapter, we use the term LTO as a generic term for various generations of the LTO Ultrium tape drives. As the specific reference to the IBM System Storage TS1040 LTO Ultrium 4 Tape Drive, we use the term LTO4.

Here, we summarize the features enhanced in the IBM LTO Ultrium 4 Tape Drive. You can get more information in 2.4, “IBM System Storage TS1040 Tape Drive” on page 74:

- ▶ **Dual-stage 16-channel head actuator**
The actuator is designed to provide precision head alignment to help support higher track density and improved data integrity.
- ▶ **Independent tape loader and threader motors and positive pin retention**
These features are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to cause the tape to thread with a higher level of reliability.
- ▶ **Graceful dynamic braking**
In the event of power failure, reel motors are designed to maintain tension and gradually decelerate instead of stopping abruptly, helping reduce tape breakage, stretching, or loose tape wraps during a sudden power outage.
- ▶ **Servo and track layout technology**
There are 704 data tracks in Ultrium 4 and 3 as compared to 512 data tracks in Ultrium 2. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

► **Surface Control Guiding Mechanism**

The Control Guiding Mechanism is designed to guide the tape along the tape path in the Ultrium 4 Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This feature helps to reduce tape damage (especially to the edges of the tape) and tape debris, which come from the damaged edges and can accumulate in the head area.

► **Adaptive read equalization**

The drive is designed to automatically compensate for dynamic changes in readback signal response.

► **Dynamic amplitude asymmetry compensation**

It is designed to dynamically optimize for linear readback response from magneto resistive (MR) read head transducers.

► **Separate writing of multiple file marks**

Separate writing of multiple file marks is designed to cause any write command of two or more file marks to cause a separate data set to be written that contains all file marks after the first file mark.

TS2340 Data Encryption

When the IBM System Storage TS2340 is ordered with the SAS interface, then the LTO4 tape drive is capable of supporting AME and SME. At the time of writing this book, the only application that supports AME is Tivoli Storage Manager. Tivoli Storage Manager provides the key for the encryption, and then, the data is encrypted and transferred to the LTO4 tape drive.

Encryption is only supported for LTO4 data cartridges.

TS2340 Data Path Failover

When the IBM System Storage TS2340 is ordered with the SAS interface, then Data Path Failover is supported for the LTO4 tape drive.

6.5 IBM System Storage TS2340 setup

Next, we introduce the necessary steps to implement and operate the IBM TS2340 Tape Drive. For a more detailed description, refer to the *IBM System Storage Tape Drive Setup, Operator and Service Guide*, GC27-2103, and *IBM System Storage Tape Drive Installation Quick Reference*, GC27-2104.

After unpacking and installing the TS2340, you need to perform a few steps to connect it to the host. First, we show you how to set up a TS2340 with a SCSI interface, and then, we show you which steps are needed when setting up the TS2340 with a SAS interface.

6.5.1 SCSI interface

To connect your TS2340 to your server, make sure that the installed SCSI HBA is supported. To find out if your HBA is supported, visit this Web site and select **TS2340**:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability>

If the HBA is supported, you can connect your TS2340 to the HBA of the server.

Note: SCSI adapters, which are part of the server's system board, are not supported.

When connecting the TS2340 to the HBA of the server, make sure that the TS2340 has a unique SCSI ID on the SCSI bus. There is a SCSI ID switch located on the rear side of the TS2340. Use a small object to change the switch. The range of SCSI IDs is 0 through 15. Generally, the SCSI ID for the HBA is set to 7. Refer to Figure 6-3.

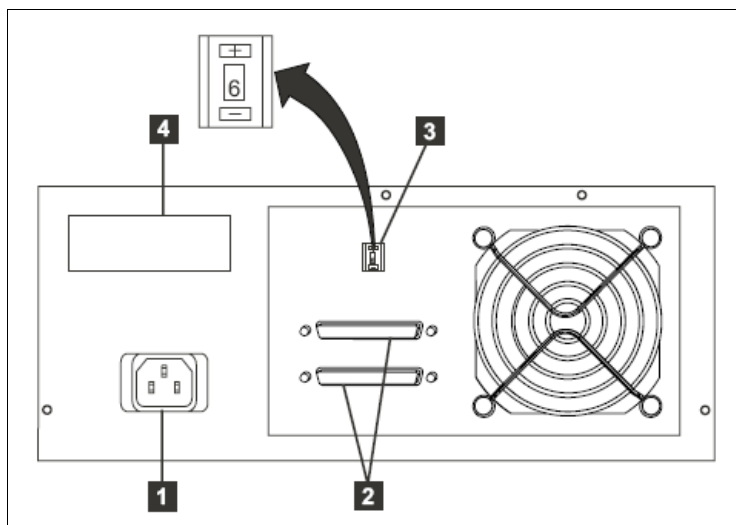


Figure 6-3 The rear view of the TS2340

The numbers in Figure 6-3 represent:

- 1.** Power receptacle
- 2.** SCSI connectors
- 3.** SCSI address switch
- 4.** Serial number label

The IBM TS2340 can be attached as the only tape drive on the HBA or can be daisy-chained with other SCSI LVD devices. We recommend that you do not use daisy-chaining because of performance reasons and also because the total length of the SCSI cable is limited to 12 m (39.4 ft.) instead of 25 m (82 ft.) when using a point-to-point connection. If you connect more devices to the HBA, the smaller the actual bandwidth is for each connected device.

On the last device of the SCSI bus, an LVD SCSI terminator must be installed. The LVD terminator is delivered with the TS2340.

Do not mix Low Voltage Differential (LVD) and High Voltage Differential (HVD) SCSI host adapters, tape drives, or terminators on the same bus, because they can become damaged.

Figure 6-4 shows a point-to-point configuration.

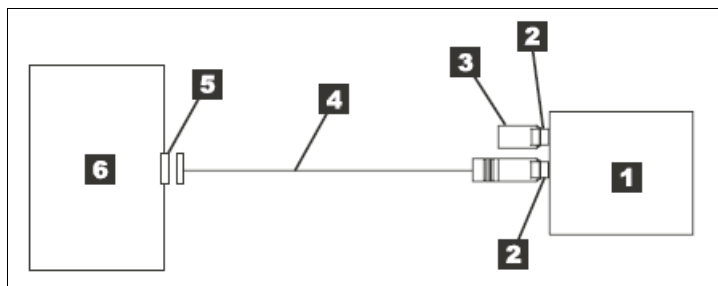


Figure 6-4 TS2340 point-to-point connection to the server

The numbers in Figure 6-4 on page 150 represent:

- 1.** TS2340
- 2.** SCSI connectors
- 3.** SCSI LVD terminator
- 4.** SCSI cable
- 5.** SCSI HBA
- 6.** Server

Figure 6-5 shows a TS2340 in a daisy-chain configuration.

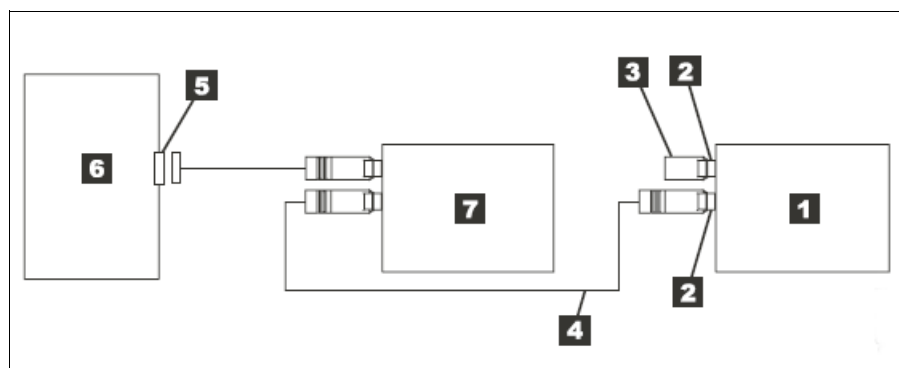


Figure 6-5 Two TS2340s connected in a daisy-chain configuration

The numbers in Figure 6-5 represent:

- 1.** TS2340
- 2.** SCSI connectors
- 3.** Terminator
- 4.** SCSI bus cable
- 5.** SCSI HBA
- 6.** Server
- 7.** TS2340

In this example, we used two TS2340s, but it can be any other LVD tape drive. The last TS2340 must have an LVD terminator installed; otherwise, the SCSI bus is open and that can result in unpredictable errors.

For maximum performance, the quantity of tape drives that can be attached to one SCSI bus is limited and is based on the type of bus that you have and the amount of data compression achieved. Ultra SCSI buses have a bandwidth of 40 MB/s; Ultra2 SCSI buses have a bandwidth of 80 MB/s; and Ultra160 SCSI buses have a bandwidth of 160 MB/s. The tape drive is capable of data transfer rates of up to 80 MB/s with no compression. For maximum performance, we recommend that you attach only one tape drive to an Ultra SCSI bus, an Ultra2 SCSI bus, or an Ultra160 SCSI bus.

Data transfer protocol time-outs for tape and disk drives are dissimilar. For that reason, we strongly recommend that you avoid running tape and disk drives on the same HBA. A configuration with tape and disk on a single HBA gives a slow and unreliable performance.

Note: Do not intermix LVD and HVD devices and HBAs on the same SCSI bus. Damage can occur, because LVD and HVD SCSI devices do not use the same voltage.

6.5.2 SAS interface

Connecting the TS2340 to the HBA of the server is straightforward. The SAS interface of the TS2340 is always an SFF-8088, and the only supported HBAs in your server are:

- ▶ LSI Logic SAS3800
- ▶ IBM SAS HBA Controller model 25R8060

Connect one end of the SAS cable to the TS2340 and the other end of the cable to the HBA of the server. The only consideration is the physical connector on the cable. We included a list of all of the available features; refer to 6.7, “Feature codes” on page 155. Figure 6-6 shows the connection to one server’s HBA.

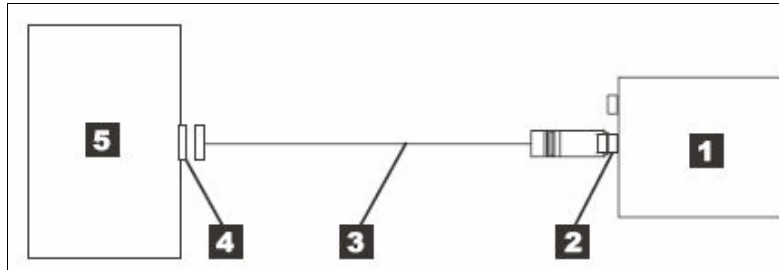


Figure 6-6 Point-to-point connection to one server

The numbers in Figure 6-6 represent:

- 1.** TS2340
- 2.** SAS connector
- 3.** SAS cable
- 4.** HBA of the server
- 5.** Server

The TS2340 has two SAS connectors, so two servers can be connected to the TS2340. Figure 6-7 on page 153 shows a configuration where the TS2340 is connected to two servers. Daisy-chaining is not allowed, because each SAS port of the TS2340 needs a dedicated HBA.

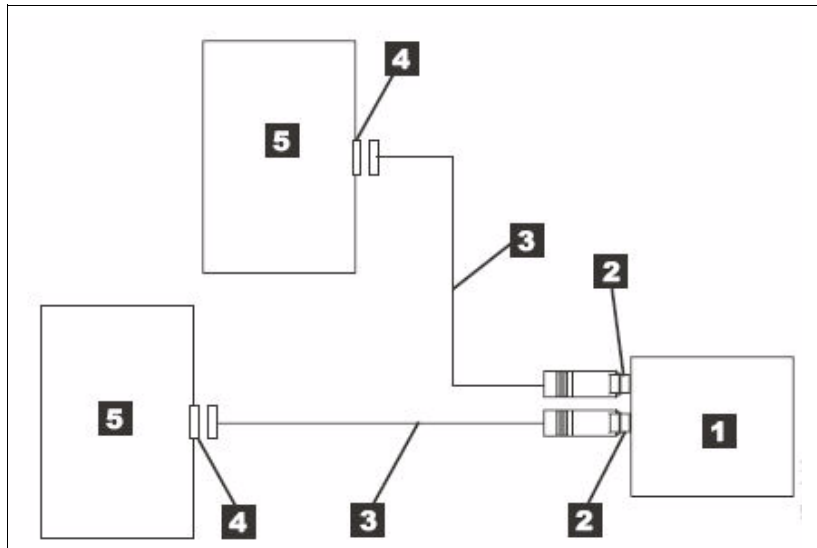


Figure 6-7 TS2340 connected to two servers

The numbers in Figure 6-7 represent:

- 1. TS2340
- 2. SAS interface
- 3. SAS cable
- 4. HBA of the server
- 5. Server

6.5.3 Installing the tape device drivers

To communicate with the TS2340, the appropriate tape device driver must be installed on your server. Depending on your host operating system, the latest tape device driver must be installed on your server. Visit this Web site:

<http://www-03.ibm.com/servers/storage/tape/1to/>

Here, you can download the latest device driver for your operating system.

Another way to get the latest device driver is to visit this Web site:

<ftp://index.storsys.ibm.com/devdrv>

Choose your operating system and download the device driver.

Step-by-step instructions to install the device driver are in the following IBM publications:

- ▶ *Implementing IBM TAPE in Unix Systems*, SG24-6502
- ▶ *Implementing IBM Tape in Linux and Windows*, SG24-6268
- ▶ *IBM Tape Device Drivers Installation and Users Guide*, GA27-2130

All publications are available and can be downloaded from the Web.

6.5.4 Firmware

At installation time, verify that the most current firmware is installed. Because the TS2340 does not have a display to show the firmware level, we recommend that you use an IBM tool called the *IBM Total Storage Diagnostic Tool (ITDT)*. ITDT scans the SCSI bus for any attached tape drive and will reflect the firmware of the tape drive.

You can also use this tool for testing the drive and collecting a drive dump for error analysis by the IBM Support Centers. The advantage of using ITDT is that it works independently of the device driver. Whatever device driver is installed, whether it is an IBM device driver or a non-IBM device driver, the TS2340 can be tested, the firmware can be updated, or a drive dump can be performed.

This tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and there are two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Window XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

In the readme file, there are installation instructions, as well as instructions about how to use ITDT.

The latest firmware for the TS2340 can be found on the following Web site:

<http://www-03.ibm.com/servers/storage/tape/1to/>

Also, you can download the latest firmware from this FTP Web site:

<ftp://index.storsys.ibm.com/358x/3580>

6.6 Physical specifications

The TS2340 is a small-sized tape drive with the following specifications:

Width	25.02 cm (9.85 in.)
Length	29.21 cm (11.5 in.)
Height	12.06 cm (4.75 in.)
Weight	6.45 kg. (14.2 lbs.)

6.7 Feature codes

In this section, we summarize the feature codes for both TS2340 models. Table 6-2 lists the feature codes and part numbers for SCSI attachment.

Table 6-2 Feature codes and part numbers for SCSI attachment

IBM Service part number	Client feature code	High Volume part number	Product description
23R3841	5602	23R7133	VHDCI/HD68 SCSI cable, 2.5 m (8.2 ft.)
23R3594	5604	23R7134	VHDCI/HD68 SCSI cable, 4.5 m (14.8 ft.)
23R3593	5610	23R7135	VHDCI/HD68 SCSI cable, 10 m (32 ft.)
35L1782	N/A	N/A	SCSI Y-cable
23R5841	N/A	N/A	SCSI LVD terminator
23R5840	N/A	N/A	SCSI LVD wrap plug
N/A	7003	96P1565	19-inch rack mount kit

Table 6-3 lists the feature codes and part numbers for SAS attachment.

Table 6-3 SAS feature codes and part numbers

Feature Code/High Volume	Name	Description
5402/95P4711	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406/95P4712	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5502/95P4713	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506/95P4714	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405/95P4278	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.



IBM System Storage TS2900 Tape Autoloader

The IBM System Storage TS2900 Tape Autoloader (Machine Type 3572) provides compact high capacity, low-cost solutions for simple unattended data backup. The library has a compact 1U form factor with easy access to tape cartridges via a removable magazine. The IBM System Storage TS2900 Tape Autoloader is an external stand-alone or rack-mountable unit that incorporates an IBM Ultrium 3 or Ultrium 4 Half-High Tape Drive. It is equipped with a Serial Attached SCSI (SAS) host adapter attachment that has a data transfer rate of up to 3 Gbps.

The IBM System Storage TS2900 Tape Autoloader has a removable cartridge magazine providing nine data cartridge slots, including a configurable two slot I/O station. IBM System Storage TS2900 Tape Autoloader is an entry point for IBM Linear Tape-Open (LTO) tape automation. This autoloader uses the IBM patented high density (HD) slot technology.

Standard features include:

- ▶ Application-Managed Encryption (AME) with LTO4
- ▶ Barcode Reader
- ▶ LCD display for local management
- ▶ Web-Guided User Interface (GUI) for remote management
- ▶ Configurable I/O station
- ▶ Removable magazine with IBM patented HD Slot technology

Optional features include:

- ▶ Transparent System-Managed Encryption (SME) and Library-Managed Encryption (LME)
- ▶ Choice of rack-mount or desktop packaging

For the remainder of this chapter, we use the terms TS2900 or TS2900 Tape Autoloader as abbreviations for the IBM System Storage TS2900 Tape Autoloader.

7.1 Description

The IBM System Storage TS2900 Tape Autoloader (Machine Type 3572 1U Autoloader) supports one LTO3 or one LTO4 Half-High tape drive.

Two models are available for TS2900:

- ▶ The *3572-S4H* comes with an Ultrium 4 Half-High Tape Drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The SAS Ultrium 4 Tape Drive comes with an SFF-8088 interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3572-S3H* comes with an Ultrium 3 Half-High Tape Drive that has a SAS attachment. The Ultrium 3 Half-High Tape Drive has a maximum native data transfer rate of up to 60 MB/s.

Note: The IBM System Storage TS2900 Tape Autoloader comes ready to be mounted in a standard 19-inch rack. Feature code 7006 must be ordered, which provides the rack mounting hardware. If you want to install the TS2900 as a desktide model, feature code 7010 must be ordered in order to provide the adequate covers.

The cartridges that are supported in the IBM System Storage TS2900 Tape Autoloader include:

- ▶ IBM LTO Tape Cartridge Ultrium 4 (800 GB native physical capacity)
- ▶ IBM LTO Tape Cartridge Ultrium 3 (400 GB native physical capacity)
- ▶ IBM LTO Tape Cartridge Ultrium 2 (200 GB native physical capacity)
- ▶ IBM LTO Tape Cartridge Ultrium 1 (100 GB native physical capacity)
- ▶ WORM cartridges

Note that cartridge support is dependent on the tape drive that is installed in the TS2900. Only the cartridge types that are supported by the LTO3 or LTO4 drive that is installed are supported in the TS2900.

The library media capacity can be further increased by using hardware compression (2:1 compression factor). The library supports the movement of any media generation in any slot or drive. It is set in the host application to limit any operations that might result in unsupported media issues.

The TS2900 has a 3 Gbps single-port SFF-8088 SAS connector. This is the same connector for all of the other IBM tape products that support the SAS interface. The drive is integrated into the library. There is no drive field-replaceable unit (FRU) or client-replaceable unit (CRU), because the entire library is a CRU.

Designed for tape automation, the TS2900 Tape Autoloader can be attached to IBM System i or i5, iSeries, AS/400, IBM System p or p5, pSeries, RS/6000, IBM z or z9™, System x, xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers. To determine the latest supported servers, visit the Web at:

<http://www-03.ibm.com/systems/storage/tape/>

The IBM Ultrium 4 LTO Tape Drive with a Fibre Channel or a SAS interface is encryption-capable. The IBM LTO4 Tape Drive supports Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

Depending on the IBM Ultrium Tape Drive installed in the TS2900, you can use the following data cartridges:

- ▶ The TS2900 uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge or the 400 GB WORM cartridge when the IBM Ultrium 3 Tape Drive is installed. The Ultrium 3 Tape Drive has the capability of writing up to 400 GB native capacity and up to 800 GB with 2:1 compression. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and read LTO1 data cartridges.
- ▶ The TS2900 uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 Tape Drive is installed. The Ultrium 4 Tape Drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with 2:1 compression. IBM Ultrium 4 Tape Drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and do not support Ultrium 1 Data Cartridges.

The library has a capacity of nine tape cartridges, providing a media capacity of up to 9.6 TB (19.2 TB with 2:1 compression) data storage per TS2900.

Figure 7-1 shows the front view of the TS2900. On the front side, you see the cartridge magazine. The I/O slot is accessible from the lower left.



Figure 7-1 IBM System Storage TS2900 Tape Autoloader

7.2 TS2900 characteristics

The TS2900 Tape Autoloader has an improved robotic system that moves along an axis from front to back between the cartridge magazine. This limited movement provides robust robotics. The standard barcode reader is installed on the picker.

7.2.1 Components

TS2900 Tape Autoloader houses a cartridge magazine, Operator Panel, Accessor, library controller card, power supply, and a Half-High Tape Drive.

Figure 7-2 on page 160 shows the top view of the TS2900. The right side of the image is the rear of the library and the left side is the front of the TS2900. The TS2900 Tape Autoloader is not a modular system and does not allow you to change parts.

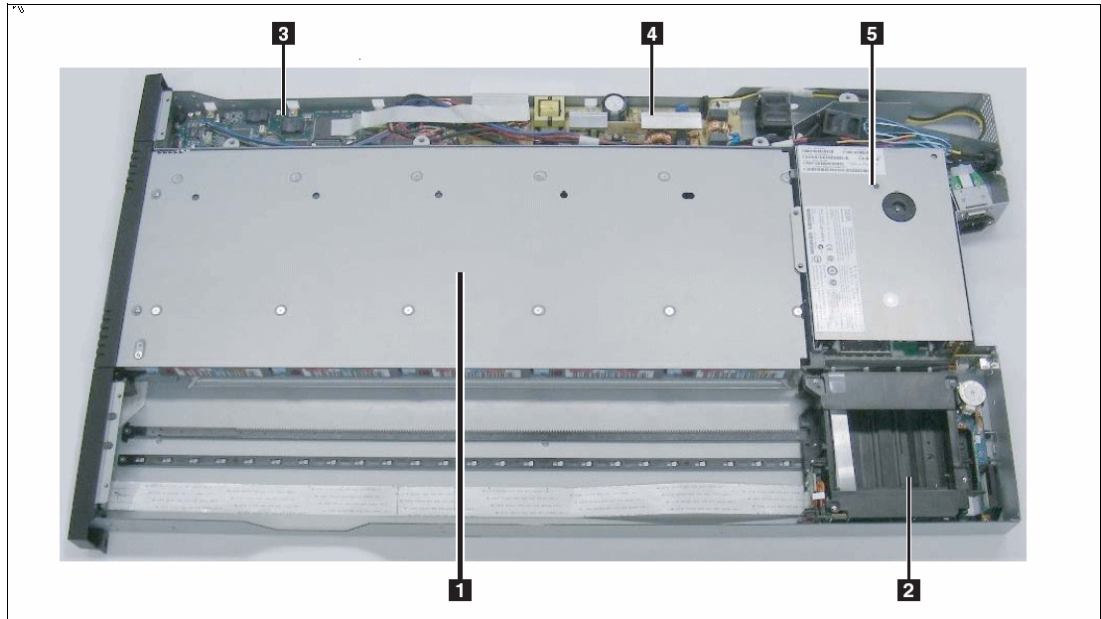


Figure 7-2 Internal top view of the TS2900 Tape Autoloader

The components that are shown in Figure 7-2 are:

- 1. Cartridge magazine:** This magazine can hold up to nine cartridges and houses the I/O slot, for a total of 10 slots. The front slot of the first column in the cartridge magazine can be configured as an I/O station or cleaning slot. The back slot of the first column of the cartridge magazine is used as the exchange slot. The I/O station is used to import and export cartridges without interrupting normal library operation. Cleaning cartridges are used to clean the tape drive heads.
- 2. Accessor:** This component contains the library robot and the barcode reader. The accessor moves cartridges to and from the cartridge magazine.
- 3. Library control board:** The library control board manages the entire library, including the Operator Panel and Accessor, and is responsible for monitoring the library to ensure that the library functions properly. It stores vital product data (VPD), such as library settings, the serial number, library logs, and Accessor calibration backup data.
- 4. Power supply:** The power supply is the sole source of power for the library.
- 5. Tape drive:** This library supports the Ultrium 3 or Ultrium 4 tape drive. The tape drive in the library is packaged in a container called a *drive sled*. The drive sled is not a CRU.

Note: Because there is no need to open the top cover of the TS2900, you must not remove it. No client serviceable components are inside the library. The whole library is a CRU. IBM provides a replacement of the TS2900 Tape Autoloader in case of defect.

In Figure 7-3 on page 161, we show you the components viewed from the rear of the TS2900 Tape Autoloader.

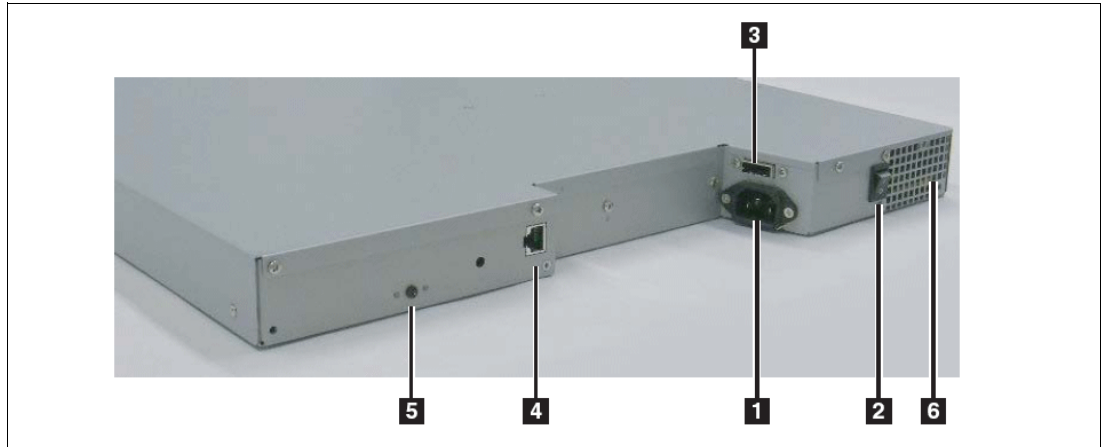


Figure 7-3 TS2900 Tape Autoloader rear panel components

The components shown in Figure 7-3 are:

1. **Power connector:** The library uses this power connector to connect to a 110/220 Volt AC power supply.
2. **Power switch:** The library is powered ON when the power supply switch on the rear panel is ON. The library has no independent power switch on the front panel.
3. **SAS connection:** Here is the Serial Attached SCSI host interface cable connection. The Ultrium 3 and the Ultrium 4 SAS drive use the SFF-8088 connection at the drive end and the SFF-8088 or SFF-8470 connection at the host adapter end.
4. **Ethernet port:** The client connects the library to the network using this port.
5. **Shipping lock screw:** The shipping lock screw is used to restrain the accessor robot assembly during transportation. Store the shipping lock screw in the storage slot on the rear panel of the library and cover it with the label for future use.
6. **Air vent:** These vents allow air to escape from the power supply and tape drive sled.

7.2.2 Operator Control Panel

The library is equipped with an Operator Control Panel (OCP). By means of the OCP, a user can perform simple actions with the medium changer. The OCP interface allows a user to monitor the medium changer operation, make configuration changes, and perform media access commands.

Note: When a user executes a medium access command through the OCP interface, the medium changer will enter the off-line state. When the medium changer is off-line, the medium changer will report Not Ready on the SCSI bus.

For information about the medium changer SCSI command, refer to *IBM System Storage TS2900 SCSI Reference*, GC27-2211.

The Operator Control Panel interface

The Operator Panel is located on the front of the library and allows users to work locally on the library. The Operator Panel features a monochrome 16-character LCD graphic display. Library operations and service functions are performed from this display. The Web User Interface allows users and administrators to view and perform several library functions from remote sites.

Figure 7-4 shows the level menu tree structure of the Operator Panel on the front of the TS2900 Tape Library. For an extensive description of the OCP functions, refer to the OCP specification in *IBM System Storage TS2900 Tape Autoloader Setup, Operator, and Service Guide*, GC27-2212.

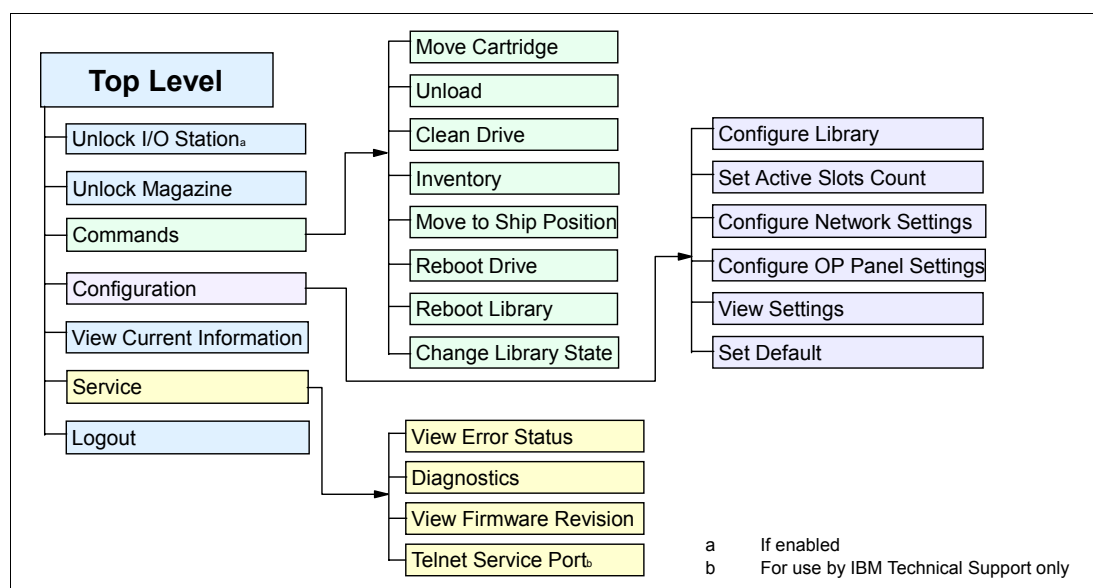


Figure 7-4 TS2900 Tape Autoloader operator menu tree

7.2.3 Robotics

The IBM System Storage TS2900 Tape Autoloader uses a new independent tape loader, threader motors, and a positive pin retention. These features are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to thread the tape with a higher level of reliability.

7.2.4 Barcode Reader

The barcode reader is an integral part of the library Accessor. The barcode reader reads each cartridge barcode label and the fiducial labels, which identify the types of cartridge magazines and tape drive installed in the library, and provides inventory feedback to the host application, Operator Panel, and Web User Interface.

The library stores the customized inventory data in memory. The code for this library supports an eight or more character volume serial number (VOLSER) on the barcode label on the tape cartridge. This library does not support a six character VOLSER.

7.2.5 Cartridge storage

The TS2900 Tape Autoloader has one removable magazine with 10 cartridge slots. The slots are organized as five High Density (HD) slots (2 x 5 = 10), but one of the ten slots is reserved for library swap space, so the magazine has a total user capacity of nine cartridges.

When the magazines are filled with cartridges, you can log in the TS2900 using the Web User Interface (UI) to look at which cartridges are stored and in which storage slot location as demonstrated in Figure 7-5 on page 163.



Figure 7-5 Inventory of the magazine using the Web User Interface

The left part of the magazine is the I/O station. You can use the Web UI to show a library map of the magazine as shown in Figure 7-5.

The I/O station is part of the magazine. You can open the I/O station using the Operator Control Panel.

7.3 IBM Ultrium LTO Half-High Tape Drives

TS2900 Tape Autoloader houses the LTO4 HH Tape Drive or LTO3 HH Tape Drive. In this section, we describe several of the highlights of the Half-High Ultrium 4 and the Half-High Ultrium 3 tape drives. The TS2900 Tape Autoloader might be an ideal tape autoloader for small clients who want to have a reliable tape drive with LTO technology. Most of the functions that we summarize in this section are common between the LTO3 and the LTO4, but they differ in performance characteristics.

7.3.1 LTO4 Half-High Tape Drive

In the following topics, we show you the characteristics of the LTO4 Half-High Tape Drive. For additional details, refer to 2.4.2, "IBM LTO4 Half-High (HH) Tape Drive" on page 77.

Performance highlights

The TS2900 Tape Autoloader incorporates the fourth-generation of IBM Half-High Ultrium 4 tape drive technology. It offers the following significant improvements over the Half-High Ultrium 3 Tape Drive in terms of performance. The maximum tape drive throughput data rate is up to 120 MB/s of native data. Data tracks are written 16 at a time.

Note: Although the TS2900 Tape Autoloader provides the capability for excellent tape performance, other components of the system might limit the actual performance achieved. Also, although the compression technology used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

Servo and track layout technology

There are 896 data tracks in Ultrium 4 (as compared to 704 data tracks in Ultrium 3) that are used to read and write data to the data cartridge. These tracks are grouped in five servo bands as explained in “Servo tracks” on page 35. The high bandwidth servo system features a low mass servo to help more effectively track servo bands and improve data throughput with damaged media in less than optimal shock and vibration environments.

Dynamic speed matching

The Ultrium 4 Half-High Tape Drive is designed to perform *dynamic speed matching* (at one of seven speeds, 31 to 120 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). Speed matching on the Ultrium 4 Half-High model ranges from 31 to 120 MB/s as compared to 30 to 60 MB/s on Ultrium 3 Half-High Tape Drives. There is a 256 MB internal data buffer in the Ultrium 4 Tape Drive as compared to the 128 MB internal data buffer in the Ultrium 3 Tape Drive.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the IBM Ultrium LTO Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. Ultrium 4 and Ultrium 3 Half-High Tape Drives use the Surface Control Guiding Mechanism.

Channel calibration

The channel calibration feature of the Ultrium 4 Tape Drive and the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Magneto resistive head design

Magneto resistive (MR) head design, which uses flat lap head technology in the MR heads for Ultrium 4, helps to minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

Separate writing of multiple file marks

Separate writing of multiple file marks is designed to request any write command of two or more file marks to cause a separate data set to be written that contains all file marks after the first file mark. This feature has two advantages:

- ▶ It helps improve performance if a subsequent append overwrites somewhere after the first file mark.
- ▶ Write of multiple file marks typically indicates a point where an append operation might occur after the first of these file marks.

This change helps prevent you from having to rewrite data sets containing client data and the first file mark if this type of an append occurs.

Sleep mode

To save energy, the LTO4 and LTO3 tape drives use a feature called *sleep mode*. To enter sleep mode, the tape drive must be inactive for a minimum of 30 seconds. The tape drive goes out of this sleeping mode after receiving a SCSI command, a command across the Library/Drive interface (LDI) or RS-422, or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

Statistical Analysis and Reporting System (SARS)

The Ultrium 4 Half-High Tape Drive and the Ultrium 3 Half-High Tape Drive use SARS to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the Cartridge Memory (CM) module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive dump is taken from the drive, the IBM Support Center can determine if the failure is in the Tape Drive itself or on the data cartridge. SARS is also used in the Ultrium 3 Half-High Tape Drive.

7.3.2 LTO3 Half-High Tape Drive

In this section, we summarize the major characteristics of the Ultrium 3 Half-High Tape Drives. Most of the functions are similar to the Ultrium 4 Half-High Tape Drive, which we described in 7.3.1, “LTO4 Half-High Tape Drive” on page 163. For additional information related to the LTO3 Half-High Tape Drive, refer to 2.3.2, “IBM LTO3 Half-High (HH) Tape Drive” on page 73. The characteristics of the Ultrium 3 Half-High Tape Drive are:

Servo and track layout technology

The Ultrium 3 Half-High Tape Drive uses 704 data tracks to read and write data to the data cartridge.

Dynamic speed matching

The Ultrium 3 Tape Drive is designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This design helps reduce the number of backhitch repositions and improves throughput performance.

Surface Control Guiding Mechanism:

This function has been designed to guide the tape along the tape path. The LTO4 HH Tape Drive has this same function.

Channel calibration The channel calibration feature of the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance.

Magneto resistive (MR)

This is a head design that uses flat lap head technology in the MR heads for Ultrium 3.

Separate writing of multiple file marks

This function is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark.

- Sleep mode** The Ultrium 3 Half-High Tape Drive has a power management function that is designed to control the drive electronics to be either completely turned off or to stay in low-power mode when the circuit functions are not needed for drive operation.
- Statistical Analysis and Reporting System (SARS)** The Ultrium 3 Half-High Tape Drive use SARS to help isolate failures between the media and the hardware.

7.4 Physical attachments

The TS2900 Tape Autoloader is only available with a Serial Attached SCSI (SAS) interface that has a data rate of 3 Gbps.

7.4.1 SAS interface

The IBM Ultrium 4 SAS Half-High and the IBM Ultrium 3 SAS Half-High tape drives installed into the TS2900 come with one SFF-8088 interface on the back of the tape drive. For a more detailed description of SAS, refer to “Serial-Attached SCSI” on page 57.

At the time of writing this book, two HBAs are supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller Model 25R8060

Figure 7-6 show the back side of the SAS Half-High Tape Drive with one SFF-8088 interface. The TS2900 SAS port is shown in Figure 7-3 on page 161.



Figure 7-6 Back side of the SAS Half-High Tape Drive

No terminator is needed, because the SCSI bus is automatically terminated.

7.4.2 Persistent binding

When you start a server, it discovers devices and assigns them SCSI target and logical unit number (LUN) IDs. It is possible for these SCSI assignments to change between restarts. Certain operating systems do not guarantee that devices are always allocated the same SCSI target ID after restarting the server. Also, certain software depends on this association, so you do not want it to change. Persistent binding addresses the issue of SCSI ID assignment.

Persistent binding is an HBA function that allows a subset of discovered targets to be bound between a server and device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive’s worldwide name (WWN) to be bound to a specific SCSI target ID.

After a configuration has been set, it survives restarts and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive, because the WWNN for the drive is location-dependent

within the library. Because the WWNN does not change, persistent binding does not need to be changed, which causes an outage.

You can find additional information about persistent binding in *Implementing IBM Tape in UNIX Systems*, SG24-6502, and *Implementing IBM Tape in Linux and Windows*, SG24-6268.

7.5 LTO data cartridges

When processing the Ultrium Tape Cartridge, the Ultrium Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time, and the Ultrium 4 tape drive writes data on 896 tracks. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the cartridge is full, or until all data is written. Refer to 2.1.4, “Tape cartridge” on page 43 for more details.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB and 800 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

The native data capacity of Ultrium data cartridges is listed in Table 7-1.

Table 7-1 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

7.5.1 Cartridge compatibility

Table 7-2 shows the compatibility matrix among the four types of Ultrium cartridges.

Table 7-2 Ultrium data cartridge compatibility

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

Capacity scaling

To control the capacity of the cartridge (for example, to obtain a faster seek time), issue the SCSI command SET CAPACITY. For information about this command, refer to the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference*, GA32-0450-01.

7.5.2 Write Once Read Many (WORM)

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a new WORM feature is available on IBM LTO Ultrium generation 3 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

WORM media

A specially formatted WORM tape cartridge is required, because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

Data security on WORM media

Certain built-in security measures help ensure that the data written on a WORM cartridge does not become compromised, for example:

- ▶ The format of an IBM Ultrium 3 and Ultrium 4 400 GB and 800 GB WORM Tape Cartridge is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.
- ▶ When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

7.5.3 Cleaning cartridge

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge cleans the drive in your library. One cleaning cartridge is shipped with the TS2900.

The TS2900 Tape Autoloader supports automatic cleaning, host-based cleaning, and manual cleaning. The library can also be configured for dedicated cleaning cartridge slots, which is achieved by reducing the number of active slots, whereby reserved slots and active slots are equal to the number of the total slots. A reserved slot is not accessible to any host application. In fact, the host has no knowledge that the slot even exists. Any reserved slot can be used to hold a cleaning cartridge. A reserved slot that contains a cleaning cartridge is referred to as a *dedicated cleaning slot*. The dedicated cleaning slots can be used for automatic cleaning and for manual cleaning. Host-based cleaning requires that the cleaning cartridge is located in a host accessible storage slot. The dedicated cleaning slots can be used by either logical library in a partitioned library. To remove a cleaning cartridge, export it from the library.

The IBM Cleaning Cartridges are valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

7.5.4 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape

(such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use.

The LTO-CM also helps determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4.

For additional details related to the LTO-CM, refer to "Cartridge memory (LTO-CM)" on page 46.

7.6 TS2900 Tape Autoloader setup

After unpacking and installing the TS2900, you must perform a few steps to connect it to a host. We describe these steps in the following section.

We provide hints and tips to make it easier for you to set up the TS2900. For a detailed description, follow the *IBM System Storage TS2900 Tape Autoloader Setup, Operator, and Service Guide*, GC27-2212.

The TS2900 Tape Autoloader is a Client Setup Unit (CSU) and will not be installed and tested by an IBM Service Support Representative (SSR). We describe:

- ▶ TS2900 Tape Autoloader initial setup
- ▶ TS2900 Library modes
- ▶ User Privilege Comparison
- ▶ Web User Interface
- ▶ Network configuration
- ▶ Encryption setting
- ▶ Setting up e-mail and Single Network Management Protocol (SNMP)
- ▶ Updating the drive and library firmware

7.6.1 TS2900 Tape Autoloader initial setup

The TS2900 Tape Autoloader can be configured and monitored remotely, and also, the update of the firmware of the library and the drive can be done remotely. These can be accomplished using the Web Interface via the Ethernet connection to access the TS2900. You configure the initial setup from the Operator Panel, which is:

- ▶ Configure Dynamic Host Configuration Protocol (DHCP): Set DHCP address for IPv4.
- ▶ Network Address: Set IP Address for IPv4.
- ▶ Library mode: **Random**

Making a direct connection to the TS2900 might require a crossover Ethernet cable. In the initial setup, you must specify which library operation mode has to be selected.

7.6.2 TS2900 Library modes

In the next section, we describe the two library modes available on the TS2900 Tape Autoloader. Figure 7-7 on page 170 shows you the Library Mode menu tree.

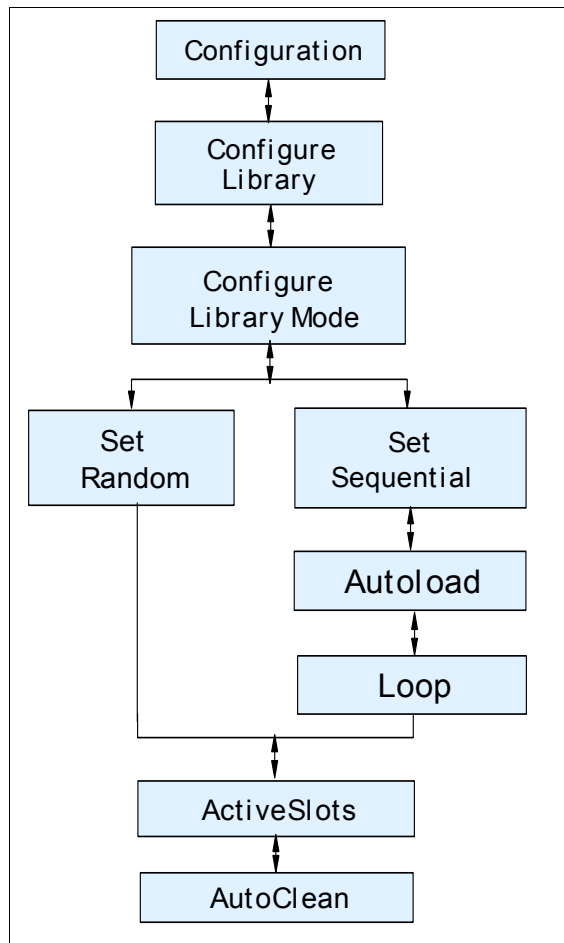


Figure 7-7 Configure: Library Settings

You can select the Library Mode from the operator mode. Use **Configuration** → **Configure Autoloader** → **Configure Loader Mode** to set the loader access mode in your TS2900. Two loader modes are available for the TS2900:

- ▶ In *Random* mode, the library allows the server's (host's) application software to select any data cartridge in any order. It is the server's responsibility to move the cartridges between the I/O station, storage slots, and tape drives. The application must execute an **audit** Tivoli Storage Manager command to get the inventory from the TS2900 so that the application is aware of the location of the data cartridges.
- ▶ In *Sequential* mode, the library firmware predefines the selection of the cartridges. After initialization, the firmware causes the library to select the first available cartridge found (counting from 1 through 9) for loading into the drive. In Figure 7-8 on page 172, you find the tree structure of the Library mode menu. In combination with Sequential mode, you can turn on two additional modes: autoload and loop.

The way in which Sequential Mode works depends on the autoload and loop settings, and they are:

- *Autoload*: Autoload mode is set to either ON or OFF:
 - If the autoload option is set to **ON**, the accessor loads the first cartridge (cartridge located in the slot with the lowest numeric value) found in the storage inventory area into the drive when the library powers on. If the library powers on with a cartridge already in the drive, sequential mode starts with that cartridge unless the

host issues a rewind and unload command to the drive. In that case, the next cartridge in sequence will be loaded into the drive.

- If the autoloader option is set to **OFF**, sequential mode is started by selecting the **Move Cartridge** command to load the first cartridge into the drive. The sequence then starts with the cartridge loaded into the drive. For example, if a cartridge from the fifth lowest numeric storage slot containing a cartridge is loaded using the **Move Cartridge** command, after the host issues a rewind/unload command, the next cartridge loaded is the cartridge from the next higher numeric slot. Cartridges do not need to be in contiguous slots.
- *Loop*: Sequential mode with Loop mode **ON** loads the cartridge in the lowest numerical slot after the cartridge in the highest numerical slot has been filled and sent back to its home slot. The accessor will immediately start loading the first cartridge into the drive when the last cartridge (cartridge in the highest numeric slot) is unloaded and placed back into storage. This mode allows endless backup operations without user interaction.

Sequential mode is stopped when a cartridge is removed from the drive using the **Move Cartridge** command. The next sequential cartridge is not loaded. To restart sequential mode, use the **Move Cartridge** command to load a cartridge. The loading sequence will resume from that numeric slot in the cartridge inventory. The number of active slots in the library determines the number of slots that the library will access before repeating each loop and the number of reserved cartridge slots.

You also define the number of *Active Slots* that you want to assign in your library. Slots can be reserved so that they are invisible to the host. It might be necessary to set the number of active slots in order to match the number of available slots to the Independent Software Vendor (ISV) software licensing.

Note: When the TS2900 Tape Autoloader is connected to a System i host, you must IPL the input/output adapter (IOA); otherwise, the System i host will not recognize the new mode. First, investigate if there are more IOAs under the input/output processor (IOP). When for example, a disk adapter is under the same IOP, this IOA will also be IPLed.

You can connect the library to the host after setting up the library mode. Only SAS host connection is available with SCSI protocol.

7.6.3 User privilege comparison

You can manually assign user privilege levels to the user accounts created within the library. User privilege levels permit you to control the access to the panels and operations within the library, preserving the integrity of the library and the data stored in it.

There are four types of user privileges in the library that you can use:

Users	This user is allowed to monitor the library but not to perform actions that affect the physical library.
Superusers	This user has authority to operate the physical and logical library but not to perform actions that affect the library configuration.
Administrator	This user has access to the physical and logical libraries, including configuration. One (limit of one) administrator user must be assigned the login name <i>admin</i> .

Service This user allows access to the entire physical and logical library. In addition, the Service user can access diagnostic tools to help identify and resolve library and drive problems.

Multiple users can be logged in the TS2900 at the same time through the Web User Interface.

7.6.4 Web User Interface

There are two ways to configure the TS2900 using the Operator Panel and the Web User Interface. We strongly recommend that you configure, manage, and control the TS2900 by using the Web User Interface. In order to use the Web User Interface, you need to set the Internet Protocol (IP) address of the TS2900 from the Operator Panel. Also, refer to 7.6.1, “TS2900 Tape Autoloader initial setup” on page 169 for more information.

To configure the TS2900, perform these steps using the Operator Panel:

1. Power on the TS2900 and wait until the hardware and software are initialized and the inventory is finished. This process takes a few minutes. The login window is displayed when the inventory is complete. Figure 7-8 shows the login window of the Operator Panel.

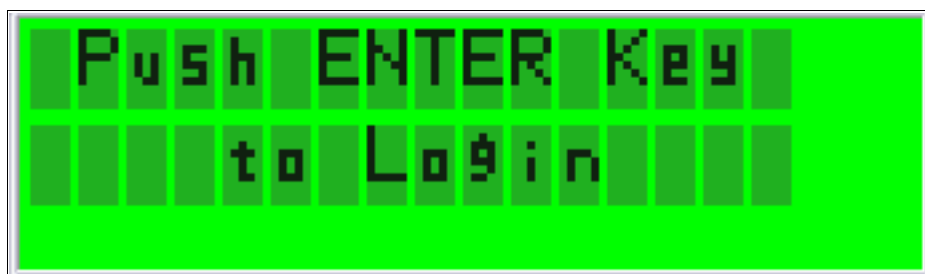


Figure 7-8 TS2900 Tape Autoloader login panel

2. To log in, press Enter to display the User Login password panel. Figure 7-9 shows the login password panel.



Figure 7-9 TS2900 Tape Autoloader Login password panel

3. Enter the 4-character password for the TS2900. The factory password is 0000. The password can be changed in the configuration menu. When the password is entered successfully, the Operator Panel displays the first available option, that is, *Unlock Magazine*. Refer to Figure 7-10 on page 173.



Figure 7-10 TS2900 Tape Autoloader Unlock Magazine panel

4. You are now logged in to the TS2900. Proceed with the IP configuration through the next options until the panel shows you *Configuration*. Refer to Figure 7-11.

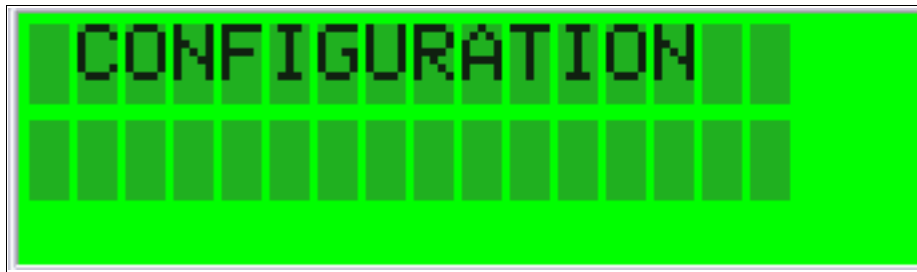


Figure 7-11 TS2900 Tape Autoloader Configuration panel

5. You can now start to configure the IP addresses, selecting **Configuration** → **Configure Network Settings**. In the Network Settings panel, configure the IP address for the TS2900 and one of the following settings:
 - Configure Link Speed
 - Configure Dynamic Host Configuration Protocol (DHCP)
 - Change IP Address
 - Change Subnet Mask
 - Change Gateway
 - Configure Time Server
6. The TS2900 can now be remotely controlled from any server in the network using the Web User Interface. However, there are prerequisites from a server point of view. The Web UI Java Applet, which is running on the TS2900, requires Java 1.5.0 or higher for full functionality and is best viewed using Internet Explorer® 7.0 or higher. If your server does not have Java installed, or if you need to upgrade your installation, download the latest version of the Java Runtime Environment (JRE™) for your platform from:
<http://www.java.com>
 Follow the instructions provided to enable and configure the Java Runtime Environment for your browser.
7. When the JRE on your server is installed or upgraded, open your browser and enter the IP address of the TS2900.

Note: If you receive a warning message the first time that you connect to the TS2900 Tape Autoloader, this message is normal and does not indicate an error.

Figure 7-12 on page 174 shows the Java security warning message.



Figure 7-12 Java security warning message

8. Select **Always trust content from this publisher** to avoid this message in subsequent browser sessions, and click **Run**. After launching the Web User Interface, the login window is displayed. You will receive a panel as shown in Figure 7-13.

Figure 7-13 TS2900 Tape Autoloader Web UI login panel

Enter the Account and Password according to the User Privilege levels that were described in 7.6.3, “User privilege comparison” on page 171.

The factory default accounts and passwords are:

- Administrator User account is *admin*, and the password is *secure*.
- Service User account is *service*, and the password is *ser001*.

9. After you log in to the TS2900 using the Web User Interface, a Welcome page is displayed. Here, you see the summary status of the TS2900 Tape Autoloader, the accessor status, drive status, firmware level, and the serial number. Figure 7-14 on page 175 shows an example of the Web UI using the Administrator account.

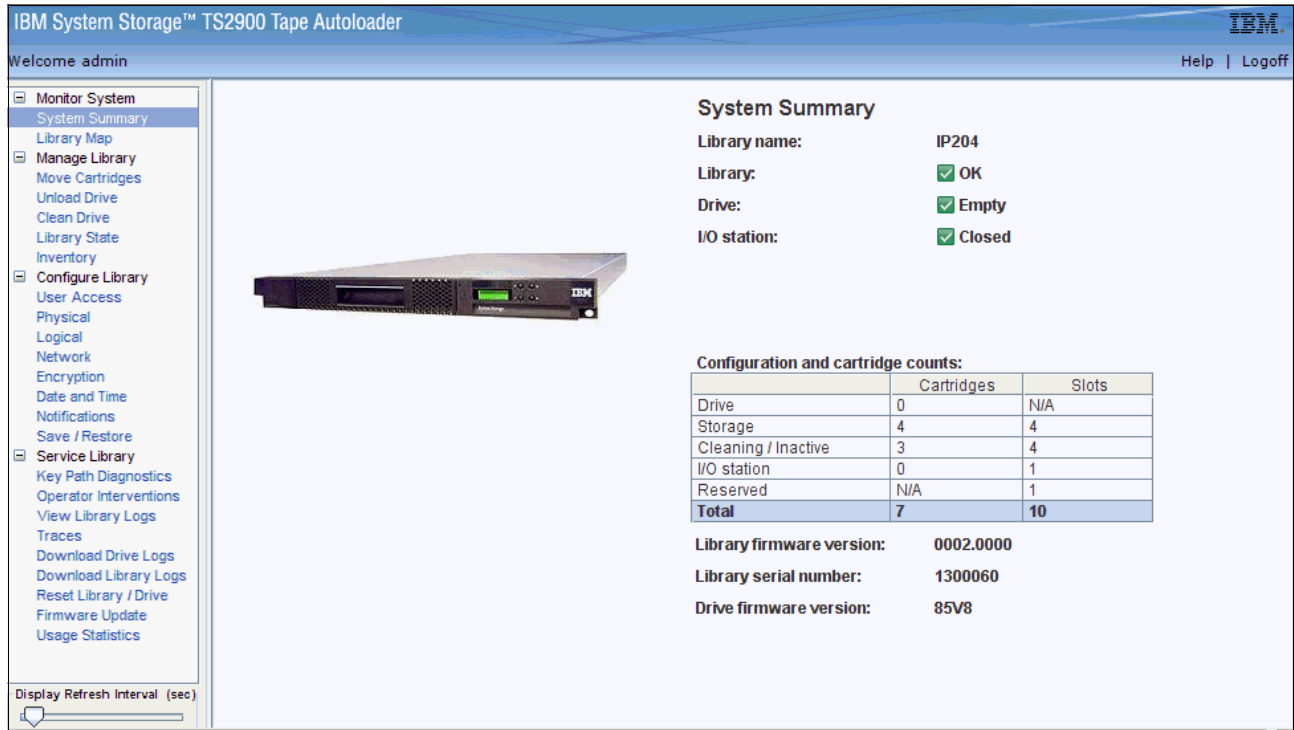


Figure 7-14 TS2900 Tape Autoloader administrator welcome page

In the next section, we continue to configure the TS2900 Network Interface and describe how to set up data encryption. For a complete overview of all the configuration settings, refer to the *IBM System Storage TS2900 Tape Autoloader Setup, Operator, and Service Guide*, GC27-2212.

7.6.5 Network configuration

In this section, we show you the network configuration panel. In this panel, you can select two types of transportation protocols, *IPv4* and *IPv6*, or both of them in a Dual Stack configuration *IPv4 + IPv6*.

If you want to set network settings, use **Configure Library** → **Network** from the Web User Interface. Figure 7-15 on page 176 shows you the Network Configuration panel viewed from the Web User Interface.

IBM System Storage™ TS2900 Tape Autoloader

Welcome admin

Help | Logoff

Network

Refresh

Ethernet Link speed: Auto

TCP/IP Settings

Security: ☐ Enable SSL for Web

IPv4 setting: ☒ Use IPv4
☐ Obtain an IP address automatically (DHCP)
☒ Use static IP address

IPv4 address: 9.11.219.204

Subnet mask: 255.255.255.0

Gateway: 9.11.219.1

IPv6 setting: ☐ Use IPv6
☒ Obtain an IP address automatically (DHCP)
☒ Obtain an IP address automatically (Stateless Auto Config)
☐ Use static IP address

IPv6 address: 2002:90B:E002:219:9:11:219:204

Prefix length (0-128): 64

Gateway: 2002:90B:E002:219:0:0:0:1

DNS server IP address: 0.0.0.0

Submit

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Figure 7-15 TS2900 Tape Autoloader network configuration panel

Note: The Internet protocols selected are used for the TS2900 Tape Autoloader IP address, subnet mask, gateway address, time server address, mail server address, SNMP trap to address, and Encryption Key Manager (EKM) server addresses.

Configure the network using the following settings:

Link speed	Ethernet duplex mode (Auto, 10Base-T Full, 10Base-T Half, 100Base-TX Full, and 100Base-TX Half).
TCP/IP settings	IPv4, IPv6, and Dual Stack IPv4 + IPv6 are supported.
Security	Select Enable SSL for Web to provide secure communications between the Web browser and the tape library.
IPv4 setting	Select Use IPv4 to enable the IPv4 Internet Protocol. Select the corresponding radio button to obtain an IP address automatically (DHCP) or use static IP address settings. Enter the following parameters if using static IP address settings:
IPv4 address	Sets the TCP/IPv4 address of the library on the network.
Subnet mask	Defines and limits users within a local network.
Gateway	Allows access outside the local network.
IPv6 setting	Select Use IPv6 to enable the IPv6 Internet Protocol. Select the corresponding radio button to obtain an IP address automatically (DHCP), to obtain an IP address using stateless auto-configuration, or to use static IP address settings. Enter the following parameter if using static IP address settings:
IPv6 address	Sets the TCP/IPv6 address of the library on the network.

Prefix Length	Decimal value indicating the number of contiguous, high-order bits comprising the network portion of the address.
Gateway	Allows access outside the local network.
DNS server IP address	Sets the IP address of the DNS server. The DNS server, if entered, allows the encryption, date and time, and notification IP addresses to be specified using hostnames instead of numerical IP addresses.

Click **Submit** to transfer the settings to the library. A dialog message is displayed when the settings have been updated successfully.

Click **Refresh** to read the current settings from the library.

7.6.6 Encryption setting

In this section, we give an overview of the steps needed to set up the tape encryption in the library.

Note: The optional Transparent Encryption Key feature enabling SME and Library-Managed Encryption (LME) is not available on a TS2900 Tape Autoloader purchased through High Volume channels.

TS2900 Tape Autoloader uses TCIP/IP to communicate with the server where the EKM is installed. The TS2900 supports up to two key manager addresses, where each key manager is specified using the IP address and port number of a server that has the EKM installed. The EKM is supported on z/OS, i5/OS, AIX, Linux, HP-UX, Sun Solaris, and Windows. The IBM EKM can be downloaded from this Web site:

<http://www-1.ibm.com/support/docview.wss?uid=ssg1S4000504>

Encryption policy is used for TS2900 to set up encryption when Library-Managed Encryption is selected. *Encryption policy* is a set of rules, or policies, that specify which data cartridges are to be encrypted. How and where these rules are set up depends on the operating environment.

To set up encryption on your TS2900 Tape Autoloader, follow these steps:

1. Go to the Welcome page of the TS2900 using the Web Interface and select **Configure Library** → **Encryption** to configure an encryption method for data being stored on tape cartridges. The panel in Figure 7-16 on page 178 shows you the Encryption menu.

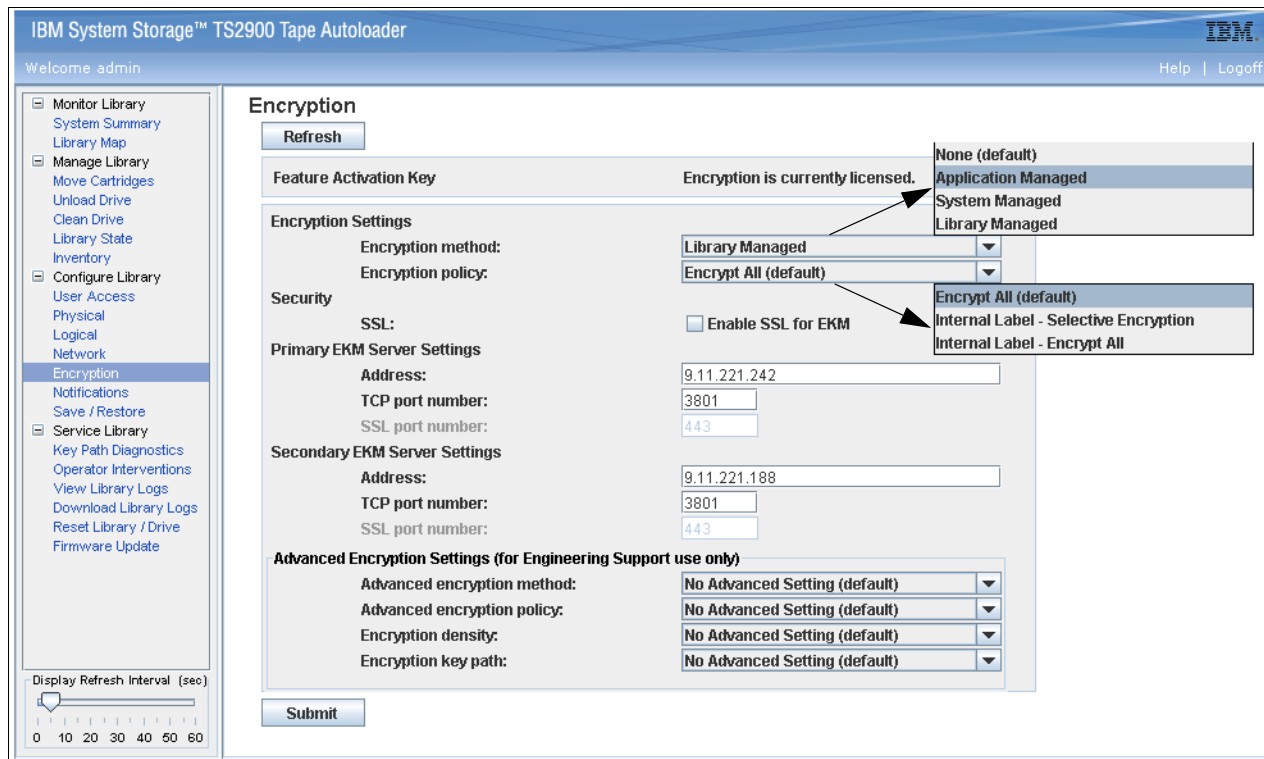


Figure 7-16 Encryption menu for TS2900 Tape Autoloader

You can specify the encryption method that you want to use. Select the **Encryption Method** pull-down menu from the Encryption panel. You have four options:

None No encryption is used.

Application-Managed Encryption

This option is used for encryption in operating environments that run an application capable of generating and managing encryption policies and keys. If you select Application-Managed Encryption, no further configuration steps are necessary.

System-Managed Encryption

This option is used for encryption in operating environments where no application is capable of key management runs. Encryption is set up implicitly through each instance of the IBM device driver.

Library-Managed Encryption

This option is used for transparent encryption by the TS2900 Tape Drive.

Note: SME and LME are transparent. A data cartridge using SME can be decrypted using LME, and a data cartridge using LME can be decrypted using SME, provided both methods have access to the same EKM keystore.

- The next step shows you how to configure the Encryption Policy. From the Welcome Page, specify **Encryption**, and then, select **Encryption Policy**. Refer to Figure 7-17 on page 179.

Three encryption policy options are available:

Encrypt All Encrypt All is the default setting. All data cartridges within the logical partition loaded into the tape drive are encrypted.

Internal Label - Selective Encryption

This option is used only for Symantec Veritas NetBackup.

Internal Label - Encrypt All

This option is used only for Symantec Veritas NetBackup.

There is also an Engineering Use Only option available. As the name implies, this option is only for IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. These options are not intended for use by the client without the guidance of IBM Support.

Select **Encrypt All** and click **Submit**.

3. The next step allows you to configure the EKM Server Setting. From the Welcome Page of the TS2900, select **Encryption**. Refer to Figure 7-17.

IBM System Storage™ TS2900 Tape Autoloader

Welcome admin

Help | Logoff

Encryption

Refresh

Feature Activation Key: Encryption is currently licensed.

Encryption Settings

Encryption method: Library Managed

Encryption policy: Encrypt All (default)

Security

SSL: ☒ Enable SSL for EKM

Primary EKM Server Settings

Address: 9.11.221.242

TCP port number: 3801

SSL port number: 443

Secondary EKM Server Settings

Address: 9.11.221.188

TCP port number: 3801

SSL port number: 443

Advanced Encryption Settings (for Engineering Support use only)

Advanced encryption method: No Advanced Setting (default)

Advanced encryption policy: No Advanced Setting (default)

Encryption density: No Advanced Setting (default)

Encryption key path: No Advanced Setting (default)

Submit

Display Refresh Interval (sec): 0 10 20 30 40 50 60

Figure 7-17 The EKM setting

In our example, we used 9.11.221.242 for the primary EKM IP address and 9.11.221.188 for the second EKM IP address. The TCP port number to access the EKM console is 3801. You can select Secure Socket Layer (SSL) for a secure access to the EKM by checking **Enable SSL for EKM**. You can see in Figure 7-17 that the port number is 443 when you enable SSL for the EKM console.

To see if a data cartridge is encrypted, use the option **Library Map** from the Welcome page and click the cartridge that is inserted in the partition that has encryption enabled. In our example, the cartridge in the drive is encrypted. Refer to Figure 7-18 on page 180.



Figure 7-18 Library Map graphical view

7.6.7 Notification

There are still a few settings to be configured before connecting the TS2900 Tape Autoloader to the host. You can change the settings by using the Operator Panel or using the Web User Interface. From the Welcome page for the TS2900, select **Notifications**. Two options are available for sending notifications to the host:

SMTP

This feature, Simple Mail Transfer Protocol (SMTP), automatically sends an e-mail containing event information to the e-mail addresses specified whenever an event of a certain level occurs. The contents of the e-mail message are similar to the information that can be obtained by Single Network Management Protocol (SNMP) traps without using SNMP management software.

SNMP

This is a set of protocols for managing complex networks. SNMP works by sending messages called *protocol data units (PDUs)* to various parts of a network. Agents, which are SNMP-compliant devices, store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

SNMP traps are alerts or status messages that can be collected, monitored, and used to proactively manage attached libraries using the SNMP protocol with the host servers. The tape library supports transmission of SNMP traps and collection of MIB information as an SNMP agent. SNMP traps can be received using an SNMP manager, and MIB information can be collected using an MIB browser.

Figure 7-19 on page 181 shows the SMTP mail Notifications setting window.

IBM System Storage™ TS2900 Tape Autoloader

Welcome admin

Help | Logoff

Monitor Library
System Summary
Library Map
Manage Library
Move Cartridges
Unload Drive
Clean Drive
Library State
Inventory
Configure Library
User Access
Physical
Logical
Network
Encryption
Notifications
Save / Restore
Service Library
Key Path Diagnostics
Operator Interventions
View Library Logs
Download Library Logs
Reset Library / Drive
Firmware Update

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Notifications

SMTP (Mail) Settings | SNMP Settings

Refresh

SMTP server address:

Sender address:

Subject:

Mail to:

01 ☒ Enable

02 ☐ Enable

03 ☐ Enable

04 ☐ Enable

Mail event:

☐ Error Events

☒ Error and Warning Events

☐ Error, Warning, and Information Events

Test

Submit

Figure 7-19 SMTP mail settings notification for the TS2900 Tape Autoloader

Figure 7-20 shows the SNMP Notifications setting window.

IBM System Storage™ TS2900 Tape Autoloader

Welcome admin

Help | Logoff

Monitor Library
System Summary
Library Map
Manage Library
Move Cartridges
Unload Drive
Clean Drive
Library State
Inventory
Configure Library
User Access
Physical
Logical
Network
Encryption
Notifications
Save / Restore
Service Library
Key Path Diagnostics
Operator Interventions
View Library Logs
Download Library Logs
Reset Library / Drive
Firmware Update

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Notifications

SMTP (Mail) Settings | SNMP Settings

Refresh

Community:

Name:

Location:

Contact:

SNMPv3 engine ID:

Trap event:

☐ Error Events

☒ Error and Warning Events

☐ Error, Warning, and Information Events

Test

Submit

Trap List

--- Select Action ---

Select	Validity	Address	Version	Community	Username
☐	Disable		v1	public	-----
☐	Disable		v1	public	-----
☐	Disable		v1	public	-----
☐	Disable		v1	public	-----

SNMPv3 User List

--- Select Action ---

Select	Validity	User Name	Authentication	Privacy
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable

Figure 7-20 SNMP notification setting window

7.6.8 Firmware upgrade

After setting up and configuring the TS2900 Tape Autoloader, we recommend that you verify that the latest firmware is installed for both the library and the tape drive. It is your responsibility to verify and maintain the firmware.

Determine the current level of firmware available from the IBM Technical Support Web sites:

<http://www.storage.ibm.com/>
<ftp://index.storsys.ibm.com>

If the installed firmware of your library or tape drive is down-level, download the firmware from the IBM Web site to your local server.

There are several options to update the firmware of the library or the tape drive. You can use the driver's application interface, for example, NTUTIL, the Web User Interface of the TS2900, or an IBM tool called IBM TotalStorage Tape Diagnostic Tool (ITDT). We recommend that you use the Web User Interface for updating the library or drive firmware.

ITDT can also be used for updating the firmware of the tape drive. This tool is driver independent and can also be used for testing the tape drives and taking drive dumps.

Note: Updating the library firmware is not supported.

The ITDT tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and it is available in two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

After updating the firmware, it is now time to populate your TS2900 Tape Autoloader with data cartridges and to connect your TS2900 to a host. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 497 for ordering data cartridges and the features.

7.6.9 SCSI Host Bus Adapter (HBA) support

For SCSI hosts, verify that the HBA of your server is supported. Check the IBM Interoperability Matrix, which will be made available at a later time at this Web site:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability>

Select **TS2900 Tape Autoloader**.

The library uses a single SCSI or Loop ID per drive and dual logical unit numbers (LUNs) to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires a host bus adapter (HBA) that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to discover the library. It will only see the tape drive.

Note: Certain HBAs, such as RAID controllers, do not support LUN scanning.

A drive with a SAS (Serial Attached SCSI) interface can be linked directly to controllers. SAS is a performance improvement over traditional SCSI, because SAS enables multiple devices (up to 128) of various sizes and types to be connected simultaneously with thinner and longer cables, and its full-duplex signal transmission supports 3.0 Gbps. Up to four Ultrium 3 or Ultrium 4 single port Half-High drives or two Ultrium 4 dual port drives can be attached. At the library end, the drive or port can be attached via a SFF-8088 cable to the interposer cable. In addition, SAS drives can be hot-plugged.

SAS drives will auto-negotiate speed. There are no configurable topologies, thus, no feature switches are associated with SAS. The SAS Ultrium 3 and Ultrium 4 Half-High drives are single-ported and can only be attached to one host. The Ultrium 3 and Ultrium 4 SAS drive uses the SFF-8088 connection at the drive end and SFF-8088 or SFF-8470 at the host adapter end. Initially, only point-to-point connections are supported.

7.6.10 Installing tape device drivers

To communicate with the TS2900 Tape Autoloader, the appropriate tape device driver must be installed on your server. Depending on your host operating system, the latest tape device driver must be installed on your server. Visit the Web site:

<http://www-03.ibm.com/servers/storage/tape/>

Select **Support & Download** and in the next window, you can type TS2900 in the search technical support box. Here, you can download the latest device driver for your operating system.

Another way to get the latest device driver is to visit this Web site:

<ftp://index.storsys.ibm.com/devdrv>

Choose your operating system and download the device driver.

We do not discuss installing the device driver in this publication. Information about how to install the device driver is described step-by-step in these books:

- ▶ *Implementing IBM Tape in Unix Systems*, SG24-6502
- ▶ *Implementing IBM Tape in Linux and Windows*, SG24-6268
- ▶ *IBM Tape Device Drivers Installation and Users Guide*, GA27-2130

All publications are available and can be downloaded from the Web.

You have now completed setting up your TS2900, installing your FC HBA, checking that your HBA is supported, and installing the correct device driver.

We recommend that you register yourself for My Support at the IBM Technical Support Web site. When you register at My Support, you will automatically receive an e-mail when there is new firmware available for the TS2900 or other news concerning the TS2900.

To register at My Support, go this Web site:

<https://www-304.ibm.com/usrsrvc/account/userservices/jsp/login.jsp?persistPage=true>

7.7 Technical specification

Next, we summarize all of the technical specifications of the TS2900 Tape Autoloader.

Physical specifications

The TS2900 is a small-sized tape drive with the following specifications:

Width	48.30 cm (19.01 in.)
Depth	85.0 cm (33.46 in.)
Height	4.4 cm (1.73 in.)
Weight	Library only 13 kg (28.66 lbs.)

Electrical specifications

The following values are for a TS2900:

- ▶ Voltage: 100 to 240 Vac
- ▶ Frequency: 50 to 60 Hz
- ▶ Power consumption: 110 W

7.8 Feature codes

Table 7-3 shows the available feature codes for the TS2900 Tape Autoloader.

Table 7-3 Feature codes

Description		Model	Feature code
3572 Rack Mount Option (FC7006) ^a	TS2900 Tape Autoloader with LTO3 HH SAS drive and with rack-mount kit	S3H	7006
	TS2900 Tape Autoloader with LTO4 HH SAS drive and with rack-mount kit	S4H	7006
	TS2900 Tape Autoloader with LTO 3 HH SAS drive and with rack-mount kit; Xcc/High Volume	S3H	7006 (SEO # 3572S3R)
	TS2900 Tape Autoloader with LTO4 HH SAS drive and with rack-mount kit; Xcc/High Volume	S4H	7006 (SEO # 3572S4R)

Description		Model	Feature code
3572 Desk-side Covers (FC7010) ^b	TS2900 Express Seller Tape Autoloader with LTO3 HH SAS drive and desktop covers	S3H	7010 (SEO # 3572S3E)
	TS2900 Express Seller Tape Autoloader w/LTO4 HH SAS drive & desktop covers	S4H	7010 (SEO # 3572S4E)
2 m (6.6 ft.) SAS/Mini-SAS 1x Cable (from HBA with SFF-8470 to drive with SFF-8088)		S4H/S3H	5402 (P/N 95P4711)
5.5 m (18 ft.) SAS/Mini-SAS 1x Cable (from HBA with SFF-8470 to drive with SFF-8088)		S4H/S3H	5406 (P/N 95P4712)
2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x Cable (from HBA/Interposer SFF-8088 to drive with SFF-8088)		S4H/S3H	5502 (P/N 95P4713)
5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x Cable (from HBA/Interposer SFF-8088 to drive with SFF-8088)		S4H/S3H	5506 (P/N 95P4714)
Transparent LTO Encryption		S4H	5901 (P/N 45E3797)
One Cleaning Cartridge		S4H/S3H	8002 (P/N 23R7008)
3572 Additional Magazine		S4H/S3H	8111 (P/N 45E3793)
Ultrium 3 Data Cart (5-pack)		S3H/S4H	8305 (P/N 95P2020)
Ultrium 4 Data Cartridges (5-pack)		S4H	8405 (P/N 95P4278)

- a. FC7006 applies to the models you see in the middle column of the table. For the High Volume Sellers, they use the SEO number when ordering the TS2900 Tape Autoloader with the rack-mountable kit.
- b. FC7010 applies to the models you see in the middle column of the table. For the High Volume Sellers, they use the SEO number when ordering the TS2900 Tape Autoloader with the rack-mountable kit.



IBM System Storage TS3100 Tape Library

The TS3100 Tape Library (Machine Type 3573, Model L2U) is a single or dual drive entry level desktop or a rack-mounted unit (requiring two rack units of an industry standard 19-inch rack) that can operate in random or sequential mode. The robotics inside the library move the cartridges to and from the tape drive, which permits unattended backup. Two removable magazines can store a total of 24 cartridges. A single dedicated mail slot (I/O station) is available for importing and exporting cartridges.

The following IBM Ultrium Tape Drives are available for the TS3100 Tape Library:

- ▶ The IBM Ultrium 4 Low Voltage Differential (LVD) Small Computer System Interface (SCSI) Tape Drive
- ▶ The IBM Ultrium 4 Fibre Channel (FC) Tape Drive
- ▶ The IBM Ultrium 4 Serial Attached SCSI (SAS) Tape Drive
- ▶ The IBM Ultrium 3 Half-High LVD SCSI Tape Drive
- ▶ The IBM Ultrium 3 Half-High SAS Tape Drive
- ▶ The IBM Ultrium 3 Full-High LVD SCSI Tape Drive
- ▶ The IBM Ultrium 3 Full-High FC Tape Drive

Up to two IBM Ultrium 3 or 4 Half-High Tape Drives or one IBM Ultrium 3 or 4 Full-High Tape Drive can be installed in the TS3100 Tape Library.

Tape Encryption is supported on the IBM Ultrium LTO4 Tape Drive with the SAS and Fibre Channel interface. The TS3100 supports Application-Managed Encryption (AME) and System-Managed Encryption (SME), as well as Library-Managed Encryption (LME). Refer to Feature code 5900, Transparent LTO Encryption.

The TS3100 Tape Library has four indicator Light Emitting Diodes (LEDs) and one Liquid Crystal Display (LCD) on the front. The LEDs can be used to indicate Ready/Activity, Use Cleaning Tape, Media Attention, and Error.

Standard features are a barcode reader and a remote management unit (RMU). We use the terms *RMU* and *Web interface* interchangeably throughout the following chapters.

In 2007, the TS3100 became Simple Network Management Protocol (SNMP)-capable.

8.1 Description

Designed for tape automation, the TS3100 Tape Library can be attached to IBM System i or i5, iSeries, AS/400, IBM System p or p5, pSeries, RS/6000, IBM z or z9, xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers. To determine the latest supported servers, visit the Web at:

<http://www-03.ibm.com/systems/storage/tape/>

The IBM Ultrium 4 LTO Tape Drive with an FC or a SAS interface is encryption-capable. The IBM LTO4 Tape Drive supports AME, SME, and LME. The TS3100 supported encryption methods are AME, SME, and LME.

Depending on what IBM Ultrium Tape Drive is installed in the TS3100 Tape Library, the following data cartridges can be used:

- ▶ The TS3100 Tape Library uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge or the 400 GB WORM cartridge when the IBM Ultrium 3 Tape Drive is installed. The Ultrium 3 Tape Drive has the capability of writing up to 400 GB native capacity and up to 800 GB with 2:1 compression. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and read LTO1 Data Cartridges.
- ▶ The TS3100 Tape Library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge or 800 GB WORM Cartridge when the IBM Ultrium 4 Tape Drive is installed. The Ultrium 4 Tape Drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with 2:1 compression. IBM Ultrium 4 Tape Drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and does not support Ultrium 1 Data Cartridges.

The library capacity is 24 tape cartridges, providing a media capacity of up to 9.6 TB (19.2 TB with 2:1 compression) data storage per TS3100. Refer to Table 8-1 for additional information.

Table 8-1 Library storage capacity and data transfer rate

Characteristics	2U library specification
Maximum storage capacity: Ultrium 4 Data Cartridges	▶ 24 data cartridges ▶ Native: 19.2 TB ▶ Compressed: 38.4 TB (2:1 compression)
Maximum storage capacity: Ultrium 3 Data Cartridges	▶ 24 data cartridges ▶ Native: 9.6 TB ▶ Compressed: 19.2 TB (2:1 compression)
Maximum data transfer rate	▶ Native: 80 MB/s (288 GB/hr.) ▶ Compressed: 160 MB/s (576 GB/hr.) (2:1 compression)

Depending on the way that the TS3100 is ordered, you specify the required drives through feature codes or through the model number. For the IBM 3573-L2u, you can use these drive feature codes:

FC8043	Ultrium 3 LVD SCSI Tape Drive Sled
FC8044	Ultrium 3 4 Gbps Fibre Channel Tape Drive Sled
FC8046	Ultrium 3 Half-High SCSI Tape Drive Sled
FC8047	Ultrium 3 Half-High SAS Tape Drive Sled
FC8143	Ultrium 4 SCSI Tape Drive Sled
FC8144	Ultrium 4 Fibre Tape Drive Sled

FC8145	Ultrium 4 SAS Tape Drive Sled
FC8147	Ultrium 4 Half-High SAS Tape Drive Sled

Via type-model-feature (TMF) through System x order entry, seven models are available for the TS3100 Tape Library:

- ▶ The *3573-L4S* comes with an IBM Ultrium 4 LVD SCSI Tape Drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI interface that can be connected to LVD fast/wide adapters. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3573-F4S* comes with an Ultrium 4 Tape Drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3573-S4S* comes with a SAS Ultrium 4 Tape Drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The SAS Ultrium 4 Tape Drive comes with an SFF-8088 interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3573-L32* comes with a Half-High Ultrium 3 LVD SCSI Tape Drive. The Ultrium 3 LVD SCSI Tape Drive has an LVD Ultra 160 SCSI interface. The Half-High Ultrium 3 Tape Drive provides a sustained native data transfer rate of 60 MB/s.
- ▶ The *3573-S32* comes with a Half-High Ultrium 3 SAS Tape Drive. The Half-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 60 MB/s.
- ▶ The *3573-F3S* comes with a Full-High Ultrium 3 native switched 4 Gbps Fibre Channel Tape Drive. The Full-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 80 MB/s.
- ▶ The *3573-L3S* comes with a Full-High Ultrium 3 LVD SCSI Tape Drive. The Full-High Ultrium 3 Tape Drive has a maximum native data transfer rate of up to 80 MB/s.

Figure 8-1 shows the front view of the TS3100 Tape Library. On the left and right sides, you see the cartridge magazines. The I/O slot is accessible from the lower left.



Figure 8-1 IBM System Storage TS3100 Tape Library

8.2 Components

The IBM TS3100 Tape Library has an improved robotic system that moves along an axis from front to back between the two cartridge magazines. This limited movement provides robust robotics. The standard barcode reader is installed on the picker.

Figure 8-2 on page 191 shows the top view of the TS3100 Tape Library. The right side of the image is the rear of the library and the left side is the front of the TS3100 Tape Library. The TS3100 Tape Library is a modular system, allowing the client to change parts easily.

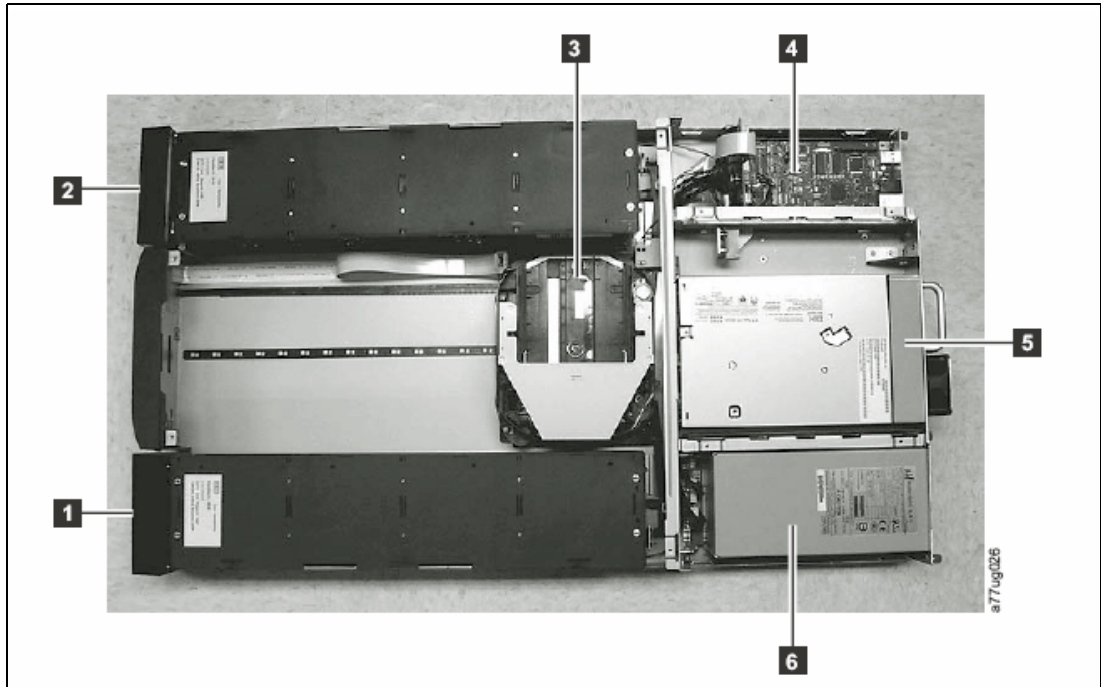


Figure 8-2 Internal top view of the tape library

The components shown in Figure 8-2 are:

- 1. Right cartridge magazine:** This magazine can hold up to twelve cartridges.
- 2. Left cartridge magazine:** This magazine can hold up to 12 cartridges and houses the I/O station.
- 3. Accessor:** This component contains the library robot and the barcode reader. The accessor moves cartridges to and from the:
 - I/O station
 - Storage slots
 - Tape drive
- 4. Library control card:** This component is a client-replaceable unit (CRU) and stores the user configuration information or vital product data (VPD). The RMU is embedded in this card.
- 5. Tape drive sled:** This library supports the Ultrium 3 or Ultrium 4 tape drive. The tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a CRU, and it is designed for easy removal and replacement.
- 6. Power supply:** The power supply is a CRU. No redundant power is available.

8.2.1 Operator Control Panel

The library is equipped with an Operator Control Panel (OCP). By means of the OCP, a user can perform simple actions with the medium changer. The OCP interface allows a user to monitor the medium changer operation, make configuration changes, and perform media access commands. For an extensive description of the OCP functions, refer to the OCP specification in *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide*, GA35-0545.

Note: When a user executes a medium access command through the OCP interface, the medium changer will enter the off-line state. When the medium changer is off-line, the medium changer will report Not Ready on the SCSI bus.

8.2.2 Robotics

The IBM TS3100 Tape Library uses a new independent tape loader, threader motors, and a positive pin retention. These features are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to thread the tape with a higher level of reliability.

8.2.3 Barcode reader

The barcode reader is an integral part of the library accessor, and it does not affect the slot capacity. The barcode reader provides inventory feedback to the host application, Operator Control Panel display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory.

8.2.4 Remote management

The Remote Management Unit (RMU) provides remote management to the library over a network. This function is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. The Ethernet connection is located on the back of the library.

When the IP address is set on the library using the Operator Control Panel (OCP), the library can be monitored and controlled remotely. Entering the IP address in a browser opens a graphical representation of the library. Service actions, such as upgrading the library and drive firmware, can be done by using the remote management facility. Figure 8-3 on page 193 shows the home page of the Web User Interface.

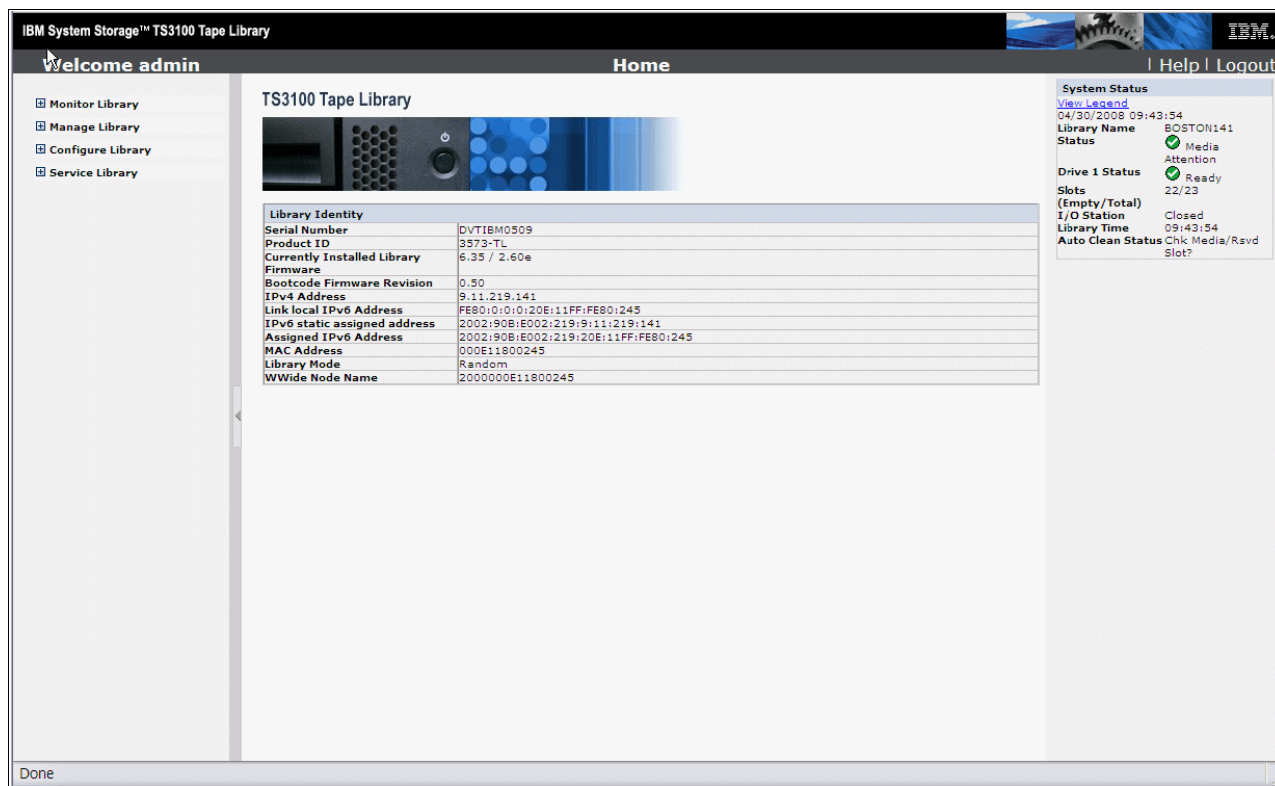


Figure 8-3 Welcome window of the Web User Interface

8.3 Cartridge storage

The IBM TS3100 Tape Library has two removable magazines in the library. The total number of cartridges is 24. The right cartridge magazine and the left cartridge magazine can hold up to 12 cartridges per magazine.

The native maximum storage capacity is 19.2 TB with the IBM Ultrium 4 Tape Drive and 9.6 TB with the IBM Ultrium 3 Tape Drive installed. The Input/Output station (or “mail slot”) is part of the left magazine. The magazines can be released using the Operator Panel or the Web User Interface. Magazine access is password-protected.

Figure 8-4 on page 194 shows the right magazine.

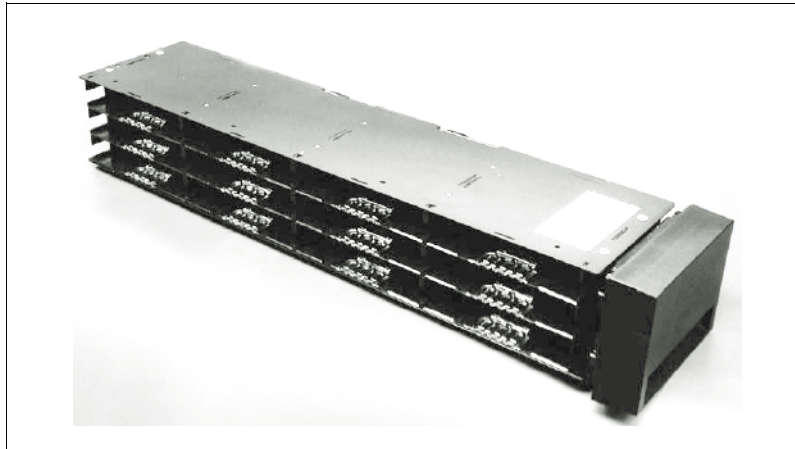


Figure 8-4 Right magazine

When the magazines are filled with cartridges, you can use the Web User Interface to see which cartridges are stored in which storage slot location as demonstrated in Figure 8-5.

IBM System Storage™ TS3100 Tape Library

Welcome admin Home | Help | Logout

[Refresh](#) Last Refresh: Wednesday, April 30, 2008 09:48 (Library Time)

Inventory Status

Drive inventory

Drive	Status	Label	Source
1	Empty	-----	

Left Magazine - Slot inventory

8	9	10	11	Left Magazine
4	5	6	7	
I/O Station	1	2	3	

☐ Cartridge details for Left Magazine

Right Magazine - Slot inventory

23	22	21	20	Right Magazine
19	18	17	16	
15	14	13	12	

☐ Cartridge details for Right Magazine

Slot #	Attn	Status	In Drive	Label	Media Loads	Comment
12		Empty		-----		
13		Empty		-----		
14		Empty		-----		
15		Empty		-----		
16		Empty		-----		
17		Empty		-----		
18		Empty		-----		
19		Empty		-----		
20		Empty		-----		
21		Empty		-----		
22		Empty		-----		
23		Empty		-----		

System Status

[View Legend](#)

04/30/2008 09:48:12

Library Name: BOSTON141

Status: ☒ Media ☒ Attention

Drive 1 Status: ☒ Ready

Slots (Empty/Total): 22/23

I/O Station: Closed

Library Time: 09:48:12

Auto Clean Status: Chk Media/Rsvd Slot?

Done

Figure 8-5 Inventory of the right magazine using the Web User Interface

Part of the left magazine is the I/O station. You can use the Web User Interface to show an inventory of the magazine as shown in Figure 8-6 on page 195.

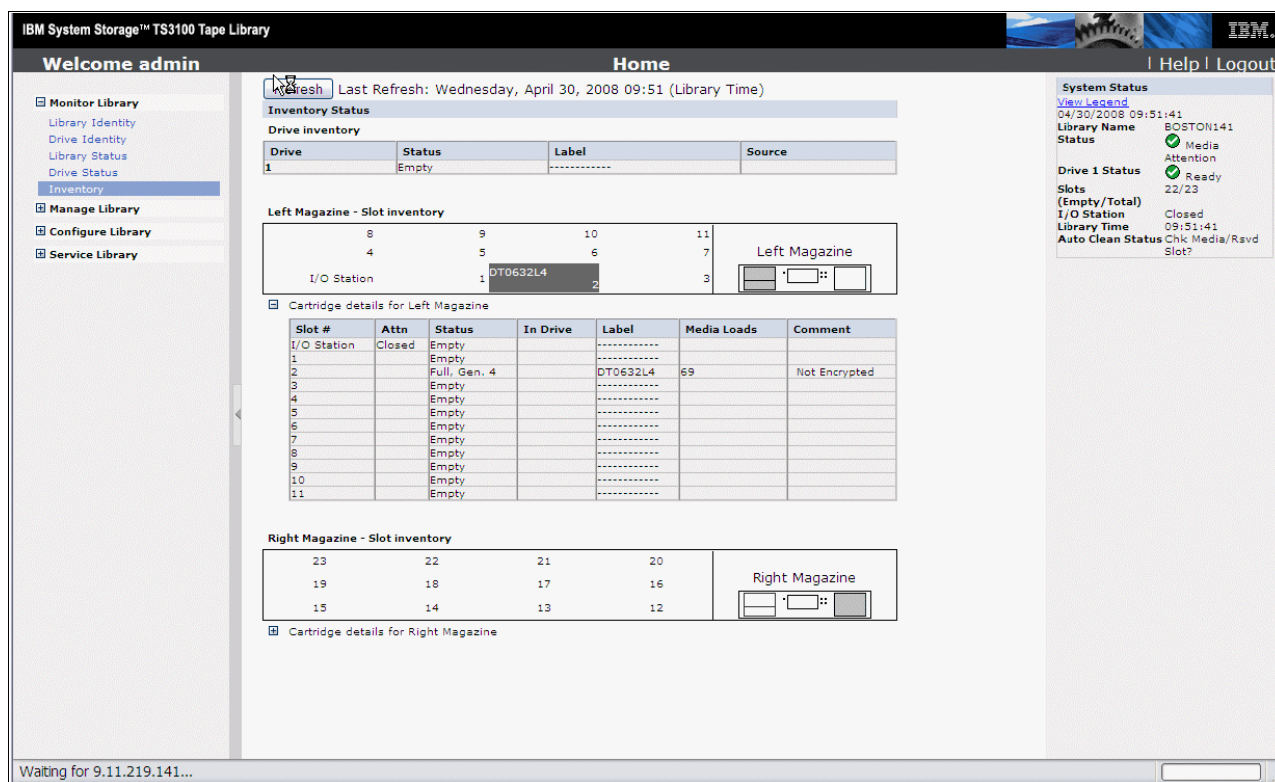


Figure 8-6 Inventory of the left magazine using the Web User Interface

Figure 8-7 shows the left magazine with the I/O station on the left side.

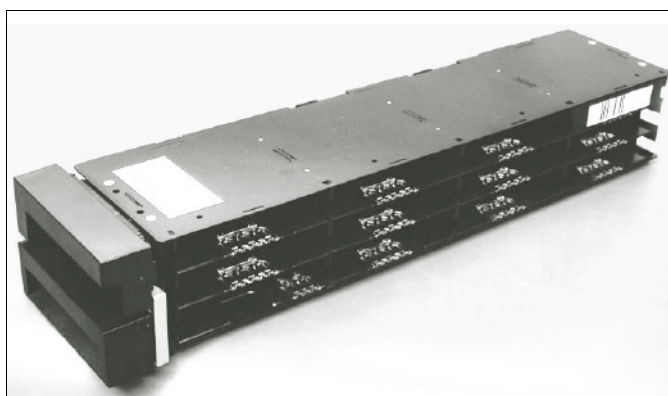


Figure 8-7 Left magazine

The I/O station is part of the left magazine. In Figure 8-8 on page 196, you can see the left magazine with the I/O slot opened. You can open the I/O station using the OCP or the Control Menu from the Web User Interface. Magazine access is password-protected.

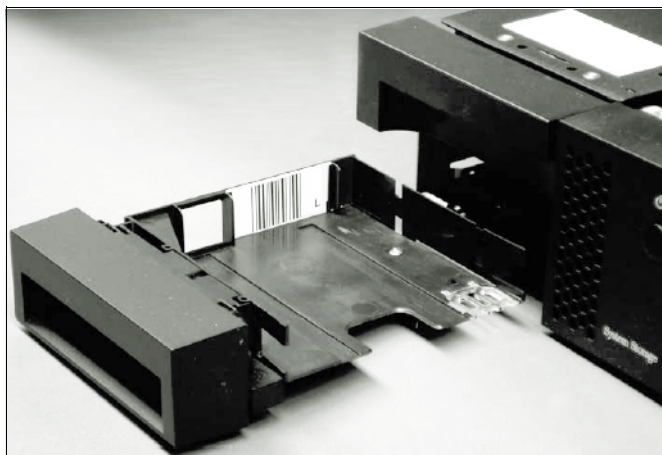


Figure 8-8 I/O station in the left magazine

8.4 LTO Ultrium Tape Drives

This library supports the Ultrium 3 and Ultrium 4 Tape Drives. Each tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a client-replaceable unit (CRU) and is designed for quick removal and replacement in the library. In the following section, we summarize the characteristics of the LTO4 and LTO3 Full-High and Half-High Tape Drives.

The Ultrium 4 Full-High Tape Drive supports:

- ▶ LVD Ultra160 with two HD68 connectors
- ▶ Serial Attached SCSI (SAS) with two SFF-8088 SAS connectors
- ▶ Fibre Channel interfaces with one LC Fibre Channel connector

The Ultrium 4 Half-High Tape Drive supports only one SAS SFF-8088 connector.

The Ultrium 3 Full-High Tape Drive supports:

- ▶ LVD Ultra160 with two HD68 connectors
- ▶ Fibre Channel interfaces with one LC Fibre Channel connector

The Ultrium 3 Half-High Drive supports:

- ▶ Serial Attached SCSI (SAS) with one SFF-8088 SAS connector
- ▶ LVD Ultra160 with two HD68 connectors

For additional details about LTO4 and LTO4 Tape Drives, refer to Chapter 2, “Overview of IBM LTO Ultrium Tape Drives” on page 29.

8.4.1 IBM Ultrium LTO4 Tape Drive

Each IBM Ultrium 4 Tape Drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. Because of its special design as a CRU, the drive can easily be replaced if necessary. Figure 8-9 on page 197 shows the Ultrium 4 drive sled with a SCSI interface. The same drive sled can also contain the 4 Gbps Fibre Channel drive or the SAS drive. For additional details, refer to 2.4.1, “IBM LTO4 Full-High (FH) Tape Drive” on page 76 and to 2.4.2, “IBM LTO4 Half-High (HH) Tape Drive” on page 77.

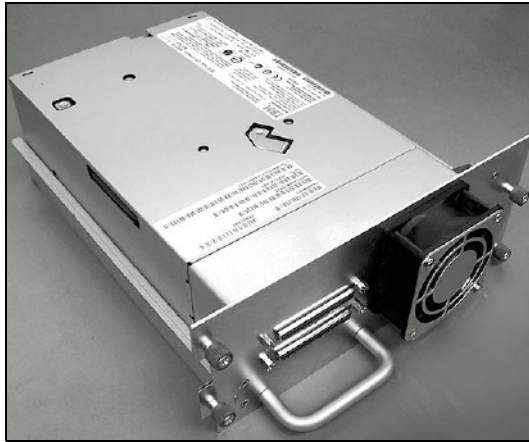


Figure 8-9 Library drive sled with an Ultrium 4 SCSI Tape Drive

Servo and track layout technology

There are 896 data tracks in Ultrium 4, compared to 704 data tracks in Ultrium 3, that are used to read and write data to the data cartridge. These tracks are grouped in five servo bands as explained in “Servo tracks” on page 35. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Speed matching

To improve the performance of the LTO4 Tape Drive, the Tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server’s host bus adapter (HBA). The LTO4 Tape Drive is negotiating with the server’s HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- ▶ Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- ▶ Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces backhitching. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the IBM Ultrium LTO tape drives. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area. The Ultrium 3, Ultrium 4, Half-High, and Full-High Tape Drives use Surface Control Guiding Mechanism.

Channel calibration

The channel calibration feature of the Ultrium 4 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Magneto resistive head design

Magneto resistive (MR) head design, which uses flat lap head technology in the MR heads for Ultrium 4, helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

Separate writing of multiple file marks

Separate writing of multiple file marks is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark. This feature has two advantages:

- ▶ It helps improve performance if a subsequent append overwrites somewhere after the first file mark.
- ▶ Write of multiple file marks typically indicates a point where an append operation might occur after the first of these file marks.

This change helps prevent having to rewrite data sets containing client data and the first file mark if this type of an append occurs.

Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI) or RS-422, or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

Statistical Analysis and Reporting System

The Ultrium 4 Half-High and Full-High Tape Drive uses SARS to help isolate failures between media and hardware. The SARS uses the data cartridge performance history saved in the Cartridge Memory (CM) module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, to mark the media as degraded, and to indicate that the hardware has degraded. When a drive dump is taken from the drive, the Support Center can determine if the failure is in the Tape Drive itself or on the Data Cartridge. SARS is also used in the Ultrium 3 Half-High and Full-High Tape Drive.

8.4.2 IBM Ultrium LTO3 Tape Drive

In this section, we describe several of the highlights of the Ultrium 3 Half-High and Full-High Tape Drives. Most of the functions are similar to the Ultrium 4 Half-High and Full-High Tape Drive described in 8.4.1, “IBM Ultrium LTO4 Tape Drive” on page 196. For additional details related to the LTO3 Tape Drive, refer to 2.3.1, “IBM LTO3 Full-High (FH) Tape Drive” on page 72 and to 2.3.2, “IBM LTO3 Half-High (HH) Tape Drive” on page 73.

LTO3 Characteristics

Here, we summarize the characteristics of the IBM Ultrium 3 Half-High and Full-High Tape Drives. They are:

- ▶ **Servo and track layout technology**
The Ultrium 3 Half-High and Full-High Tape Drive use 704 data tracks to read and write data to the data cartridge.

- ▶ **Dynamic speed matching**
The Ultrium 3 Tape Drive is designed to perform dynamic speed matching (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This design helps reduce the number of backhitch repositions and improves throughput performance.
- ▶ **Surface Control Guiding Mechanism**
This function has been designed to guide the tape along the tape path. This method uses the surface of the tape, rather than the edges, to control the tape motion.
- ▶ **Channel calibration**
The channel calibration feature of the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance.
- ▶ **Magneto resistive (MR)**
This is a head design, which uses flat lap head technology in the MR heads for Ultrium 3.
- ▶ **Separate writing of multiple file marks**
This function is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark.
- ▶ **Sleep mode**
The Ultrium 3 Half-High and Full-High Tape Drives have a power management function that is designed to control the drive electronics to be either completely turned off or stay in low-power mode when the circuit functions are not needed for drive operation.
- ▶ **Statistical Analysis and Reporting System (SARS)**
The Ultrium 3 Half-High and Full-High Tape Drives use SARS to help isolate failures between the media and the hardware.

8.5 Physical attachments

The IBM TS3100 Tape Library is available with three interfaces:

- ▶ SCSI Ultra Fast/Wide 160 LVD
- ▶ 4 Gbps Native Fibre Channel
- ▶ SAS 3 Gbps

8.5.1 SCSI Ultra Fast/Wide 160 LVD

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) using multi-drop interconnection (daisy-chaining). For each daisy-chained device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

The Ultrium 3 drive uses shielded, HD68, 68-pin connectors and can attach directly to a two byte wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

8.5.2 Fibre Channel interface

Ultrium 3 and 4 Fibre Channel tape drives use LC duplex fiber optic cables. The maximum distances that a library supports on a Fibre Channel link are determined by the link speed, the type of fiber (50-micron or 62.5-micron), and the device to which the library is attached.

If the library attaches to an HBA, refer to the distances that are supported by the HBA. If the library attaches to a switch, the supported distances are:

- ▶ For a 50-micron cable:
 - 1 Gbit link speed = up to 500 m (1640 ft.)
 - 2 Gbit link speed = up to 300 m (984 ft.)
 - 4 Gbit link speed = up to 150 m (492 ft.)
- ▶ For a 62.5-micron cable:
 - 1 Gbit link speed = 175 m (574 ft.)
 - 2 Gbit speed link = 150 m (492 ft.)
 - 4 Gbit speed link = 70 m (230 ft.)

The 4 Gbps Native Fibre Channel drive port can be configured in the following methods:

- ▶ LN Port: (default setting) An automatic configuration that tries arbitrated loop first, then switched fabric
- ▶ L Port: Arbitrated loop
- ▶ N Port: Point-to-point protocol in a switched fabric topology

8.5.3 SAS interface

The SAS interface is new in the IBM Ultrium Tape Drive family and the IBM Ultrium 4 SAS Full-High Tape Drive comes with two SFF-8088 interfaces on the back of the tape drive. The IBM Ultrium 3 SAS Half-High Tape Drive comes with one SAS interface on the back of the drive. For a more detailed description of SAS, refer to “Serial-Attached SCSI” on page 57.

At the time of writing this book, two HBAs are supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller model 25R8060

Figure 8-10 shows the back side of the SAS Full-High Tape Drive with two SFF-8088 interfaces.



Figure 8-10 The back side of the SAS Full-High Tape Drive

Figure 8-11 on page 201 show the back side of the SAS Half-High Tape Drive with one SFF-8088 interface.



Figure 8-11 The back side of the SAS Half-High Tape Drive

No terminator is needed, because the SCSI bus is automatically terminated.

8.5.4 Persistent binding

When you start up a server, it discovers devices and assigns them SCSI target and LUN IDs. It is possible for these SCSI assignments to change between restarts. Certain operating systems do not guarantee that devices are always allocated the same SCSI target ID after restarting. Also, some software depends on this association, so you do not want it to change. Persistent binding addresses the issue of SCSI ID assignment.

Persistent binding is an HBA function that allows a subset of discovered targets to be bound between a server and device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID.

After a configuration has been set, it survives restarts and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive, because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, persistent binding does not need to be changed, which causes an outage.

You can find additional information about persistent binding in *Implementing IBM Tape in UNIX Systems*, SG24-6502, and *Implementing IBM Tape in Linux and Windows*, SG24-6268.

8.5.5 Encryption

The LTO Ultrium 4 Tape Drive supports host Application-Managed Encryption (AME) and System-Managed Encryption (SME), using T10 encryption methods, for SAS and Fibre Channel drives only. Data encryption is supported with LTO Ultrium 4 Data Cartridges only. Encryption is also supported for library firmware Version 4.0 and higher and drive firmware level 74H4 or higher.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. The encryption policy and encryption keys are provided by the host application or host server. A drive digital certificate is installed at manufacturing time. Each drive receives a unique serial number and certificate. The T10 application can validate each drive instance by checking the drive's digital certificate. AME is supported on AIX, Windows 2000 Server, Linux, and Solaris. Encryption requires the latest device drivers that are available on the ftp download site:

<ftp://ftp.software.ibm.com/storage/devdrv/>

The LTO Ultrium 4 encryption environment can be complex and requires knowledge beyond that of a product-trained IBM service support representative (SSR). In the Tape Storage environment, the Encryption function on tape drives (desktop, stand-alone, and within libraries) is configured and managed by the client. In certain instances, SSRs will be required to enable encryption at a hardware level when service access or service password-controlled access is required.

Tape Encryption is available at no charge for AME. Feature Code (FC) 1604 (for the TS3500 Tape Library) or FC5900 (for all other tape libraries) and FC9900 must be ordered when you are planning to work with SME.

Note: The optional Transparent Encryption Key feature enabling SME and Library-Managed Encryption (LME) is not available on TS3200 and TS3100 models purchased through High Volume channels.

8.6 LTO data cartridges

When processing the Ultrium Tape Cartridge, the Ultrium Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time, and the Ultrium 4 drive writes data on 896 tracks. For additional details, refer to 2.1.4, “Tape cartridge” on page 43.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB and 800 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

The native data capacity of Ultrium data cartridges is listed in Table 8-2.

Table 8-2 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

8.6.1 Cartridge compatibility

Table 8-3 shows the compatibility among the four types of Ultrium cartridges.

Table 8-3 Ultrium data cartridge compatibility

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

8.6.2 Write Once Read Many (WORM)

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a new WORM feature is available on IBM LTO Ultrium generation 3 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

The IBM Ultrium LTO4 Tape Drive uses the LTO4 WORM cartridges and gives full support for the use of WORM data cartridges.

WORM media

A specially formatted WORM tape cartridge is required, because standard Read/Write media are incompatible with the WORM feature. Each WORM cartridge has a unique, worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

Data security on WORM media

Certain built-in security measures help to ensure that the data written on a WORM cartridge does not become compromised, for example:

- ▶ The format of an IBM Ultrium 3 and Ultrium 4 400 GB and 800 GB WORM Tape Cartridge is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.
- ▶ When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

8.6.3 Cleaning cartridge

A specially labeled IBM LTO Universal Ultrium Cleaning Cartridge will clean the drive in your library. One cleaning cartridge ships with the IBM TS3100 Tape Library.

The drive itself determines when a head needs cleaning and communicates this information to the library. When the cleaning is finished, the drive ejects the cartridge, and the picker takes the cartridge and places it back in any storage slot. To remove a cleaning cartridge, export it from the library.

The IBM Cleaning Cartridge is valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

8.6.4 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use.

The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location, so that the next time that this cartridge is inserted and the Write command is issued, the drive is enabled to quickly locate the next available recording area and begin recording.

The LTO-CM also helps to determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated.

Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4. Refer to “Cartridge memory (LTO-CM)” on page 46 for more details.

8.7 IBM TS3100 Tape Library setup

In the following section, we provide an introduction to the necessary steps to implement, manage, and operate the IBM TS3100 Tape Library. For a more detailed description, refer to the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide*, GA35-0545.

After unpacking and installing the IBM TS3100 Tape Library, you must perform a few steps to connect it to a host.

8.7.1 User interfaces

There are two ways to configure the library: using the Operator Control Panel (OCP) and the Web User Interface. *You use the OCP and the Web User Interface to complete the installation of the IBM TS3100 Tape Library.* The OCP is located on the front panel of the library and the Web User Interface is accessed via the Web browser.

The Operator Control Panel interface

The Operator Control Panel operates in one of two modes:

- ▶ User Interaction mode: This mode is employed when you press buttons on the Operator Control Panel.
- ▶ System Driven mode: This is the normal mode of operation. In this mode, the OCP displays the status associated with the actions that were caused by commands issued via the drive's internal (drive to library) serial interface.

When you press and release an OCP button, the OCP automatically transitions to User Interaction mode. User Interaction mode will continue until three minutes after you stop pressing buttons or until the requested accessor action stops, whichever is longer. At this time, the OCP returns to System Driven mode.

If necessary, the Operator Control Panel automatically transitions to the System Driven mode. When this transition occurs, the library must remember what you were doing before the display mode changed. Therefore, the next button pressed only transitions the OCP to the User Interaction mode from the System Driven mode. In the case of the activated user security feature, the User Interaction mode is restricted to the Login and Monitor menu items, until a user logs in with a correct password.

Web User Interface

You can perform many of the same operations performed from the Operator Control Panel remotely using the Web User Interface. The Web User Interface lets you monitor and control your library from any terminal connected to your network or through the World Wide Web.

The Web User Interface hosts a dedicated, protected Internet site that displays a graphical representation of your library. After establishing a connection to the library, open any HTML browser and enter the IP address of the library. To configure the Web User Interface, you must set the IP address. The library supports *IPv4*, *IPv6*, or *Dual Stack IPv4 + IPv6* transportation.

For IPv4 or Dual Stack IPv4 + IPv6, enter your library's static IP Address using the 0.0.0.0 format (four octets).

For IPv6, enter your library static IP Address or Router Assigned IP Address using the following format: http://[0:0:0:0:0:0:0:0]. To determine your Router Assigned IP Address, navigate to **Monitor** → **Library** → **Network** on the Operator Control Panel. For the IPv6 Router Assigned Addresses to be displayed on the Operator Control Panel, the Network must be configured to IPv6 only, and the Stateless Autoconfig must be set to ON.

Figure 8-12 show you the Network Configuration panel view from the Web User Interface.

Figure 8-12 TS3100 Network Configuration panel

8.7.2 Configuring the IBM TS3100 Tape Library

One of the benefits of the IBM TS3100 Tape Library is the standard Remote Management Unit (RMU). You can configure and monitor the IBM TS3100 Tape Library remotely, as well as update the firmware of the library and the drive remotely. RMU uses an Ethernet connection to access the IBM TS3100 Tape Library. For the initial setup, you can use the default configuration, which is:

- ▶ Dynamic Host Configuration Protocol (DHCP): On
- ▶ Network Address: 0.0.0.0
- ▶ Drive ID:
 - 4 for a SCSI Drive
 - 4 for a Fibre Channel Drive
- ▶ Library mode: Random

Making a direct connection to the IBM TS3100 Tape Library might require a crossover Ethernet cable.

Figure 8-13 shows the Library Mode menu and the configuration options.

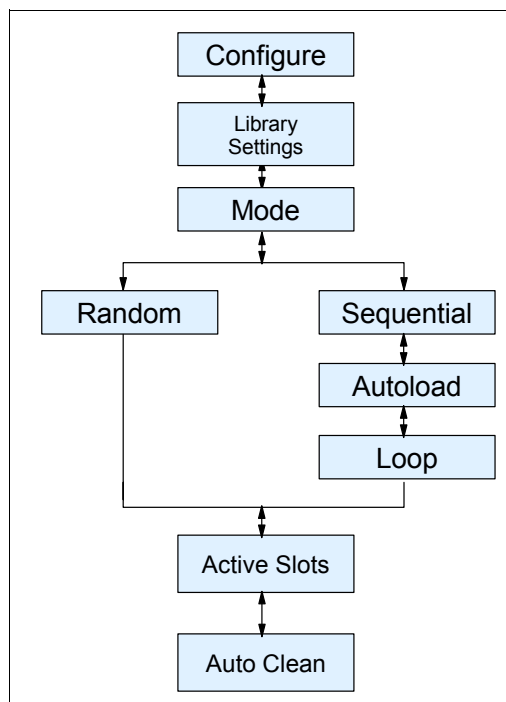


Figure 8-13 Configure: Library Settings

From the Mode menu, select **Library Mode**. Two library modes are available for the IBM TS3100 Tape Library:

- In *Random* mode, the library allows the server's (host's) application software to select any data cartridge in any order.
- In *Sequential* mode, the library's firmware predefines the selection of the cartridges. After initialization, the firmware causes the library to select the first available cartridge found (counting from 1 through 22) for loading into the drive. In Figure 8-13, you find the tree structure of the Library mode menu.

In combination with Sequential mode, you can turn on two additional modes:

Autoload	Sequential mode with autoload mode ON loads the first cartridge automatically if the library powers ON with an empty drive.
Loop	Sequential mode with loop mode ON loads the cartridge in slot 1 after the cartridge in slot 22 has been filled and sent back to its home slot. This function allows endless backup operations without user interaction.

You also define the number of Active Slots that you want to assign in your library. Slots can be reserved so that they are invisible to the host. It might be necessary to set the number of active slots in order to match the number of available slots to the Independent Software Vendor (ISV) software licensing.

Note: When the IBM TS3100 Tape Library is connected to a System i, you must IPL the input/output adapter (IOA); otherwise, System i will not recognize the new mode.

You can connect the library to the host after setting up the library mode. Here are several considerations before you connect the library to the host. Two host connections are available: SCSI and the Fibre Channel connection.

8.7.3 SCSI Host Bus Adapter (HBA) support

For SCSI hosts, verify that the HBA of your server is supported. Check the IBM Interoperability Matrix, which you can find at:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability>

Select **TS3100 Tape Library** as shown in Figure 8-14.

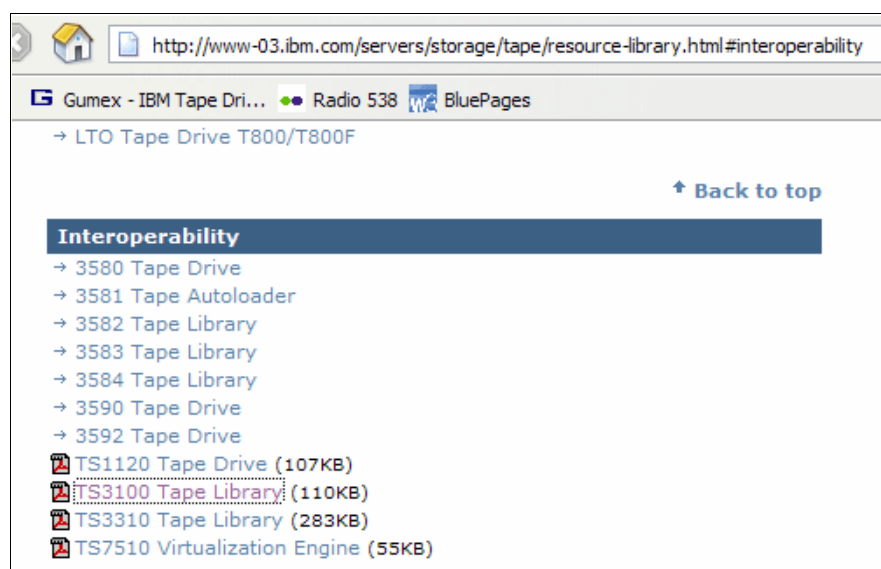


Figure 8-14 Interoperability Web site

The library uses a single SCSI or Loop ID per drive and dual logical unit numbers (LUNs) to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires a host bus adapter (HBA) that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to discover the library. It will only see the tape drive.

Note: Certain HBAs, such as RAID controllers, do not support LUN scanning.

If you daisy-chain the IBM TS3100 Tape Library, the last device on the bus must have a SCSI terminator installed. The IBM Ultrium 3 LVD tape device supports a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) using a multi-drop interconnection. For each daisy-chained device, you must reduce the maximum cable length by 0.5 m (1.6 ft.).

8.7.4 Fibre Channel (FC)

Make sure that the FC HBA of your server is supported. Check the IBM HBA Support Web site at:

<http://www-03.ibm.com/servers/storage/support/config/hba/index.wss>

Select **TS3100 (3573) with Ultrium 3 FCP drives**, as shown in Figure 8-15 on page 208.

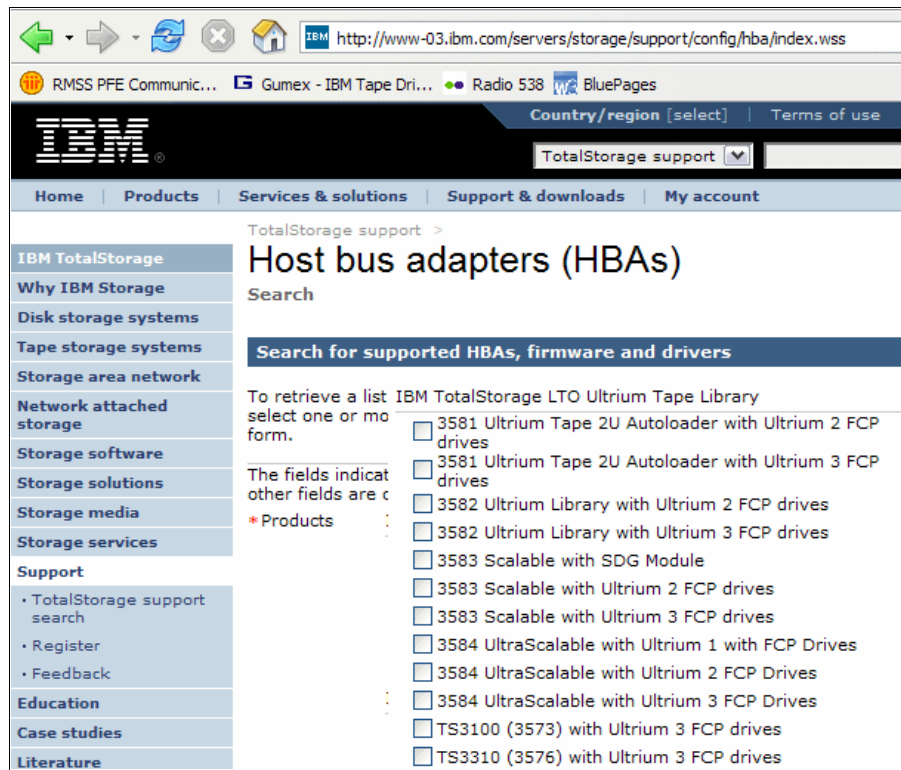


Figure 8-15 Fibre Channel HBA Support Web site

Another way to find out if your Fibre Channel Tape Drive is supported is to visit this Web site:

<http://www-03.ibm.com/systems/storage/tape/ts3100/index.html>

Figure 8-16 on page 209 shows the link to the IBM Technical Support Web site. Click **System Storage Interoperation Center** and follow the instructions.

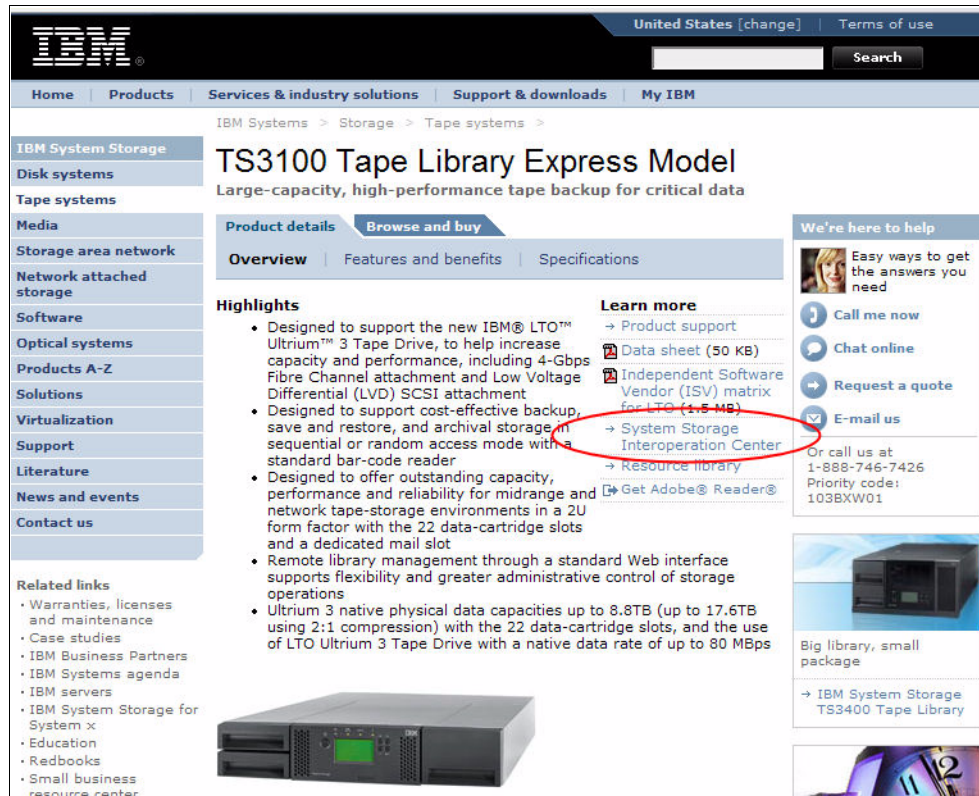


Figure 8-16 System Storage Interoperation Center TS3100

8.7.5 Serial Attached SCSI (SAS)

At the time of writing this book, there is no information available on the Web. Two HBAs, however, are supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller model 25R8060

8.7.6 Firmware

At installation time, verify that the most current firmware is installed for both the library and the tape drive. The IBM TS3100 Tape Library is designed as a Client Setup Machine (CSU), and it is the client's responsibility to have the current firmware. Determine the current level of firmware that is available from IBM Technical Support Web sites:

<http://www.ibm.com/storage/lto>

<ftp://index.storsys.ibm.com>

The preferred way to update the drive firmware is to use the Web User Interface to update the library and the drive firmware. The RMU or Web User Interface comes standard with the IBM TS3100 Tape Library, which provides a much simpler method for System i clients to update firmware than was previously available. The Field Microcode Replacement (FMR) function is not supported on the IBM TS3100 Tape Library.

The IBM TotalStorage Diagnostic Tool (ITDT) is an alternate way to update the drive firmware, take a dump of a drive, and to test the drive and library. This tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and there are two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

The ITDT supports both SCSI and Fibre Channel drives. The ITDT does not use any installed device driver and is therefore also an excellent tool to use to test the drives. After the IBM TS3100 is connected to the host and the ITDT is started from a command prompt, the tool scans the bus, and it finds and displays all IBM LTO devices. You can also use tapeutil via the SCSI interface.

Using the ITDT, you can force dumps on a drive and have the output sent to an IBM Support Center for further analysis.

8.7.7 Cartridge magazines

The IBM TS3100 Tape Library has two removable magazines in the library. Magazine access can be password-protected. For safety reasons, the accessor motion stops when a magazine is removed.

You can release the magazines using the Operator Control Panel or the Web User Interface. In case the Operator Control Panel or Web User Interface-initiated process fails or the library no longer has power, a manual emergency release is available.

The I/O station is part of the left magazine. To open the I/O station, grasp the lower handle of the left magazine and gently pull the I/O station open. To close the I/O station, gently push it back into the left magazine.

Inserting cartridges into the IBM TS3100 Tape Library

The last task is to insert cartridges into the IBM TS3100 Tape Library:

1. Unlock the cartridge magazines by using the OCP or the Web User Interface.
2. Remove both magazines from the library.
3. Insert cartridges in the magazine. Do not store in the I/O station.
4. Insert cartridges in any slot of the right magazine.
5. Put both magazines back into the library.

8.8 Physical specifications

The TS3100 Tape Library is a medium-sized tape library with the following dimensions:

Width	44.74 cm (17.6 in.)
Depth	74 cm (29.1 in.)
Height	8.76 cm (3.4 in.)
Weight	With one drive and without media 15.59 kg (34.37 lbs.)

8.9 Feature codes

The IBM TS3100 Tape Library can be ordered with the optional features listed in Table 8-4.

Table 8-4 Optional features

Feature code	Description
5096	LC-SC Fibre Channel Cable Interposer
5602	2.5 m (6.6 ft.) VHDCI/HD68 SCSI Cable
5604	4.5 m (14.9 ft.) VHDCI/HD68 SCSI Cable
5610	10 m (32.9 ft.) VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. Provides license keys to enable SME and LME
6005	5 m (16.4 ft.) LC/LC Fibre Cable
6013	13 m (42.7 ft.) LC/LC Fibre Cable
6025	25 m (82 ft.) LC/LC Fibre Cable
7002	Rack Mount Kit with Power Cord
8002	Universal Cleaning Cartridge
8043	Ultrium 3 LVD SCSI Tape Drive
8044	Ultrium 3 4 Gbps Fibre Channel Tape Drive
8046	Ultrium 3 Half-High LVD SCSI Tape Drive
8047	Ultrium 3 Half-High SAS Tape Drive
8106	Right Side Magazine Set
8143	Ultrium 4 Full-High LVD SCSI Tape Drive
8144	Ultrium 4 Full-High Fibre Channel Tape Drive

Feature code	Description
8145	Ultrium 4 Full-High SAS Tape Drive
8305	Data Cartridges (GEN3) 5-pack
8405	Data Cartridges (GEN4) 5-pack
9848	Additional Rack to power distribution unit (PDU) Line Cord
9900	Encryption Configuration. This feature needs to be ordered when encryption will be used in the library. It includes publication updates with information about enabling and configuring the library to support encryption. This feature also provides an Encryption Key Manager (EKM) publication.

Table 8-5 lists the feature codes available for SAS attachment.

Table 8-5 SAS Feature Codes

Feature code/High Volume	Name	Description
5402	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and drives.
5502	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges only with ordering the TS2340.



IBM System Storage TS3200 Tape Library

The IBM System Storage TS3200 Tape Library (Machine Type 3573 Model L4U) is a midrange level desktop or a rack-mounted unit (requiring four rack units of an industry standard 19-inch rack). The IBM TS3200 Tape Library operates in random or sequential mode. You can partition the IBM TS3200 Tape Library into a maximum of four logical libraries when four drives are installed. A mixture of a SCSI drive, a Fibre Channel drive, and a Serial Attached SCSI (SAS) drive is supported when the IBM TS3200 Tape Library is partitioned (but not within the same logical library).

The IBM TS3200 Tape Library supports both data path and control path failover when you install Feature Code (FC) 1682. The robotics inside the library move the cartridges from and to the drives so unattended backups can take place. The four standard removable magazines can store a total of 48 cartridges. The IBM TS3200 Tape Library comes with three I/O slots for importing and exporting cartridges.

The following IBM Ultrium Tape Drives are available for the TS3200 Tape Library:

- ▶ The IBM Ultrium 4 Low Voltage Differential (LVD) SCSI Tape Drive
- ▶ The IBM Ultrium 4 Fibre Channel (FC) Tape Drive
- ▶ The IBM Ultrium 4 Serial Attached SCSI (SAS) Tape Drive
- ▶ The IBM Ultrium 3 Half-High LVD SCSI Tape Drive
- ▶ The IBM Ultrium 3 Half-High SAS Tape Drive
- ▶ The IBM Ultrium 3 Full-High LVD SCSI Tape Drive
- ▶ The IBM Ultrium 3 Full-High FC Tape Drive

Up to four IBM Ultrium 3 Half-High Tape Drives or two IBM Ultrium 3 or 4 Full-High Tape Drives can be installed in the TS3200 Tape Library. Refer to Feature Code 5900, Transparent LTO Encryption, for SME and LME support.

Application-Managed Encryption (AME), Library-Managed Encryption (LME), and System-Managed Encryption (SME) are supported on the IBM Ultrium LTO4 Tape Drive with the SAS and Fibre Channel interface.

Standard features are a barcode reader and a remote management unit (RMU).

9.1 TS3200 Tape Library description

Designed for tape automation, you can attach the TS3200 Tape Library to IBM System i or i5, iSeries, AS/400, IBM System p or p5, pSeries, RS/6000, IBM z or z9, System x, xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers. To determine the currently supported servers, visit the Web at:

<http://www.ibm.com/storage/lto>

This Web site shows you product details, and you can refer to the Interoperability Matrix.

The library capacity is 48 tape cartridges, providing a maximum native media capacity of up to 38.4 TB (76.8 TB with 2:1 compression) data storage per unit.

Depending on what IBM Ultrium Tape Drive is installed in the TS3200 Tape Library, you can use the following data cartridges:

- ▶ The TS3200 Tape Library uses the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge when the IBM Ultrium 3 Tape Drive is installed. The Ultrium 3 Tape Drive has the capability of writing up to 400 GB native capacity and up to 800 GB with 2:1 compression. IBM Ultrium 3 Tape Drives can read and write LTO Ultrium 2 Data Cartridges and read LTO1 data cartridges.
- ▶ The TS3200 Tape Library uses the IBM TotalStorage LTO Ultrium 800 GB Data Cartridge when the IBM Ultrium 4 Tape Drive is installed. The Ultrium 4 Tape Drive has the capability of writing up to 800 GB native capacity and up to 1600 GB with 2:1 compression. IBM Ultrium 4 Tape Drives can read and write LTO Ultrium 3 Data Cartridges, can read Ultrium 2 Data Cartridges, and does not support Ultrium 1 Data Cartridges. Refer to Table 9-1 for additional information.

Table 9-1 Library storage capacity and data transfer rate

Characteristics	4U Library Specification
Maximum storage capacity: Ultrium 4 Data Cartridges	▶ 48 data cartridges ▶ Native: 38.4 TB ▶ Compressed: 75.2 TB (2:1 compression)
Maximum storage capacity: Ultrium 3 Data Cartridges	▶ 48 data cartridges ▶ Native: 19.2 TB ▶ Compressed: 38.4 TB (2:1 compression)
Maximum data transfer rate	▶ Native: 80 MB/s (288 GB/hr.) ▶ Compressed: 160 MB/s (576 GB/hr.) (2:1 compression)

Depending on the way the TS3200 is ordered, you specify the required drives through feature codes or through the model number. For the IBM 3573-L4u, you can use these drive feature codes:

FC8043	Ultrium 3 LVD SCSI Tape Drive Sled
FC8044	Ultrium 3 4Gbps Fibre Channel Tape Drive Sled
FC8046	Ultrium 3 Half-High SCSI Tape Drive Sled
FC8047	Ultrium 3 Half-High SAS Tape Drive Sled
FC8143	Ultrium 4 SCSI Tape Drive Sled
FC8144	Ultrium 4 Fibre Tape Drive Sled
FC8145	Ultrium 4 SAS Tape Drive Sled
FC8147	Ultrium 4 Half-High SAS Tape Drive Sled

Via type-model-feature (TMF) through System x order entry, seven models are available for the TS3200 Tape Library:

- ▶ The *3573-L4S* comes with an IBM Ultrium 4 LVD SCSI Tape Drive. The Ultrium 4 LVD SCSI drive has an LVD Ultra 160 SCSI interface that can be connected to LVD fast/wide adapters. The Ultrium 4 Tape Drive has a native data transfer rate of 120 MB/s.
- ▶ The *3573-F4S* comes with an Ultrium 4 Tape Drive with a 4 Gbps Fibre Channel interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3573-S4S* comes with a SAS Ultrium 4 Tape Drive that has a SAS interface, which has a native data transfer rate of up to 3 Gbps. The SAS Ultrium 4 Tape Drive comes with an SFF-8088 interface. The Ultrium 4 Tape Drive provides a sustained native data transfer rate of 120 MB/s.
- ▶ The *3573-L32* comes with a Half-High Ultrium 3 LVD SCSI Tape Drive. This Ultrium 3 LVD SCSI Tape Drive has an LVD Ultra 160 SCSI interface. The Half-High Ultrium 3 Tape Drive provides a sustained native data transfer rate of 60 MB/s.
- ▶ The *3573-S32* comes with a Half-High Ultrium 3 SAS Tape Drive. The Half-High Ultrium 3 Tape Drive has a native data transfer rate of up to 60 MB/s.
- ▶ The *3573-F3H* comes with a Full-High Ultrium 3 LVD SCSI Drive. The Full-High Ultrium 3 Tape Drive has a native data rate of up to 80 MB/s.
- ▶ The *3573-L3H* comes with a Full-High Ultrium 3 4 Gbps Fibre Channel Tape Drive. The Full-High Ultrium 3 Tape Drive has a native data rate of 80 MB/s.

Figure 9-1 shows the front view of the TS3200 Tape Library with the cartridge magazines on the left and on the right sides.



Figure 9-1 IBM System Storage TS3200 Tape Library

9.2 Components

The TS3200 Tape Library has an improved robotic system that moves in the center of the unit. The standard barcode reader is on the picker, and the improved accessor makes the robotics extremely robust. Three I/O slots for importing and exporting cartridges are part of the lower left magazine.

This is a list of the primary components of the IBM TS3200 Tape Library:

- ▶ Operator Control Panel (OPC).
- ▶ Two cartridge magazines are on the right side, and two cartridge magazines are on the left side. The I/O slots are part of the lower left magazine.
- ▶ Accessor

This component contains the library robot and the barcode reader. The accessor moves cartridges to and from the:

 - I/O slots
 - Storage slots
 - Tape drives
- ▶ Library control card

This component is a client replaceable unit (CRU) and stores the user configuration information or vital product data (VPD). The Remote Management Unit (RMU) is embedded on this card also.
- ▶ Tape drive sled

This library supports the Ultrium 3 and Ultrium 4 tape drives. The tape drive in the library is packaged in a container called the *drive sled*. The drive sled is a CRU, and it is designed for easy removal and replacement.
- ▶ Power supply

The power supply is a CRU.

9.2.1 Operator Control Panel

The library is equipped with an Operator Control Panel (OCP). By means of the OCP, a user can perform simple actions with the medium changer. The OCP interface allows a user to monitor the medium changer operation, make configuration changes, and perform media access commands. For an extensive description of the OCP functions, refer to the OCP specification in *IBM System Storage TS3100 Tape Library and TS3200 Tape Library: Setup, Operator, and Service Guide*, GA35-0545.

Note: When a user executes a medium access command through the OCP interface, the medium changer will enter the off-line state. When the medium changer is off-line, the medium changer will report Not Ready on the SCSI bus.

9.2.2 Robotics

The TS3200 Tape Library uses a new independent tape loader, threader motors, and a positive pin retention. These features are designed to help improve the reliability of loading and unloading a cartridge and to retain the pin even if tension is dropped. An independent loader motor coupled with the positive pin retention is designed to thread the tape with a high level of reliability.

9.2.3 Barcode reader

The barcode reader is an integral part of the library accessor. The barcode reader provides inventory feedback to the host application, Operator Control Panel (OCP) display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory.

9.2.4 Remote Management Unit

The Remote Management Unit (RMU) provides remote management to the library over a network. This function is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. The 10/100 MB Ethernet port can be in auto-negotiated or fixed mode for a 10 MB connection and use half and full duplex for the 100 MB connection. The Ethernet connection is located on the back side of the library.

When the IP address is set on the library using the OCP, you can monitor and control the library remotely. Entering the IP address in a browser opens a graphical representation of the library. You can perform service actions, such as upgrading the library and drive firmware, by using the remote management facility.

Figure 9-2 shows the Home page of the IBM TS3200 Tape Library Web User Interface. The graphical representation is processed on the Library Control Card.

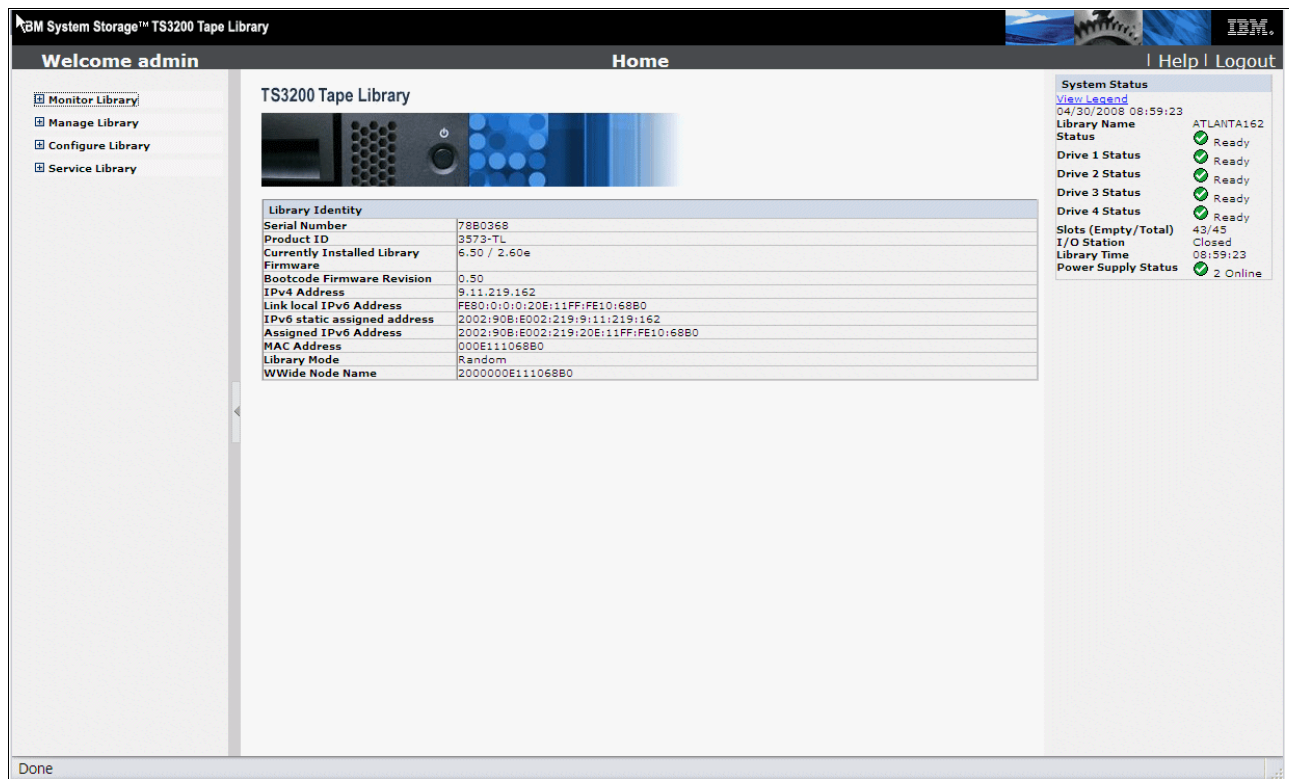


Figure 9-2 Home page of the IBM TS3200 Tape Library Web User Interface

9.3 Control and data path failover and load balancing

The TS3200 Tape Library can use path failover to help enhance availability. This optional feature provides automatic control path failover to a preconfigured redundant control path in the event that a host adapter or control path drive is lost. This works without stopping the current job in progress. AIX, Linux, Solaris, HP-UX, and Windows for the Full-High drive with Fibre Channel and SAS attachments support this function. When you use the IBM tape device driver, all support this function.

Figure 9-3 on page 218 summarizes control path and data path failover with the TS3200.

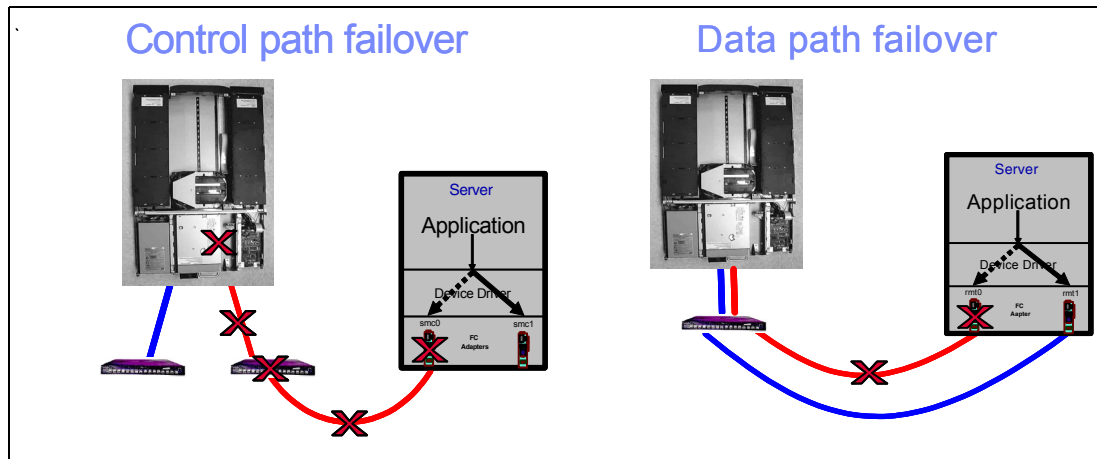


Figure 9-3 Control path and data path failover

As shown on the right side of Figure 9-3, data path failover and load balancing support native Fibre Channel Ultrium 3 and Ultrium 4 Tape Drives in the Tape Library using the IBM tape device driver for AIX, Linux, Solaris, HP-UX, and Windows. *Data path failover* is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

When accessing a tape drive device that has been configured with alternate pathing across multiple host ports, the IBM device driver is designed to automatically select a path through the host bus adapter (HBA) that has the fewest open tape devices and assign that path to the application. This autonomic self-optimizing capability is called *load balancing*. The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices, and the device driver balances the number of applications using each HBA in the machine.

This can help optimize HBA resources and improve overall performance. Further, data path failover provides autonomic self-healing capabilities similar to control path failover. Data path failover is designed to fail over to an alternate data path in the event of a failure in the primary host-side path. Data path failover and load balancing for Ultrium 3 Tape Drives require the optional path failover FC1682.

You use the OCP to install the FC1682 code, which you must also install on the attached server. Refer to the *IBM Tape Device Drivers Installation and User's Guide*, GA27-2130, for instructions about how to install the Data path failover license key.

9.4 Cartridge storage

The IBM TS3200 Tape Library has four removable magazines in the library. The total number of storage cartridges is 48. The native maximum storage capacity is 38.4 TB when using the Ultrium 4 data cartridges, and the maximum compressed capacity is 76.8 TB using 2:1 compression. The three Input/Output slots are part of the lower left magazine. Use the OCP or the Web User Interface to release the magazines. Magazine access is protected by a password.

6. When the IBM TS3200 Tape Library fills up with cartridges, use the Web User Interface to show the inventory of each magazine. Figure 9-4 shows the inventory of the lower left cartridge magazine that is filled with seven cartridges. Note the three slot I/O station on the left.

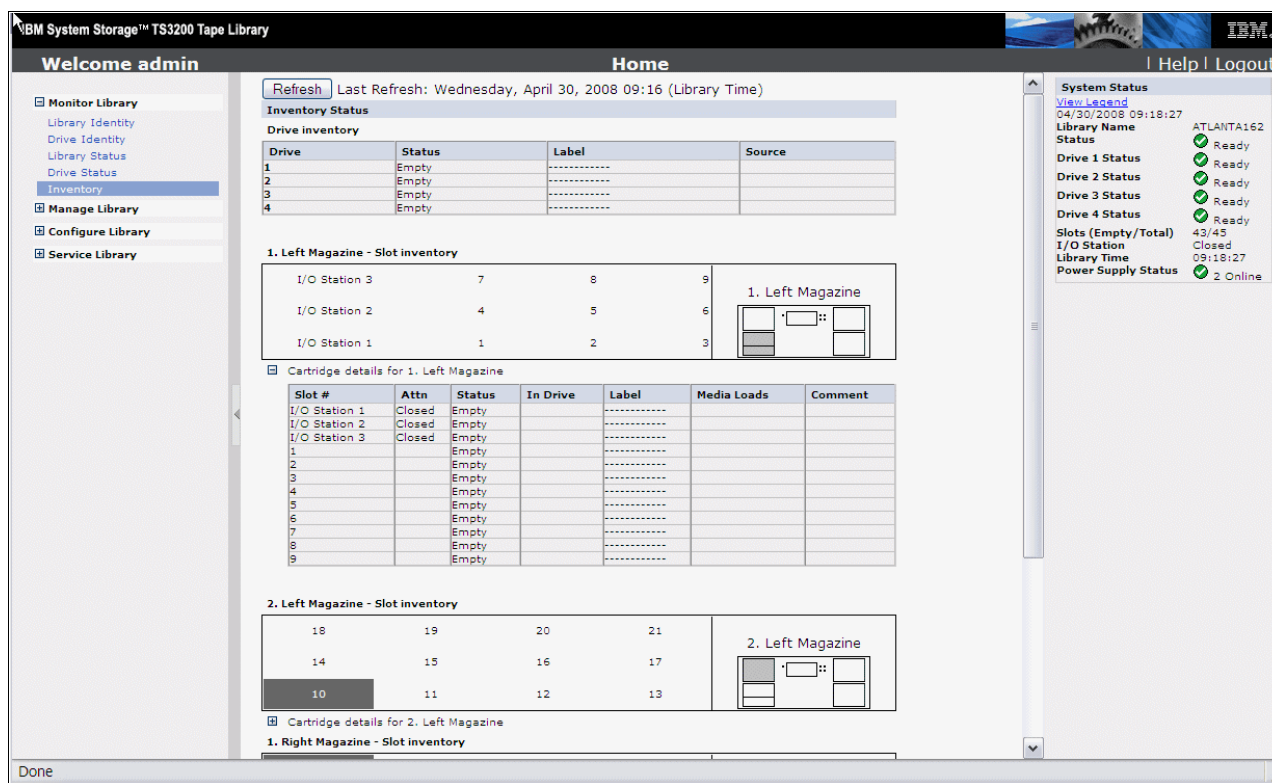


Figure 9-4 Lower left magazine: IBM TS3200 Tape Library

9.5 LTO Ultrium Tape Drives

This library supports the Ultrium 3 and Ultrium 4 Tape Drives. Each tape drive in the library is packaged in a container called a *drive sled*. The drive sled is a client-replaceable unit (CRU) and is designed for quick removal and replacement in the library. In the following section, we summarize the characteristics of the LTO4 and LTO3 Full-High and Half-High Tape Drives.

The Ultrium 4 Full-High Tape Drive supports:

- ▶ LVD Ultra160 with two HD68 connectors
- ▶ Serial Attached SCSI (SAS) with two SFF-8088 SAS connectors
- ▶ Fibre Channel interfaces, with one LC Fibre Channel connector

The Ultrium 4 Half-High Tape Drive supports only one SAS SFF-8088 connector.

The Ultrium 3 Full-High Tape Drive supports:

- ▶ LVD Ultra160 with two HD68 connectors
- ▶ Fibre Channel interfaces with one LC Fibre Channel connector

The Ultrium 3 Half-High Tape Drive supports:

- ▶ Serial Attached SCSI (SAS) with one SFF-8088 SAS connector
- ▶ LVD Ultra160 with two HD68 connectors

For additional details about LTO4 and LTO4 Tape Drives, refer to Chapter 2, “Overview of IBM LTO Ultrium Tape Drives” on page 29.

9.5.1 IBM LTO Ultrium 4 Tape Drive

Each IBM Ultrium 4 Tape Drive contains the electronics and logic for reading and writing data, controlling the tape drive, managing the data buffer, and handling error recovery procedures. Because of its special design as a CRU, the drive can easily be replaced if necessary. Figure 9-5 shows the Ultrium 4 drive sled with a SCSI interface. The same drive sled can also contain the 4 Gbps Fibre Channel drive or the SAS drive. For additional details, refer to 2.4.1, “IBM LTO4 Full-High (FH) Tape Drive” on page 76 and to 2.4.2, “IBM LTO4 Half-High (HH) Tape Drive” on page 77.

Figure 9-5 shows the Ultrium 4 Tape drive sled with a SCSI interface. A similar drive sled is also used for the 4 GB Fibre Channel (FC) drive and the SAS drive.

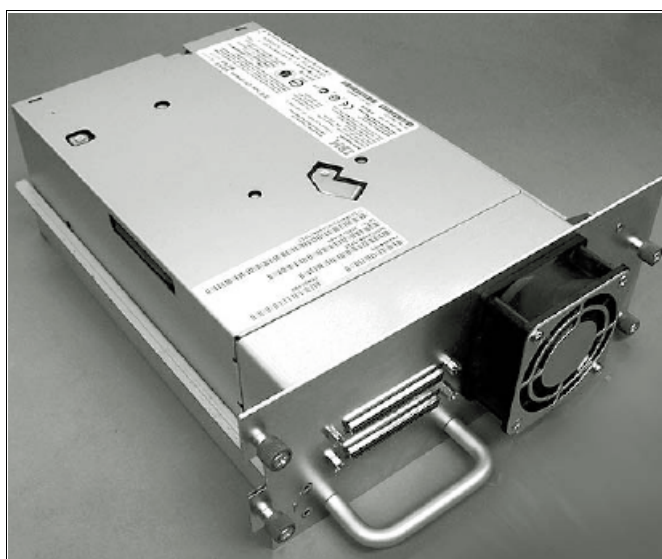


Figure 9-5 Ultrium Drive Sled

Servo and track layout technology

There are 896 data tracks used to read and write data to the data cartridge. These tracks are grouped in five Servo bands. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Speed matching

To improve the performance of the LTO4 Tape Drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's HBA. The LTO4 Tape Drive is negotiating with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- ▶ Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- ▶ Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces backhitching. Backhitching is the condition that

occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

Surface Control Guiding Mechanism

The IBM patented Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the IBM Ultrium LTO Tape Drive. This method uses the surface of the tape, rather than the edges, to control tape motion. This helps reduce the tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Channel calibration

The channel calibration feature of the Ultrium 4 Tape Drive customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI) or RS-422, or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

9.5.2 IBM LTO Ultrium 3 Tape Drive

In this section, we describe several of the highlights of the Ultrium 3 Half-High and Full-High Tape Drives. Most of the functions are similar to the Ultrium 4 Half-High and Full-High Tape Drive described in 9.5.1, “IBM LTO Ultrium 4 Tape Drive” on page 220. For additional details related to the LTO3 Tape Drive, refer to 2.3.1, “IBM LTO3 Full-High (FH) Tape Drive” on page 72 and to 2.3.2, “IBM LTO3 Half-High (HH) Tape Drive” on page 73.

LTO3 Characteristics

Here, we summarize the characteristics of the IBM Ultrium 3 Half-High and Full-High Tape Drives. They are:

- ▶ **Servo and track layout technology**
The Ultrium 3 Half-High and Full-High Tape Drives use 704 data tracks to read and write data to the data cartridge.
- ▶ **Dynamic speed matching**
The Ultrium 3 Tape Drive is designed to perform dynamic speed matching (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive’s native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This design helps reduce the number of backhitch repositions and improves throughput performance.
- ▶ **Surface Control Guiding Mechanism**
This function has been designed to guide the tape along the tape path. This method uses the surface of the tape, rather than the edges, to control the tape motion.

- ▶ **Channel calibration**
The channel calibration feature of the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance.
- ▶ **Magneto resistive (MR)**
This is a head design, which uses flat lap head technology in the MR heads for Ultrium 3.
- ▶ **Separate writing of multiple file marks**
This function is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark.
- ▶ **Sleep mode**
The Ultrium 3 Half-High and Full-High Tape Drive has a power management function that is designed to control the drive electronics to be either completely turned off or stay in low-power mode when the circuit functions are not needed for drive operation.
- ▶ **Statistical Analysis and Reporting System (SARS)**
The Ultrium 3 Half-High and Full-High Tape Drive uses SARS to help isolate failures between the media and the hardware.

Figure 9-6 shows the interior of the TS3200 with four Ultrium 3 Half-High drives installed.



Figure 9-6 Interior of the TS3200 with four Ultrium 3 Half-High drives installed

Figure 9-7 on page 223 shows the back side of the TS3200. In the upper two positions are SAS tape drives, and in the lower two positions are LVD Ultra160 tape drives.

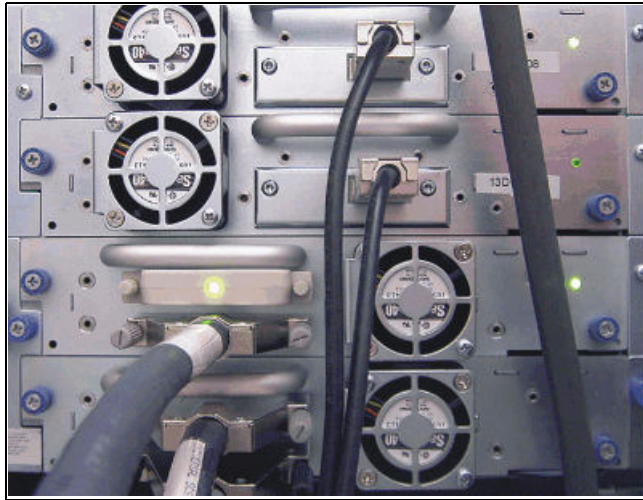


Figure 9-7 Back side of the TS3200

9.6 Physical attachments

The IBM TS3200 Tape Library is available with three interfaces:

- ▶ SCSI Ultra Fast/Wide 160 LVD
- ▶ Native Fibre Channel 4 Gbps
- ▶ SAS 3 Gbps

9.6.1 SCSI Ultra Fast/Wide 160 LVD

IBM LVD tape devices support a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) using a multi-drop interconnection (daisy-chaining). For each daisy-chained device, you must reduce the maximum cable length by 0.5 m (1.6 ft.).

The Ultrium 3 drive uses shielded, VHDCI, 68-pin connectors and can attach directly to a two byte-wide SCSI cable.

The Ultrium 3 LTO drive provides a sustained native data transfer of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge.

Note: A faster bus does not imply that an attached device will support that data rate, but that multiple devices can operate on the bus at the maximum speed. To ensure the best performance, if possible, avoid daisy-chaining.

9.6.2 Native Fibre Channel 4 Gbps

Ultrium 3 and 4 Fibre Channel tape drives use LC duplex fiber optic cables. The maximum distances that the library supports on a Fibre Channel link are determined by the link speed, the type of fiber (50-micron or 62.5-micron), and the device to which the library is attached.

If the library attaches to a HBA, refer to the distances that are supported by the HBA. If the library attaches to a switch, the supported distances are:

- ▶ For a 50-micron cable:
 - 1 Gbit link speed = up to 500 m (1640 ft.)
 - 2 Gbit link speed = up to 300 m (984 ft.)
 - 4 Gbit link speed = up to 150 m (492 ft.)
- ▶ For a 62.5-micron cable:
 - 1 Gbit link speed = 175 m (574 ft.)
 - 2 Gbit speed link = 150 m (492 ft.)
 - 4 Gbit speed link = 70 m (230 ft.)

You can configure the 4 GB Native Fibre Channel drive port in the following methods:

- ▶ LN Port: (default setting) An automatic configuration that tries arbitrated loop first, then switched fabric
- ▶ L Port: Arbitrated loop
- ▶ N Port: Point-to-point protocol in a switched fabric topology

9.6.3 Serial Attached SCSI (SAS)

The SAS interface is new in the IBM Ultrium Tape Drive family and the IBM Ultrium 4 SAS Full-High Tape Drive comes with two SFF-8088 interfaces on the back of the tape drive. The IBM Ultrium 3 SAS Half-High Tape Drive comes with one SAS interface on the back of the drive. For a more detailed description of SAS, refer to “Serial-Attached SCSI” on page 57.

At the time of writing this book, two HBAs are supported:

- ▶ LSI Logic SAS3800X
- ▶ IBM SAS HBA Controller model 25R8060

Figure 9-8 shows the back side of the SAS Full-High Tape Drive with two SFF-8088 interfaces.



Figure 9-8 Back side of the Full-High SAS Tape Drive

Figure 9-9 shows the back side of the SAS Half-High Tape Drive with one SFF-8088 interface.



Figure 9-9 Back side of the Half-High SAS Tape Drive

No terminator is needed, because the SCSI bus is automatically terminated.

9.6.4 Persistent binding

When a server starts up, it discovers devices and assigns SCSI target and LUN IDs. It is possible for these SCSI assignments to change between restarts. Certain operating systems do not guarantee that devices are always allocated the same SCSI target ID after restarting. Also, certain software depends on this association, so you do not want it to change. Persistent binding addresses the issue of SCSI ID assignment.

Persistent binding is an HBA function that allows a subset of discovered targets to be bound between a server and device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID.

After a configuration is set, it survives restarts and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive, because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, you do not need to change persistent binding, which causes an outage.

You can find additional information about persistent binding in *Implementing IBM Tape in UNIX Systems*, SG24-6502, and *Implementing IBM Tape in Linux and Windows*, SG24-6268.

9.6.5 Encryption

The LTO Ultrium 4 Tape Drive supports host Application-Managed Encryption (AME) using the T10 encryption method, and System-Managed Encryption (SME) for SAS and Fibre Channel drives only. Tape Encryption is supported with LTO Ultrium 4 Data Cartridges only. Encryption is also supported for library firmware Version 1.95 and higher.

The encryption-enabled drive contains the necessary hardware and firmware to encrypt and decrypt host tape application data. Encryption policy and encryption keys are provided by the host application or host server. A drive digital certificate is installed at manufacturing time. Encryption requires the latest device drivers that are available on the ftp download site:

<ftp://ftp.software.ibm.com/storage/devdrv/>

The LTO Ultrium 4 encryption environment can be complex and requires knowledge beyond that of a product-trained IBM service support representative (SSR). In the Tape Storage environment, the Encryption function on tape drives (desktop, stand-alone, and within libraries) is configured and managed by the client. In certain instances, IBM SSRs will be required to enable encryption at a hardware level when service access or service password-controlled access is required.

Tape Encryption is available at no charge for AME. Feature Codes 5900 and 9900 must be ordered when you are planning to work with SME.

Note: The optional Transparent Encryption Key feature enabling System-Managed Encryption and Library-Managed Encryption is not available on TS3200 and TS3100 models purchased through High Volume channels.

9.7 LTO data cartridges

When processing the Ultrium Tape Cartridge, the Ultrium Tape Drive uses a linear, serpentine recording format. The Ultrium 3 drive reads and writes data on 704 tracks, sixteen tracks at a time, and the Ultrium 4 drive writes data on 896 tracks. For additional details, refer to 2.1.4, “Tape cartridge” on page 43.

To ensure that your IBM Ultrium Tape Drive conforms to the IBM specifications for reliability, use only IBM LTO Ultrium tape cartridges. The IBM TotalStorage LTO Ultrium 400 GB and 800 GB Data Cartridge cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

All four generations contain 1/2-inch, dual-coated, metal-particle tape. The native data capacity of Ultrium data cartridges is listed in Table 9-2.

Table 9-2 Native capacity

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

9.7.1 Cartridge compatibility

Table 9-3 shows the compatibility of the four generations of Ultrium Data Cartridges.

Table 9-3 Ultrium Data Cartridge compatibility

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

9.7.2 Write Once Read Many (WORM)

Certain records retention and data security applications require a Write Once Read Many (WORM) method for storing data on tape. To meet this data storage requirement, a new WORM feature is available on IBM LTO Ultrium generation 3 drives. You can enable the WORM feature by upgrading to WORM-capable drive firmware and using a special WORM tape cartridge.

The IBM Ultrium LTO4 Tape Drive uses the LTO4 WORM cartridges and gives full support for the use of WORM data cartridges.

WORM media

Because standard Read/Write media is incompatible with the WORM feature, a specially formatted WORM tape cartridge is required with the worldwide cartridge identifier (WWCID), which comprises the unique Cartridge Memory (CM) chip serial number and the unique tape media serial number.

Data security on WORM media

Certain built-in security measures help to ensure that the data written on a WORM cartridge does not become compromised, for example:

- ▶ The format of an LTO3 400 GB WORM or an LTO4 800 GB Tape Cartridge is unlike that of standard Read/Write media. This unique format prevents a drive that lacks WORM-capable firmware from writing on a WORM tape cartridge.
- ▶ When the drive senses a WORM cartridge, the firmware prohibits changing or altering user data already written on the tape. The firmware keeps track of the last appendable point on the tape.

9.7.3 Cartridge Memory chip (LTO-CM)

All generations of the IBM LTO Ultrium Data Cartridges include a Linear Tape-Open Cartridge Memory (LTO-CM) chip that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use.

The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location, so that the next time that this cartridge is inserted and the Write command is issued, the drive is enabled to quickly locate the next available recording area and begin recording.

The LTO-CM also helps to determine the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever a tape cartridge is unloaded, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes for Ultrium 3 and 8192 bytes for Ultrium 4. Refer to "Cartridge memory (LTO-CM)" on page 46 for more details.

9.7.4 Cleaning cartridge

A specially labeled IBM LTO Ultrium Cleaning Cartridge cleans the drive in your library. One ships with the IBM TS3200 Tape Library.

The drive itself determines when to clean a head and communicates this information to the library. When the cleaning finishes, the drive ejects the cartridge and then takes the cartridge to place it back in its designated cleaning slot.

To remove a cleaning cartridge from its designated cleaning slot, export it from the library.

IBM Cleaning Cartridges are valid for 50 uses. The cartridge's LTO-CM chip tracks the number of times that the cartridge is used.

9.8 IBM TS3200 Tape Library setup

In the following section, we provide a global overview of the steps to implement, manage, and operate the IBM TS3200 Tape Library. We give you hints and tips. For a detailed description, follow the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator, and Service Guide*, GA32-0545.

After unpacking and installing the IBM TS3200 Tape Library, you must perform a few steps to connect it to a host.

9.8.1 User interfaces

There are two ways to configure the library: using the OCP and the Web User Interface. To complete the installation of the IBM TS3200 Tape Library, you use both the OCP and the Web User Interface. The OCP is located on the front panel of the library, and you access the Web User Interface via the Web browser. The Ethernet connection is located on the back of the IBM TS3200 Library.

Operator Control Panel interface

The Operator Control Panel operates in two modes:

- ▶ *User Interaction mode*: Employ this mode when a user presses buttons on the Operator Control Panel.
- ▶ *System Driven mode*: This is the normal mode of operation. In this mode, the OCP displays status associated with the actions that were caused by commands issued via the drive's internal (drive to library) serial interface.

When you press and release an OCP button, the OCP automatically transitions to User Interaction mode. User Interaction mode continues until three minutes after you stop pressing buttons, or the requested accessor action stops, whichever is longer. At which time, the OCP returns to System Driven mode.

If necessary, the Operator Control Panel automatically transitions to the System Driven mode. When this occurs, the library must remember what you were doing before the display mode changed. Therefore, the next button pressed only transitions the OCP to the User Interaction mode from the System Driven mode. In cases where you have the user security feature activated, the User Interaction mode is restricted to Login and Monitor menu items, until a user logs in with a correct password.

Web User Interface

You can perform many of the same operations from the Operator Control Panel or remotely by using the Web User Interface. The Web User Interface lets you monitor and control your library from any terminal connected to your network or through the Web.

The Web User Interface hosts a dedicated, protected Internet site that displays a graphical representation of your library. After establishing a connection to the library, open any HTML browser and enter the IP address of the library. To configure the Web User Interface, you must set the IP address. Library supports *IPv4*, *IPv6*, or Dual Stack *IPv4 + IPv6*.

For *IPv4* or Dual Stack *IPv4 + IPv6*, enter your library's static IP Address using the 0.0.0.0 format (four octets).

For *IPv6*, enter your library static IP Address or Router Assigned IP Address using the following format: `http://[0:0:0:0:0:0:0:0]`. To determine your Router Assigned IP Address, navigate to **Monitor** → **Library** → **Network** on the Operator Control Panel. For the IPv6

Router Assigned Addresses to be displayed on the Operator Control Panel, the Network must be configured to IPv6 only and the Stateless Autoconfig must be set to ON.

Figure 9-10 shows you the Network Configuration panel view from the Web User Interface.

Figure 9-10 TS3200 Network Configuration panel

9.8.2 Configuring the IBM TS3200 Tape Library

One of the benefits of the IBM TS3200 Tape Library is the standard Remote Management Unit (RMU). The IBM TS3200 Tape Library can be configured and monitored, and the firmware of the library and the drive can be updated remotely. To access the IBM TS3200 Tape Library, RMU uses an Ethernet connection. Figure 9-10 shows you the Network Configuration frame from the Web User Interface.

For the initial setup, you can use the default configuration, which is:

- ▶ Dynamic Host Configuration Protocol (DHCP): On
- ▶ Network Address: 0.0.0.0
- ▶ Drive ID:
 - 4 for the first SCSI drive or Fibre Channel drive
 - 5 for the second SCSI drive or Fibre Channel drive
- ▶ Library mode: Random

Making a direct connection to the IBM TS3200 Tape Library might require a crossover Ethernet cable.

Figure 8-13 on page 206 shows the Library Mode menu and the process flow to configure the TS3100 and is also valid for configuration of the TS3200 with one logical library.

Figure 9-11 on page 230 shows the Library Mode menu and the process flow for configuring the TS3200 with two logical libraries.

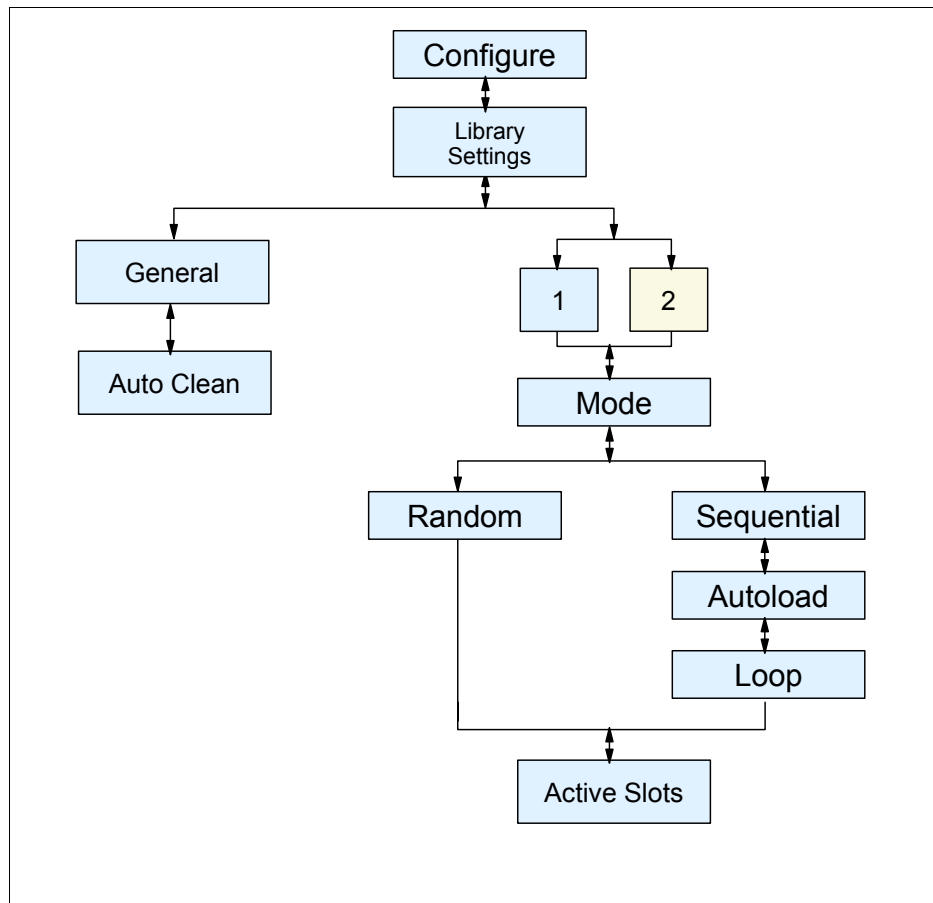


Figure 9-11 Library Mode menu for the IBM TS3200 Tape Library

From the Mode menu, you select the Library Mode for each of the logical libraries. Two library modes are available for the IBM TS3200 Tape Library:

- In *Random* mode, the library allows the server's (host's) application software to select any data cartridge in any order.
- In *Sequential* mode, the library's firmware predefines the selection of the cartridges. After initialization, the firmware causes the library to select the first available cartridge found (counting from 1) for loading into the drive. In Figure 9-11, you find the tree structure of the Library mode menu.

In combination with Sequential mode, you can turn on two additional modes:

Autoload	Sequential mode with autoload mode ON loads the first cartridge automatically if the library powers on with an empty drive.
Loop	Sequential mode with loop mode ON loads the cartridge in slot 1 after the cartridge in the highest numerical slot has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

You also define the number of *Active Slots* that you want to assign in your library. You can reserve slots, so that they are invisible to the host. It might be necessary to set the number of active slots in order to match the number of available slots to the Independent Software Vendor (ISV) software licensing.

Note: When the IBM TS3200 Tape Library is connected to a System i, you must do an IPL on the I/O adapter (IOA). Otherwise, System i does not recognize the new mode.

Partitioning the IBM TS3200 Tape Library

You can partition the IBM TS3200 Tape Library into a maximum of four logical libraries. A mixture of a SCSI drive, a Fibre Channel drive, or a SAS drive is allowed. All three types of attachment can be intermixed within the same logical library.

When there are four drives installed, and partitioning is set up for four logical libraries, then each logical library is assigned one magazine and the I/O slots are shared among the four logical libraries. If installed, the cleaning cartridge is also shared among the four logical libraries.

For detailed instructions about partitioning the IBM TS3200 Tape Library, refer to the *IBM System Storage TS3100 Tape Library and TS3200 Tape Library Setup, Operator, and Service Guide*, GA32-0545.

9.8.3 Host Bus Adapter (HBA) support

HBA support is available for SCSI attachment and for Fibre Channel attachment.

SCSI hosts

Before connecting the IBM TS3200 Tape Library to your host, make sure that the installed HBA in your server is supported.

Note: SCSI adapters, which are part of the server's system board, are not supported.

Check the IBM Interoperability Matrix on the Web:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html#interoperability>

The library uses a single SCSI or Loop ID per drive and dual logical unit numbers (LUNs) to control the tape drive (LUN 0) and library accessor (LUN 1). The library requires an HBA that supports LUN scanning. If it is not enabled, your host system will not scan beyond LUN 0 and will fail to discover the library. It will only see the tape drive.

If the IBM TS3200 Tape Library is daisy-chained, the last device on the bus must have a SCSI terminator installed. The IBM Ultrium 3 LVD tape device supports a bus length of 25 m (82 ft.) point-to-point and 12 m (39.4 ft.) using a multi-drop interconnection. For each daisy-chained device, the maximum cable length must be reduced by 0.5 m (1.6 ft.).

Note: Certain HBAs, such as RAID controllers, do not support LUN scanning.

9.8.4 Fibre Channel

If you want to connect the IBM TS3200 Tape Library to a Fibre Channel HBA, check the following Web site to see if the installed HBA in your server is supported:

<http://www-03.ibm.com/systems/storage/tape/ts3200/index.html>

Figure 9-12 on page 232 shows the IBM Technical Support Web site. To determine which HBA is supported, click **System Storage Interoperation Center** and follow the instructions.

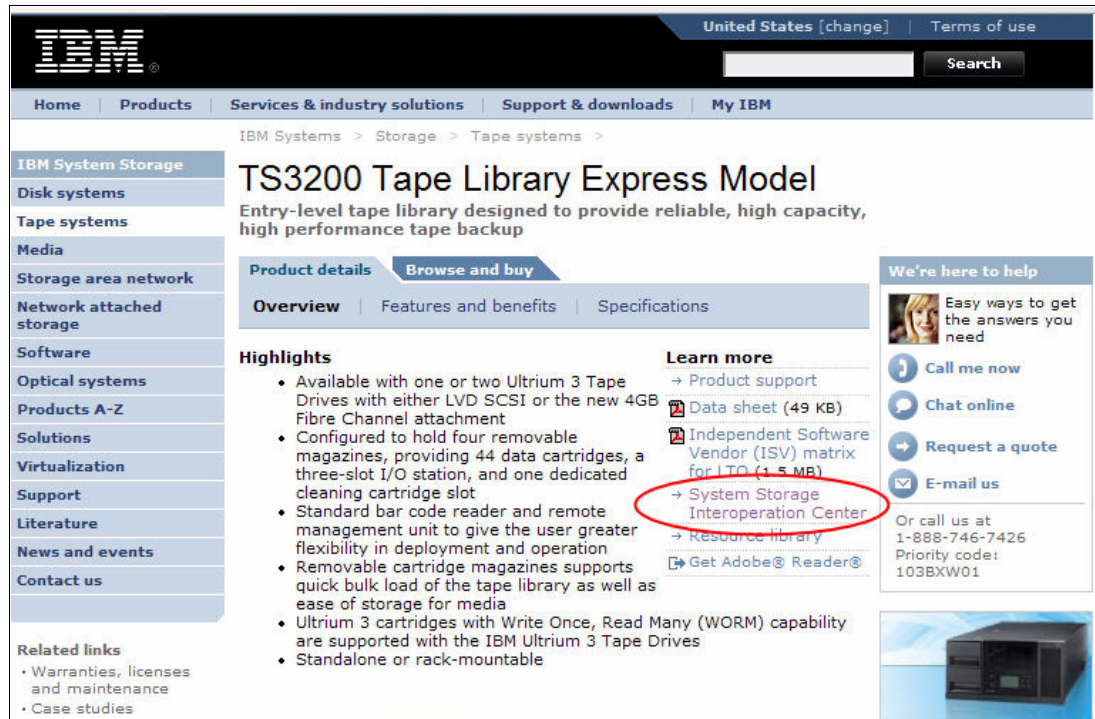


Figure 9-12 System Storage Interoperation Center

9.8.5 Firmware

At installation time, make sure that the actual firmware for the library and the drives is installed on your IBM TS3200 Tape Library. The IBM TS3200 Tape Library is designed as a Client Setup Machine (CSU), and it is the client's responsibility to have the current firmware installed. Determine the current level of firmware available from these IBM Technical Support Web sites:

<http://www.ibm.com/storage/lto>
<ftp://index.storsys.ibm.com>

The preferred way to update the firmware of the IBM TS3200 Tape Libraries is to use the Web User Interface for the library firmware and for the drives.

The RMU or Web User Interface comes standard with the IBM TS3200 Tape Library. This provides a much simpler method for System i clients to update firmware than was previously available. The Field Microcode Replacement (FMR) function is not supported on the IBM TS3200 Tape Library.

The IBM TotalStorage Diagnostic Tool (ITDT) is an alternate way to update the drive firmware, take a dump of a drive, and to test the drive and library. This tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)

- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and it is available in two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

Both SCSI and Fibre Channel drives are supported. ITDT does not use any installed device driver and is therefore also an excellent tool for testing the drives. After the IBM TS3200 Tape Library is connected to the host and ITDT is started from a command prompt, the tool scans the bus and finds and displays all of the IBM LTO devices. Using tapeutil via the SCSI interface is also supported.

Using ITDT, you can force dumps on a drive and have the output sent to an IBM Support Center for further analysis.

9.8.6 Cartridge magazines

The IBM TS3200 Tape Library has four removable magazines. Magazine access can be password-protected. For safety reasons, the accessor motion stops when a magazine is removed or inserted.

Figure 9-13 shows the four removable magazines.



Figure 9-13 Left and right cartridge magazines of the TS3200 Tape Library

The magazines can be released using the OCP or the Web User Interface. In case the OCP or Web User Interface-initiated process has failed or the library no longer has power, a manual emergency release is available.

The I/O (Input/Output) station is part of the lower left magazine. To open the I/O station, grasp the lower handle of the lower left magazine and gently pull the I/O station open. To close the I/O station, gently push it back into the left magazine.

Figure 9-14 shows the back side of the I/O station with the finger holes that allow you to push the cartridges out of the I/O station.



Figure 9-14 TS3200 I/O station in the lower left magazine

Inserting cartridges into the IBM TS3200 Tape Library

To insert cartridges into the IBM TS3200 Tape Library, follow these steps:

1. Unlock the cartridge magazines using the OCP or the Web User Interface.
2. Remove all magazines from the library.
3. Insert cartridges in the magazine. Do not store in the I/O slots or in the dedicated cleaning cartridge slot.
4. Insert the cleaning cartridge in the dedicated cleaning cartridge slot, which is the top slot of the back column of the lower left magazine. Refer to Figure 9-6 on page 222 for the correct location.
5. Put all magazines back into the library.

9.8.7 Physical dimensions

The TS3200 Tape Library is a medium-sized library with the following dimensions:

- ▶ Width: Rack mount 44.75 cm (17.6 in.), stand-alone 44.75 cm (17.6 in.)
- ▶ Depth: Rack mount 74 cm (29.13 in.), stand-alone 81 cm (31.9 in.)
- ▶ Height: Rack mount 17.52 cm (6.9 in.), stand-alone 18.52 cm (7.3 in.)
- ▶ Weight with one drive and without media: 21.32 kg (47 lbs.)

9.8.8 Element addressing

To manipulate the media within the IBM TS3200 Tape Library, the host must reference each movement with a source and target destination. This is done using *element addressing*, which specifies which slots are used as target and destination.

9.9 Feature codes

You can order the IBM TS3200 Tape Library with the features shown in Table 9-4. Refer to the product publications for detailed information.

Table 9-4 Features for the IBM TS3200 Tape Library

Feature code	Description
1682	Path Failover
1901	Additional Power Supply
5096	LC-SC Fibre Cable Interposer
5602	2.5 m (8.2 ft.) VHDCI/HD68 SCSI Cable
5604	4.5 m (14.8 ft.) VHDCI/HD68 SCSI Cable
5610	10 m (32 ft.) VHDCI/HD68 SCSI Cable
5900	Transparent LTO Encryption. Provides license keys to enable SME and LME
6005	5 m (16.4 ft.) LC/LC Fibre Cable
6013	13 m (42.7 ft.) LC/LC Fibre Cable
6025	25 m (82 ft.) LC/LC Fibre Cable
7002	Rack Mount Kit with Power Cord
8002	Universal Cleaning Cartridge
8043	Ultrium 3 LVD SCSI Drive Sled
8044	Ultrium 3 4 GB Fibre Drive Sled
8046	Ultrium 3 Half-High LVD SCSI Tape Drive
8047	Ultrium 3 Half-High SAS Tape Drive
8143	Ultrium 4 Full-High LVD SCSI Tape Drive
8144	Ultrium 4 Full-High Fibre Channel Tape Drive
8145	Ultrium 4 Full-High SAS Tape Drive
8106	Right Side Magazine Set
8305	Data Cartridge (Generation 3) 5-pack
9848	Additional Rack to Power Distribution Unit (PDU) Line Cord
9900	Encryption Configuration. This feature must be ordered when encryption will be used in the library. It includes publication updates with information about enabling and configuring the library to support encryption. This feature also provides an Encryption Key Manager (EKM) publication.

Table 9-5 on page 236 lists the feature codes for SAS attachment.

Table 9-5 SAS feature Codes

Feature Code/High Volume	Description	
5402	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and drives.
5502	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges and can only be ordered when ordering the TS2340.



IBM System Storage TS3310 Tape Library

The TS3310 Tape Library is a highly expandable Ultrium LTO library that allows you to start small with a 5U base unit available in desktop or rack-mounted configurations. Over time, as your need for tape backup expands, you can add additional 9U expansion modules, each of which contains space for additional cartridges, tape drives, and a redundant power supply. The entire system grows vertically. Currently, available configurations include the 5U base library module alone or with up to four 9U modules.

The TS3310 Tape Library offers a broad range of configuration possibilities. The smallest configuration includes a base unit with one to two LTO3 or LTO4 tape drives, 24 TB of native tape storage (30 slots), and 6 I/O slots. This configuration will be upgradeable to a fully configured rack-mounted library 41U high with up to 18 LTO3 or LTO4 tape drives with over 321.6 TB of native tape storage and up to 54 I/O slots.

The new Serial Attached SCSI (SAS) IBM Ultrium 4 Tape Drive is also supported in the TS3310.

The IBM Ultrium LTO4 Fibre Channel and Serial Attached SCSI (SAS) tape drives are encryption-capable and support Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

10.1 Product description

The IBM System Storage TS3310 Tape Library (TS3100 Tape Library) is a highly modular, vertically scalable library design offering:

- ▶ A 5U desktop or rack-mounted base module providing up to two IBM Ultrium 3 Tape Drives or two IBM Ultrium 4 Tape Drives, 30 storage slots, and six I/O slots.
- ▶ Up to four 9U expansion modules can be installed in each one providing up to four IBM Ultrium 3 Tape Drives or IBM Ultrium 4 Tape Drives and 92 storage slots, 12 of which you can optionally configure as I/O slots.
- ▶ IBM Ultrium 3 Tape Drive support, both SCSI Ultra160 Low Voltage Differential (LVD) and 4 Gbps native switch fabric Fibre Channel drives are supported and can be mixed in a physical library.
- ▶ IBM Ultrium 4 Tape Drive support 4 Gbps Fibre Channel and 3 Gbps SAS, which can be mixed in the physical library.
- ▶ Remote management is supported through a Web interface. Local management is done through a color touch panel.
- ▶ IBM patented Multi-Path Architecture with logical library support to share the library between multiple homogeneous or heterogeneous systems or applications.
- ▶ Support for a wide range of systems including System p, pSeries, System x, xSeries, System i, iSeries, AS/400, RS/6000, Intel, Hewlett-Packard (HP), and Sun.
- ▶ Native Storage Management Initiative Specification (SMI-S) support.
- ▶ A barcode reader.

Optionally, you can install the following features:

- ▶ Path failover for both control paths and data paths
- ▶ Capacity on Demand (COD) to non-disruptively provide extra capacity
- ▶ Redundant power supplies for each module
- ▶ Rack mounting

A fully expanded TS3310 Tape Library today occupies 41U of rack space and a potential maximum of 402 storage slots (160.8 TB of storage on Ultrium 3 media at native capacity, 169.6 TB at 2:1 compression, and 321.6 TB of storage on Ultrium 4 media at native capacity, 643.2 TB at 2:1 compression).

All configurations require one TS3310 Tape Library Model L5B base module. Expansion is provided through the addition of TS3310 Tape Library Model E9U expansion modules.

The TS3310 Tape Library supports all three encryption methods:

- ▶ Application-Managed Encryption is available at no charge
- ▶ Library-Managed Encryption is available with Feature Code (FC) 5900 and FC9900
- ▶ System-Managed Encryption is available with FC5900 and FC9900

10.1.1 TS3310 Tape Library Model L5B (Machine type 3576)

The base module, which you can see in Figure 10-1 on page 239, offers as standard:

- ▶ A Library Control Module (LCM) with remote management interface.
- ▶ 30 storage slots.
- ▶ Six I/O slots (configurable as storage slots if the library is expanded).

- ▶ A color touch-sensitive window Operator Panel for local management.
- ▶ Cartridge handling robotics.
- ▶ IBM patented Multi-Path Architecture with logical library support to allow the control of the library by one or multiple systems through multiple paths.
- ▶ Native SMI-S 1.2 support.
- ▶ Up to two Ultrium 3 or Ultrium 4 Tape Drives.
- ▶ A power distribution unit (PDU). A second PDU is optionally available for redundancy.
- ▶ Path failover for data path and control paths can be enabled through a chargeable license.
- ▶ Licensing to enable the use of up to 82 storage slots (additional storage slots beyond the 30 present in the base module require an expansion module).

You can install the base module, shown in Figure 10-1, as a desktop, deskside, or frame-mounted device.



Figure 10-1 Front view of TS3310 Tape Library Model L5B

10.1.2 TS3310 Tape Library Model E9U (Machine type 3576)

You can stack an expansion module above or below the base module (seen in Figure 10-2 on page 240). This configuration has the following features:

- ▶ There are 80 storage slots and 12 I/O slots. The I/O slots can be configured to be storage slots.
- ▶ Up to four Ultrium 3 or Ultrium 4 Tape Drives.
- ▶ A power distribution unit (PDU). A second optional PDU is available for redundancy.
- ▶ There are 46 of the total slots in the first expansion module that are immediately usable (due to the licensing that was provided with the base module). The rest can be non-disruptively enabled by installing a license for Capacity Expansion (FC1682). Subsequent expansion modules require Capacity Expansion features to enable the use of storage slots in increments of 46.
- ▶ A 5U base module and one 9U expansion module can be installed as either a desk-side device or in a rack. If two 9U expansion modules are installed, they must be rack-mounted.



Figure 10-2 Front of TS3310 Tape Library 41U

10.2 Library expansion

As we described earlier, the base library can be “scaled up” with the addition of expansion modules. Regardless of the number of expansion modules, the TS3310 Tape Library uses a single robust “flow through” design robotic system to access all drives and media. It never requires complex pass-through ports or elevator systems, which removes the need for expensive duplication of robotics and control electronics with each library expansion. It also results in more reliable operations.

Expansion modules can be implemented above or below the base module and approximately 2.5 hours are required from start to finish. When multiple expansion modules are used, they can be installed around the base module if desired.

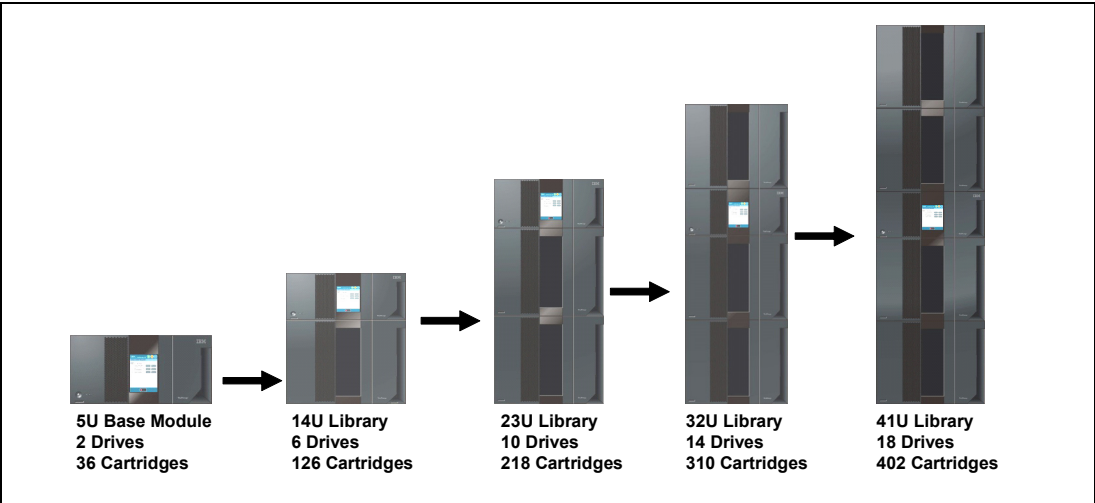


Figure 10-3 TS3310 expansion path

The addition of each expansion module provides a total of 92 storage slots, which are enabled through the use of “Capacity on Demand” licenses. Note that the base module ships with licensing for 82 slots. This effectively means that when you add the first expansion module, half the slots are immediately available without the requirement to acquire additional licenses.

You can configure the I/O slots in each module as a group to operate as I/O slots or storage slots (at least one group must operate as I/O slots). This provides a high degree of flexibility. In a library configuration of one L5B base unit and one 9EU expansion unit, for example, there are three possible combinations:

- ▶ A total of 6 I/O slots (all in the base module)
- ▶ A total of 12 I/O slots (using the slots in the expansion module)
- ▶ A total of 18 I/O slots (using the slots in the base module and the expansion module)

Expansion of the TS3310 Tape Library is extremely granular and highly configurable. Table 10-1 demonstrates the many configuration options available as the base module expands.

Table 10-1 Library configurations showing I/O slots, storage slots, and drive combinations

Library configuration	Number of available I/O station slots ¹	Number of accessible storage slots	Total slots ²	Number of expansion license keys
5U library (control module)	6	30	36	No license key required
14U library (control module + 9U expansion module)	6/12/18	76/70/ 64	82	No license key
	6/12/18	122/116/110	128	One license key required to enable the full capacity of a 14U library

Library configuration	Number of available I/O station slots¹	Number of accessible storage slots	Total slots²	Number of expansion license keys
23U library (control module + 2 9U expansion modules)	6/12/18/24/30	122/116/110/104/98	128	No license key
	6/12/18/24/30	168/162/156/150/144	174	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30	212/206/200/194/188	218	Two license keys required to enable the full capacity of a 23U library
32U library (control module + 3 9U expansion modules)	6/12/18/24/30/36	168/162/156/150/144/138	174	No license key
	6/12/18/24/30/36	212/206/200/194/188/182	218	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30/36	260/254/248/242/236/230	266	Two license keys enable an additional 46 slots on each of two 9U expansion modules
	6/12/18/24/30/36	304/298/292/286/280/274	310	Three license keys required to enable the full capacity of a 32U library

Library configuration	Number of available I/O station slots ¹	Number of accessible storage slots	Total slots ²	Number of expansion license keys
41U library (control module + 4 9U expansion modules)	6/12/18/24/30/36/42	212/206/200/194 188/182/176	218	No license key
	6/12/18/24/30/36/42	260/254/248/242 236/230/224	266	Each license key enables full capacity of one 9U expansion module
	6/12/18/24/30/36/42	304/298/292/286 280/274/268	310	Two license keys enable an additional 46 slots on each of two 9U expansion modules
	6/12/18/24/30/36/42	352/346/340/334 328/322/316	358	License keys enable an additional 46 slots on each of three 9U expansion modules
	6/12/18/24/30/36/42	394/388/382/376 370/364/358	402	Four license keys required to enable the full capacity of a 41U library
1. The I/O station in the 9U expansion module contains 12 slots that can be configured as either I/O or storage slots. If the 9U expansion module I/O slots are configured as I/O, the control module slots can be configured as storage slots. 2. The number of available I/O and storage slots listed in the preceding table are adjusted for the unusable slots in each configuration that are not accessible due to space restrictions, which limit the movement of the picker.				

10.3 Front panel components

Figure 10-4 on page 244 shows the front panel components of the TS3310.

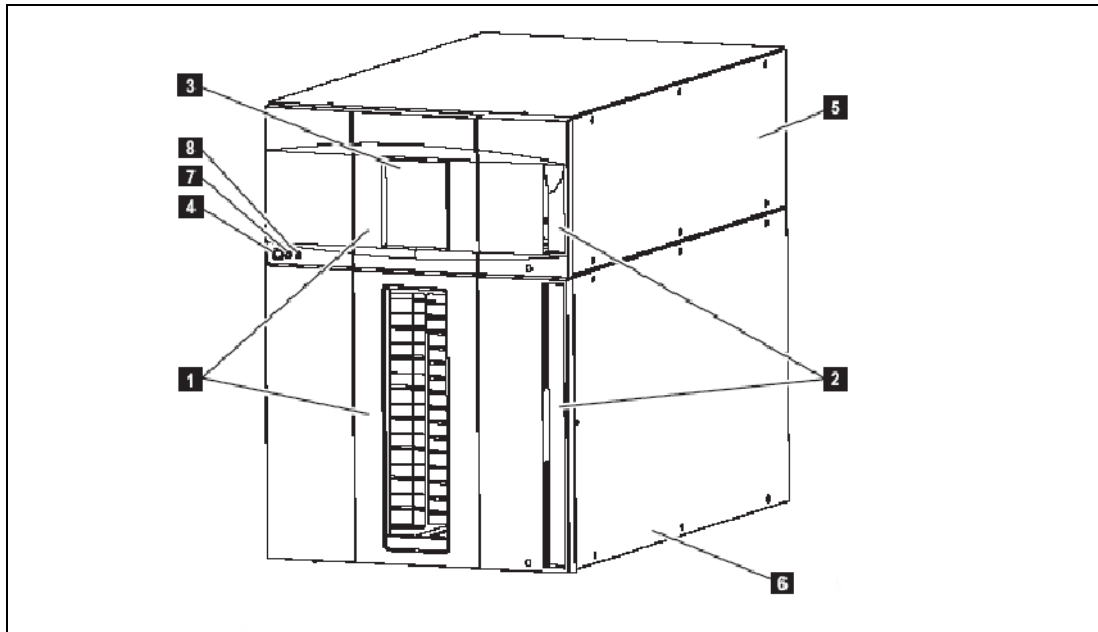


Figure 10-4 Elements visible in the front view of a 14U library configuration

The elements shown in Figure 10-4 are:

1. Access doors
2. I/O stations
3. Operator Panel
4. Power button
5. 5U control module
6. 9U expansion module
7. Green Power ON Light Emitting Diodes (LEDs)
8. Amber Operator Intervention Alert LED

All library configurations include the base module. The base module contains the robotics, library control blade (LCB), and touch-sensitive display. The base module also contains an I/O station, fixed storage slots, one or two tape drives, and one or two power supplies.

10.3.1 Expansion module

Like the control module, the expansion module also provides fixed storage slots, tape drive slots, and power supply slots. The I/O station in an expansion module can be configured as storage. If an expansion module contains only cartridges, all power is derived from the control module.

10.3.2 I/O station

I/O stations are located on the front panel of the library and enable inserting and removing cartridges without interrupting normal library operations. A base module I/O station has a capacity of six cartridges. A 9U expansion module I/O station has a capacity of 12 cartridges.

When an operator places cartridges in the I/O station, the Operator Panel prompts to request Logical Library assignment. The operator must respond to this prompt within two minutes; otherwise, the library assigns the tapes instead to the physical library from which the host application will not have access. All cartridges in the I/O station are assigned as a group. That is, if an operator had cartridges for several logical libraries, the cartridges must be sorted into separate groups prior to being placed in the I/O station.

After an I/O station slot is assigned to a logical library, only that logical library can access that slot. The I/O station is shared among all logical libraries, but the I/O station slots are owned by one logical library at a time. In a 5U library, the six I/O station slots cannot be configured as storage.

10.3.3 Access door

Each base module and expansion module has a door on the front panel that allows access to the internal components of the library. This door is locked by the I/O station. To open the access door, you must first open the I/O station.

Note: When any access door is opened, all in-progress motion commands stop, the picker lowers to the bottom of the library, and the library is taken offline (the library must be put back online manually). When the access door is closed, the library returns any media in the picker to its original storage slot.

10.3.4 Operator Panel

The Operator Panel is the touch-sensitive display device located on the access door of the control module. Library operations and service functions are performed from this display. The Web User Interface offers part of the same functionality as the Operator Panel via a Web browser, which enables remote access to the library. For more information about the Operator Panel and the Web User Interface, refer to 10.7, “Library management” on page 251.

10.3.5 Power button

Pressing the Power button on the front panel of a control module turns the picker and Operator Panel ON or OFF; however, power is still applied to the power supplies. The Power button is used during library shutdown and to manually restart the library.

10.3.6 Front panel LEDs

Two LEDs are located on the front of the library to the right of the Power button. The color indicates the problem area:

Green	Power on LED. When lit, this LED indicates that the library power is ON.
Amber	Operator Intervention Alert LED. When lit, this LED indicates that library, drives, or media Operator Interventions exist. To access the Operator Intervention, select Tools → Operator Intervention from the Operator Panel.

10.4 Rear panel components

Figure 10-5 shows the rear view of a 14U (one base module and one expansion module) library and its major components.

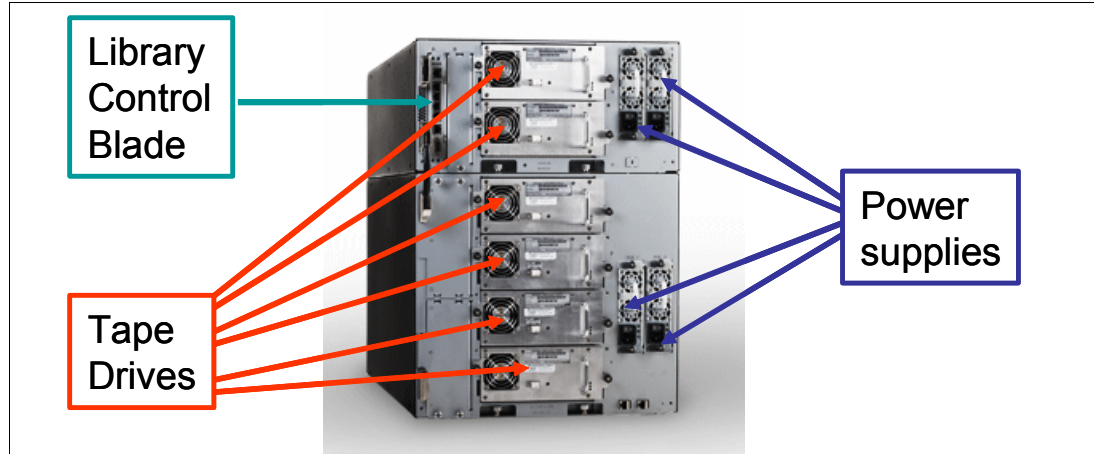


Figure 10-5 Rear panel view of 14U library

10.4.1 Library Control Blade (LCB)

The Library Control Blade manages the entire library, including the Operator Panel and picker, and is responsible for running system tests to ensure that the library functions properly. The LCB houses the Compact Flash Card, which stores vital product data (VPD), such as library settings, the serial number, and so forth. The LCB indicates status with three light emitting diodes (LEDs).

The LCB LEDs indicate status by the rate at which they blink. The color of the LED identifies the area of the component being reported:

► **Green:** Processor Status:

Solid ON	Processor not operating.
Solid ON for three seconds, then blinks twice	LCB firmware is downloading.
One blink per second	Normal: Processor operating.
Ten blinks per second	Identify mode.
Solid OFF	Processor not operating.

► **Amber:** Health Status:

One blink per second	Main processor not operating.
Solid OFF	Normal: Blade operational.

► **Blue:** Power Control Status:

Solid ON	Swap mode: LCB is powered down and can be removed.
One blink per ten seconds	Normal: LCB on.
Solid OFF	LCB not receiving power.

It is the combination of these LEDs and respective specific timing of their being ON that indicates a good or faulty status of the LCB. All three LEDs on solid ON for more than twenty minutes indicate a bad or corrupted compact flash.

10.4.2 Tape drives

The library supports Ultrium 3 SCSI and Fibre Channel tape drives and Ultrium 4 SAS and Fibre Channel tape drives. Tape drives are hot-addable (library power remains ON and operations of the installed tape drives are still active). Drives can be removed and installed without tools. The drive sled itself is a client-replaceable unit (CRU).

SCSI tape drives are attached directly to a host. Fibre Channel tape drives can be directly attached to a host or a Storage Area Network (SAN). At the time of writing this book, SAS tape drives only supported a point-to-point connection from the tape drive to the server's HBA. Drives mounted in sleds are installed into tape drive slots in the rear of the library. If a tape drive slot is empty, a metal plate covers the empty drive slots to prevent debris from entering the library.

Figure 10-6 shows the back side of the SAS tape drive with two SFF-8088 interfaces.



Figure 10-6 The back side of the SAS tape drive

10.4.3 Power supply

The library supports single and redundant power configurations. A single power configuration has a power supply installed in the left slot of each library module. A redundant power configuration has power supplies installed in both slots of each library module. When using two power supplies in a single module, the power load is spread evenly over both power supplies. If one of the power supplies fails, the power load will be drawn entirely from the functioning supply.

The single configuration has a single AC line input and a single DC power supply. The optional redundant configuration has dual AC line input and dual DC power supplies. A power supply can be hot-swapped if the library has a redundant power supply. A redundant power supply can be hot-added. A power switch is located on every power supply on a control module and an expansion module. This switch is used to remove all power from the library for emergency and service situations. Except in emergency situations, use the shutdown procedure before switching off the power switch.

The power system of the library contains the following components:

- ▶ Power supply
- ▶ AC power cord

The power supply has three LEDs that provide status information. These LEDs, located to the right of the power switch, are green, amber, and blue in color:

- ▶ Green indicates a good AC or DC status.
- ▶ Amber indicates a degraded status.
- ▶ Blue indicates a fault status.

10.5 Interior components

Storage columns and the robotic system are located within the body of the library.

10.5.1 Storage columns

Storage columns within the library store cartridges while they are not loaded into a drive. The library contains six storage columns. One of those six columns is the I/O station.

10.5.2 Robotic system

The robotic system includes the Y-axis assembly that houses the Y motor, the picker (which is attached to the carrier), and the barcode scanner. The climber moves the robotic system within the library. The picker (robotic arm) has fingers that enable it to grab tape cartridges and move them to and from the I/O station, storage slots, and drives. The barcode scanner reads each cartridge barcode label and the fiducial labels that identify the types of cartridge magazines and tape drives installed in the library.

10.6 Optional features

The TS3310 Tape Library is highly configurable, and enhanced functionality is available through the provision of optional features.

10.6.1 Ultrium 4 Tape Drives

This library supports the Ultrium 4 Tape Drive. Each tape drive in the library is packaged in a container called a *drive sled*. The drive is a CRU, and it is designed for quick removal and replacement in the library. The IBM Ultrium 4 Tape Drive supports SAS or Fibre Channel interfaces. Refer to Chapter 2, “Overview of IBM LTO Ultrium Tape Drives” on page 29 for more information.

Servo and track layout technology

There are 896 data tracks in Ultrium 4 (compared to 704 data tracks in Ultrium 3) that are used to read and write data to the data cartridge. These tracks are grouped in five servo bands as explained in “Servo tracks” on page 35. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

Speed matching

To improve the performance of the LTO4 Tape Drive, the tape drive uses a technique called *speed matching* to dynamically adjust its native (uncompressed) data rate to the slower rate of the server's host bus adapter (HBA). The LTO4 Tape Drive negotiates with the server's HBA, setting up a speed with the best performance. Six speeds are available when reading or writing the generation 3 or generation 4 cartridge format. Native rates are:

- ▶ Generation 3: 30, 40, 50, 60, 70, or 80 MB/s
- ▶ Generation 4: 30, 48, 66, 84, 103, or 120 MB/s

If the server is between two of the native rates, the drive calculates the appropriate data rate at which to operate. Speed matching reduces *backhitching*. Backhitching is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is usually the result of a mismatch between the data rates of the connected server and the tape drive.

Channel calibration

The performance of the LTO4 tape drive is further optimized by a feature called *channel calibration*. Channel calibration is the process in which the drive automatically customizes each Read/Write data channel to compensate for variations in the recording channel's transfer function, the media, the characteristics of the drive head, and so forth.

Sleep mode

To save energy, the LTO4 tape drives use a feature called *sleep mode*. To enter sleep mode, the LTO4 tape drive must be inactive for a minimum of 30 seconds. The LTO4 tape drive will go out of this sleeping mode again after receiving a SCSI command, a command across the Library/Drive interface (LDI) or RS-422, or on a load or unload request. When in sleep mode, the drive response time to commands that do not require media motion increases by up to ten microseconds. Commands that require media motion might be delayed an additional 100 milliseconds, because the tape must be retensioned.

Redundant power supply

You can hot swap the optional redundant configuration power supplies (FC1900) without interrupting library operation. Each supply in a control module and expansion module includes its own input AC line cord. During redundant operation, each supply carries one-half the power load. If a line cord or power supply fails, the second supply sources the complete power load. Optionally, you can install a single power supply and line cord if redundant power is not required. The second power supply slot is physically covered in this configuration. The library can be upgraded to redundant power at a later time.

10.6.2 Ultrium 3 Tape Drives

This library supports the Ultrium 3 Tape Drive. Each tape drive in the library is packaged in a container called a *drive sled*. The drive is a CRU, and it is designed for quick removal and replacement in the library. The IBM Ultrium 3 Tape Drive supports LVD Ultra160 SCSI or Fibre Channel interfaces. It features two HD68 connectors, two SAS SFF-8088 connectors, or one LC Fibre Channel connector (FC8042 for Fibre Channel or FC8037 for SCSI). Refer to Chapter 2, "Overview of IBM LTO Ultrium Tape Drives" on page 29 for more information.

Note: LTO3 Ultra160 SCSI, SAS, and Fibre Channel drives are allowed in the same physical library, but not in the same logical library.

LTO3 characteristics

Here, we describe several of the highlights of the Ultrium 3 Tape Drives. Most of the functions are similar to the Ultrium 4 Tape Drive that we described in 10.6.1, "Ultrium 4 Tape Drives" on page 248. They are:

- ▶ **Servo and track layout technology**

The Ultrium 3 Tape Drive uses 704 data tracks to read and write data to the data cartridge.

- ▶ **Dynamic speed matching**

The Ultrium 3 Tape Drive is designed to perform *dynamic speed matching* (at one of four speeds of 30, 40, 50, or 60 MB/s) to adjust the tape drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This design helps reduce the number of backhitch repositions and improves throughput performance.

- ▶ **Surface Control Guiding Mechanism**
This function has been designed to guide the tape along the tape path. This method uses the surface of the tape rather than the edges to control the tape motion.
- ▶ **Channel calibration**
The channel calibration feature of the Ultrium 3 Tape Drive customizes each Read/Write data channel for optimum performance.
- ▶ **Magneto resistive (MR)**
This is a head design that uses flat lap head technology in the MR heads for Ultrium 3.
- ▶ **Separate writing of multiple file marks**
This function is designed to request any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark.
- ▶ **Sleep mode**
The Ultrium 3 Tape Drive has a power management function that is designed to control the drive electronics to be either completely turned off or stay in low-power mode when the circuit functions are not needed for drive operation.
- ▶ **Statistical Analysis and Reporting System (SARS)**
The Ultrium 3 Tape Drive uses SARS to help isolate failures between the media and the hardware.

10.6.3 Feature licenses

A *feature license* controls the setting of feature-enabled flags that are based on a user input key and the library serial number that is stored in the library vital product data (VPD). A unique key exists for each library based on an encryption of the chassis serial number and a feature code. After a feature is enabled, it cannot be disabled. The library's serial number can only be assigned at the factory. The library uses feature licenses to enable the Capacity On Demand feature and the Path Failover feature.

Capacity expansion (FC1640)

At any time, the Capacity Expansion feature (FC1640) allows you to enable the unused storage slots within a library via a firmware license key. The TS3310 Tape Library Model L5B control module includes license key enablement for a total of 82 cartridges, thus enabling all of the cartridge slots in the control module and approximately half of the capacity of an added expansion module. To enable the remaining cartridge storage slots, you must purchase the Capacity Expansion feature (FC1640) for each expansion module that you want to fully enable. For example, one Capacity Expansion feature (FC1640) is required to totally access and enable all available cartridge slots in a 14U configured library (one control module and one expansion module). Two Capacity Expansion features (FC1640) are required to totally access and enable all available cartridge slots in a 23U configured library (one control module and two expansion modules). Refer to 10.2, "Library expansion" on page 240 for more details.

You can see the library's current configuration from the Operator Panel via the Capacity View home window and from the Web User Interface by selecting **Monitor System** → **System Summary**.

Advanced Reporting (FC1650)

Advanced Reporting (FC1650) is a licensed feature that enables the TS3310 to export the drive's read and write history data, tape alerts, and the entire media pool that is associated with the library by using two report formats. The two report formats are:

- ▶ Drive Utilization Reporting
- ▶ Media Integrity Analysis

The Advanced Reporting feature provides diagnostics and trend analysis. This licensed feature is a valuable tool that helps you identify how tape resources are being utilized. You can easily identify if the drive resources are not being fully utilized, so that you can reallocate jobs, decreasing the backup window completion time. The Drive Utilization Report provides you a clear and quantifiable method to determine if additional drives are needed. For major details and a view of the Advanced Reporting panels, refer to 10.7.5, “Advanced Reporting” on page 259.

Path failover (FC1682)

The Path failover feature includes the license keys for activating control path failover and data path failover.

Control path failover

A *control path* is a logical path into the library through which a server sends standard SCSI Medium Changer commands to control the logical library. Additional control paths reduce the possibility that failure in one control path will cause the entire library to be unavailable. Use of the control path failover feature further reduces that possibility.

Data path failover

Data path failover is designed to provide a failover mechanism in the IBM device driver that enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without stopping the current job in progress. This feature allows you flexibility in SAN configuration, availability, and management.

The control path failover license key can be installed by using the Operator Panel and selecting **Setup** → **License**. Or, you can use the Web User Interface and select **Manage Library** → **Setting** → **Feature Licenses**.

Data path failover (DPF) requires a minimum of two paths from the host to a specific tape drive. It allows the IBM device driver to automatically fail over to a redundant path if there is a failure of a host bus adapter (HBA) or a SAN device between the host and the tape drive.

The DPF registration ID is not installed on the library. When needed, it is entered at the host.

For more information about installing the license key on the host, refer to the *IBM Tape Device Driver Installation and User's Guide*, GA27-2130.

Tip: The Control Path Failover key is five digits, and the Data Path Failover key is sixteen digits.

10.7 Library management

The library has two interfaces for management:

- ▶ The Operator Panel for local management
- ▶ A Web User Interface (UI) for remote management

The Operator Panel is located on the front door of the control module (CM) and allows operators to work locally on the library by using the touch panel. The Web UI allows users to view and perform several library functions from remote sites and is best viewed using Internet Explorer 4.0 or higher.

The library is also SMI-S 1.2 compliant. This capability allows Storage Resource Management Applications, such as the IBM Total Productivity Center, to manage the library (along with other SMI-S compliant devices, for example, SAN switches and disk arrays) from a single location.

10.7.1 Operator Panel

The Operator Panel is physically attached to the front door of the base module. The user interface appears on the touch-sensitive LCD display of the Operator Panel for executing basic library management functions. Audible feedback, such as key click sounds, are generated when you touch a button on the touch-sensitive display.

To access the menus, you must first log in using the keyboard display, which appears when you touch the panel.

Note: To use the touch-sensitive display effectively, tap lightly to make your selections.

The first display shown is the welcome window (Figure 10-7). The welcome window provides tabular data about the capacity of the various areas of the library. Use this window to see a quick summary of the capacity of the library.

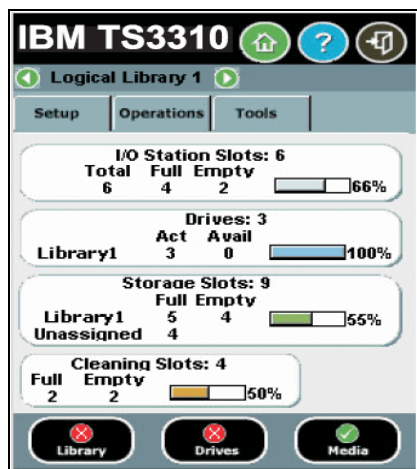


Figure 10-7 Operator Panel welcome window

System summary and subsystem status

You can gauge the health of the library by three subsystem status buttons located at the bottom of the home page. These buttons provide easy access to the health of the library for faster recovery if problems occur. You can select the buttons to view detailed information about the library and gain access to library subsystems. The three subsystems are:

- Library** Opens a library menu selection window and then opens the operator interventions for the library.
- Drives** Opens the operator intervention window for drives.
- Media** Opens the operator intervention window for media.

Each button has three states, which are indicated by color. The three states are:

- ▶ Good: Green
- ▶ Degraded: Yellow (An operator intervention has been created.)

- Investigate: Red (An operator intervention has been created; however, the library might still be operational.)

If users have access to more than one logical library, they can navigate to other logical libraries using arrows next to the logical library name at the top of the window. If an administrative user is logged in, a view of the physical library appears. If a user is logged in, the first logical library to which that user has access, in alphabetical order, appears.

Menus available from the Operator Panel

The following three menus organize commands into logical groups:

- The **Setup menu** consists of commands that you can use to set up and configure various aspects of the library, including logical libraries' connectivity, network, physical library, users, date and time, licenses, and Simple Network Management Protocol (SNMP) trap registration.
- The **Operations menu** consists of commands that enable you to change the library's mode of operations, insert and remove cartridges, load and unload drives, move media, and shut down and restart the library.
- The **Tools menu** consists of commands that you can use to maintain your library, such as viewing operator interventions, capturing a snapshot of the library, identifying ports, and updating firmware using a Field Microcode Replacement (FMR) cartridge.

Figure 10-8 shows a menu tree showing all of the functions that are available from the Operator Panel interface.

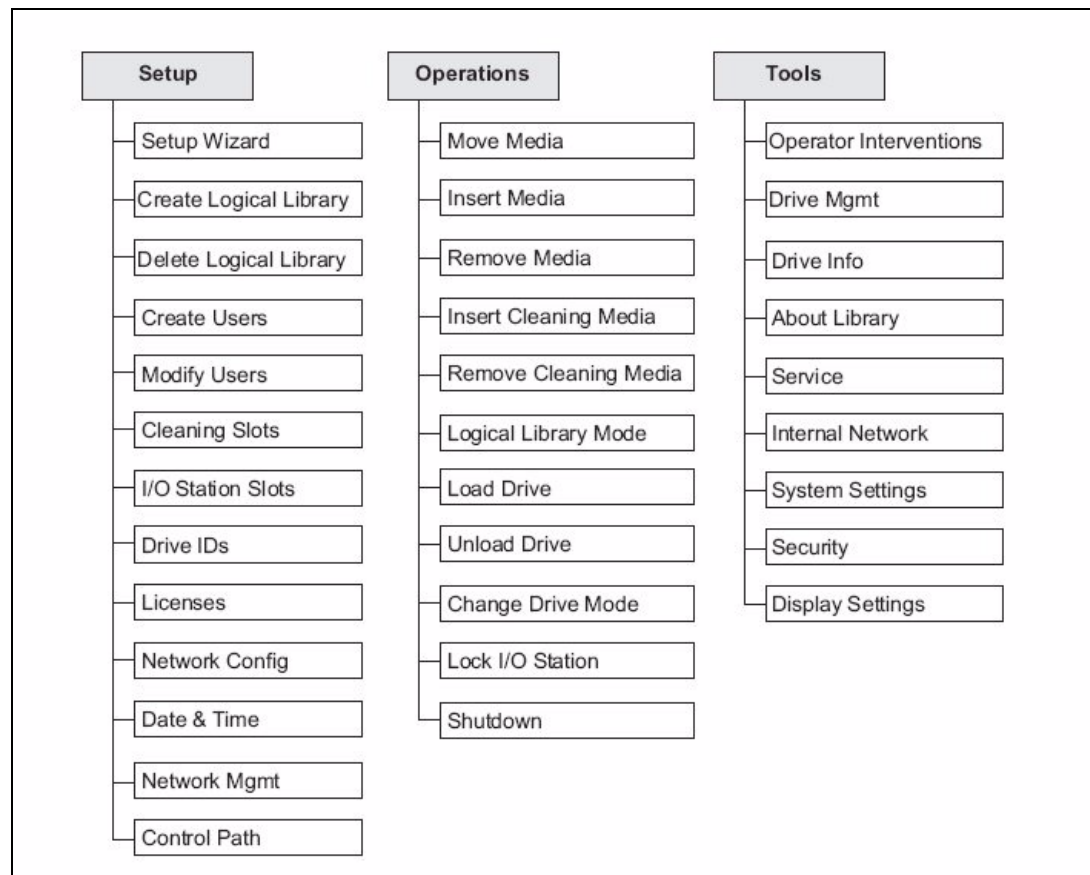


Figure 10-8 Operator Panel menu tree

10.7.2 Web User Interface

The Web User Interface (Web UI) is accessible from a Web browser and is best viewed using Internet Explorer 4.0 or higher. To manage the library using the Web UI, you must set up the initial network configuration of the library from the Operator Panel touch-sensitive display.

Logging in to the Web User Interface

To log in, you need the initial login information:

User: admin
Password: secure

Note: Before exiting the Web UI, you must log out by clicking **LOGOUT** in the upper right corner of any Web UI window. Failure to log out can cause problems to further logins with your library.

Lightweight Directory Access Protocol support (LDAP)

LDAP is the industry standard Internet protocol that provides centralized user account management. Enabling LDAP allows existing user accounts residing on an LDAP server to be integrated into the library's current user account management subsystem. User account information is centralized and shared by different applications, simplifying user account management tasks.

The library supports the Microsoft Active Directory® LDAP server. Windows Services for UNIX 2.5 is required for this support. User password schemes must be encrypted using UNIX cryptography. In addition, user names (uid) and passwords (user password) must be created using lowercase characters to be compatible with the library.

For LDAP users with user privileges, access to the library's logical libraries is determined by group assignment on the LDAP server. Groups must be created on the LDAP server with names that correspond to the library logical library names. Users with user privileges must be assigned to these groups on the LDAP server to have access to the corresponding logical libraries on the library. LDAP users with administrative privileges have access to all logical libraries and administrative functions and do not need to be assigned to logical library related groups on the LDAP server.

Note: When LDAP is enabled, the login screen gives the user a choice between using local authentication (the login and password are stored on the library) or LDAP authentication (the login and password are stored on a server, and the user must specify the LDAP domain name). If LDAP access is disabled, the LDAP options will not appear on the login screen.

Figure 10-9 on page 255 shows the IBM TS3310 Sign On window.

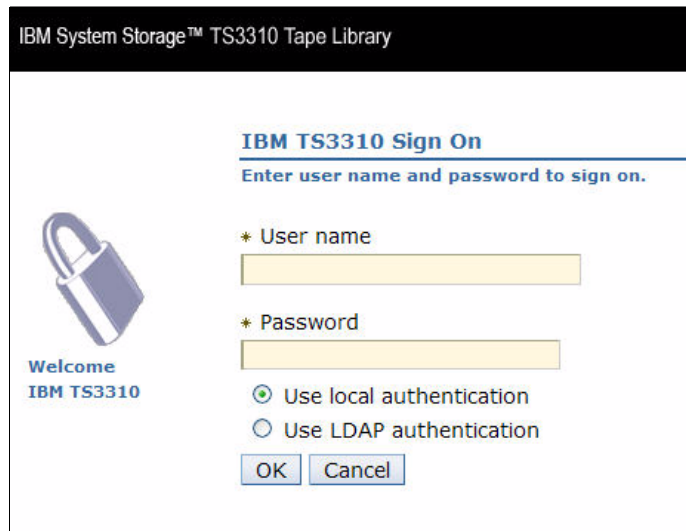


Figure 10-9 IBM TS3310 Sign On window

After you log in, the TS3310 Welcome page is shown. Refer to Figure 10-10.

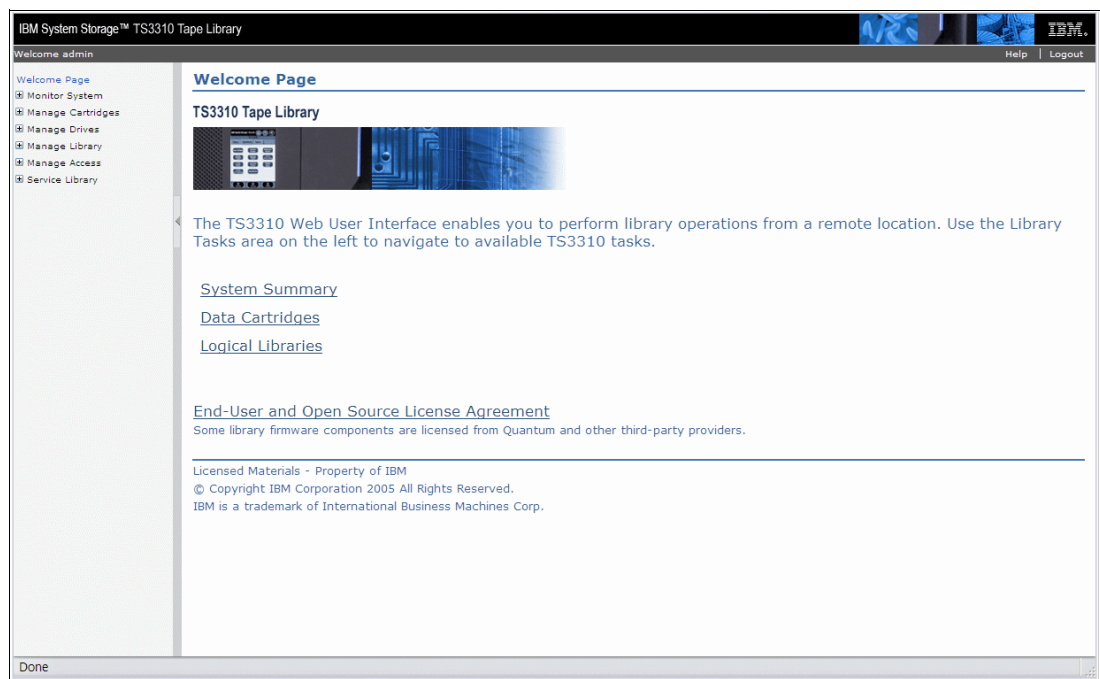


Figure 10-10 TS3310 Welcome Page

Menus available from the Web User Interface

Figure 10-11 on page 256 lists the panels available from the Web User Interface.

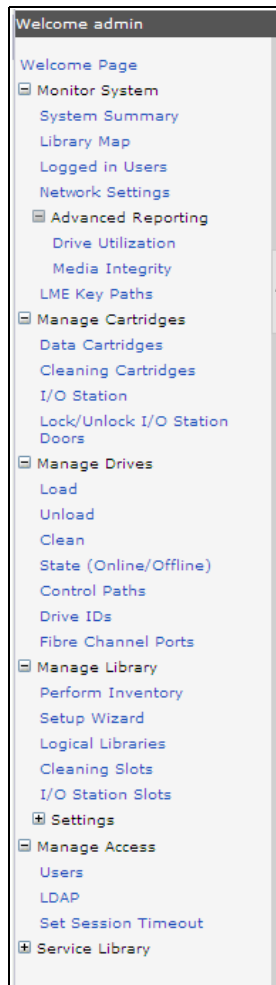


Figure 10-11 Web User Interface menu

Under **Settings**, additional important features are available:

- ▶ Feature licenses
- ▶ Date and time
- ▶ E-mail notifications
- ▶ Simple Mail Transfer Protocol (SMTP) (Mail) configuration
- ▶ Contact information
- ▶ Network
- ▶ SNMP
- ▶ SNMP traps
- ▶ Ethernet Speed/Duplex settings
- ▶ Save and restore configuration

Under **Service Library**, additional important options are available:

- ▶ Operator Interventions
- ▶ Capture Library Logs
- ▶ Capture Drive Logs
- ▶ View/Update Library Firmware Level
- ▶ View/Update Drive Firmware Level
- ▶ Reset Drive
- ▶ Shutdown/Restart Library

User privileges

User privilege levels are manually assigned to user accounts created within the library. Controlling access to windows and operations within the library preserves the integrity of the library and the data that is stored within the library.

There are two types of user privileges in the library:

- ▶ *Administrative users* are allowed access to the entire physical library and all of its logical libraries. One and only one administrator user must be assigned the login name `admin`.
- ▶ *Users* are allowed to operate a logical library, but they cannot perform actions that affect the physical library.

User privileges include:

- ▶ A screen saver is invoked after ten minutes of inactivity on the Operator Panel. The Web User Interface (UI) does not use a screen saver. The User, Administrative user, or Service user, who is inactive between 10 and 30 minutes, returns to the last accessed window when activating the display again.
- ▶ Any logged in User, Administrative user, or Service user, who is inactive for more than 30 minutes, is logged out.
- ▶ Up to eighteen Users and one Administrative user can be logged in at one time on the Web UI. Only one user (Administrative or Service) can be logged in at one time on the Operator Panel. One Administrative user can disconnect another Administrative user.
- ▶ Any user can be logged in to only one interface at a time.
- ▶ When a Service user logs in, all other Users and Administrative users are logged out and notified that they cannot perform actions on the library. A message is posted that Service is logged in and no other users can access the library until after Service has logged out.

10.7.3 Native SMI-S support

Storage Management Initiative Specification (SMI-S) compliance is discussed in greater detail in “IBM tape libraries and SMI-S” on page 382. To summarize, the TS3310 Tape Library conforms to SMI-S 1.2 via an agent that is embedded within the library. SMI-S 1.2 conformance means that the TS3310 Tape Library adheres to the Storage Management Initiative Specification Version 1.2 defined by the Storage Network Interface Association (SNIA).

The purpose of the standard management interface is to allow multiple storage management devices (for example, SMI-S compliant tape libraries, disk arrays, and SAN switches) from many vendors to all be managed from a single Storage Resource Management Application, such as IBM Total Productivity Center.

In practice, the following type of information is visible:

Library	Status, number of drives, number of changers, number of cartridges, number of slots, model, vendor, description, owner, contact, firmware version, element manager, lock present, locked state, and security breach state
Drive	Status, needs cleaning, number of mounts, worldwide node name (WWNN)/worldwide port name (WWPN), firmware version, and location
Changer	Status, media-flip supported, WWNN/WWPN, and firmware version
I/O Port	Extended state and location

Cartridge	Label, capacity, type, whether cleaner media, whether dual-sided, location, and media description

In addition, you can start the native management tool, which in the case of the TS3310 Tape Library means the Web interface, from the Total Productivity Center.

10.7.4 IBM TotalStorage Productivity Center support

The IBM TotalStorage Productivity Center (TPC) is a suite of storage infrastructure management tools, which can help you to reduce the complexity of managing your storage environments. Since July 2007, TotalStorage Productive Center (TPC) Version 3.3 has supported the IBM TS3310 Tape Library. In order to work with TPC, the TS3310 firmware must have release *300G.GS010* or higher installed. For the TS3310 Tape Library:

- ▶ TPC TapeManager displays the physical entities of the IBM TS3310 Tape Library.
- ▶ Alerts are not supported for the IBM TS3310 Tape Library.
- ▶ Worldwide Node Names (WWNNs) are not reported for TS3310.
- ▶ The IBM TS3310 Common Information Model (CIM) Agent is imbedded, and no extra CIM Agent is needed.

The IBM TotalStorage Productivity Center Suite is designed to:

- ▶ Help centralize the management of your storage infrastructure from a single interface using role-based administration and single sign-on
- ▶ Provide a single management application with modular integrated components that are easy to install and provide common services for simple, consistent configuration and consistent operations across host, fabric, and storage systems
- ▶ Manage performance and connectivity from the host file system to the physical disk, including in-depth performance monitoring and analysis of SAN fabric performance
- ▶ Manage the capacity utilization and availability of storage systems, file systems, and databases
- ▶ Monitor, manage, and control (zone) SAN fabric components
- ▶ Automate capacity provisioning of file systems
- ▶ Monitor and track the performance of SAN-attached SMI-S compliant storage devices
- ▶ Manage advanced replication services (Global Mirror, Metro Mirror, and FlashCopy®) on the disk systems

IBM TotalStorage Productivity Center can help you:

- ▶ Manage the capacity utilization of storage systems, file systems, and databases
- ▶ Automate file-system capacity provisioning
- ▶ Perform device configuration and management of multiple devices from a single user interface
- ▶ Tune and proactively manage the performance of storage devices on the Storage Area Network (SAN)
- ▶ Manage, monitor, and control your SAN fabric

It is a single integrated solution designed to help you to improve your storage, by combining the assets, capacity, performance, and operational management, traditionally offered by separate Storage Resource Management, Storage Area Network Management, and Device Management applications into a single platform. For major details regarding the TotalStorage Productivity Center, link to the following Web site:

<http://www-03.ibm.com/systems/storage/software/center/index.html>

Also, refer to 13.2, “Management tools and technologies” on page 376.

10.7.5 Advanced Reporting

Advanced Reporting (FC1650) is a licensed key that enables the following functions of the TS3310 Tape Library:

- ▶ Drive Resource Utilization Reporting
- ▶ Media Integrity Analysis Reporting

These user-configurable reporting features provide graphical displays for both diagnostic and trend analysis data, which enable you to evaluate tape drive and media performance and drive utilization parameters. Advanced Reporting is only available to Administrative and Service users through the Web User Interface. Data for Advanced Reporting needs to persist for 12 months, but it is also limited to 1 MB. The persisted data is checksum-protected and will persist through a library power loss. The raw data for these reports can also be downloaded and e-mailed as a Comma Separated Values (.csv) file through the remote Web UI.

Drive Analysis Reporting

This function records drive Read/Write history, which can be used to identify drives or groups of drives that are nearing 100% utilization. It will also identify drive resources that are not being fully utilized. These reports will provide you with the information necessary to determine if and when additional drives are necessary.

Data collected and saved for these reports includes:

- ▶ Drive location (module, row)
- ▶ Drive serial number
- ▶ Logical library
- ▶ Megabytes read
- ▶ Megabytes written
- ▶ Time and date of mount in Greenwich mean time (GMT)
- ▶ Time and date of dismount (in GMT)
- ▶ Media motion time (in seconds)
- ▶ Media barcode

You can select **Monitor System** → **Advanced Reporting** → **Drive Utilization**, and you see the panel shown in Figure 10-12 on page 260. In this example, there is no data on the library for the drive utilization reports.

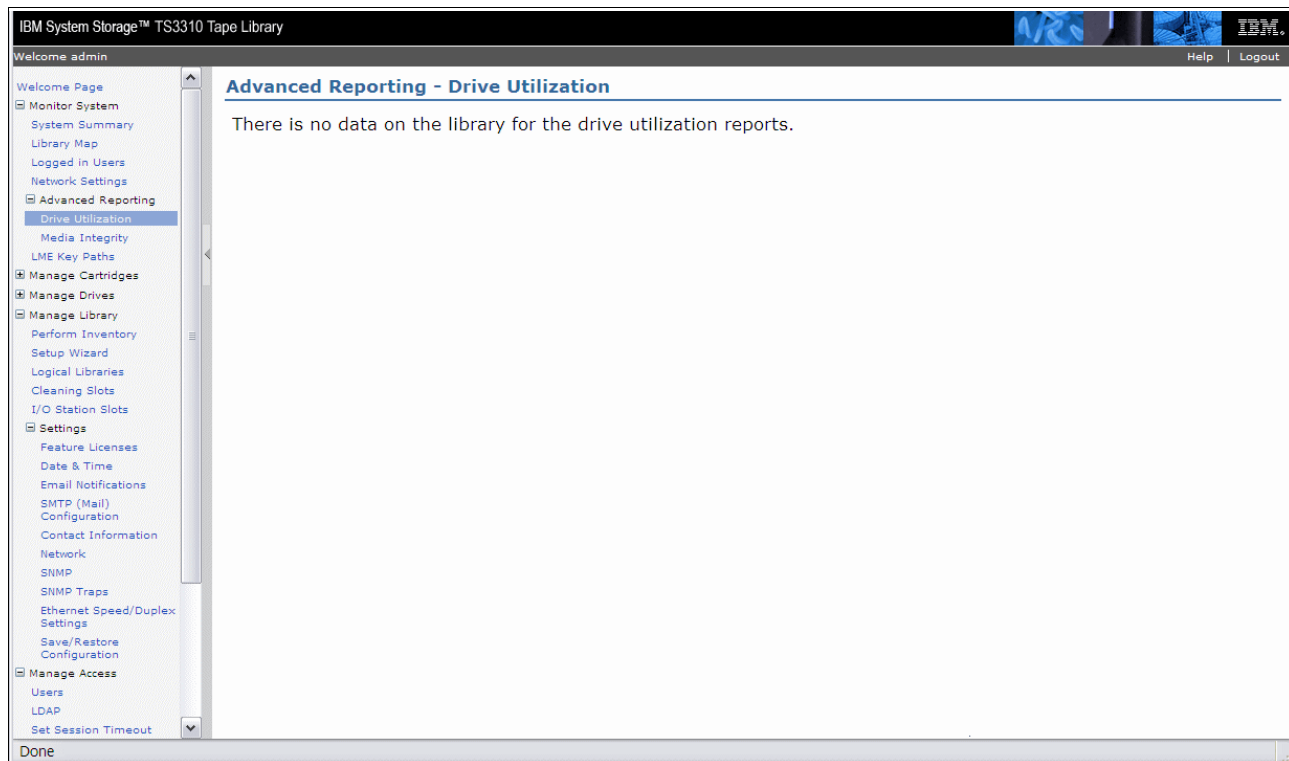


Figure 10-12 TS3310 Advanced Reporting Drive Utilization

Media Integrity Analysis Reporting

This function records TapeAlert events to measure and evaluate media and drive performance in the library. The administrator can request and configure various reports to assist in managing the overall reliability and performance of the media and drives. Data collected and saved for these reports includes:

- ▶ Media barcode
- ▶ Drive serial number
- ▶ TapeAlert value
- ▶ Occurrence count of TapeAlert
- ▶ Time and date of last TapeAlert occurrence (in GMT)

You can select **Monitor System** → **Advanced Reporting** → **Media Integrity**, and you see the panel shown in Figure 10-13 on page 261.

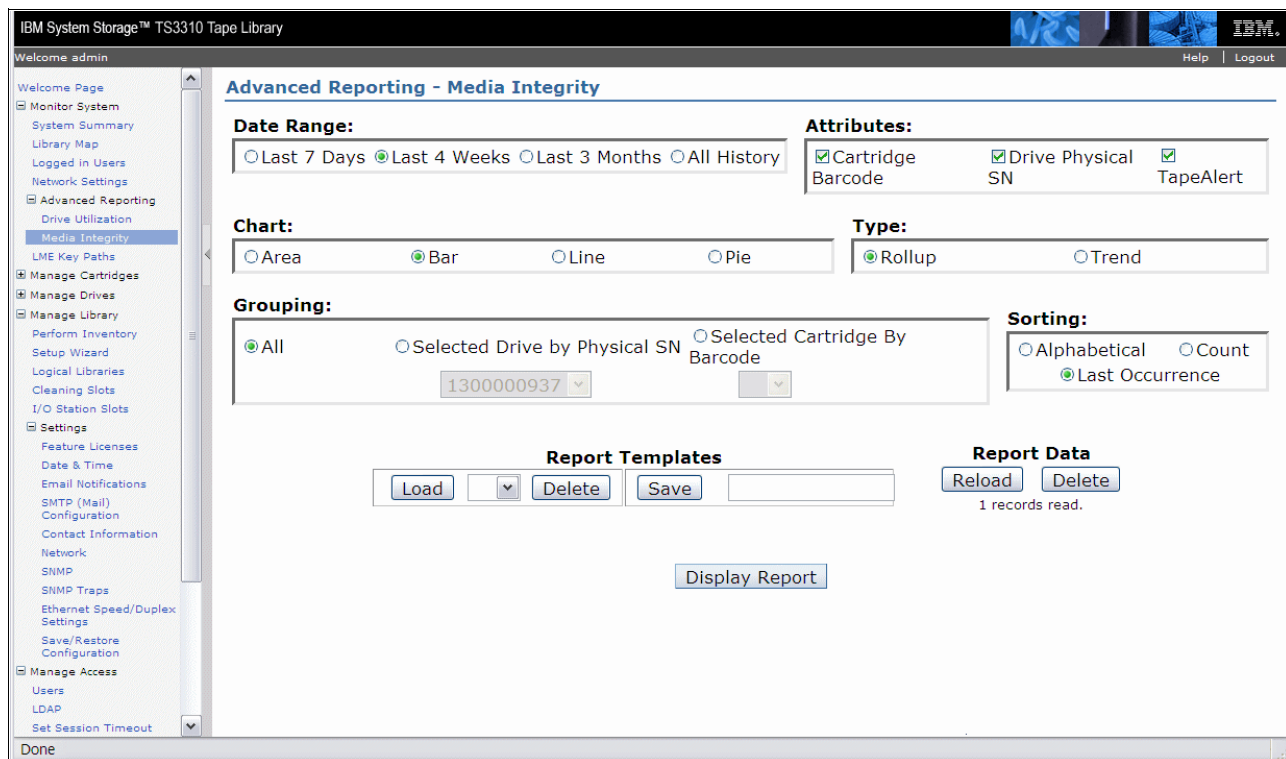


Figure 10-13 TS3310 Advanced Reporting Media Integrity

You can select parameters on the Advanced Reporting Media Integrity panel and then click **Display Report**. You will see a new panel similar to that shown in Figure 10-14.



Figure 10-14 TS3310 Advanced Reporting Media Integrity Report chart

10.7.6 Encryption

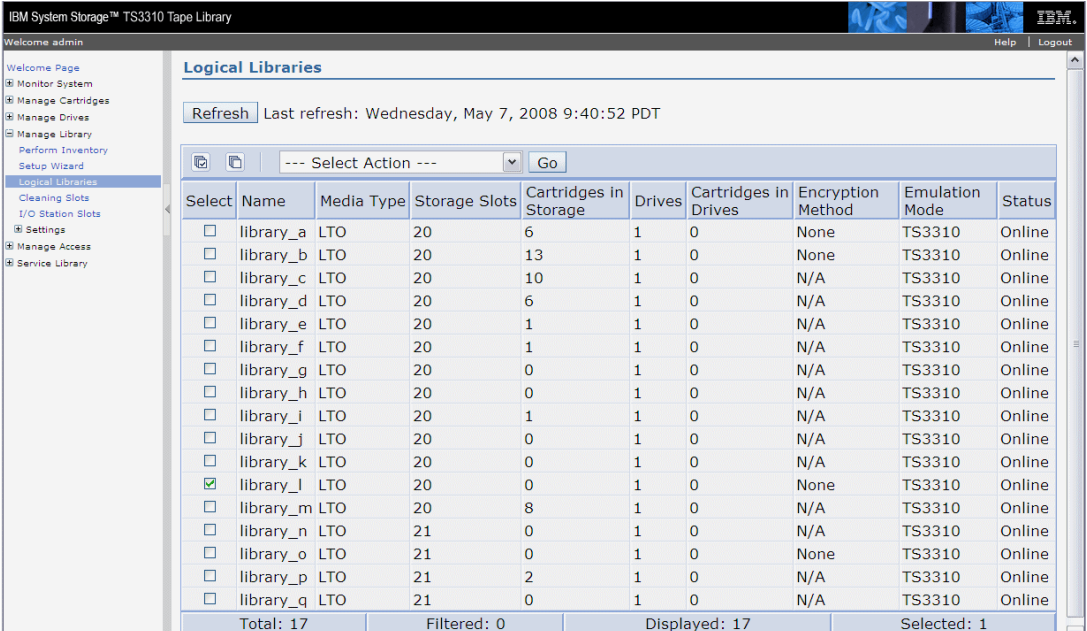
The TS3310 library supports host Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME) for SAS and Fibre Channel drives only. Data encryption is supported with LTO Ultrium 4 Data Cartridges only.

Application-Managed Encryption is available at no charge, and at the time of writing this publication, Tivoli Storage Manager was the only application that supports AME.

System-Managed Encryption and Library-Managed Encryption both need FC5900 and FC9900. FC5900 is a Transparent LTO Encryption Feature, which provides a license key to enable SME and LME. FC9900 is a feature that must be ordered when encryption will be used in the TS3310. It includes publication updates with information about enabling and configuring the TS3310 to support Encryption. This feature also provides the Encryption Key Manager (EKM) publications.

Before setting up Tape Encryption on the TS3310, you must already have installed your EKM on a server in your network. An EKM is needed when SME or LME will be configured.

Encryption can be set up for each logical library. For configuring encryption, log in to the TS3310 by using the Web User Interface. Then, select **Manage Library** → **Logical Library** and select the logical library that you want to modify. After selecting the logical library in the pull-down menu, select **Modify Encryption Method**, select your preferred method, and click **OK**. Figure 10-15 and Figure 10-16 on page 263 show the types of encryption methods that you can select.



Select	Name	Media Type	Storage Slots	Cartridges in Storage	Drives	Cartridges in Drives	Encryption Method	Emulation Mode	Status
☐	library_a	LTO	20	6	1	0	None	TS3310	Online
☐	library_b	LTO	20	13	1	0	None	TS3310	Online
☐	library_c	LTO	20	10	1	0	N/A	TS3310	Online
☐	library_d	LTO	20	6	1	0	N/A	TS3310	Online
☐	library_e	LTO	20	1	1	0	N/A	TS3310	Online
☐	library_f	LTO	20	1	1	0	N/A	TS3310	Online
☐	library_g	LTO	20	0	1	0	N/A	TS3310	Online
☐	library_h	LTO	20	0	1	0	N/A	TS3310	Online
☐	library_i	LTO	20	1	1	0	N/A	TS3310	Online
☐	library_j	LTO	20	0	1	0	N/A	TS3310	Online
☐	library_k	LTO	20	0	1	0	N/A	TS3310	Online
☒	library_l	LTO	20	0	1	0	None	TS3310	Online
☐	library_m	LTO	20	8	1	0	N/A	TS3310	Online
☐	library_n	LTO	21	0	1	0	N/A	TS3310	Online
☐	library_o	LTO	21	0	1	0	None	TS3310	Online
☐	library_p	LTO	21	2	1	0	N/A	TS3310	Online
☐	library_q	LTO	21	0	1	0	N/A	TS3310	Online
Total: 17			Filtered: 0		Displayed: 17			Selected: 1	

Figure 10-15 TS3310 Logical Library Encryption

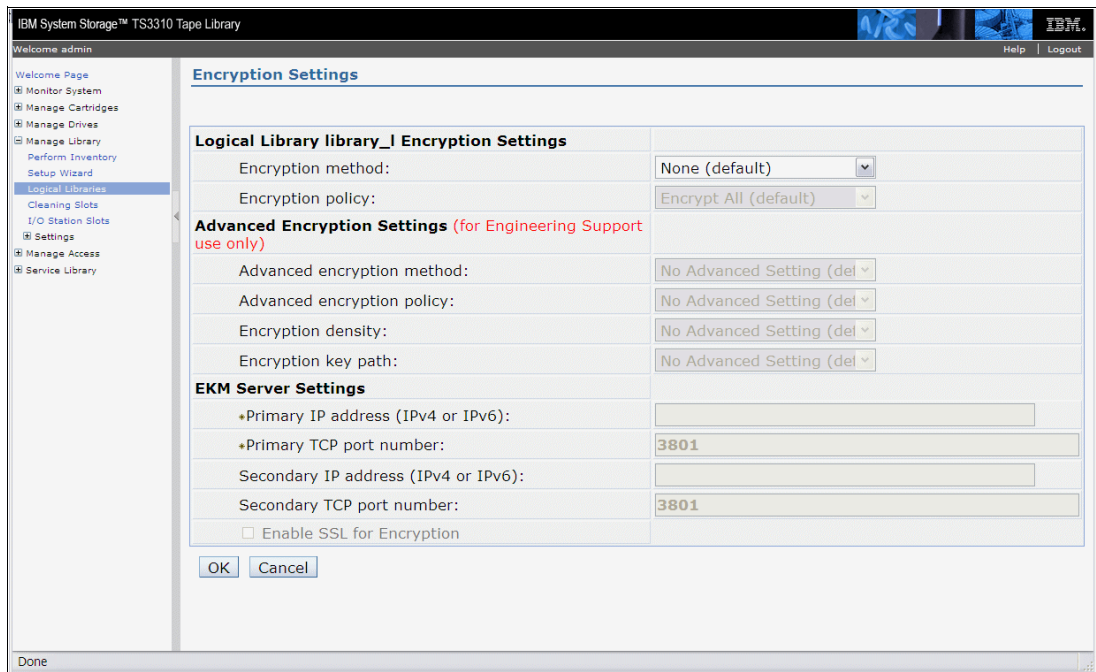


Figure 10-16 Encryption Method selection

Four options are available:

None No encryption is used on partition two.

Application-Managed Encryption

Use this option for encryption in operating environments that run an application capable of generating and managing encryption policies and keys. If you select Application-Managed Encryption, no further configuration steps are necessary. At the time of writing this publication, the only application-managed capable application was Tivoli Storage Manager.

System-Managed Encryption

Use this option for encryption in operating environments where no application is capable of key management runs, and encryption is set up implicitly through each instance of the IBM device driver.

Library-Managed Encryption

Use this option for transparent encryption by the TS3310 Tape Library tape drive.

There is also an **Engineering Use Only** option available. This option is only for IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. These options are not intended for use by the client without the guidance of IBM Support.

For more detailed instruction about how to set up encryption on the TS3310, read the *IBM System Storage Tape Library Planning and Operator Guide*, GC27-2107.

Encryption requires the latest device drivers, which are available on the ftp download Web site:

<ftp://ftp.software.ibm.com/storage/devdrv/>

10.8 Multi-path architecture

Multi-path architecture allows multiple systems to share the library's robotics without middleware or a dedicated server (host) acting as a Library Manager. The library is controlled through the same physical connection as that used for the tape drives. Multi-path architecture allows additional control paths and data paths to be configured for any one logical library.

Multi-path architecture has a number of benefits:

- ▶ Eliminates the need for a separate dedicated control path to the library, removing a single point of failure.
- ▶ Allows for control path failover. If one control path is lost, for example, due to tape drive hardware failure, the library can still be operated through a different path without the need for manual intervention.
- ▶ Allows for data path failover. For example, if access to a drive via one HBA is lost, a separate path can be used without the need for manual intervention.
- ▶ Allows the library to be partitioned into multiple logical libraries. Each system connected to the library (through the tape drives) considers that it has access to an entire library (rather than merely part of a physical library) and is unaware that the robotics are actually shared.

Multi-Path architecture is compliant with SCSI and Fibre Channel interfaces.

The library is certified for SAN solutions, such as LAN-free backup.

10.8.1 Using multiple logical libraries for library sharing

Multiple logical libraries are an effective way for the library to simultaneously back up and restore data from heterogeneous applications. For example, the library can be partitioned so that it processes:

- ▶ Commands from Application 1 (about Department X) in Logical Library A
- ▶ Commands from Application 2 (about Department Y) in Logical Library B
- ▶ Commands from Application 3 (about Department Z) in Logical Library C

In this configuration, the storage slots and drives in each logical library are dedicated to that library and are not shared among other libraries. Commands issued by the applications travel to the library through three unique control paths. Thus, the data processing for:

- ▶ Department X is confined to the storage slots and drives in Logical Library A
- ▶ Department Y is confined to the storage slots and drives in Logical Library B
- ▶ Department Z is confined to the storage slots and drives in Logical Library C

10.8.2 Using multiple control paths

In addition to creating multiple logical libraries, any logical library can be configured to have more than one control path. When configuring additional control paths, additional library sharing configurations and availability options are made possible. Access to the logical library is on a first-come, first-served basis, and each control path for a logical library can accept commands while the library is in use by another control path. By default, a logical library can communicate with the server only through the first LUN 1-enabled drive that is installed in the partition. Note that Microsoft Windows 2000 Removable Storage Manager and Microsoft Windows Server 2003 Removable Storage Manager (RSM™) do not support multiple control paths within a logical library. We recommend that you disable RSM in order to use this feature.

To add or remove additional control paths, use the Operator Panel or the Web User Interface. For a particular logical library, you can enable as many control paths as there are drives in that logical library.

10.8.3 Using multiple control paths for control path failover

Command failures and time-outs are costly. You want your library to run smoothly and efficiently. To ensure continued processing, the library offers an optional control path failover feature that enables the host device driver to resend the command to an alternate control path for the same logical library. With control path failover installed, the alternate control path can include another HBA, SAN, or library control path drive. The device driver initiates error recovery and continues the operation on the alternate control path without interrupting the application. AIX, Linux, Solaris, HP-UX, and Windows hosts are currently supported for this feature. The control path failover feature can be installed by the client.

Note: The control path failover feature is activated by a license key.

For more information about using the control path failover feature, refer to the *IBM Tape Device Driver Installation and Users Guide*, GA27-2130.

10.8.4 Using multiple data paths for data path failover

Data path failover and load balancing exclusively support native Fibre Channel Ultrium 3 and Ultrium 4 Tape Drives in the library using the IBM device driver for AIX, Linux, Solaris, HP-UX and Windows. Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables multiple redundant paths to be configured in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. The failover mechanism allows flexibility in SAN configuration, availability, and management.

When accessing a tape drive device that has been configured with alternate paths across multiple host ports, the IBM device driver automatically selects a path through the host bus adapter (HBA) that has the fewest open tape devices and assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*.

The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices and balance the number of applications using each HBA in the machine. The dynamic load balancing support can help optimize resources and improve overall performance.

Furthermore, data path failover provides autonomic self-healing capabilities similar to control path failover, with transparent failover to an alternate data path in the event of a failure in the primary host-side path. Data path failover and load balancing for Ultrium 3 and Ultrium 4 Tape Drives require an optional feature, Data Path Failover FC1682. This feature is activated by installing a license key on the host.

10.9 Setup

The TS3310 Tape Library is a client setup product (CSU). For detailed information about setup, refer to the *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477. These steps are necessary to configure a newly installed library. Each step is explained in detail in the *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477:

1. Log in to the Operator Panel.
2. Access the Setup Wizard.
3. Ensure that all hardware is installed.
4. Set up the library network configuration.
5. Enter license keys.
6. Assign cleaning cartridge slots.
7. Assign I/O station slots.
8. Assign logical libraries.
9. Set the date and time.
10. Import cleaning cartridges.
11. Populate your library with data cartridges.
12. Register for My Support.

There is no need to log in the first time that you turn on your library. The Setup Wizard appears on the Operator Panel and guides you through the setup. The Setup Wizard times out after one hour. If the Setup Wizard times out, you will be able to log back in to the library with the default Admin account. In addition, certain default configuration settings are made if you have not already specified them:

- ▶ Network settings will be DHCP-enabled.
- ▶ I/O station slots: 6
- ▶ Cleaning cartridge slots: 1
- ▶ Logical libraries: 1

You can restart the Setup Wizard at any time after you log in.

10.9.1 Network setup

Here, we show you the network configuration panel. In this panel, you can select two types of transportation protocols, *IPv4* and *IPv6*, or both of them in a Dual Stack configuration: *IPv4 + IPv6*.

If you want to set network settings, use **Manage Library** → **Settings** → **Network** from the Web User Interface. Refer to Figure 10-17 on page 267.

IBM System Storage™ TS3310 Tape Library

Welcome admin

Help | Logout

Welcome Page
 Monitor System
 Manage Cartridges
 Manage Drives
 Manage Library
 Perform Inventory
 Setup Wizard
 Logical Libraries
 Cleaning Slots
 I/O Station Slots
 Settings
 Feature Licenses
 Date & Time
 Email Notifications
 SMTP (Mail) Configuration
 Contact Information
 Network
 SNMP
 SNMP Traps
 Ethernet Speed/Duplex
 Settings
 Save/Restore
 Configuration
 Manage Access
 Service Library

Network Settings

+Host Name:
 library

DNS Primary:
 9.11.224.130

DNS Secondary:
 9.11.224.114

☐ Enable SSL for the Web User Interface

☒ Use IPv4

☐ Obtain an IP address automatically (DHCP)

☒ Use static IP address

+IP Address:
 9.11.219.149

+Net Mask:
 255.255.255.0

+Gateway:
 9.11.219.1

☒ Use IPv6

☐ Enable IPsec

☐ Obtain an IP address automatically (DHCP)

☒ Obtain an IP address automatically (Stateless Auto Config)

☐ Use static IP address

Submit Changes

Done

Figure 10-17 TS3310 Network setup

Note: The Internet protocols selected are used for the TS3310 Tape Library IP address, subnet mask, gateway address, time server address, mail server address, SNMP trap-to address, and EKM server addresses.

The panel displayed in Figure 10-17 shows the library network settings, which were set by the user during the configuration setup. Here is a description of the panel:

- Host Name** This is the name of your host server.
- DNS Primary** Here, you enter the primary network identifier.
- DNS secondary** Here, you enter the secondary network identifier.
- Enable SSL for the Web User Interface**

Check this box if you want to allow the security feature, Secure Socket Layer (SSL), when using the Web User Interface. Secure Socket Layer (SSL) is a protocol used for transmitting data securely over the Internet. If SSL is enabled, browsers, such as Netscape and Microsoft Internet Explorer, use a private key that encrypts the data before it is transferred. The recipient of this secured data can then use that key to decode the information. Enabling SSL also enables an SSL-based secure authentication method for SMI-S (Storage Management Initiative Specification).

- Use IPv4** Check this box if you want the library to use Internet Protocol version 4 to manage the Internet Protocol (IP) addresses in your network. To use IPv4, you must specify whether the library will obtain an address automatically or will use a specific, predefined address.

Obtain an IP address automatically (DHCP)

Dynamic Host Configuration Protocol is a communications protocol that lets network administrators centrally manage and automate the assignment of Internet Protocol (IP) addresses in an organization's network. Choose this option to allow the library to determine the IP address.

Use Static IP Address

Check this box to enter an IP address for the library using IPv4. You must enter the IP Address, Net Mask, and Gateway information.

IP Address Here you type the Internet Protocol Address of your library.

Net Mask This is the mask used to determine to what subnet an IP address belongs.

Gateway This is the node on a network that serves as an entrance to another network.

Use IPv6 Check this box if you want the library to use Internet Protocol version 6 to manage the Internet Protocol (IP) addresses in your network. IPv6 uses a longer IP address string than IPv4 and requires you to enter a prefix length. To use IPv6, you must specify whether the library will obtain an address automatically and the format for assigning the address or whether the library will use a specific predefined address.

Obtain an IP address automatically (DHCP)

Dynamic Host Configuration Protocol is a communications protocol that lets network administrators centrally manage and automate the assignment of Internet Protocol (IP) addresses in an organization's network. Choose this option to allow the library to determine the IP address using DHCP.

Obtain an IP address automatically (Stateless Auto Config)

IPv6 allows you to obtain an address for a library without a separate dynamic host configuration protocol (DHCP) server as in IPv4. Choose this option to assign an address without DHCP.

Use Static IP Address

Check this box to enter an IP address for the library using IPv6. You must enter the IP Address Prefix Length and Gateway information.

You click **Submit Changes** to apply all of the changes that you have made. If you want to see the previous network settings, you can select **Monitor System** → **Network Settings** from the Web UI, and you see the panel shown in Figure 10-18 on page 269.

For additional information related to the IPv6 transportation protocol, refer to Appendix B, "IPv6" on page 511.

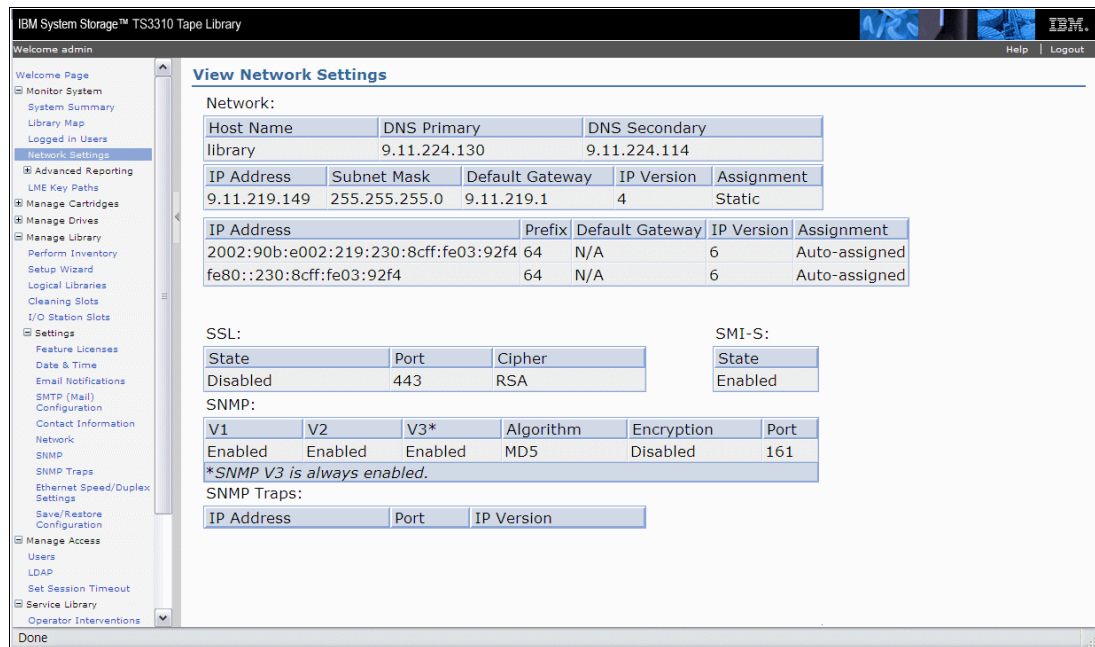


Figure 10-18 TS3310 View Network Setting

10.10 Working with logical libraries

Logical libraries are virtual sections within a library that present the appearance of multiple, separate libraries for purposes of file management, access by multiple users, or dedication to one or more host applications. By default, the library has one logical library, which includes all of the library's resources.

There are two ways to create logical libraries:

- *Automatically* where the library divides the available resources equally among the number of logical libraries chosen.
- *Manually* where an administrative user assigns the number of slots per logical library. You can only create logical libraries manually through the Web User Interface.

Note: When changing the logical library mode from online to offline, all host application commands in progress at the start of the mode change are completed.

Administrative users can create, modify, delete, and control access to all logical libraries. Users can be given access to only certain logical libraries and denied access to others. At a minimum, a logical library consists of one tape drive and one slot. The tape drive or slot cannot be shared with another logical library (cleaning cartridges, which can be shared among all logical libraries, are exceptions to the sharing restrictions). I/O station slots and cleaning slots are shared among all logical libraries. Each logical library is specific to a tape drive interface, for example, SCSI or Fibre Channel. Mixed media are allowed within logical libraries. For example, a logical library can contain LTO2 and LTO3 tape cartridges.

Automatically creating logical libraries

When the library automatically creates logical libraries, the available resources are divided equally among the number of logical libraries created. Prior to creating logical libraries, you must first designate the desired number of cleaning slots and I/O slots (if an expansion

module is present). This designation is necessary, because the Automatic Create Logical Library function divides all available storage slots among the chosen number of logical libraries.

From the Operator Panel, all remaining available resources are divided among the number of automatically created logical libraries. Use the Web UI to manually create logical libraries.

Note: On the Web UI, all logical libraries must be deleted in order for the Automatic button to appear. If the Automatic button does not appear, delete all existing logical libraries.

Manually creating logical libraries

Every logical library must have at least one drive and one storage slot assigned to it. For example, if the library has two tape drives and 12 slots available, the maximum number of logical libraries that you can create is two. Up to 12 slots can be allocated between the two logical libraries in any configuration.

If the library has only one logical library with all resources assigned to it, that logical library must be deleted before reallocating resources to a new logical library.

You might need to provide information for the following fields:

- ▶ Emulation Type emulates the logical library.
- ▶ Logical Library Name can be up to a maximum of 12 alphanumeric characters.
- ▶ Media Barcode Format defaults to the last eight characters.
- ▶ Automatic Drive Cleaning is enabled by default and requires at least one cleaning cartridge and a communication interface to the tape drive with the ability of the tape drive to indicate that cleaning is needed.
- ▶ Number of Slots is the number of tape cartridge slots that are to be allocated to the new logical library.

Deleting logical libraries

A logical library can be deleted when it is no longer needed. After a logical library is deleted, its resources become unassigned and can be used to create additional logical libraries or added to existing logical libraries.

Changing logical library access

An administrative user can control which logical libraries a specified user can access. Do this by modifying a user's account. To change logical library access, you must provide the following information:

- ▶ Password: This is a unique string of alphanumeric characters that can be viewed and modified by the Administrator.
- ▶ Privilege level: This is the level of library functions to which a user is assigned access.

Changing logical library modes

By default, the library has one logical library enabled. The logical library mode must be changed in order to modify the logical library or library. There are two logical library modes:

- ▶ Online: The normal operating condition for a logical library. In this mode, the robotics are enabled, and all host application commands are processed.
- ▶ Offline: The logical library does not process any host application commands. If a logical library is taken offline, the physical library and other logical libraries are not affected.

You can take the physical library or any of its logical libraries online or offline. Certain operations require that the logical library is offline. Administrative users can take a logical library offline rather than the entire library in order to minimize the disruption of library operations. Administrative users must manually change the logical library mode to online or offline from the Operator Panel or the Web UI.

When you are changing logical library mode, be aware of the following information:

- ▶ The Online/Offline button toggles between states.
- ▶ If a logical library is in use, the Online/Offline button is grayed out.
- ▶ Set the button to read Online to take either the physical library or a logical library, depending on the current view, to an online state, which is the normal operating condition. In this mode, the robotics are enabled, and all host commands are processed.
- ▶ Set the button to read Offline to take either the physical library or a logical library, depending on the current view, to an offline state. If only the physical library is taken offline, logical libraries will not process robotics commands, even though they are online. If only a logical library is taken offline, neither the physical library nor the other logical libraries are affected.

10.11 Operating procedures

For a full description of all operating procedures, refer to the *TS3310 Tape Library Setup and Operator Guide*, GA32-0477.

This section discusses:

- ▶ Upgrading firmware
- ▶ Understanding cartridge assignment in libraries (loading and unloading cartridges)
- ▶ Using cleaning cartridges

10.11.1 Upgrading firmware

The following sections give you information about upgrading library and drive firmware.

Note: When updating firmware:

- ▶ Ensure that all host applications are varied offline.
- ▶ Do not power off the drive until the update is complete, or the firmware can be corrupted.

Updating library firmware

Updating library firmware must be performed by Administrative users from the Web UI.

To update library firmware:

1. Download the latest level of library firmware to your host computer from this Web site:
<http://www-1.ibm.com/servers/storage/tape/ltc/>
2. From the Web UI, select **Service Library** → **Update Library Firmware**.

Browse to the file on your computer, select the .tgz file that was downloaded from the IBM Web site, and then click **Update Library Firmware**. The Web UI indicates when the operation completes. This means that the firmware file has been successfully moved from the host computer to the library.

Wait for the library to restart before resuming normal library operations. It will be several minutes before the library restarts.

Important: After the update process starts, you must wait until the library restarts. Do not attempt to interrupt the process in any way, or the upgrade will not be successful.

Updating the library firmware takes approximately 30 minutes.

Updating drive firmware

The best way to update drive firmware is to use the driver's application interface, SCSI, or Fibre Channel.

There are tools readily available to facilitate this process. The recommended tool, the IBM TotalStorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

The ITDT tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and it is available in two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

Other tools, such as ntutil and TapeUTIL, can also be used for drive firmware updates. The library also supports drive firmware update by creating and using an Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware is:

1. Download the latest drive firmware to your host computer from this Web site:
<http://www-1.ibm.com/servers/storage/tape/lto/>
2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Important: Be careful to select the correct firmware. There is different firmware to use for Fibre Channel drives, SCSI drives, and SAS drives.

Using ITDT to update drive firmware

A newly designed tool, ITDT, has multiple functional capabilities and is a quick, convenient, and efficient method for drive firmware updates. As a note, drive dump retrievals can be performed by the tool as well.

Here are several of the capabilities of this tool:

- ▶ Firmware update capability via SCSI to all IBM LTO tape drives.
- ▶ The tool does not require any special device drivers.
- ▶ The tool is available for most major platforms (Windows, AIX, SUN, Linux, and NetWare).
- ▶ The tool is capable of uploading drive dump files.
- ▶ The tool's primary function is to thoroughly test a drive. However, if the library is online to the server or host where the tool resides, ITDT communicates with the drive through the library to load and unload a test cartridge, thereby exercising library functions.
- ▶ The tool scans the SCSI bus to find and display all IBM LTO devices for selection. The tool does not display or, therefore, allow you to select any non-IBM device.
- ▶ Each function has a Help selection that explains the required syntax, as well as a brief explanation of the particular function.
- ▶ A readme text file is posted with the .exe for a thorough explanation of initial tool download information from the Web, as well as an explanation of tool capabilities.
- ▶ The tool is currently a command line tool that you start by simply typing the executable name, `itdt`, from the directory where the tool is located.

Other methods for updating drive firmware

The procedure varies when updating drive firmware by using the SCSI or Fibre Channel SAS, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard, or Microsoft).

If using an IBM tape device driver, you can update drive firmware using the `tapeutil` or `ntutil` tools. These tools are explained in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430-12.

Note: Using the Web User Interface takes about 30 minutes to update 18 drives. The mechanism for updating the drives has been improved.

10.11.2 Understanding cartridge assignment in the library

When a cleaning data cartridge is placed in the I/O station, the library scans the I/O station, and then a window displays asking the operator to assign the cartridge to "System" or to a logical library. Cleaning cartridges are assigned to "System", which makes them available to all drives regardless of the logical library to which the drive is assigned. Data cartridges are assigned to a logical library, which restricts them from being accessed by another logical library. A drive FMR cartridge placed in the I/O station for drive firmware update must also be assigned as a SYSTEM cartridge when the assignment window is presented after the I/O station door is closed. Selecting CANCEL or allowing the assignment window to time out will default all newly discovered cartridges in the I/O station to SYSTEM cartridges.

After a cartridge is assigned to "System" or to a logical library, the cartridge must be physically exported from the library to the I/O station, and then moved to a different slot in the I/O station before it can be reassigned to a new destination within the library. If the cartridge is

left in the same I/O station slot, the library will retain the same assignment, even if the I/O station door is opened and closed.

Cartridges that are placed in the I/O station *before* the library is powered ON will not have an initial assignment. To “force” an assignment window for newly discovered cartridges, the I/O station must be opened and then closed. Shuffling of the cartridges to different I/O station slots is not necessary. Cartridges that are assigned prior to power OFF and remaining in the same I/O station slots retain their original assignment.

10.11.3 Using cleaning cartridges

During the setup of the library, between one and four slots are assigned as cleaning slots. All cleaning cartridges must have “CLNXXX” as part of their barcode in order for the library’s barcode scanner to recognize it as a cleaning cartridge.

Drives can either be cleaned by the library automatically as required or by an application. If using automatic library cleaning, the cleaning cartridge must be imported as follows:

- ▶ From the Operator Panel: select **Operations** → **Import Cleaning Media**
- ▶ From the Web User Interface: select **Manage Cartridges** → **Cleaning Cartridges**

If using an application to initiate tape drive cleaning, use the application itself to import the cleaning cartridge correctly. In Tivoli Storage Manager, you use a command similar to the following command when you have a single cleaning cartridge in one of the I/O ports:

```
checkin libvolume <library name> search=bulk status=cleaner checklabel=barcode  
cleanings=10
```

Note the “cleanings” option. Check the documentation that came with your cleaning cartridge to determine the number of times that this cartridge can be used.

Note: Do not manually initiate drive cleaning unless requested by support engineers. LTO drives are self-cleaning and will require infrequent cleaning using cleaning cartridges.

After a cleaning cartridge expires, it is necessary to remove the cartridge from the library. If the library uses automatic cleaning, do this:

- ▶ From the Operator Panel: select **Operations** → **Export Cleaning Media**
- ▶ From the Web User Interface: select **Manage Cartridges** → **Cleaning Cartridges**

If the application controls drive cleaning, use the application’s own commands to eject the tape. In Tivoli Storage Manager, you enter the following command:

```
checkout libvol <library name> <label> remove=yes checklabel=no
```

10.12 Supported environments

For a current list of supported server platforms, operating systems, host bus adapters, SCSI adapters, and SAN switches, refer to the following Web site:

<http://www.ibm.com/servers/storage/tape/lto>

Locate and select **TS3310** → **Product Details** → **Interoperability Matrix**.

The list of supported environments constantly changes. The details provided are current as of September 2008 but will rapidly become out-of-date. They are provided merely as an indication of the breadth of current support.

10.12.1 Supported server platforms

The TS3310 is supported on the following servers:

- ▶ Hewlett-Packard servers
- ▶ IBM System i, iSeries, and AS/400
- ▶ IBM System p, pSeries, and RS/6000
- ▶ IBM System z Linux and zSeries Linux
- ▶ IBM System x and Intel-based servers
- ▶ SUN servers

10.12.2 Supported operating systems

The TS3310 Tape Library is supported on the following operating systems at the minimum levels indicated:

- ▶ OS/400® V5R2 or later.
- ▶ i5/OS V5R3, or later.
- ▶ AIX 5L V5.1, V5.2, V5.3, or later.
- ▶ Sun Solaris 9 and 10.
- ▶ Microsoft Windows 2000 Server (build 2195 or later).
- ▶ Microsoft Windows Server 2003 (build 3790 or later).
- ▶ Microsoft Windows Server 2008 SP1
- ▶ HP-UX 11.0, 11iv1 (11.11), 11iv2 (11.23), and 11iv3 (11.31). HP-UX patches might be required.
- ▶ Linux distributions:
 - Red Hat Enterprise Linux Version 4 or 5
 - SUSE® Linux Enterprise Server 9 or 10
 - Asianux 2.0 or 3.0

10.12.3 Supported storage software

For a current list of host software versions and release levels that support the TS3310 Tape Library, refer to the following Web site and view the Interoperability Matrix:

http://www-03.ibm.com/servers/storage/tape/1to/1to_isv.html

The following Storage Software products support the TS3310 Tape Library at the time of writing this book. However, we urge you to refer to the previous Web site to confirm supported levels, platforms, and prerequisites:

- ▶ BakBone Software: Netvault
- ▶ CommVault Systems: Galaxy
- ▶ CA: BrightStor ARCserve Backup
- ▶ EMC: Networker
- ▶ HP: OpenView Storage Data Protector 5.1 and 5.5
- ▶ IBM: Backup, Recovery and Media Services (BRMS)
- ▶ IBM: Tivoli Storage Manager
- ▶ Symantec: Backup Exec
- ▶ Symantec: NetBackup

Tivoli Storage Manager and other offerings provide storage and tape management software for the TS3310. Tivoli Storage Manager supports the base unit from Version 5.2.7 and 5.3.2.

10.13 Specifications

This section provides details of the physical specifications and the operating environment for the TS3310 Tape Library.

10.13.1 Timings

The following timings are approximate and provided as merely indicative values:

To perform an inventory of a 5U library	1 minute
To perform an inventory of a 14U library	4 minutes
To mount a cartridge in a 5U library	15 seconds
To mount a cartridge in a 14U library	18 seconds
To unmount a cartridge in a 5U library	30 seconds
To unmount a cartridge in a 14U library	35 seconds

10.13.2 Physical specifications

Physical specifications are provided for both the L5B module stand-alone and the 14U library configuration.

Model L5B

A 5U library configuration has the following physical specifications:

- ▶ Width: 443.2 mm (17.45 in.)
- ▶ Depth: 801.4 mm (31.55 in.)
- ▶ Height: 219.7 mm (8.65 in.)
- ▶ Weight: 38.6 kg (85 lbs.)
- ▶ Maximum configuration: Two drives and two power supplies

Model L5B plus E9U

A 14U library configuration has the following physical specifications:

- ▶ Width: 443.2 mm (17.45 in.)
- ▶ Depth: 801.4 mm (31.55 in.)
- ▶ Height: 620.8 mm (24.44 in.)
- ▶ Weight: 88.5 kg (195 lbs.)
- ▶ Maximum configuration: Six drives and four power supplies

10.13.3 Operating environment

This list details the supported operating environment for all library configurations:

- ▶ Temperature: 10 - 38 degrees C (50 - 110 degrees F)
- ▶ Relative Humidity: 20 - 80 percent
- ▶ Maximum Wet Bulb (Caloric Value): 26 degrees C, 79 degrees F
- ▶ Electrical Power: 0.2 kVA
- ▶ Capacity of Exhaust: 54 cfm for 5U, 148 cfm for 9U
- ▶ Caloric Value: 0.68 kBTU/hr.
- ▶ Sound Power Level (LwAd): 6.2 Bels idle, 6.7 Bels operating
- ▶ Leakage current: 0.75 mA at 212 Vac per power supply

10.14 Feature codes

Table 10-2 identifies the model numbers and feature codes associated with the TS3310 Tape library. Table 10-3 on page 278 identifies the SAS feature codes.

Table 10-2 Machine type, model numbers, and feature codes

Description	Machine	Model	Feature	Comment
TS3310 Tape Library	3576 3576	L5B E9U	N/A	Base module Expansion module.
Transparent LTO Encryption	N/A	N/A	5900	Required for SME and LME.
LTO Ultrium 3 Fibre Drive (4 Gb)	N/A	N/A	8042	LC interface. Cable required. See below.
LTO Ultrium 3 LVD Ultra160 Drive	N/A	N/A	8037	HD68 interface. Cable required. See below.
LTO Ultrium 4 SAS Drive	N/A	N/A	8139	SFF-8088 interface.
LTO4 Ultrium Fibre Channel drive	N/A	N/A	8142	Fibre Channel interface.
Redundant Power Supply	N/A	N/A	1900	Optional. Each module shipped with one power distribution unit (PDU), supports two PDUs.
Path Failover	N/A	N/A	1682	Optional.
Capacity Expansion	N/A	N/A	1640	Optional.
Advanced Reporting	N/A	N/A	1650	Optional.
Rack mount kit	N/A	N/A	8006	Optional for 5U and 14U libraries. Required for larger libraries.
Encryption configuration	N/A	N/A	9900	Documentation for encryption.
Library and Drive code update	N/A	N/A	0500	Optional. IBM will upgrade firmware as required.

Table 10-3 SAS feature codes

Feature Code	Name	Description
5402	2 m (6.6 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5406	5.5 m (18 ft.) SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a SAS (SFF-8470) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5500	Mini-SAS/550x 4x Interposer	This feature provides a 1x4 interposer with mini-SAS/550x connections for connecting the library and the drives.
5502	2 m (6.6 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a Mini-SAS (SFF-8088) connector on one end and a Mini-SAS (SFF-8088) connector on the other end.
5506	5.5 m (18 ft.) Mini-SAS/Mini-SAS 1x cable	This feature provides a SAS cable with a mini-SAS (SFF-8088) connector on one end and a mini-SAS (SFF-8088) connector on the other end.
8405	Ultrium 4 Data Cartridges (5-pack)	This feature provides five unlabeled 800 GB data cartridges and can only be ordered when ordering the TS2340.

Power cords

The following power cord features are available:

▶ 9800	9-foot (2.8 m) Power Cord, 125 V, 15 A	U.S. and Canada
▶ 9820	9-foot (2.8 m) Power Cord, 250 V, 16 A (AC)	France and Germany
▶ 9821	9-foot (2.8 m) Power Cord, 250 V, 11 A	Denmark
▶ 9825	9-foot (2.8 m) Power Cord, 250 V, 13 A	UK and China
▶ 9827	9-foot (2.8 m) Power Cord, 250 V, 6-16 A	Israel
▶ 9828	9-foot (2.8 m) Power Cord, 255 V, 10 A	Switzerland
▶ 9829	9-foot (2.8 m) Power Cord, 250 V, 16 A	South Africa
▶ 9830	9-foot (2.8 m) Power Cord, 250 V, 10 and 16 A	Italy
▶ 9831	9-foot (2.8 m) Power Cord, 250 V, 10 A	Australia
▶ 9833	9-foot (2.8 m) Power Cord, 250 V, 15 A	U.S. and Canada
▶ 9834	9-foot (2.8 m) Power Cord, 250 V, 10 A	Uruguay
▶ 9835	9-foot (2.8 m) Power Cord, 125 V, 15 A	Taiwan
▶ 9840	9-foot (2.8 m) Power Cord, 250 V, 10 A	China (PRC)
▶ 9841	9-foot (2.8 m) Power Cord, 250 V, 10 A	Taiwan
▶ 9842	9-foot (2.8 m) Power Cord, 125 V, 12 A	Japan

- ▶ 9843 9-foot (2.8 m) Power Cord, 250 V, 12 A Japan
- ▶ 9844 9-foot (2.8 m) Power Cord, 250 V, 12 A Korea
- ▶ 9845 9-foot (2.8 m) Power Cord, 250 V, 10 A India
- ▶ 9846 9-foot (2.8 m) Power Cord, 125 V, 10 A Brazil
- ▶ 9847 9-foot (2.8 m) Power Cord, 250 V, 10 A Brazil
- ▶ 9848 Rack to Power Distribution Unit (PDU) Line Cord, 110 V, 10 A
- ▶ 9986 6-foot (1.8 m) Power Cord, 125 V, 15 A Chicago, U.S., and Canada

Fibre Channel cables

The LTO3 Fibre Channel Tape Drive has an LC connector. A cable will be required to connect this either directly to a system HBA or a switch. These feature codes are available:

- ▶ FC6005: 5 m (16.4 ft.) LC-LC Fibre Channel Cable
- ▶ FC6013: 13 m (42.7 ft.) LC-LC Fibre Channel Cable
- ▶ FC6025: 25 m (82 ft.) LC-LC Fibre Channel Cable
- ▶ FC5096: Interposer SC-LC Fibre

SCSI cables

One differential terminator and 0.4 meter drive-to-drive cable are included with each SCSI tape drive. The IBM LTO Ultrium 3 LVD SCSI Tape Drive comes with an HD68 connector for SCSI attachment.

Features for specifying SCSI cables and their respective lengths are:

- ▶ FC5602: 2.5 m (8.2 ft.)
- ▶ FC5604: 4.5 m (14.9 ft.)
- ▶ FC5610: 10 m (32.9 ft.)

These cables have a VHDCI connector on one end and an HD68 connector on the other end.

10.15 Publications

The following publications are included with the Model L5B hardware:

- ▶ *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477
- ▶ *IBM System Storage TS3310 Tape Library Maintenance Information for IBM Service Personnel*, GA32-0478
- ▶ *IBM System Storage TS3310 Tape Library SCSI Reference*, GA32-0476
- ▶ *IBM Tape Device Driver Installation and Users Guide*, GA27-2130



IBM System Storage TS3400 Tape Library

The IBM System Storage TS3400 Tape Library (Machine type 3577, Model 5LU) is designed to offer high performance drive technology and automation for the Open Systems environment. The IBM System Storage TS3400 Tape Library is a five unit (5U) external desktop or rack-mountable tape library that incorporates up to two IBM System Storage TS1120 Tape Drives or the new Generation 3 TS1130 (3592-E06) Tape Drives. To support the TS1130 Tape Drives, the new library firmware Release 3 or higher is required.

The IBM System Storage TS1120 Tape Drive has a native capacity of 700 GB when using the IBM Extended Data Cartridge (JB), or 500 GB when using the IBM Data Cartridge (JA). The IBM System Storage TS1120 Tape Drive has a native rate of up to 100 MB/s. The IBM System Storage TS1120 Tape Drive has a dual-ported switched fabric 4 Gbps Fibre Channel attachment. The tape drives must be ordered separately with the final order.

The IBM System Storage TS1130 Tape Drive has a native capacity of 1000 GB (1.0 TB) when using the IBM 3592 Extended Data Cartridge (JB), or 640 GB when using the IBM 3592 Enterprise Cartridge (JA). The TS1130 Tape Drive has a native data rate of up to 160 MB/s. The IBM TS1130 Tape Drive has a dual-ported switched fabric 4 Gbps Fibre Channel attachment.

The IBM System Storage TS3400 Tape Library supports the IBM TS1120 and the TS1130 built-in encryption capabilities. The supported encryption methods are Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

The IBM System Storage 3592-J1A Tape Drive is not supported in the IBM System Storage TS3400 Tape Library.

11.1 TS3400 Tape Library description

Designed for tape automation, the IBM System Storage TS3400 Tape Library can be attached to IBM System i or i5, IBM iSeries, AS/400, IBM System p or p5, IBM pSeries, RS/6000, IBM z or z9, IBM xSeries, Hewlett-Packard (HP), Sun, UNIX, and PC servers.

For the remainder of this chapter, we might use the term TS3400 as a abbreviation for IBM System Storage TS3400 Tape Library, and we might use the term 3592 Model E tape drives as an abbreviation for IBM System Storage TS1120 Tape Drive and for IBM System Storage TS1130 Tape Drive.

To determine the currently supported servers, visit the Web at:

<http://www-03.ibm.com/systems/storage/tape/library.html#interoperability>

The IBM System Storage TS1120 Tape Drive supports a data transfer rate of up to 100 MB/s. The IBM Tape Cartridge 3592 Extended Data (JB) and Write Once Read Many (WORM) (JX) cartridges are designed to provide a native physical capacity of up to 700 GB (2.1 TB with 3:1 compression).

The IBM System Storage TS1130 Tape Drive supports a data transfer rate up to 160 MB/s. With the 3592 JB cartridge, the native capacity is 1.0 TB uncompressed (3.0 TB with 3:1 compression).

The IBM System Storage TS3400 Tape Library has two removable cartridge magazines providing 18 data cartridge slots, including a three slot I/O station. The total native storage capacity is 12.6 TB when using the 700 GB data cartridges with IBM System Storage TS1120 Tape Drive, and total native storage capacity is 18.0 TB when using the 700 GB data cartridges with IBM System Storage TS1130 Tape Drive.

The IBM System Storage TS3400 Tape Library incorporates IBM Multi-Path Architecture with one or two logical libraries when two 3592 Model E tape drives are installed. The only attachment to the host is a 4 Gbps switch fabric Fibre Channel connection. The TS1120 and TS1130 tape drives have two Fibre Channel (FC) dual-ported ports to be connected to the host. The IBM System Storage TS1130 provides a sustained native data transfer rate of 160 MB/s against the 100 MB/s of the IBM System Storage TS1120 Tape Drive.

Standard features for the IBM System Storage TS3400 Tape Library are control path and data path failover, a barcode reader, dual power supplies, remote management, and the capability to use the IBM System Storage TS3400 Tape Library in sequential or random access mode.

The TS3400 will be installed by an IBM Service Support Representative (SSR) and in case the TS3400 has a defect, an IBM SSR comes on-site to replace the defective parts. However, it is the client's responsibility to update the drive and library firmware.

Figure 11-1 on page 283 shows the front view of the TS3400.



Figure 11-1 IBM System Storage TS3400 Tape Library

Two removable magazines are located on the left side. The Operator Panel, which has a monochrome LCD graphic display, is in the middle. Library operations and service functions are performed from this display. For your convenience, there is a transparent plastic window so you can observe the internal robotics of the TS3400. The I/O slot is accessible from the lower left.

The TS3400 has three status Light Emitting Diodes (LEDs) and four push buttons to configure the library.

Figure 11-2 on page 284 shows the interior view of the TS3400. The front is on the left side of and the back of the TS3400 is on the right side.

11.2 Components

The TS3400 is made for automated backups. The movement is done using a robust accessor, which moves the tapes between the drive, the storage slots, and the I/O station. The Barcode Reader is an integral part of the library accessor.

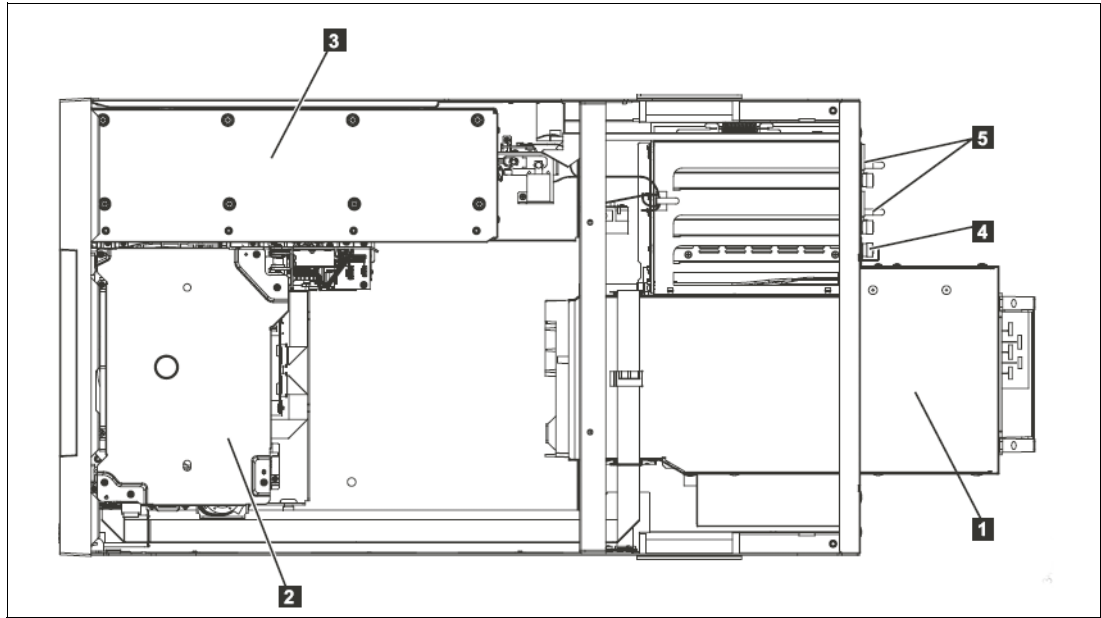


Figure 11-2 Interior components of the IBM System Storage TS3400 Tape Library

The numbers in Figure 11-2 represent the following components:

- 1.** The 3592 Model E tape drives. The second 3592 Model E Tape Drive is installed above the first tape drive.
- 2.** Library Accessor with the integral Barcode Reader.
- 3.** Cartridge magazines. The three slot I/O station is located in the bottom magazine.
- 4.** Library Control Blade (LCB). This component is a client-replaceable unit (CRU) and stores the user configuration information and vital product data (VPD). The Remote Management Unit (RMU) is embedded on this card.
- 5.** Two redundant power supplies.
- 6.** Robotics.

The TS3400 has an accessor assembly that contains the library robotics system, the picker, and the barcode reader. The accessor moves the cartridges between the:

- ▶ I/O station
- ▶ Storage slots
- ▶ Tape drives

Figure 11-3 on page 285 shows the accessor assembly.

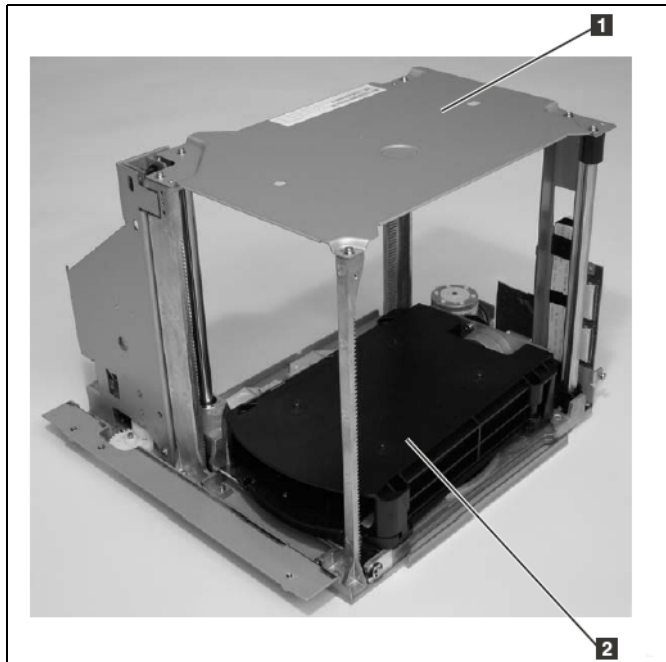


Figure 11-3 TS3400 Accessor Assembly with the picker

The numbers points to the following components:

- 1.** Accessor assembly
- 2.** Picker

The complete accessor assembly moves backward and forward in the TS3400 on an X-axis rail using a rack and pinion gear driven by the X-axis motor. The X-axis is located on the left lower side and the picker is moved up and down along a Y-axis using a belt driven by the Y-axis motor located on the lower right side.

The picker rotates on a swivel plate assembly using a combination of swivel motor and gears. The picker has a finger that enables it to grab tape cartridges and move them to and from the I/O station, storage slots, and drives.

11.2.1 Barcode reader

The barcode reader is an integral part of the library accessor, and it does not affect the slot capacity. The barcode reader provides inventory feedback to the host application, Operator Control Panel display, and Web User Interface by reading cartridge barcode labels. The library stores the customized inventory data in memory. When an application, for example, Tivoli Storage Manager, executes an audit command, the inventory on the inserted data cartridges is transferred to the application so that the application knows which data cartridges are inserted in the TS3400. Figure 11-4 on page 286 shows the barcode reader of the TS3400. The photo is taken in front of the picker assembly, and you can see that the barcode reader is an integral part of the picker assembly.



Figure 11-4 Barcode reader of the TS3400

11.2.2 Library Control Blade (LCB)

The LCB manages the entire library, including the Operator Panel and the accessor. It is responsible for monitoring the TS3400 to ensure that the library is functioning properly. The LCB stores the vital product data (VPD), including the library settings, serial number, library logs, and accessor calibration backup data.

Figure 11-5 shows you the LCB.

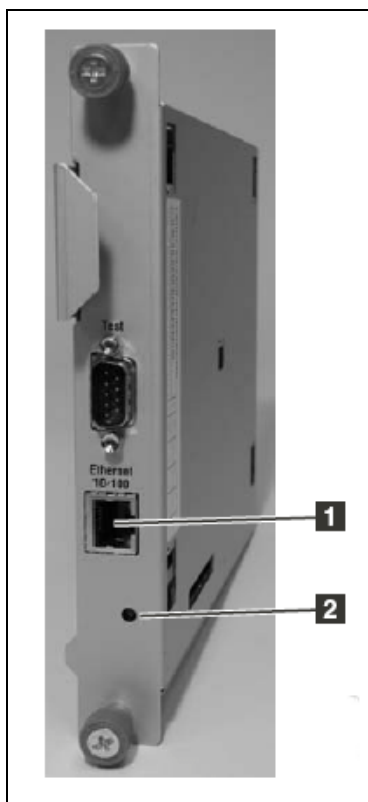


Figure 11-5 Library Control Blade

The numbers represent the following components:

- 1.** Ethernet port for network connection
- 2.** Ethernet activity LED

The RS-232 serial port above the Ethernet port is for use for IBM engineering purposes only. The Ethernet port is used for remote management to the library over a network. This function

is imbedded in the Library Control Card. The library can be attached to the network using the 10/100 MB Ethernet port. When the IP address is set on the library using the Operator Control Panel, the library can be monitored and controlled remotely. By entering the IP address in a browser, a graphical representation of the library will be opened. Service actions, such as upgrading the library and drive firmware can be done by using the remote management facility. Figure 11-6 shows the Welcome page of the Web User Interface of the TS3400.

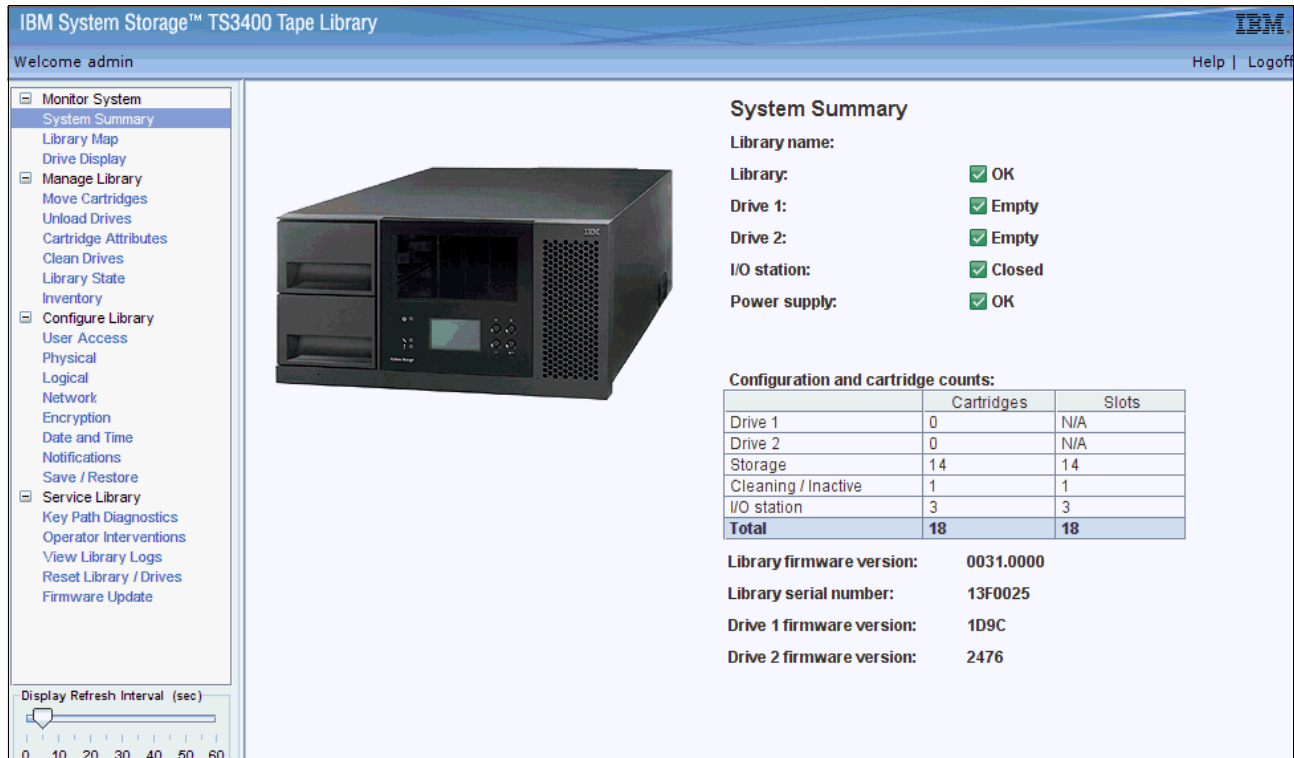


Figure 11-6 Welcome page of the IBM System Storage TS3400 Tape Library

The Welcome page shows the summary of the TS3400, the library, and the drive firmware. We were impressed by the option to manually adjust the refresh rate of the display. We strongly recommend that you configure and use the Web User Interface for monitoring, maintaining, and configuring the TS3400. In older IBM automation products, the Web User Interface was a billable feature, but with the TS3400, it comes as a standard option, and we encourage you to use it.

11.2.3 Cartridge magazines

The TS3400 has two removable and identical cartridge magazines. Each storage magazine can hold up to nine data cartridges. The first three slots of the lower left cartridge magazine can be configured as an I/O station, and the last two slots in the upper magazine can be configured as cleaning slots.

Figure 11-7 on page 288 shows one cartridge magazine of the TS3400 with five cartridges inserted.



Figure 11-7 Cartridge magazine of the TS3400

The TS3400 is a highly flexible tape library. One of its advantages is that the first three storage slots of the lower cartridge magazine can be configured as an I/O station. You can use the Web User Interface or the Operator Panel to configure the I/O station.

In Figure 11-8, you can see the TS3400 and the three storage slots, which can be configured as an I/O station.



Figure 11-8 I/O station of the TS3400

In Figure 11-8, the number 1 points to the I/O station.

For your convenience, in Figure 11-9 on page 289, we also show you the location coordinates of the two cartridge magazines and various configuration possibilities.

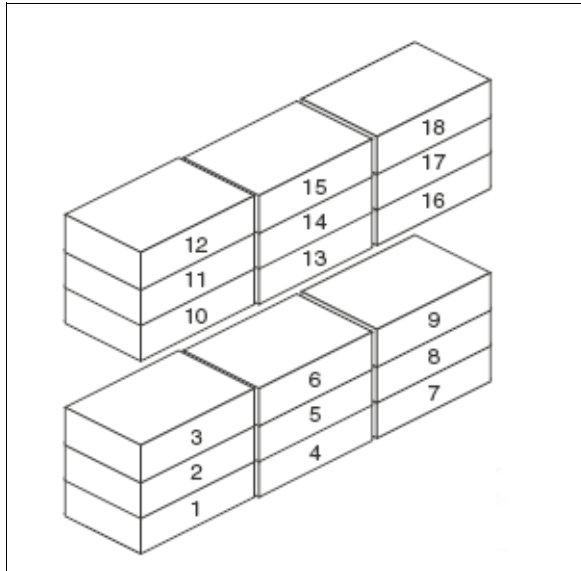


Figure 11-9 Location coordinates of the TS3400

Many applications use storage element addressing to move data cartridges between the I/O station, tape drives, and storage slots. Figure 11-10 and Figure 11-11 on page 290 show the storage element addressing with and without the I/O station configured.

Figure 11-10 shows the storage element addressing as storage.

0x100B (4107)	0x100E (4110)	0x1011 (4113)		
0x100A (4106)	0x100D (4109)	0x1010 (4112)		
0x1009 (4105)	0x100C (4108)	0x100F (4111)		
0x1002 (4098)	0x1005 (4101)	0x1008 (4104)		
0x1001 (4097)	0x1004 (4100)	0x1007 (4103)		
0x1000 (4096)	0x1003 (4099)	0x1006 (4102)		
<table><tr><td>DRIVE 2 0x101 (257)</td></tr><tr><td>DRIVE 1 0x100 (256)</td></tr></table>			DRIVE 2 0x101 (257)	DRIVE 1 0x100 (256)
DRIVE 2 0x101 (257)				
DRIVE 1 0x100 (256)				

Figure 11-10 Storage element addressing of the TS3400 as storage

Figure 11-11 on page 290 shows the storage element addressing of the TS3400 with the I/O station configured.

0x100B (4107)	0x100E (4110)	0x1011 (4113)		
0x100A (4106)	0x100D (4109)	0x1010 (4112)		
0x1009 (4105)	0x100C (4108)	0x100F (4111)		
0x12 (18)	0x1005 (4101)	0x1008 (4104)		
0x11 (17)	0x1004 (4100)	0x1007 (4103)		
0x10 (16)	0x1003 (4099)	0x1006 (4102)		
<table><tr><td>DRIVE 2 0x101 (257)</td></tr><tr><td>DRIVE 1 0x100 (256)</td></tr></table>			DRIVE 2 0x101 (257)	DRIVE 1 0x100 (256)
DRIVE 2 0x101 (257)				
DRIVE 1 0x100 (256)				

Figure 11-11 Storage element addressing of the TS3400 with the I/O station configured

Slots are numbered from the bottom to the top and from the front to the back within each magazine cartridge. Slot locations 1 to 9 are in the lower cartridge, and slot locations 10 to 18 are in the upper cartridge. Slot locations 1 to 3 can be configured as I/O station slots to import and export tape cartridges. When the I/O station is configured, the number of data cartridge slots is reduced to 15.

The library beeps a warning when a host computer accesses the library while the I/O station is open. When this occurs, the accessor stops traversing the library and the library queues Small Computer System Interface (SCSI) commands for five minutes.

Slot locations 17 and 18 can be configured as cleaning cartridge slots for both automatic cleaning and manual cleaning. If only one slot is allocated for cleaning cartridges, slot location 18 is selected. The cleaning slots are used for all drives in the physical library. When the library has two cleaning cartridges, the cartridge with the higher cleaning count usage is selected for the automatic cleaning function.

The Web User Interface can be used for a quick overview of the inserted cartridges. Figure 11-12 on page 291 shows the inventory of the TS3400.

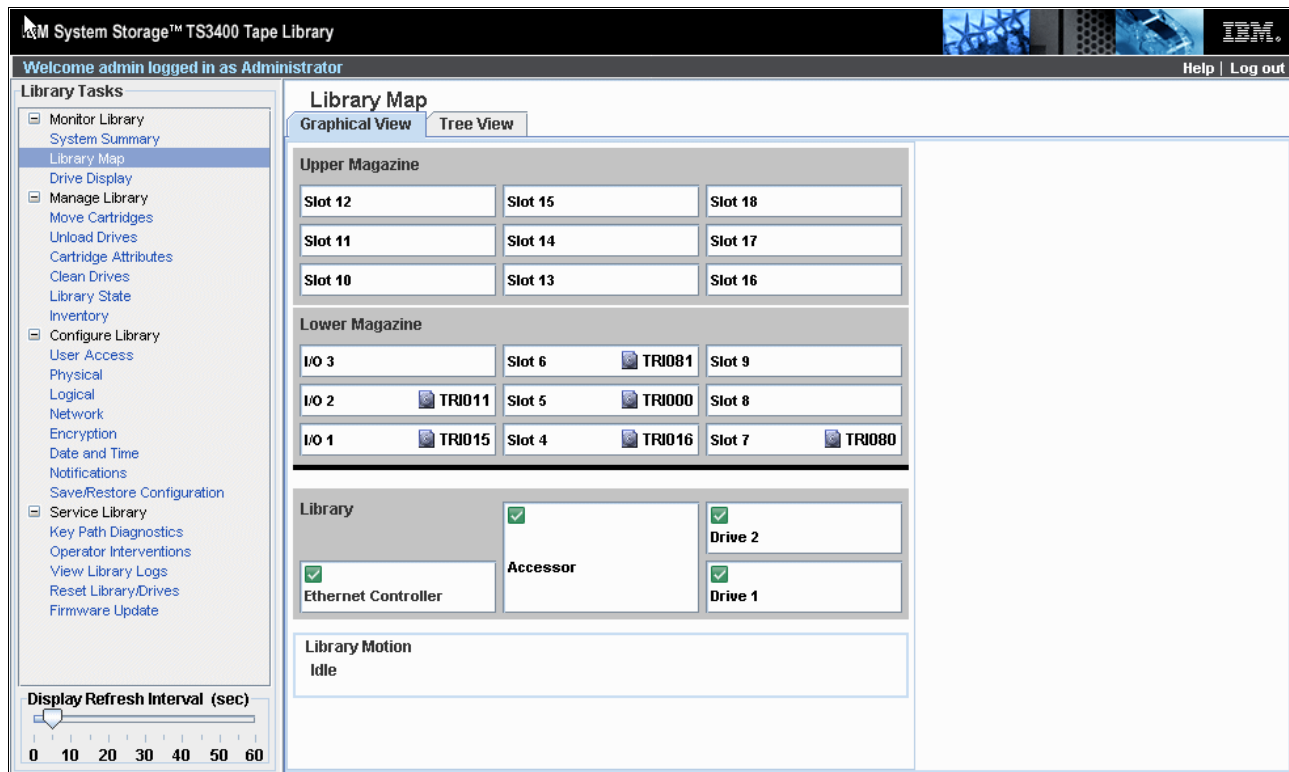


Figure 11-12 Inventory of the TS3400 using the Web User Interface

11.2.4 Tape drives

In the TS3400, up to two IBM System Storage TS1120 Tape Drives (3592-E05) or up to two IBM System Storage TS1130 Tape Drives (3592-E06) can be installed. Mixed drive configuration is only supported in Open Systems environments. In a single tape drive configuration, the tape drive must be installed in the lower tape drive position. When two tape drives are installed in the TS3400, the physical library can be partitioned into two logical libraries. Each logical library has one drive and one magazine for storage slots. The I/O station storage slots, however, are shared by the two logical libraries.

You can configure 3592 Model E tape drives in the same TS3400 and in the same logical library or in two logical libraries.

Each tape drive is packaged in a container called a *drive canister*. The drive is a field-replaceable unit (FRU) and can be hot-swapped, which means that it is not necessary to power off the TS3400 to replace a single drive.

We summarize the highlights of the 3592 Model E tape drives for you in the next sections.

Data encryption

The 3592 Model E tape drives include data encryption capabilities within the drive itself. This capability is intended to provide clients with a greater ability to protect information if tape cartridges are lost or stolen by supporting the storage of the data in an encrypted form. The IBM Encryption Key Manager component for the Java platform can help generate and manage encryption keys for 3592 Model E tape drives. This feature uses standard key repositories on supported platforms and supports three encryption management methods: Application-Managed Encryption, System-Managed Encryption, or Library-Managed Encryption.

Dynamic speed matching

To improve system performance, the tape drive uses a technique called *dynamic speed matching* to adjust its native (uncompressed) data rate to the slower data rate of the attached server. IBM System Storage TS1130 Tape Drive has a data buffer of 1 GB compared to the IBM System Storage TS1120 Tape Drive that has a data buffer of 512 MB.

Channel calibration

The channel calibration feature of the 3592 Model E tape drives customize each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

Control path failover

A *control path* is a logical path into the library through which a server sends standard Medium Changer commands to control the logical library. Additional control paths reduce the possibility that failure in one control path will cause the entire library to be unavailable. Use of the control path failover feature further reduces that possibility.

Data path failover

Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a Storage Area Network (SAN) environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without canceling the current job in progress. This capability allows you flexibility in SAN configuration, availability, and management.

Figure 11-13 shows the front view of the IBM System Storage TS1130 Tape Drive.

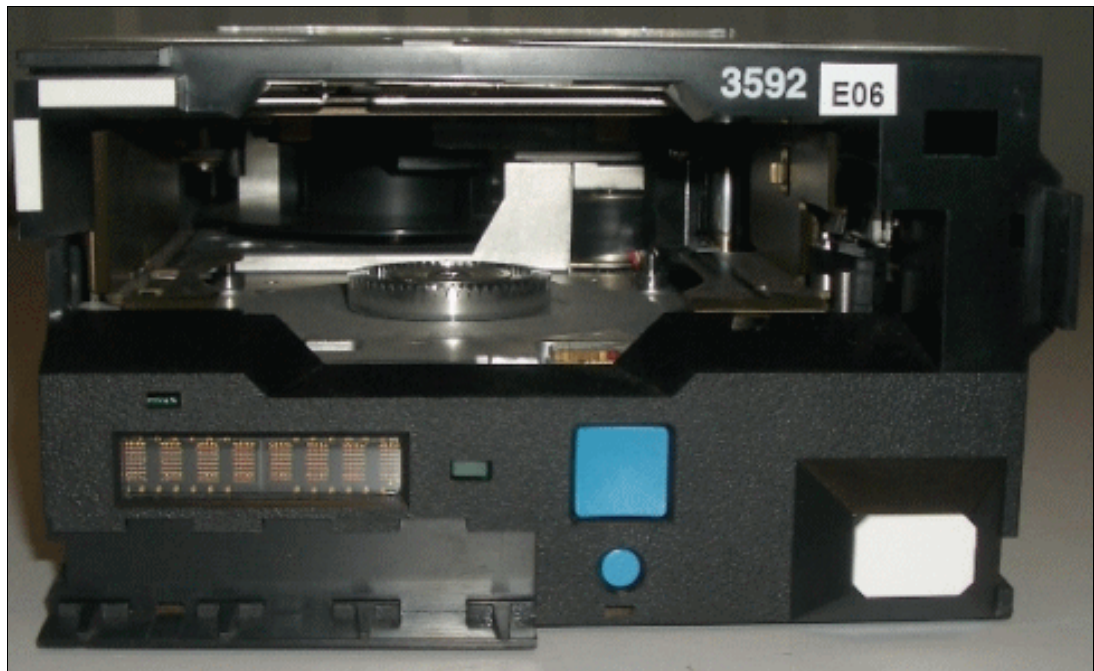


Figure 11-13 TS1130 Tape Drive front view

Figure 11-14 on page 293 shows the IBM System Storage TS1130 Tape Drive.

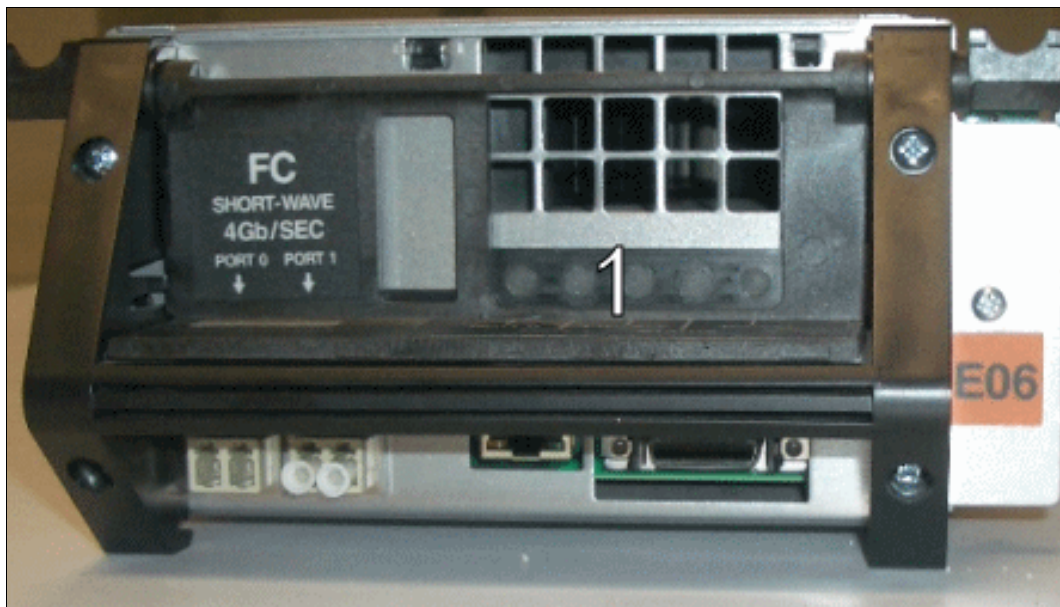


Figure 11-14 IBM System Storage TS1130 Tape Drive

In Figure 11-14, the number 1 points to the TS1130 activity LEDs. For a detailed description, refer to 3.5, “The IBM System Storage TS1130 Tape Drive” on page 109.

11.2.5 IBM Tape Drive attachment

The 3592 Model E tape drives have a dual-ported 4 Gbps native switched fabric Fibre Channel interface, which offers attachment flexibility in an Open Systems environment. The Tape Drives have two independent Fibre Channel interfaces, or ports. Both ports run the SCSI protocol with Fibre Channel tape support. Two ports allow concurrent attachment of two independent Fibre Channel configurations to each drive. One or both ports can be attached to a variety of Open Systems servers, switches, hubs, and directors.

The TS1120 and TS1130 tape drives support industry standard shortwave LC-Duplex fiber optic cables, which allow cable lengths of up to 500 m (1640 ft.) with 50 micron core fiber.

11.2.6 Data cartridges

The IBM TotalStorage Enterprise Tape Cartridge 3592 is an advanced metal particle tape specifically optimized for the enterprise tape environment. It is available in three sizes. The Data Cartridge 3592 has a standard capacity of 500 GB in E2 format and 300 GB in E1 format (JA media). The Extended Capacity Cartridge 3592 has a capacity of 700 GB in E2 format only (JB media). The Economy Tape Cartridge 3592 has a standard capacity of 100 GB in E2 format and 60 GB in E1 format (JJ media).

All cartridges can be encrypted. The capacities of data cartridges can be increased through data compression, with the actual compression and capacity depending upon the specific data. WORM cartridges are also available in all sizes (JW, JX, and JR media, respectively).

For all available capacities of the data cartridge and ordering features, refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497.

11.3 TS3400 Tape Library setup

The following section provides a global overview of the steps to implement, manage, and operate the TS3400. We provide hints and tips to make it easier for you to set up the TS3400. For a detailed description, follow the *IBM System Storage TS3400 Planning and Operator Guide*, GC27-2107.

The TS3400 will be installed and tested by an IBM Service Support Representative (SSR). After the installation and the testing phase, the SSR turns the TS3400 over to the client. We will describe the following setup steps for the TS3400:

- ▶ Setting up the Web User Interface
- ▶ Configuring the network
- ▶ Configuring the tape drives
- ▶ Partitioning the TS3400
- ▶ Setting up encryption
- ▶ Setting up e-mail and Single Network Management Protocol (SNMP)
- ▶ Updating the drive and library firmware

11.3.1 Web User Interface

There are two ways to configure the TS3400: using the Operator Panel and the Web User Interface. We strongly recommend that you configure, manage, and control the TS3400 by using the Web User Interface. In order to use the Web User Interface, you can use the default Internet Protocol (IP) address of the TS3400: 192.168.1. Or, you can change the IP address using the Operator Panel. We explain which steps must be followed to change the IP address using the Operator Panel. To configure the TS3400:

1. First, power on the TS3400 and wait until the hardware and software are initialized and the inventory is finished. This process takes several minutes. The login window is displayed when the inventory is complete. Figure 11-15 shows the login window of the Operator Panel.



Figure 11-15 TS3400 login window using the Operator Panel

2. To log in, press Enter to display the User Login password window. Figure 11-16 on page 295 shows the login password window.



Figure 11-16 Login password window of the TS3400

3. Enter the 4-character password for the TS3400. The factory password is 0000. The password can be changed in the configuration menu. When the password is entered successfully, the Operator Panel Top of Menu window is displayed.

Note: The Top of Menu window is the first menu that is displayed when you are logged in to the TS3400.

Figure 11-17 shows the Top of Menu window.



Figure 11-17 Top of Menu window of the TS3400

4. You are now logged in to the TS3400 and can start to configure the TS3400 IP address.

In order to configure the IP address, from the Top of Menu window, select **Configuration** → **Network Settings** → **IP address**. Here, you can configure the IP address for the TS3400 or one of the following settings:

- Link Speed
- Dynamic Host Configuration Protocol (DHCP)
- Subnet Mask Address
- Simple Network Time Protocol (SNTP)
- Media Access Control (MAC) address

5. The TS3400 can now be remotely controlled from any server in the network. However, there are prerequisites from a server point of view. The Web User Interface Java Applet, which is running on the TS3400, requires Java 1.5.0 or higher for full functionality and is best viewed using Internet Explorer 6.0 or higher. Internet Explorer 7.0 or higher is required for IPv6. If your server does not have Java installed or you need to upgrade your installation, download the latest version of the Java Runtime Environment (JRE) for your platform from:

<http://www.java.com>

Follow the instructions provided to enable and configure the Java Runtime Environment for your browser.

- When the JRE on your server is installed or upgraded, open your browser and enter the IP address of the TS3400.

Note: If you receive a warning message the first time that you connect to the TS3400, this message is normal and does not indicate an error.

Figure 11-18 shows the Java security warning message.



Figure 11-18 Java security warning message

- Select **Always trust content from this publisher** to avoid this message in subsequent browser sessions. After launching the Web User Interface by clicking **Run**, the login window is displayed. Refer to Figure 11-19.

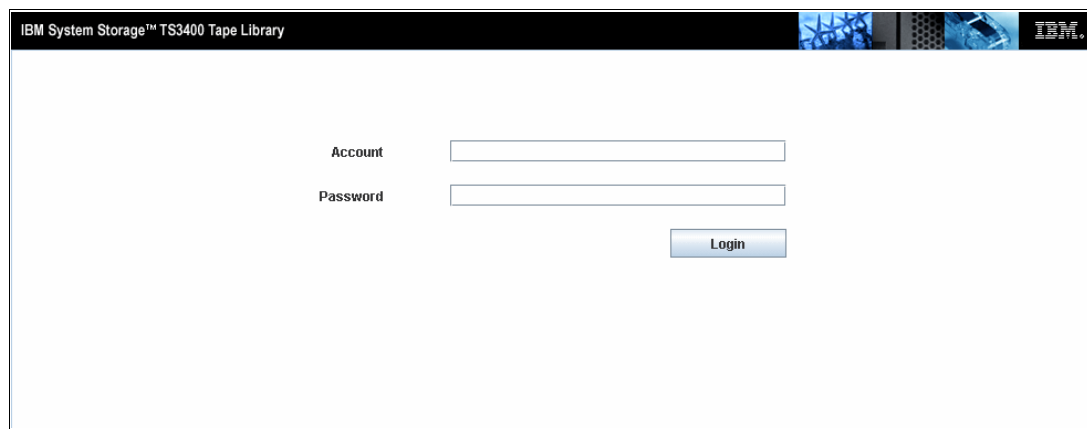


Figure 11-19 IBM System Storage TS3400 Tape Library login window

The default available user accounts and passwords are:

- Administrator account: admin, password: secure
- User account: user, password: user

After logging in, the Welcome page is displayed. Figure 11-20 on page 297 shows an example of using the Administrator account.

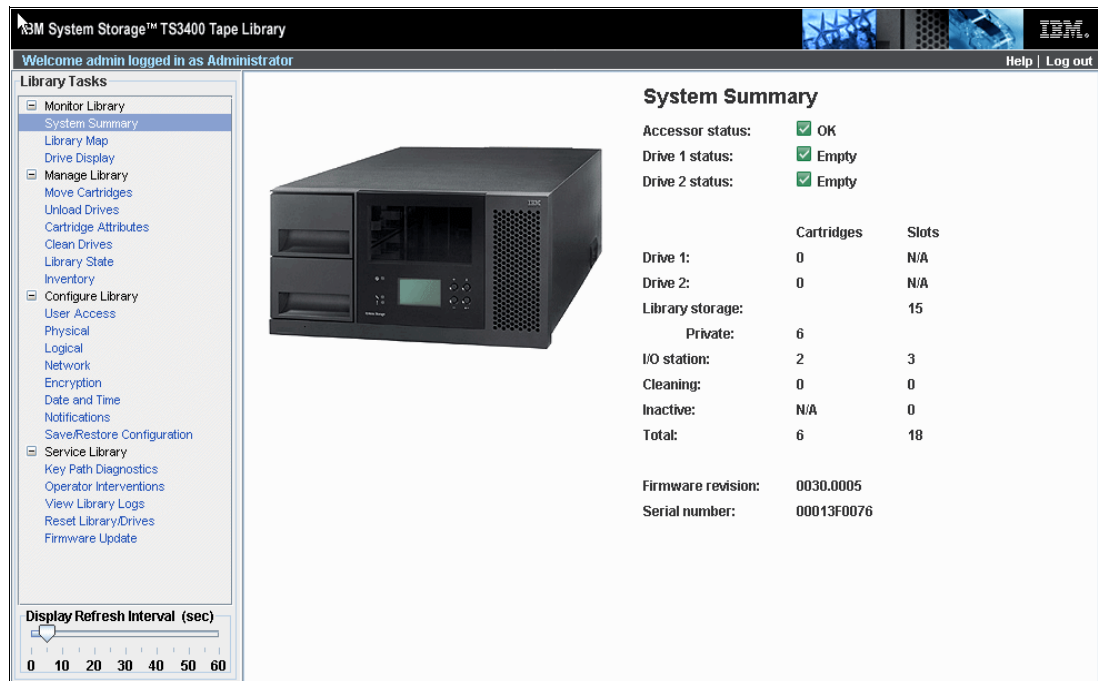


Figure 11-20 Administrator Welcome page of the TS3400

We will now continue configuring the TS3400; however, we will not cover all configuration options. We discuss partitioning the TS3400 into two logical libraries, and we describe data encryption. For a complete overview of all of the configuration settings, refer to the *IBM System Storage TS3400 Tape Library Planning and Operator Guide*, GC27-2107.

11.3.2 Configuring network

Here, we show you the network configuration panel. In this panel, you can select from two types of transportation protocols, *IPv4* and *IPv6*, or both of them in a Dual Stack configuration, *IPv4 + IPv6*.

If you want to set network settings:

1. Use **Configure Library** → **Network** from the Web User Interface. Refer to Figure 11-21 on page 298.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator

Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical
 - Logical
 - Network**
 - Encryption
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Network

Ethernet Link speed: Auto

TCP/IP Settings

Security: ☐ Enable SSL for Web

IPv4 setting: ☒ Use IPv4

☐ Obtain an IP address automatically (DHCP)

☒ Use static IP address

IPv4 address: 9.11.219.171

Subnet mask: 255.255.255.0

Gateway: 9.11.219.1

IPv6 setting: ☒ Use IPv6

☐ Obtain an IP address automatically (DHCP)

☐ Obtain an IP address automatically (Stateless Auto Config)

☒ Use static IP address

IPv6 address: 2002:90B:E002:219:9:11:219:171

Prefix length (0-128): 64

Gateway: 2002:90B:E002:219:0:0:0:1

DNS server IP address: 0.0.0.0

Refresh Submit

Figure 11-21 TS3400 Network configuration panel

Note: The Internet protocols selected are used for the TS3400 Tape Library IP address, subnet mask, gateway address, time server address, mail server address, SNMP trap to address, and EKM server addresses.

2. Configure the network using the following settings:

Link speed	Ethernet duplex mode (Auto, 10Base-T Full, 10Base-T Half, 100Base-TX Full, 100Base-TX Half).
TCP/IP settings	IPv4, IPv6, and Dual Stack IPv4 + IPv6 are supported.
Security	Select Enable SSL for Web to provide secure communications between the Web browser and the tape library.
IPv4 setting	Select Use IPv4 to enable the IPv4 Internet Protocol. Select the corresponding radio button to obtain an IP address automatically (DHCP) or use static IP address settings. Enter the following parameters if using static IP address settings:
IPv4 address	Set the TCP/IPv4 address of the library on the network.
Subnet mask	Defines and limits users within a local network.
Gateway	Allows access outside the local network.
IPv6 setting	Select Use IPv6 to enable the IPv6 Internet Protocol. Select the corresponding radio button to obtain an IP address automatically (DHCP), to obtain an IP address using stateless auto-configuration, or use static IP address settings. Enter the following parameter if using static IP address settings:
IPv6 address	Sets the TCP/IPv6 address of the library on the network.
Prefix Length	Decimal value indicating the number of contiguous, high-order bits comprising the network portion of the address.
Gateway	Allows access outside the local network.

DNS server IP address

Sets the IP address of the DNS server. The DNS server, if entered, allows the encryption, date and time, and notification IP addresses to be specified using host names instead of numerical IP addresses.

3. Click **Submit** to transfer the settings to the library. A dialog message is displayed when the settings have been updated successfully.
4. Click **Refresh** to read the current settings from the library.

11.3.3 Configuring tape drives

The installed tape drives can be configured separately, and the following options are available: Topology, Loop ID, and Fibre Channel Link Speed. For a detailed description of every option, refer to the *IBM System Storage TS3400 Tape Library Planning and Operator Guide*, GC27-2107.

The 3592 Model E Tape Drives can be configured using the **Physical** option in the **Configure Library** from the Web User Interface. Refer to Figure 11-22 for reference.

The screenshot displays the IBM System Storage TS3400 Tape Library Web User Interface. The top banner shows the title "IBM System Storage™ TS3400 Tape Library" and the user "Welcome admin logged in as Administrator". A sidebar on the left lists "Library Tasks" including Monitor Library, Manage Library, Configure Library, and Service Library. The "Physical" configuration page is active, showing settings for two tape drives. For each drive, the "Topology" is set to "L-Port", "Loop ID" is 72 for Drive 1 and 73 for Drive 2, "Fibre channel link speed" is "Auto", and "Drive emulation mode" is "3592E05". Radio buttons for "I/O station" and "Auto cleaning" are set to "Enable". A "Number of cleaning slots" field is set to 0. "Refresh" and "Submit" buttons are at the bottom right. A "Display Refresh Interval (sec)" slider is at the bottom left, set to 10 seconds.

Drive	Topology	Loop ID (0-126)	Fibre channel link speed	Drive emulation mode
Drive 1 (Port 0/1)	L-Port	72	Auto	3592E05
Drive 2 (Port 0/1)	L-Port	73	Auto	3592E05

Figure 11-22 TS3400 Tape Drives settings

Each Fibre Channel tape drive in the TS3400 must have a unique Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel topology. Table 11-1 on page 300 shows the default loop IDs.

Table 11-1 Default loop IDs and their associated AL_PAs

Drive position	Default loop ID	Default AP_PA
1	1	X'E8'
2	2	X'E4'

You can change a Loop ID by using the TS3400 Operator Panel or Web User Interface. Using a method called *hard addressing*, the TS1120 or TS1130 then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Loop ID values range between 0 and 126. The higher the number of the Loop ID (and AL_PA), the lower the priority of the devices in the loop.

You can also specify Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called *soft addressing*. To dynamically arbitrate the AL_PA, specify a Loop ID of 126 or 127.

Logical unit number (LUN) assignments

All SCSI command communications between the host and the library always access LUN 1 (all other LUNs are invalid addresses). The first drive in each logical library is mandatory and is enabled automatically by library firmware. These devices are compatible with the SCSI-3 standard. The Medium Changer SCSI ID is the same as the SCSI ID for the control path drive. You can enable additional drives to optionally provide Medium Changer (LUN 1) addressing by configuring more than one logical library or by enabling additional control paths.

Persistent binding

When a server is started, devices are discovered and assigned SCSI target and LUN IDs. It is possible for these SCSI assignments to change between restarts. Certain operating systems do not guarantee that devices will always be allocated the same SCSI target ID after restarting. Also, certain software depends on this association, so you do not want it to change. The issue of SCSI ID assignment is addressed by persistent binding.

Persistent binding is a host bus adapter (HBA) function that allows a subset of discovered targets to be bound between a server and a device. Implemented by a worldwide node name (WWNN) or worldwide port name (WWPN), persistent binding causes a tape drive's worldwide name (WWN) to be bound to a specific SCSI target ID. After a configuration has been set, it survives restarts and any hardware configuration changes, because the information is preserved. If a drive needs to be replaced, the new drive assumes the WWNN of the old drive, because the WWNN for the drive is location-dependent within the library. Because the WWNN does not change, persistent binding does not need to be changed, which causes an outage.

11.3.4 Partitioning

When two tape drives are installed in the TS3400, the library can be partitioned into two logical libraries. When the TS3400 is partitioned, two hosts can be connected to the library. However, when a I/O station is configured, it must be shared between the two logical libraries. Be aware of the following situation. When the TS3400 is partitioned and the I/O is configured, opening the I/O station can post a message to one of the attached hosts while running a backup. To make this clearer, we will explain it with an example.

The TS3400 is partitioned, and two hosts are connected. One host is an AIX server with Tivoli Storage Manager and the other host is a System i partition running Backup Recovery and

Media Services (BRMS). It is possible to run a backup simultaneously on both hosts. Now, the AIX host is finished, but the System i backup is still running with the backup, and the operator wants to export the cartridges from the AIX host. When the operator opens the I/O station, i5/OS posts a message that the I/O station is open. The operator has to wait until the System i backup job is finished, and then the operator can open the I/O station. The TS3400 is working on a first come-first served basis. The application with the first move request for a data cartridge will be served first.

When configuring logical partitioning, different library modes are available for each logical library. Each logical library can be set up differently. It is important to set the control path for the second logical partition. The control path for Drive 1 is always enabled. We will use an example to explain how to set up two logical libraries. We use the Web User Interface for setting up the logical libraries. Logical libraries can also be configured using the Operator Panel, but we prefer and recommend using the Web User Interface. First, we explain the modes.

Random mode

In Random mode, the library allows the server's (host's) application software to select any data cartridge in any order. It is the server's responsibility to move the cartridges between the I/O station, storage slots, and tape drives. The application must execute an **audit** Tivoli Storage Manager command to get the inventory from the TS3400 so that the application is aware of the location of the data cartridges.

Sequential mode

In Sequential mode, the library firmware predefines the selection of the data cartridges. After initialization, the firmware causes the library to select the first available data cartridges found (counting from the I/O station through to the last slot in the library) for loading into the drive. The following options are available when using Sequential mode:

- ▶ **Autoload:** Sequential mode with autoload ON loads the first available cartridge (slot with the lowest numerical value that contains a cartridge) automatically if the library powers ON with an empty drive.
- ▶ **Loop:** Sequential mode with loop ON loads the cartridge in the lowest numerical slot after the cartridge in the highest numerical slot has been filled and sent back to its home slot, which allows endless backup operations without user interaction.

The way in which Sequential mode works depends on the autoload and loop settings:

1. If the autoload option is set to **ON**, the accessor loads the first cartridge (cartridge located in the slot with the lowest numeric value) found in the storage inventory area into the drive when the library powers ON. If the library powers ON with a cartridge already in the drive, sequential mode starts with that cartridge unless the host issues a rewind and unload command to the drive. In that case, the next cartridge in sequence will be loaded into the drive.
2. If the autoload option is set to **OFF**, sequential mode is started by selecting the **Move Cartridge** command to load the first cartridge into the drive. The sequence then starts with the cartridge loaded into the drive. For example, if a cartridge from the fifth lowest numeric storage slot containing a cartridge is loaded using the **Move Cartridge** command, after the host issues a rewind/unload command, the next cartridge loaded is the cartridge from the next higher numeric slot. Cartridges do not need to be in contiguous slots.

If the loop option is set to **ON**, the accessor will immediately start loading the first cartridge into the drive when the last cartridge (cartridge in the highest numeric slot) is unloaded and placed back into storage.

Sequential mode is stopped when a cartridge is removed from the drive using the **Move Cartridge** command. The next sequential cartridge is not loaded. To restart sequential mode, use the **Move Cartridge** command to load a cartridge. The loading sequence will resume from that numeric slot in the cartridge inventory. The number of active slots in the library determines the number of slots that the library will access before repeating each loop and the number of reserved cartridge slots.

Note: When the TS3400 is connected to a System i host, you must IPL the input/output adapter (IOA); otherwise, the System i host will not recognize the new mode. First, investigate if there are more IOAs under the input/output processor (IOP). When for example, a disk adapter is under the same IOP, this IOA will also be IPLed.

We will now partition the TS3400 into two logical libraries, and we will configure one logical library in Sequential mode and one logical library in Random mode. The first step is to configure the TS3400 with Partition 1 in Sequential Mode with loop and auto loop. In Step two, we configure the TS3400 with Partition 2 in Random Mode. The steps are:

1. From the Welcome page, choose **Logical** as shown in Figure 11-23. We changed the settings for Partition 1 and Partition 2. Notice that Partition 1 has the control path disabled. When Sequential mode is enabled, the control path is automatically disabled. This make sense, because it is the library that takes care of loading and unloading the cartridges in the drive.

Figure 11-23 shows the first step of configuring the TS3400.

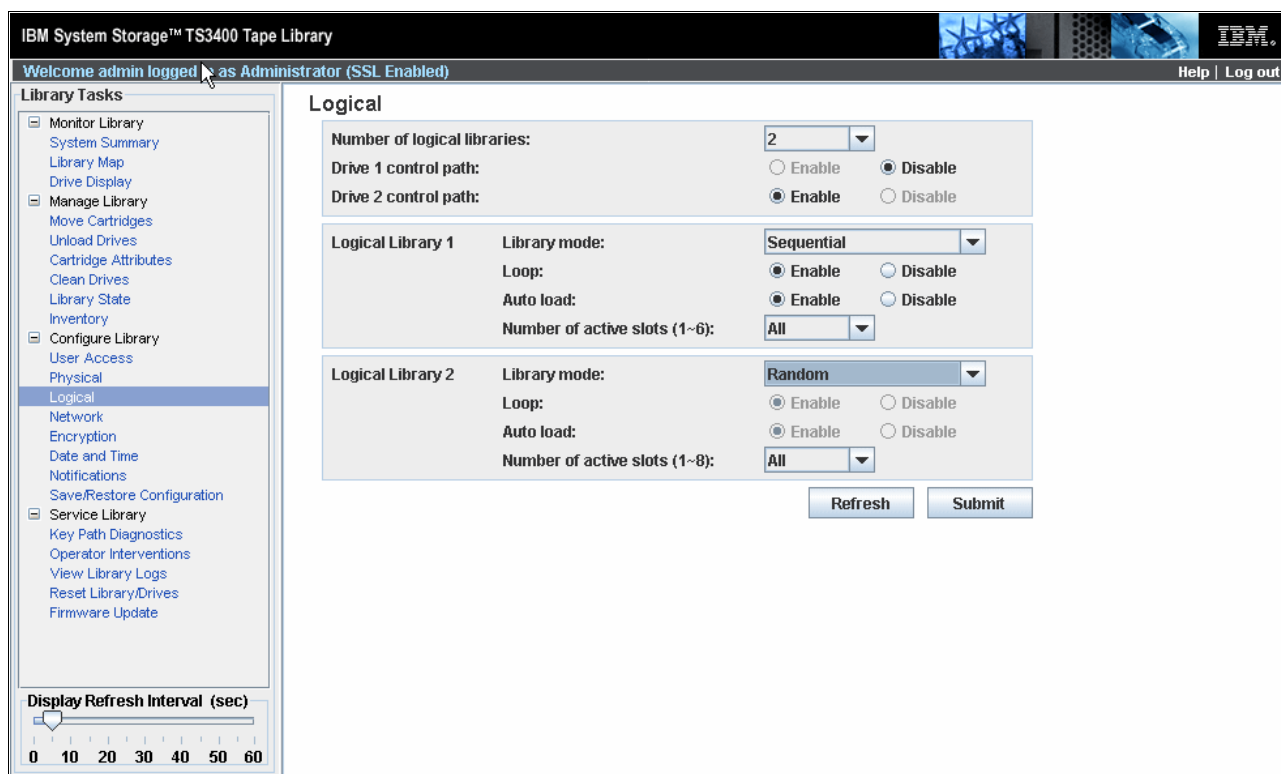


Figure 11-23 Partitioning the TS3400

No restart of the TS3400 is required for changing the Library mode of the logical libraries.

- After setting up the logical library, you now have to decide if you want to use the I/O station. Remember that when you enable the I/O station, Partition 1 will lose three storage slots. When you want to enable the I/O station, choose Physical on the Welcome page; refer to Figure 11-24. The I/O station is shared between the logical libraries.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical**
 - Logical
 - Network
 - Encryption
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Physical

Library I/O station: ☐ Enable ☒ Disable

Auto cleaning: ☐ Enable ☒ Disable

Number of cleaning slots (1~2):

Drive 1 (Port 0/1) Topology: L-Port L-Port

Loop ID (0~126):

Fibre channel link speed: Auto Auto

Drive emulation mode: 3592E05

Drive 2 (Port 0/1) Topology: L-Port L-Port

Loop ID (0~126):

Fibre channel link speed: Auto Auto

Drive emulation mode: 3592E05

Refresh Submit

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Figure 11-24 Configuring the TS3400 I/O station

- Click **Submit** to enable the I/O station. The TS3400 response is shown in Figure 11-25 on page 304.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical**
 - Logical
 - Network
 - Encryption
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Physical

Library I/O station: ☒ Enable ☐ Disable

Auto cleaning: ☐ Enable ☒ Disable

Number of cleaning slots (1~2):

Drive 1 (Port 0/1) Topology: L-Port L-Port

Loop ID (0~126):

Fibre channel link speed: Auto Auto

Drive emulation mode: 3592E05

Drive 2 (Port 0/1) Topology: L-Port L-Port

Loop ID (0~126):

Fibre channel link speed: Auto Auto

Drive emulation mode: 3592E05

Display Refresh Interval (sec):

0 10 20 30 40 50 60

Figure 11-25 After enabling the I/O station

The Web User Interface is a user friendly way to monitor and configure the TS3400.

In the Physical menu, you can also configure how many cleaning slots you want to use. When two cleaning slots are configured, those slots are not usable as storage slots. Storage slot numbers 18 and 17 (in that order) can be configured as cleaning slots. Cleaning cartridges are shared between the two logical libraries. It can be confusing to determine how many storage slots you can actually use. Table 11-2 on page 305 makes it clearer for you.

Table 11-2 The number of available storage slots

Partition	I/O station	Auto cleaning	Active data cartridge slots ^a
OFF	OFF	OFF	Slots 1 to 18 are available in a single logical library.
		ON	Slots 1 to 17 (1 to 16) are available in a single logical library.
	ON	OFF	Slots 4 to 18 are available in a single logical library.
		ON	Slots 4 to 17 (4 to 16) are available in a single library.
ON	OFF	OFF	Slots 1 to 9 are available in drive 1 logical library.
			Slots 10 to 18 are available in drive 2 logical library.
		ON	Slots 1 to 9 are available in drive 1 logical library.
			Slots 10 to 17 (10 to 16) are available in drive 2 logical library.
	ON	OFF	Slots 4 to 9 are available in drive 1 logical library.
			Slots 10 to 18 are available in drive 2 logical library.
		ON	Slots 4 to 9 are available in drive 1 logical library.
			Slots 10 to 17 (10 to 16) are available in drive 2 logical library.

a. The numbers in parentheses indicate the data cartridge slots available when the number of auto cleaning cartridges is set to 2.

Let us summarize what we did so far. We are able to access the TS3400 using the Web User Interface. And, the TS3400 is partitioned in two logical libraries:

- ▶ Partition one is in Sequential mode.
- ▶ Partition two is in Random mode.

The next step can be to configure one or both logical libraries with encryption. These optional setup steps to enable Encryption are described in 11.3.5, "Tape Encryption" on page 306.

11.3.5 Tape Encryption

TS1120 and TS1130 tape drives installed in the TS3400 support data encryption on any size of IBM TotalStorage Enterprise Tape Cartridge 3592, including WORM cartridges. That means that they are capable of performing hardware encryption. The tape drives are encryption-capable but must be configured first using the Web User Interface.

Encryption is performed at full line speed in the tape drive after compression (encryption is more efficiently done after compression). The data cartridge is encrypted as a whole; it is never partly encrypted.

Encryption involves the use of several kinds of encryption keys. How those encryption keys are generated, maintained, controlled, and transmitted depends on the operating environments where the TS3400 is installed. Certain applications are capable of performing key management, for example, Tivoli Storage Manager. For environments without this type of application, IBM provides the IBM Encryption Key Manager (EKM) component for the Java platform to perform all necessary key management tasks, such as generating, protecting, storing, and maintaining the encryption keys that are used to encrypt information being written to and decrypt information being read from the data cartridge.

The 3592 Model E tape drives communicate through the TS3400, which uses TCIP/IP to communicate with the server where the EKM is installed. The TS3400 supports up to two key manager addresses, where each key manager is specified using the IP address and port number of a server that has the EKM installed. The EKM is supported on z/OS, i5/OS, AIX, Linux, HP-UX, Sun Solaris, and Windows. The IBM EKM can be downloaded from this Web site:

<http://www-1.ibm.com/support/docview.wss?uid=ssg1S4000504>

There are three Tape Encryption methods: Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME). During write operations, the tape drives use an encryption key to encrypt the data and, during read operations, a decryption key to decrypt the data. The SME and LME methods use an Encryption Key Manager and a keystore to manage and store the keys. With AME, the application is responsible for managing keys and communicating the keys to the tape drive.

When a scratch cartridge is loaded, for SME and LME, the drive communicates with the key manager, which provides the keys to encrypt the data. When data is appended, it must be encrypted with the same key as the existing data on the cartridge. The data encryption and decryption keys must stay with the data and cannot be stored unencrypted. They are stored in the Cartridge Memory of the cartridge and at the beginning of tape in an encrypted format. The data encryption and decryption keys are encrypted with another set of keys, known as key encryption keys (KEK). The KEKs are also provided by the key manager and are referenced by key labels that you define. These labels can be shared with authorized external users of the data cartridge.

Encryption policy is used for TS3400 to set up encryption for the partition that is configured with encryption. *Encryption policy* is a set of rules, or policies, that specify which data cartridges are to be encrypted. How and where these rules are set up depends on the operating environment.

Note: The IBM System Storage TS1120 Tape Drive that was produced before 8 September 2006 does not have the capability to encrypt data on the data cartridge. However, there is a chargeable upgrade available (Feature Code (FC) 5592) to upgrade the IBM System Storage TS1120 Tape Drive. This encryption capability includes drive hardware, as well as microcode additions and changes.

To set up encryption on your TS3400:

1. Go to the Welcome page of the TS3400 using the Web User Interface and select **Encryption**, and the window shown in Figure 11-26 will be displayed.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator (SSL Enabled) Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical
 - Logical
 - Network
- Encryption**
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Encryption

Library 1 Library 2

Security

SSL: ☐ Enable SSL for EKM

Primary EKM Server Settings

Address: 9.11.221.242

TCP port number: 3801

SSL port number: 3801

Secondary EKM Server Settings

Address: 9.11.219.108

TCP port number: 3801

SSL port number: 3801

Encryption Settings

Encryption method: Library Managed

Encryption policy: Encrypt All (default)

Advanced Encryption Settings (for Engineering Support use only)

Advanced encryption method: No Advanced Setting (default)

Advanced encryption policy: No Advanced Setting (default)

Encryption density: No Advanced Setting (default)

Encryption key path: No Advanced Setting (default)

Refresh Submit

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Figure 11-26 Encryption menu for the TS3400

On partition two, you are now able to set the methods of encryption that you want to use. Select the **Encryption Method** pull-down menu and you have four possible options:

None No encryption is used on partition two.

Application-Managed Encryption

Use this option for encryption in operating environments that run an application capable of generating and managing encryption policies and keys. If you select Application-Managed Encryption, no further configuration steps are necessary. At the time of writing this publication, the only Application-Managed Encryption-capable application was Tivoli Storage Manager.

System-Managed Encryption

Use this option for encryption in operating environments where no application is capable of key management runs. Encryption is set up implicitly through each instance of the IBM device driver.

Library-Managed Encryption

Use this option for transparent encryption by the TS3400 Tape Library tape drive.

Note: SME and LME are transparent. A data cartridge using SME can be decrypted using LME, and a data cartridge using LME can be decrypted using SME, provided both methods have access to the same EKM keystore.

2. The next step is to configure the Encryption Policy. From the Welcome Page, select **Encryption** → **Encryption Policy**.

The following three encryption policy methods are available for partition two:

Encrypt All Encrypt All is the default setting. All data cartridges within the logical partition loaded into the tape drive are encrypted.

Internal Label - Selective Encryption

This option is used only for Symantec Veritas NetBackup.

Internal Label - Encrypt All

This option is used only for Symantec Veritas NetBackup.

There is also an Engineering Use Only option available. As the name implies, this option is only for IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. These options are not intended for use by the client without the guidance of IBM Support.

Older TS1120s can be installed in the TS3400, but those tape drives do not support encryption because of a vintage internal chip set. However, all 3592 Model E tape drives ordered with the TS3400 are encryption-capable.

Select **Encrypt All** and click **Submit**.

3. The next step is to configure the EKM server setting. From the Welcome Page of the TS3400, select **Encryption**. Refer to Figure 11-27.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator (SSL Enabled)

Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical
 - Logical
 - Network
 - Encryption**
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Display Refresh Interval (sec): 0 10 20 30 40 50 60

Encryption

Library 1 Library 2

Security

SSL: ☒ Enable SSL for EKM

Primary EKM Server Settings

Address: 9.11.221.242

TCP port number: 3801

SSL port number: 3801

Secondary EKM Server Settings

Address: 9.11.219.108

TCP port number: 3801

SSL port number: 3801

Encryption Settings

Encryption method: Library Managed

Encryption policy: Encrypt All (default)

Advanced Encryption Settings (for Engineering Support use only)

Advanced encryption method: No Advanced Setting (default)

Advanced encryption policy: No Advanced Setting (default)

Encryption density: No Advanced Setting (default)

Encryption key path: No Advanced Setting (default)

Refresh Submit

Figure 11-27 The EKM settings for the TS3400

In our example, we used 9.11.221.242 for the primary EKM IP address and 9.11.219.108 for the secondary EKM IP address. You can also select Secure Socket Layer (SSL) for the access to the EKM if you prefer.

To see if a data cartridge is encrypted, use the option **Library Map** from the Welcome page and click the cartridge that is inserted in the partition that has encryption enabled. In our example, the cartridge in slot 14 is not encrypted. Refer to Figure 11-28.

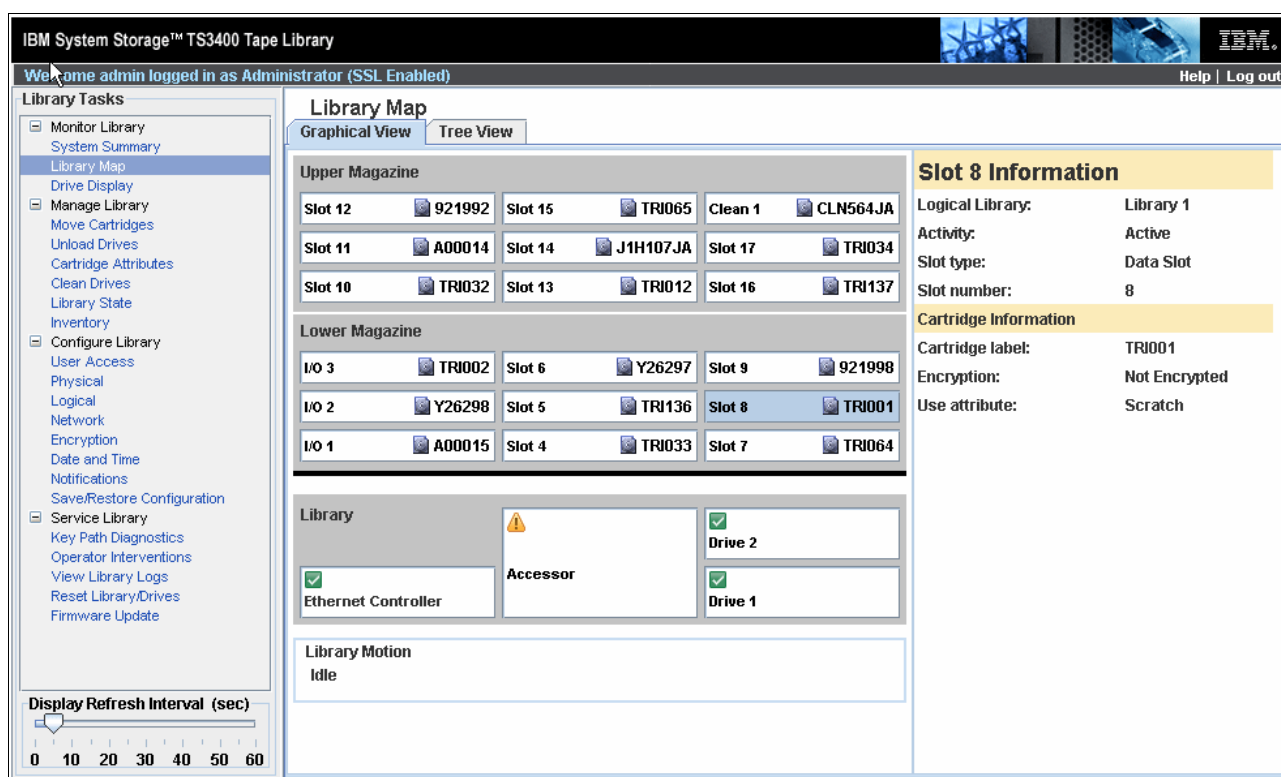


Figure 11-28 Library map graphical view TS3400

11.3.6 Notification

There are still two settings to configure before connecting the TS3400 to the host. You can change the settings using the Operator Panel or using the Web User Interface. From the Welcome page for the TS3400, select **Notifications**. Two options are available for sending notifications to the host:

SMTP

This feature automatically sends an e-mail containing event information to the e-mail addresses specified whenever an event of a certain level occurs. The contents of the e-mail message are similar to the information that can be obtained by Single Network Management Protocol (SNMP) traps without using SNMP management software.

SNMP

This is a set of protocols for managing complex networks. SNMP works by sending messages, which are called *protocol data units (PDUs)*, to different parts of a network. Agents, which are SNMP-compliant devices, store data about themselves in Management Information Bases (MIBs) and return this data to the SNMP requesters, such as the host's monitoring application.

SNMP traps are alerts or status messages that can be collected, monitored, and used to proactively manage attached libraries using the SNMP protocol with the host servers. The tape library supports the transmission of SNMP traps and the collection of MIB information as an SNMP agent. SNMP traps can be received using an SNMP manager, and MIB information can be collected using an MIB browser.

Figure 11-29 shows the SMTP Mail Settings window.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator (SSL Enabled) Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical
 - Logical
 - Network
 - Encryption
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Notifications

SMTP (Mail) Settings SNMP Settings

SMTP server address: 9.56.224.216

Sender address: fuji@storage.tucson.ibm.com

Subject: Please check the RAS 5U 13F0025

Mail to:

01	☒ Enable	jbeard@us.ibm.com
02	☒ Enable	albin@us.ibm.com
03	☐ Enable	ebengds@us.ibm.com
04	☐ Enable	

Mail event:

☐ Error Events

☒ Error and Warning Events

☐ Error, Warning, and Information Events

Test

Refresh Submit

Figure 11-29 E-mail settings notification for the TS3400

Figure 11-30 shows the SNMP notification setting window.

IBM System Storage™ TS3400 Tape Library

Welcome admin logged in as Administrator (SSL Enabled) Help | Log out

Library Tasks

- Monitor Library
 - System Summary
 - Library Map
 - Drive Display
- Manage Library
 - Move Cartridges
 - Unload Drives
 - Cartridge Attributes
 - Clean Drives
 - Library State
 - Inventory
- Configure Library
 - User Access
 - Physical
 - Logical
 - Network
 - Encryption
 - Date and Time
 - Notifications
 - Save/Restore Configuration
- Service Library
 - Key Path Diagnostics
 - Operator Interventions
 - View Library Logs
 - Reset Library/Drives
 - Firmware Update

Display Refresh Interval (sec)

0 10 20 30 40 50 60

Notifications

SMTP (Mail) Settings SNMP Settings

Community: tsccsnmp

Name: IBM_RAS_TEST 13F0025

Location: 1100/9032 RAS Area

Contact: Jon Beard

SNMPv3 engine ID: 80:00:00:77:03:00:30:13:d3:83:18

Trap event:

☒ Error Events

☐ Error and Warning Events

☐ Error, Warning, and Information Events

Test Refresh Submit

Trap List

Select	Validity	Address	Version	Community	Username
☐	Enable	2002:90b:e002:219:9:11::v1	v1	tsccsnmp	----
☐	Disable		v1	public	----
☐	Disable		v1	public	----
☐	Disable		v1	public	----

SNMPv3 User List

Select	Validity	User Name	Authentication	Privacy
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable
☐	Disable		Disable	Disable

Figure 11-30 SNMP notification setting window

11.3.7 Firmware upgrade

After setting up and configuring the TS3400, we recommend that you verify that the latest firmware is installed for both the library and the tape drive. At installation time, the IBM Support Service Representative (SSR) verifies both firmware levels but it is your

responsibility to maintain the firmware. Determine the current level of firmware available from the IBM Technical Support Web sites:

<http://www.storage.ibm.com/>
<ftp://index.storsys.ibm.com>

If the installed firmware of your library or tape drive is down-level, download the firmware from the IBM Web site to your local server.

There are several options to update the firmware of the library or the tape drive. You can use the driver's application interface, for example, NTUTIL, the Web User Interface of the TS3400, or an IBM tool called IBM TotalStorage Tape Diagnostic Tool (ITDT). We recommend that you use the Web User Interface for updating the library or drive firmware.

ITDT can also be used for updating the firmware of the tape drive. This tool is driver independent and can also be used for testing the tape drives and taking drive dumps.

Note: Updating the library firmware is not supported.

ITDT tool is supported on the following servers:

- ▶ Microsoft Windows Server 2008 SP1
- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

The latest version of the ITDT is V2.0, and it is available in two types:

ITDT-SE	This version is similar to the previous ITDT version and is mainly a command line driven tool.
ITDT-GE	This version is called ITDT Graphics Edition and is a Graphical User Interface version that you use if the operating systems running on the servers are Windows XP or Windows Server 2003. Install Java before using ITDT-GE. You can download a Java version from: http://www.ibm.com/java http://www.java.com

You can download the ITDT tool from this IBM Web site:

<http://www-03.ibm.com/servers/storage/support/>

To locate the tool, search on *ITDT V2.0*.

After updating the TS3400 firmware, it is now time to populate your TS3400 with data cartridges and to connect your TS3400 to the your host. The TS3400 that we used was already populated with data cartridges in order to give you the examples.

For ordering data cartridges and the features, refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 497.

11.3.8 Host bus adapter (HBA) support

In order to connect your TS3400 to the host, you have to ensure that the installed Fibre Channel HBA in your server is supported.

On the technical Support Web site from IBM, you can find the System Storage Interoperation Center (SSIC). This Web site is a starting point to find out if your HBA supports the TS1120 Tape Drive. Remember that for each Fibre Channel HBA, there is a required minimum level of the Basic Input Output System (BIOS). Unpredictable problems can occur when the BIOS is not at the required level. Always install the latest available BIOS level for your HBA, as well as the latest device driver for your operating system. The Web site for the System Storage Interoperation Center is:

<http://www-01.ibm.com/systems/support/storage/config/ssic/index.jsp>

We provide an example with a System p server with AIX 5.3 and a 6228 HBA. The System Storage Interoperation Center will take you step-by-step through all the choices. Refer to Figure 11-31 for IBM TS1120 Tape Drive.

Country/region [select] Terms of use

TotalStorage support [select] Search

Home Products Services & industry solutions Support & downloads My IBM

Storage support > Disk Storage Systems >

System Storage Interoperation Center
Technical support

TS1120 (3592 E05) support - Fibre Channel
Host platform: IBM System p (IBM AIX 5.3)

→ Interoperability Search Results Overview
→ HBA/SAN
→ General notes

[New search](#)

Fibre Channel supported host bus adapter - IBM FC 6228

Product: TS1120 (3592 E05)
Operating system: IBM AIX 5.3
Host bus adapter minimum required levels

Supported host bus adapter information		
Model	Device driver	Firmware/FCode
IBM FC 6228	5.3	3.91A1

Notes

1. After the HBA driver is loaded, any reset by a utility or firmware download, will cause the new PRLI frame sent to incorrectly not advertise FCP-2 tape recovery support. Workaround is to disable/enable the driver in the device manager window

Last accessed: Tue, 3 Apr 2007 05:28:44 Greenwich Mean Time, GMT

Figure 11-31 System Storage Interoperation Center

The highlighted areas point to the IBM System Storage TS1120 Tape Drive, the host platform (AIX 5.3), the supported HBA (6228), and the firmware level 3.91A1.

Note: The HBA 6228 is one of many supported HBAs. Refer to the SSIC Web site for all supported FC HBAs:

<http://www-01.ibm.com/systems/support/storage/config/ssic/index.jsp>

11.3.9 Installing device drivers

To communicate with the TS3400, the appropriate device driver must be installed on your server. Depending on your host operating system, the latest device driver must be installed on your server. Visit the Web site:

<http://www-03.ibm.com/servers/storage/tape/>

Select **Support & Download**, and in the next window, you can type TS3400 in the search technical support box. Here, you can download the latest device driver for your operating system.

Another way to get the latest device driver is to visit this Web site:

<ftp://index.storsys.ibm.com/devdrv>

Choose your operating system and download the device driver.

We do not discuss installing the device driver in this publication. Information about how to install the device driver is described step-by-step in:

- ▶ *Implementing IBM Tape in Unix Systems, SG24-6502*
- ▶ *Implementing IBM Tape in Linux and Windows, SG24-6268*
- ▶ *IBM Tape Device Driver Installation and Users Guide, GA27-2130*

All publications are available and can be downloaded from the Web.

You have now completed setting up your TS3400, installing your FC HBA, checking that your HBA is supported, and installing the correct device driver.

Congratulations. We recommend that you register yourself for My Support at the IBM Technical Support Web site. When you register at My Support, you will automatically receive an e-mail when there is new firmware available for the TS3400 or other news concerning the TS3400. To register at My Support, go this Web site:

<https://www-304.ibm.com/usrsrv/account/userservices/jsp/login.jsp?persistPage=true>

11.4 Technical specifications

In the next section, we summarize all of the technical specifications of the TS3400.

Physical specifications

The TS3400 is a midrange-sized IBM Automation Tape Library with the following physical specifications:

- ▶ Width: 44.5 cm (17.5 in.)
- ▶ Depth: 89.5 cm (32.2 in.)
- ▶ Height: 22.15 cm (8.7 in.)
- ▶ Weight (library only): 31 kg (68.3 lbs.)

Electrical specifications

The following values are for a TS3400 with two installed TS1120 or TS1130 tape drives:

- ▶ Voltage: 100 to 240 Vac.
- ▶ Frequency: 50 to 60 Hz.
- ▶ Power consumption: 117.85 W.

Performance specifications for the TS3400

The TS3400 has the following performance specifications:

- ▶ Inventory:
 - Full cartridges with barcode labels: 40 sec.
 - Full cartridges without barcode labels: 100 sec.
 - No cartridges: 100 sec.
- ▶ Average access time (maximum):
 - X direction (one way): 3 sec.
 - Y direction (one way): 4.5 sec.
 - Picker direction (one way): 3 sec.

11.5 Feature codes

Table 11-3 shows the available feature codes for the TS3400.

Table 11-3 Feature codes

Description	Feature code
Library and Drive Code Update (one time visit)	0500
Tape Drive Removal	1663
Tape Drive (3592-E05)	4685
LC-SC Fibre Cable Interposer	5096
LC-SC Fibre Channel Cable (5 m)	6005
LC-SC Fibre Channel Cable (13 m)	6013
LC-SC Fibre Channel Cable (25 m)	6025
Rack Mount Kit with 2 RML cords	7004
Additional Cartridge Magazine	8109
3592 Cleaning Cartridge	8802
3592-E05 Drive Plant Ship	9685
3592-E06 Drive Plant Ship	9691
Encryption Configuration (Documentation)	9900



IBM System Storage TS3500 Tape Library

The IBM System Storage TS3500 Tape Library leverages the LTO and Enterprise 3592 drive technologies within the same library. The TS3500 was previously known as the IBM TotalStorage 3584 Tape Library and still has the machine type 3584.

The TS3500 Tape Library provides tape storage solutions for the large, unattended storage requirements from today's midrange up to enterprise (z/OS and Open Systems) environment. This chapter only covers information relating to the TS3500 Tape Library attachment in an Open Systems environment. For information about TS3500 Tape Library attachment to a System z environment, refer to *IBM System Storage TS3500 Tape Library with System z Attachment: A Practical Guide to Enterprise Tape Drives and TS3500 Tape Automation*, SG24-6789.

Combining reliable, automated tape handling and storage with reliable, high-performance IBM LTO Ultrium tape and 3592 drives, the TS3500 Tape Library offers outstanding retrieval performance with typical cartridge move times of less than three seconds.

The TS3500 Tape Library can be partitioned into multiple logical libraries. This makes it an excellent choice for consolidating tape workloads from multiple heterogeneous Open Systems servers and enables the support for System z attachment in the same library.

In addition, the TS3500 Tape Library provides outstanding reliability and redundancy, through the provision of redundant power supplies in each frame, an optional second cartridge accessor, control and data path failover, and dual grippers within each cartridge accessor. Both library and drive firmware can now be upgraded non-disruptively, that is, without interrupting the normal operations of the library.

The TS3500 supports Tape Encryption on the following tape drives: IBM System Storage TS1040 Tape Drive and IBM 3592 models E Tape Drive. IBM 3592 models E Tape Drive includes TS1130 and TS1120. All three Encryption methods are supported: Application-Managed Encryption (AME), System-Managed Encryption (SME), and Library-Managed Encryption (LME).

12.1 Model description

The IBM TS3500 Tape Library (machine type 3584) is a modular tape library consisting of frames that house tape drives and cartridge storage slots. You can install a single-frame base library (Figure 12-1 on page 317) and grow it to 16 frames, tailoring the library to match your system capacity requirements.

Table 12-1 gives the capacities of the supported combinations of frames, tape drives, and their capacities.

Table 12-1 TS3500 Tape Library frame capacity

Models	Drives in frames	Maximum cartridges ^a	Maximum capacity without compression
L52, D52, L53, and D53	Ultrium Tape Drives	6887 L53+15XD53	5509 TB
L32 and D32	Ultrium Tape Drives	6881 L32+15XD32	5509 TB
L22, D22, L23, and D23	3592 Tape Drives	6260 L23+15XD23	6260 TB (TS1130) 4382 TB (TS1120) 1878 TB (J1A)
L23 and S24	3592 Tape Drives	15110 (3592 cartridge) ^b	15110 TB (TS1130) 10577 TB (TS1120) 4533 TB (J1A)
L53 and S54	Ultrium Tape Drives	19889 (LTO cartridge) ^c	15911 TB

a. Support for more than 6887 cartridges will be available after general availability of the S24™ and S54 frames

b. Reserve 1% of the slots per S24 frame for sufficient shuffle locations.

c. Reserve 1% of the slots per S54 frame for sufficient shuffle locations.

The high granularity of the IBM TS3500 Tape Library configurations, its features, and its capacities are designed to match a wide variety of client requirements.

The IBM TS3500 Tape Library is an excellent choice if you:

- ▶ Are experiencing rapid growth in online storage requirements
- ▶ Are considering tape libraries with software for automatic backup, archive, or fast-access tape operation to accommodate growth and reduce manual operations
- ▶ Have standardized on IBM LTO Ultrium format tape or need to use Enterprise Tape Drives
- ▶ Are looking for an IBM tape solution requiring large cartridge capacity and fast data streaming transfer capability
- ▶ Have high-availability and reliability requirements

In the top right corner of Figure 12-1 on page 317, you can see the minimum configuration of a TS3500 Tape Library, as well as the maximum configuration with 16 frames beneath that.



Figure 12-1 Maximum and minimum TS3500 Tape Library configurations

Seven frames are currently available to build a TS3500 Tape Library. Each frame is identified by a three character model number (L23, L53, D23, D53, S24, S54, or HA1), which describes the nature of the frame. Libraries are built of modules as follows:

- ▶ Every library requires a base frame (model Lxx) to which optional expansion frames (model Dxx or model Sxx) can be added. Only one base frame is permitted in each library configuration.
- ▶ Base and Expansion frames support either:
 - LTO1, 2, 3, and 4 Tape Drives (Model x53 Frames)
 - IBM System Storage 3592 models E Tape Drives and 3592 Tape Drive Model J1A (Model x23 Frames)
- ▶ An optional second accessor is made available through the addition of the Model HA1 Frames.

Model Lxx and Dxx frames can be intermixed with each other and installed frame models with the provision that there is only one base frame in each library. S24 can be attached to the tape library that has 3592 drives installed and S54 can be attached to the tape library that has LTO drives installed. L22 and D22 frames can be upgraded to the respective x23 Frames, and L52 and D52 frames can be upgraded to the respective x53 Frames, which provides investment protection and considerable flexibility in configuration and expansion.

The following list introduces the currently available frame models:

- ▶ *TS3500 Tape Library Model L53*: A base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 Ultrium Tape Drives and up to 287 IBM Ultrium Tape Cartridges.

- ▶ *TS3500 Tape Library Model D53*: An expansion frame that can be used to provide an additional 12 Ultrium Tape Drives and a maximum of up to 440 storage slots (this depends on the number of tape drives installed). Up to 15 expansion frames can be installed with a base frame.
- ▶ *TS3500 Tape Library Model L23*: A base frame that can be installed on its own or in combination with expansion frames. It can host up to 12 IBM 3592 tape drives and a maximum of up to 260 storage slots (this depends on the features installed).
- ▶ *TS3500 Tape Library Model D23*: An expansion frame that can be used to provide an additional 12 IBM 3592 Model E tape drives and a maximum of up to 400 storage slots (this depends on the number of tape drives installed). Up to 15 expansion frames can be installed with a base frame.
- ▶ *TS3500 Tape Library Model S24*: A driveless, high-density, storage-only expansion frame for up to 1000 3592 tape cartridges. *You can install up to 15 expansion frames with a base frame. Advanced Library Management System (ALMS) is required for any library with a Model S24 Frame. This frame can optionally be configured as Service Bay B.*
- ▶ *TS3500 Tape Library Model S54*: A driveless, high-density, storage-only expansion frame for up to 1320 Ultrium (LTO) tape cartridges. You can install up to 15 expansion frames with a base frame. Advanced Library Management System (ALMS) is required for any library with a Model S54 Frame. This frame can optionally be configured as Service Bay B.
- ▶ *IBM 3584 Tape Library Model HAI*: In conjunction with service bay features on the TS3500 Tape Library models D23 and D53, this frame provides for the installation of a second library accessor that is designed to operate simultaneously with the first accessor and service mount requests in the IBM TS3500 Tape Library.

In addition to the D-Frames, there is also a 4 I/O station door available for either LTO or 3952 tape drives. One I/O station door has 4 I/O stations with a total of 64 storage slots.

A maximum of three 4 I/O station doors are allowed per TS3500. This maximum configuration then results in a total number of 14 I/O stations. All 4 I/O station doors must be the same type: either LTO or 3952. No intermix is allowed. Feature Code (FC) 1451 must be ordered as a prerequisite when ordering a 4 I/O station door. Two Feature Codes are available:

- ▶ FC1685: 4 LTO I/O station D-Frame
- ▶ FC1656: 4 3592 I/O station D-frame

Note. All 4 I/O station doors must be the same type. There is no mixed media support.

12.1.1 TS3500 frames for IBM LTO Ultrium Fibre Channel drives

The TS3500 Tape Library models L53 and D53 integrate the TS1030 and TS1040 LTO Ultrium 4 Gbps Fibre Channel Tape Drive. The Model L53 Frame includes an enhanced Frame Controller Assembly (FCA) with two power supplies (for redundancy), an optimized dual-gripper cartridge accessor, on demand storage slot capacity, and 16-slot I/O stations. The Model D53 Frame can be attached to current or installed frame models.

TS3500 Tape Library Model L53

The L53 can be installed on its own as a complete library enclosure, shown in Figure 12-2 on page 319, or it can have up to 15 expansion frames attached to it. This frame provides the major library components for the whole library, whether it has single or multiple frames. It also provides cartridge storage capacity for LTO media and it can be equipped with IBM Ultrium 1, 2, 3, and 4 tape drives. The expansion frames must be added to the right of the L53 frame.

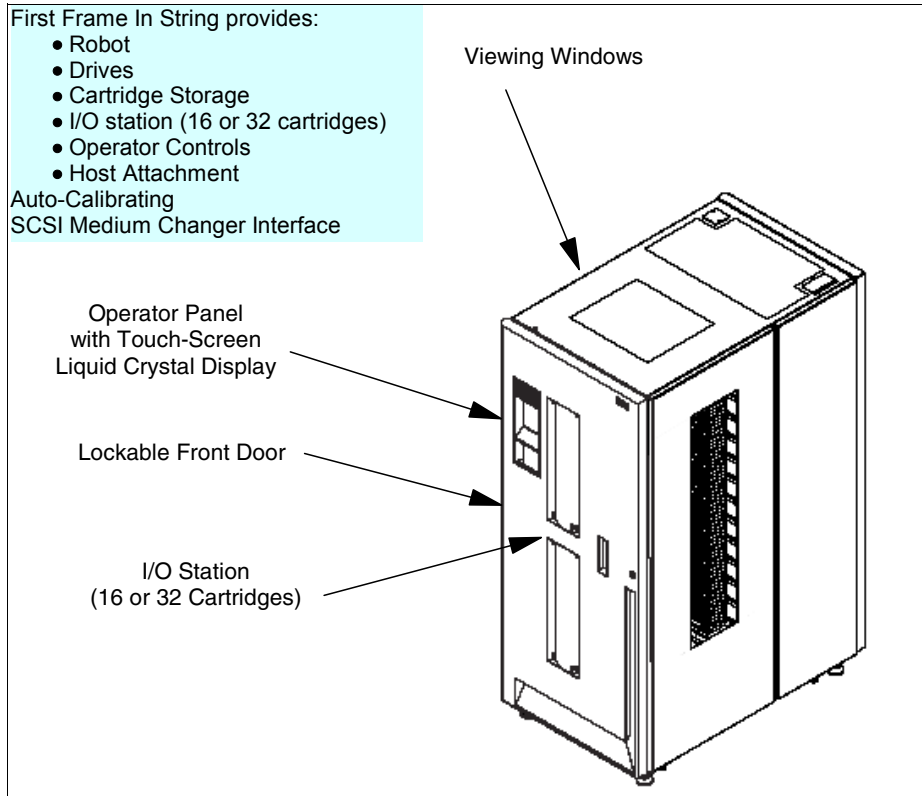


Figure 12-2 IBM TS3500 Tape Library L53 base frame view from front left

The number of LTO cartridge storage slots ranges from 64 to 287. With the minimum configuration, there are just 64 slots available for use, but the maximum of 287 slots is already physically installed. Additional slots can be added for use by simply enabling them through a license key.

The Intermediate Capacity feature (FC1643) gives a total amount of usable cartridge slots of 129. This feature is required to add a Full Capacity feature (FC1644), which gives the capacity of 287 cartridge slots. The full capacity feature is in turn required to add an Additional I/O Slots feature (FC1658 for LTO or FC1659 for 3592) or to attach an optional expansion frame.

This gives a maximum data capacity for the L53 of 229 TB native (up to 458 TB with 2:1 data compression).

Up to 12 IBM Ultrium drives can be installed. All generations of IBM Ultrium LTO tape drives can be installed in the same frame. As you add more than four drives or install the additional I/O station, there is an incremental reduction in storage slots (Table 12-2 on page 320). It is also possible to install the LTO FC Drive Mounting Kit (FC1514) in advance in order to simplify future tape drive installation, but it will also reduce the number of available slots.

Table 12-2 L53 frame capacity

Type of Capacity On Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0 to 12	16	64
Intermediate	0 to 12	16	129
Full	0 to 4	16	287
Full	5 to 8	16	273
Full	9 to 12	16	261
Full	0 to 4	32	245
Full	5 to 8	32	231
Full	9 to 12	32	219

Each TS3500 Model L53 has a standard 16-slot LTO cartridge input/output station for importing or exporting cartridges from the library without requiring re-inventory or interruption of library operations. Optional features can provide 16 additional input/output slots for LTO (FC1658) or 3592 media (FC1659). The lockable library door can be opened for bulk-loading IBM LTO Ultrium tape cartridges. Re-inventory of the cartridges is done in fewer than 60 seconds per frame each time that the library door is closed. A barcode reader mounted on the autochanger scans the cartridge labels at less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library.

TS3500 Tape Library Model D53

The D53 frame, shown in Figure 12-3, has the same footprint as the model L53.

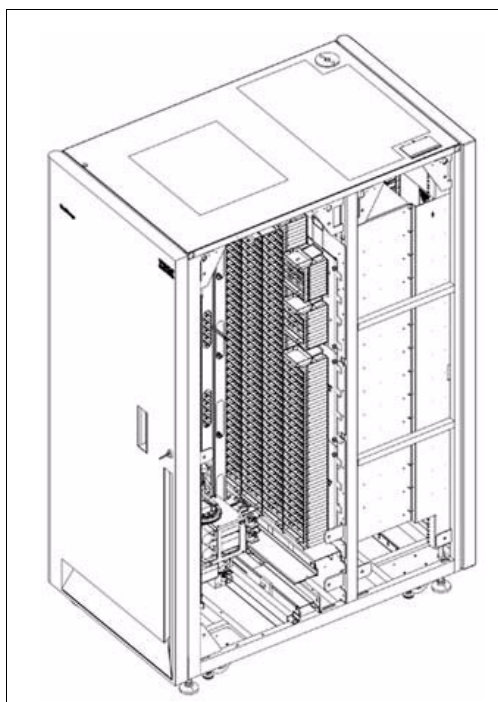


Figure 12-3 IBM TS3500 Tape Library Model D53 viewed from the right

The D53 cannot be installed on its own. It must be connected to a library with a base frame and optionally multiple expansion frames. Up to 16 frames can be connected as shown in Figure 12-1 on page 317.

If one or more tape drives are installed in the D53, the Enhanced Frame Control Assembly Feature (FC1451) is required along with the LTO Fibre Drive Mounting Kit (FC1514). This feature provides the hardware and firmware required to support IBM LTO Ultrium drives within the D53 and also provides a redundant AC line feed for the L frame accessor. The Frame Control Assembly Feature is also required if the LTO Fibre Drive Mounting Kit (FC1504) is installed.

You can easily configure D53 frames according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D53 frame is ready to host LTO drives. The LTO Fibre Drive Mounting Kit (FC1514) prepares the drive slots for hosting an LTO drive. This enables you to install or move LTO drives without any additional hardware changes.

With the installation of drives and Drive Mounting Kits, the storage slot capacity is reduced as shown in Table 12-3.

Table 12-3 D53 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	440
1 - 4	422
5 - 8	408
9 -12	396

A fully configured IBM TS3500 Tape Library with one L53 frame and 15 D53 frames supports up to 192 drives. An L53 base frame and 15 D53 expansion frames with a minimal drive configuration provide a maximum capacity of 6887 storage slots with a total capacity of 5.5 PB without compression.

The base L23 or L53 is always on the left and as many as 15 additional D53 and D23 expansion frames can be added to the right side. During the installation of additional D53 frames, the x-rail of the L frame where the accessor resides will be extended, so that the accessor can move through the newly installed frame.

If a D53 is being added to an installed L32 or D32 frame, FC1610 is required, because the D53 is a shorter frame. This feature includes a short rear side cover for the Model D32/L32 frame and the Model D23/D53 front and rear side covers.

An additional 16-slot input/output station for LTO media must be ordered via FC1658 if attaching a D53 expansion frame to an L23 base frame.

Up to four additional 4 I/O station doors can be installed in the TS3500, and FC1451 is a prerequisite when installing a 4 I/O station door. Figure 12-4 on page 322 shows the 4 I/O station D-Frame. A Light Emitting Diode (LED) status panel is located on the right upper corner. The LEDs represent the amount of cartridges per I/O station and if the I/O station is locked. The I/O door has a total number of 64 slots, 16 slots per I/O station.

The 4 I/O station door reduces the frame storage slot capacity by 160 for a model D23 and by 176 for a model D53. The I/O stations increase the maximum library I/O station slots from 32 to 224 due to a maximum of three D23 or D53 I/O frames in the sixteen frame library. The D23 and D53 models are compatible with existing models L22, L32, L52, D22, D32, and D52.

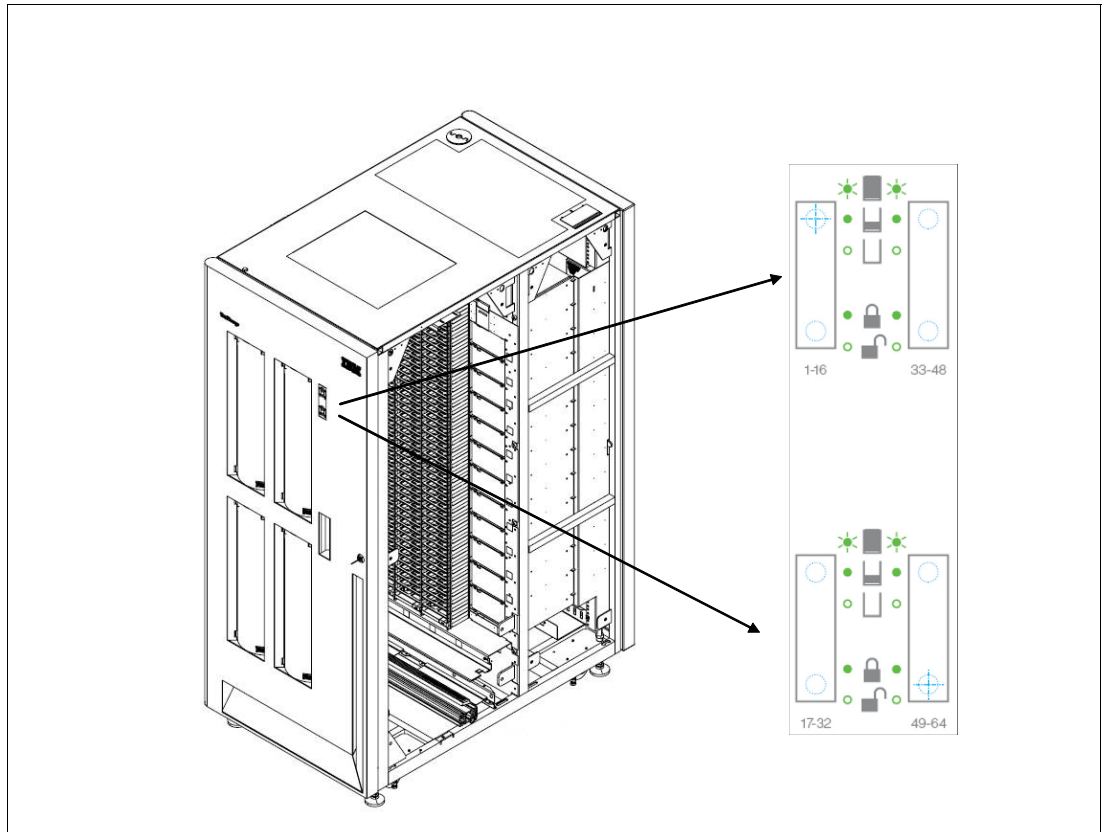


Figure 12-4 A 4 LTO I/O station D frame

Figure 12-5 on page 323 shows a graphical overview of the 4 I/O station door using the Web User Interface. In our example, there are five cartridges imported in the upper right I/O station, and when you put your cursor on the data cartridge, it will show you the volume label.

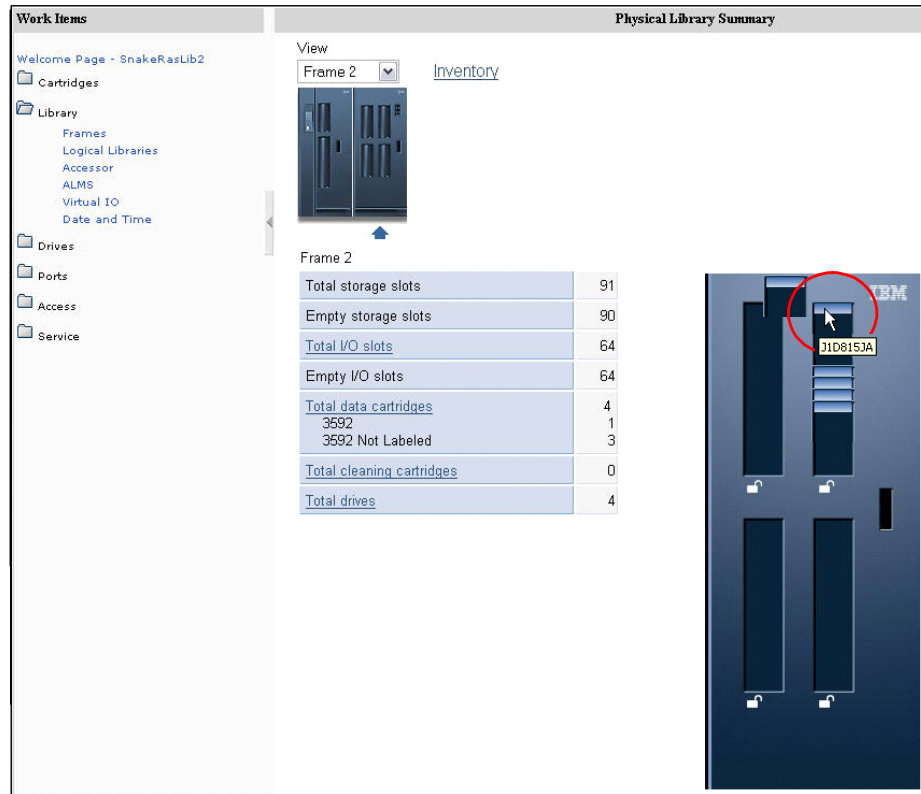


Figure 12-5 A graphical overview of the 4 I/O station door using the Web User Interface

12.1.2 IBM TS3500 Tape Library frames L23 and D23

The Model L23 and D23 frames integrate the TS1130 Tape Drive and TS1120 Tape Drive with a 4 Gbps dual-ported switched fabric Fibre Channel attachment, as well as the IBM 3592-J1A Tape Drive. The TS3500 Tape Library Model L23 and D23 frames can be attached to LTO Frames, and, therefore, IBM 3592 models E Tape Drives and LTO tape drives can be intermixed within the same TS3500 Tape Library.

IBM 3592 models E tape drives used in the IBM TS3500 Tape Library models L23 and D23 are designed for automation and use a tape cartridge with a form factor similar to the IBM 3590 tape cartridges. The 3592 models E Tape Drives have a dual-ported 4 Gbps Fibre Channel interface. TS1120 Tape Drive has a native data rate of up to 100 MB/s, and TS1130 Tape Drive has a native data rate of up to 160 MB/s. The 3592 models E Tape Drives are designed to provide high levels of performance, functionality, and cartridge capacity supporting the 3592 tape format, including Write Once Read Many (WORM) media support.

IBM System Storage TS3500 Model L23 Frame

The TS3500 Model L23 Frame provides cartridge slots for 3592 media and support for up to twelve IBM 3592 Tape Drives with an incremental reduction of storage slots beyond four drives or with additional I/O slots. This model has the same footprint as the model L53. The L23 can be installed on its own as a complete library enclosure, or up to 15 Model D23 or D53 frames can be attached to it. The library capacity and number of drives can be expanded to meet changing needs.

The L23 frame provides the major library components for the whole library, regardless of whether it has single or multiple frames. The expansion frames must be added to the right of the L53 frame.

The number of 3592 cartridge storage slots ranges from 58 to 260. The minimum configuration provides 58 slots that are available for actual use, although all 260 slots are already physically installed. To enable the additional slots for use (up to the total of 260), obtain an additional license key by ordering one of the following Capacity On Demand features. The Intermediate Capacity feature (FC1643) gives a total number of 117 usable cartridge slots. This feature is required to add a Full Capacity feature (FC1644), which gives you the capacity of 260 cartridge slots. The Full Capacity feature is required to add an additional I/O Slots feature (FC1658 or FC1659) or to attach the optional expansion frame models D23 or D53.

Up to 12 IBM 3592 Tape Drives can be installed. Adding more than four drives or drive mounting kits, or installing the additional I/O station, will reduce the number of storage slots available for use (refer to Table 12-4). You can also install the 3592 Fibre Channel (FC) Drive Mounting Kit (FC1513 or FC1515) for 3592 tape drives in advance, which will simplify future tape drive installation. This kit reduces the storage slots to the appropriate number and provides the power supply and necessary cables for installing a TS1130 or TS1120 drive.

Table 12-4 L23 frame capacity

Type of Capacity On Demand expansion feature	Quantity of tape drives + drive mounting kits	Quantity of I/O slots	Quantity of storage slots
Entry	0 to 12	16	58
Intermediate	0 to 12	16	117
Full	0 to 4	16	260
Full	5 to 8	16	248
Full	9 to 12	16	237
Full	0 to 4	32	222
Full	5 to 8	32	210
Full	9 to 12	32	199

Each L23 has a standard 16-slot 3592 cartridge input/output station for importing or exporting cartridges from the library without requiring re-inventory or interruption of library operations. Optional features can provide 16 additional input/output slots for LTO media. The lockable library door can be opened for bulk-loading cartridges. Re-inventory of the cartridges is done in fewer than 60 seconds per frame each time that the library door is closed. A barcode reader mounted on the autochanger scans the cartridge labels at less than one minute per frame. A door lock is included to restrict physical access to cartridges in the library.

IBM System Storage TS3500 Model D23 Frame

The D23 frame has the same footprint as the Model L23. The D23 cannot be installed on its own. It must be connected to a base frame and optionally other expansion frames. Up to 16 frames can be connected.

If one or more tape drives are installed in the D23, the Enhanced Frame Control Assembly Feature is also required (FC1451). This feature provides the hardware and firmware required to support IBM 3592 drives within the D23 and provides a redundant line feed for the L23 or L53 accessor.

You can easily configure D23 frames according to future requirements. By installing the Enhanced Frame Control Assembly (FC1451), the D23 frame is ready to host 3592-J1A,

TS1120, or TS1130 tape drives. The 3592 Fibre Channel Drive Mounting Kit (FC1513 or FC1515) prepares the drive slots for hosting a 3592 Model E Tape Drive. This enables you to install or move 3592 drives without any additional hardware changes.

With the installation of drives or drive mounting kits, the storage slot capacity is reduced as shown in Table 12-5.

Table 12-5 D23 frame capacity

Quantity of tape drives + drive mounting kit	Quantity of slots in frame
0	400
1 - 4	383
5 - 8	371
9 -12	360

A fully configured IBM TS3500 Tape Library with one L23 frame and 15 D23 frames supports up to 192 drives. An L23 base frame and 15 D23 expansion frames with a minimal drive configuration provide a maximum capacity of 6260 storage slots with a total capacity of 6260 TB without compression using the TS1130 Tape Drive.

The base frame (model Lxx) is always on the left and as many as 15 additional expansion frames (model Dxx or Sxx) can be added to the right side. During the installation of additional D23 or S24 frames, the x-rail of the L frame where the accessor resides is extended, so that the accessor can move through the newly installed frame.

If a D23 or S24 is added to an installed L32 or D32 frame, FC1610 is required, because the D23 or S24 is a shorter frame. This feature includes a short rear side cover for the Model D32/L32 Frame and the Model D23/D53 front and rear side covers.

If attaching a D23 or S24 frame to an L53 frame, the First Expansion Frame Attachment Feature (FC9002) for the L53 must be specified. Subsequent expansion requires the Additional Expansion Frame Attachment feature (FC9003).

Additional 16-slot I/O stations for 3592 media must be ordered via FC1659 if attaching a D23 or S24 frame to an L53.

12.1.3 IBM TS3500 Tape Library storage only frames S24 and S54

IBM System Storage TS3500 storage only frame includes the Model S24 Frame and the Model S54 Frame. The TS3500 Tape Library Model S24 and S54 frames are *high density (HD) version 1* storage only expansion frames compatible with existing TS3500 Tape Libraries and frames.

The Advanced Library Management System (ALMS) (see 12.5, “ALMS” on page 355) is required for support Sxx frames.

The TS3500 Tape Library Model S24 expansion frame is designed for 3592 data cartridges. You can add up to 15 Model S24 expansion frames to the TS3500 Model L22 or L23 base frame to increase 3592 cartridge storage. Each Model S24 Frame supports up to 1000 IBM 3592 cartridge slots.

The TS3500 Tape Library Model S54 expansion frame is designed for LTO data cartridges. You can add up to 15 Model S54 expansion frames to the TS3500 Tape Library Model L32, L52, or L53 base frame to increase LTO cartridge storage. Each Model S54 Frame supports up to 1320 LTO cartridge slots.

High Density (HD) technology

The depth of a cartridge location in an HD slot is known as the *tier*. The cartridge immediately accessible in the HD slot is a tier 1 cartridge. Behind that is tier 2 and so on. The maximum tier in an LTO HD slot is tier 5. The maximum tier in a 3592 HD slot is tier 4, because the 3592 cartridge is slightly longer than the LTO cartridge. The single HD slots on the door side of HD frames and in non-HD frames are referred to as *tier 0 slots*.

Figure 12-6 shows a graphical exterior view of S24 frame. The S54 frame has the similar exterior view. The difference is that S54 has Tier 5 slots inside.

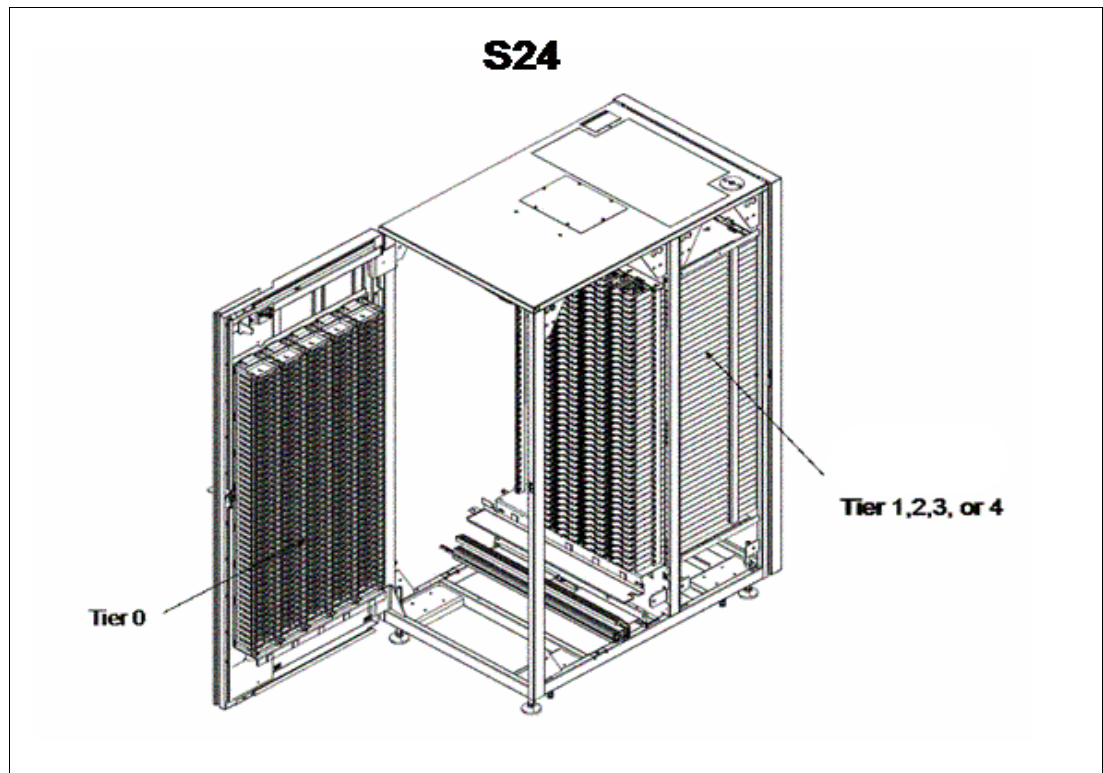


Figure 12-6 S24 frame

Figure 12-7 on page 327 shows the side view of the HD frame.

The S24 frame supports up to a total of 5 tiers (Tier 0 to Tier 4) with up to 200 IBM 3592 cartridge slots for each tier. The S54 frame supports up to total of 6 tiers (Tier 0 to Tier 5) with up to 220 IBM LTO cartridge slots for each tier.

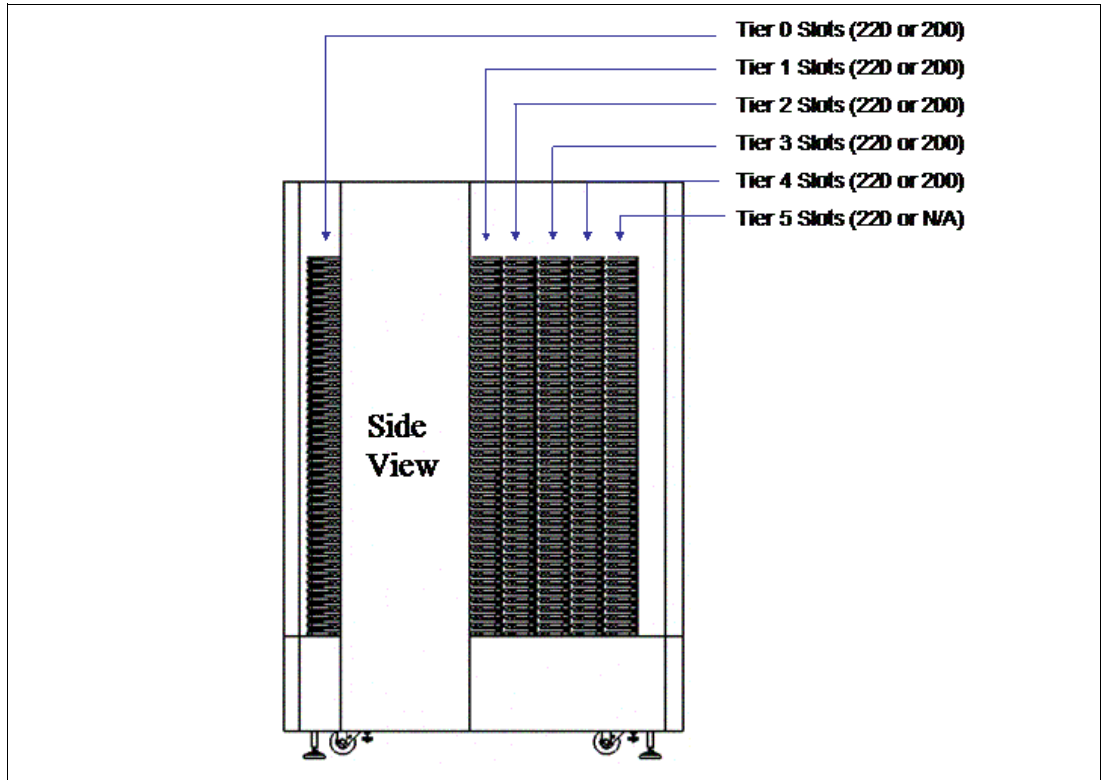


Figure 12-7 Sxx frame side view

LED lighting

New internal LED lighting as shown in Figure 12-8 is added to the HD frame, because the window at the top of the frame has been removed.



Figure 12-8 internal LED lighting

Library configurations supported by HD frames

The HD frames support a variety of library configurations. They provide support as:

- ▶ Mixed media, LTO only, and 3592 only media in non-HA libraries
- ▶ Active frames in HA LTO only or 3592 only libraries
- ▶ Service bay B in HA LTO only or 3592 only libraries

The HD frames *do not provide* support for the following library configurations:

- ▶ Active frames in a HA mixed media library
- ▶ Service bay B in a HA mixed media library

Capacity on Demand for HD frame

HD frames support HD Capacity on Demand (CoD), and you can add slot capacity non-disruptively to Sx4 frames. FC1645 provides on demand activation of an additional 400 slots of capacity (Tiers 3 and 4) for Model S24. FC1646 provides on demand activation of an additional 660 slots of capacity (Tiers 3, 4, and 5) for Model S54.

HD frame concept

Accessing any cartridge in Tier 2 or greater requires a shuffle operation. A *shuffle* is the process of moving cartridges in lower tiers into the gripper or other available slots in order to be able to access cartridges in higher tiers (Tiers 2 or greater). Tier 2 cartridges only require a swap using the dual grippers (assuming both grippers are usable).

In order to reduce the occurrence of shuffle operations and to take advantage of the typical repeated accesses of cartridges, the role of a “*cartridge cache*” is given to all single deep (Tier 0) slots in a library that contains HD slots.

Even with the concept of a cartridge cache, cartridges still need to be moved into HD slots (for example, cartridge insertions and cartridge cache destage operations). In order to improve the predictability of the performance penalty of shuffle operations, the library firmware load balances the placement across all HD slots in the library string. Furthermore, the library monitors for a specific “fullness” threshold at which predictability of performance cannot be maintained and will provide sufficient warnings to the user of this degraded state, for example, UI, SNMP, or TapeAlert. The objective is for this threshold to be no less than 98% of the total physical capacity.

Due to the predictable tiered performance impact of cartridges in HD slots, the concept of a “cartridge cache” is introduced with the HD frame. The *cartridge cache* is defined as all single HD slots in the library, whether door-side or drive-side in any frame. The cache is managed with a Least Recently Used (LRU) algorithm. The library firmware records the date and time of the most recent usage (virtual or physical move) for each cartridge. Nominally (but with some exceptions), a cartridge that is being demounted from a drive will be moved to a cartridge cache slot. When an empty cache slot is not available, the firmware compares the usage data and perform an LRU cache destage move (from a cache slot to an HD slot). This LRU destage requires the usage of an internal Exchange Medium command in order to swap the demount cartridge with the cartridge to be demoted from cache.

Cartridges are located in the frames where the appropriate drives that can process them also are located. The TS3500 Tape Library without HD frame operates in *fixed home cell mode*, which means that the cartridges are returned to their home cell. The TS3500 Tape Library with HD frame operates in *floating home cell mode*.

12.1.4 IBM 3584 High Availability Unit HA1

The IBM 3584 High Availability Frame Model HA1 can be added to the IBM TS3500 Tape Library Base Frame models. In conjunction with a service bay feature on the TS3500 Tape Library Model D23, S24, or L23, the Model HA1 provides for the installation and operation of a second library accessor that is designed to operate simultaneously with the first accessor and service mount requests in the IBM TS3500 Tape Library. It is designed to non-disruptively fail over to a redundant accessor when any component of either accessor fails, which helps maintain availability and reliability. This design also includes the ability to add one or more Model D53 or D23 frames to an IBM TS3500 Tape Library that has an attached Model HA1 with minimal disruption.

Dual active accessor support is provided in a mixed media library. This includes any combination of 3592 and LTO Ultrium media types. For example, a single library can have 3592, Ultrium 1, Ultrium 2, Ultrium 3, and Ultrium 4 media installed and configured. The Advanced Library Management System (ALMS) (refer to 12.5, “ALMS” on page 355) is required for support of dual accessors and two or more media types.

When dual accessors are installed and an attached host issues a command for cartridge movement, the library automatically determines which accessor can perform the mount in the most timely manner. If the library's primary accessor fails, the second accessor assumes control and eliminates system outage or the need for operator intervention.

A dual accessor library will have two garage areas called *service bays* (refer to Figure 12-9 on page 330). Service Bay A (the 3584 High Availability Frame Model HA1) is to the left of and adjacent to the L-frame, when facing the front door. Service Bay B (a modified TS3500 Tape Library Model D23 or D53) is to the right of the last active frame in the library.

The TS3500 Tape Library Model HA1 itself provides only a frame, which serves as Service Bay A for the original accessor for the TS3500 Tape Library Model Lxx. The second accessor is provided by ordering the Service Bay B Configuration and Dual Accessor feature (FC1440) on a TS3500 Tape Library Expansion Frame Model D23 or D53. When this feature is ordered on a Model D23 or D53, that expansion frame will be reserved and function as a Service Bay B for the second accessor. This feature needs to be initially installed on a new Model D23 or D53 Frame that is added to the IBM TS3500 Tape Library when ordering the Model HA1. If your library already contains the service bays and you decide to add one or more D23 or D53 expansion frames, Service Bay B will be converted to an expansion frame, the new frame or frames will be added to the right, and the last frame on the right will be converted to Service Bay B. The downtime for this process is designed to be less than an hour.

The service bays will be regular library frames, but they will not have drives, power supplies, or node cards. Storage slots within the service bays will only be used to test service actions. Figure 12-9 on page 330 demonstrates how the service bays surround the other library frames.

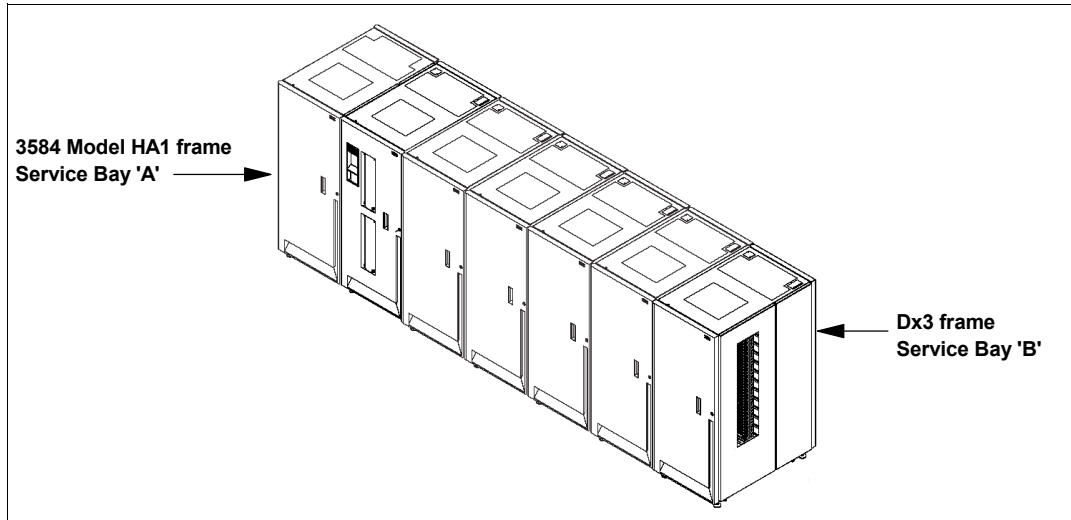


Figure 12-9 Location of service bays in the IBM TS3500 Tape Library

To summarize, implementing nondisruptive accessor failover requires:

- ▶ A 3584 Model HA1 Frame to act as Service Bay A
- ▶ High Availability Library feature (FC9040) for the Lxx frame
- ▶ Advanced Library Management System feature (FC1690)
- ▶ A D53 or D23 frame to operate as Service Bay B for the second accessor
- ▶ Additional expansion frame attachment (FC9003)
- ▶ Service Bay B Configuration with Accessor (FC1440)

12.2 Library components

Figure 12-10 on page 331 shows the major components of TS3500 Tape Library Lxx frame.

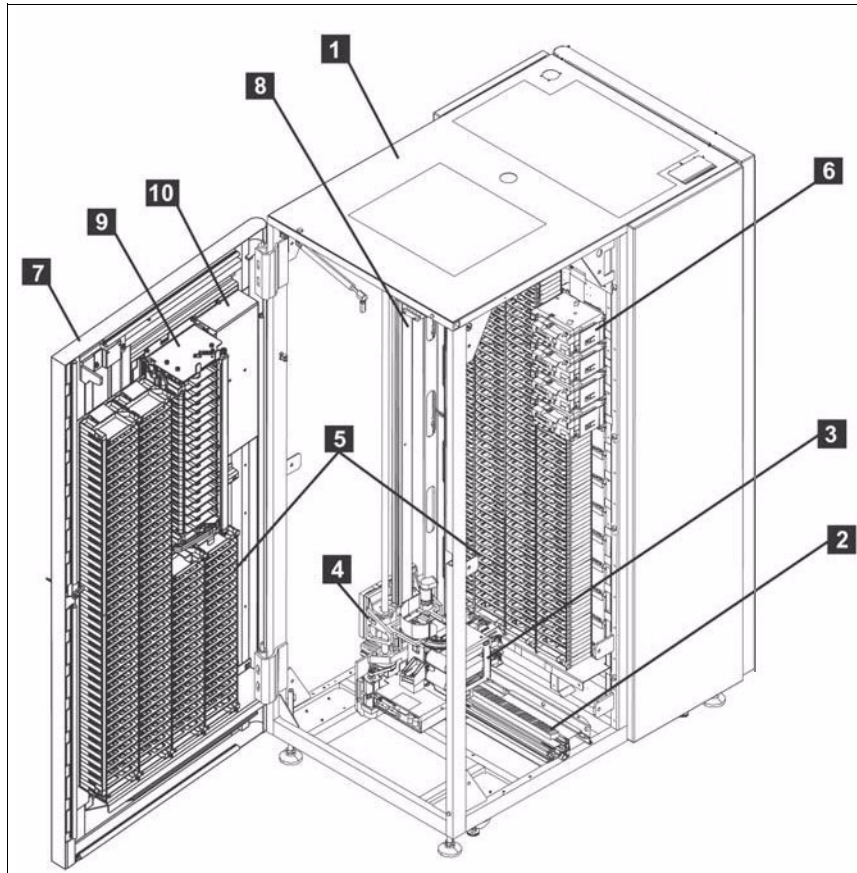


Figure 12-10 IBM TS3500 Tape Library showing major library components

The components shown in Figure 12-10 are:

1. Library frame
2. x-rail system
3. Cartridge accessor with optimized dual-gripper transport mechanism
4. Accessor controller
5. Cartridge storage slots
6. IBM LTO Ultrium Tape Drives or 3592 Tape Drives
7. Front door
8. Door safety switch
9. I/O stations
10. Operator Panel and Operator Panel controller

Other important components, which are not indicated in Figure 12-10, include the frame control assembly (FCA), the enhanced FCA, and the patch panel.

12.2.1 Tape drives supported in the TS3500 Tape Library

This section introduces the types of drives that can be installed in the 3584 Tape Library.

The LTO Ultrium Tape Drives and the 3592 Tape Drives are high performance, high capacity, data storage units that can be installed in the TS3500 or 3584 Tape Library. Up to 12 drives can be installed in each frame of the library, but the two types of drives cannot be mixed in the same frame. You can identify a drive by examining the logo at its front or by inspecting the label at the rear of the drive's canister.

You or your IBM Service Support Representative (SSR) can update the firmware of your tape drives, except IBM Ultrium 1 tape drives, without scheduling downtime. This enhancement is called a *nondisruptive drive firmware update*. It is available through the Web User Interface and for the IBM SSR through the CETool, but it is not supported by the SCSI interface. It is not available if you use ITDT or tapeutil.

Note: The nondisruptive drive firmware update takes 30-40 minutes per drive, as compared to less than one minute per drive when using ITDT or tapeutil.

LTO Ultrium Tape Drives

The TS1030 and TS1040 are Linear Tape-Open (LTO) tape drives that facilitate 4 Gbps Fibre Channel connectivity. You can identify the type of model LTO tape drives by the logo at the front of the drive or by the label at the rear of the drive's canister.

When a cartridge is labeled according to proper IBM barcode label specifications, the last character of its volume serial (VOLSER) number indicates the generation of the media. For example, a cartridge with a VOLSER of 000764L3 is an Ultrium 3 cartridge; a cartridge with a VOLSER of 003995L2 is an Ultrium 2 cartridge. To enhance library performance, Ultrium 3 and Ultrium 2 Tape Drives include speed matching, channel calibration, and power management. *Speed matching* dynamically adjusts the drive's native (uncompressed) data rate to the slower data rate of a server. *Channel calibration* customizes each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics. *Power management* reduces the drive's power consumption during idle power periods.

For further information regarding this tape drive, refer to 2.3, "IBM System Storage TS1030 Tape Drive" on page 70 and 2.4, "IBM System Storage TS1040 Tape Drive" on page 74.

IBM 3592 Tape Drives

IBM Total Storage 3592 Tape Drives include three generations of tape products: 3592 Tape Drive Model J1A, TS1120 Tape Drive, and TS1130 Tape Drive. The 3592-J1A has been withdrawn from marketing, and we do not cover it in this section. For more information about the J1A Tape Drive, refer to 3.7, "IBM TotalStorage Enterprise 3592 Model J1A Tape Drive" on page 121.

IBM System Storage TS1120 Tape Drive

Introduced in October 2005, the IBM System Storage TS1120 Tape Drive is the second generation of a new family of tape products that are designed to meet the growing needs of both new and existing IBM tape clients across a wide range of environments. The TS1120 Tape Drive is the follow-on to the IBM 3592 Tape Drive Model J1A and the highly successful 3590 Enterprise Tape Drive. It has 500 GB of native capacity in a half-inch format tape cartridge and has a native data rate of up to 100 MB/s. By its design, it is also a foundation of future generations, and it helps to protect the client investment in tape cartridges.

With its higher performance, greater capacity, and smaller size, as compared to a 3590 Tape Drive, the use of the TS1120 Tape Drive can help save costs as you reduce your number of tape drives and cartridges, and the associated floor space.

Highlights of the TS1120 Tape Drive are:

- ▶ Up to 100 MB/s native data rate, over 2.5 times the 40 MB/s of the 3592 Model J1A, and over seven times the 14 MB/s of the 3590 E or H models
- ▶ Up to 700 GB native cartridge capacity

- ▶ A larger, 512 MB internal buffer
- ▶ Dual-ported switched fabric 4 Gbps Fibre Channel attachments
- ▶ Small form factor that allows double the drives in a single 3494 frame, as compared to the 3590 Tape Drive
- ▶ High reliability and high-availability design
- ▶ Additional performance and access improvements over the 3592-J1A

TS1120 data cartridges are available as machine type 3599. The 3599 media models include:

- ▶ R/W 700 GB Data Cartridge
- ▶ R/W 500 GB Data Cartridge
- ▶ R/W 100 GB Data Cartridge
- ▶ WORM 700 GB
- ▶ WORM 500 GB
- ▶ WORM Economy 100 GB

For further information regarding this tape drive, refer to 3.5, “The IBM System Storage TS1130 Tape Drive” on page 109.

IBM System Storage TS1130 Tape Drive

The IBM System Storage TS1130 Tape Drive (machine type 3592 Model E06) is the third tape drive generation of the IBM 3592 tape family. This generation provides again higher capacity and performance compared to the predecessor 3592 Model E05. The TS1130 records in two new recording formats that support both encryption and non-encrypted recording. *Enterprise format 3* (EFMT3) is used to represent the new non-encrypted recording format and *enterprise encrypted format 3* (EEFMT3) is used to denote the new encrypted recording format. With the new EFMT3/EEFMT3 recording formats, the non-compressed capacity of the extended length MEDIA9 and MEDIA10 cartridges is increased from 700 GB to 1 TB.

The 3592 Model E06 is downward read compatible (n-2) to the 3592 Model J1A format (EFMT1) and is downward write-compatible (n-1) to the 3592 Model E05 formats (EFMT2/EEFMT2). All current media types are supported.

Host interfaces to System z and open platforms are maintained; the IBM System Storage TS1130 Tape Drive is supported by IBM 3592 Model J70 Tape Controller, the TS1120 Tape Controller (Model C06), and the TS7700 Virtual Engine using 4 Gb dual port fiber cards. There is no support for the 3494 Model B10/B20 Virtual Tape Server. It allows for integration into the IBM TotalStorage 3494 library, the TS3500 library, the TS3400 library, a stand-alone rack, and the Sun Silo.

The TS1130 Tape Drive provides the following cartridge capacity:

1000 GB (1 TB)	with JB or JX media
640 GB	with JA or JW media
128 GB	with JJ or JR media

When writing in E06 mode, the data rate of TS1130 Tape Drive is dependent on the cartridge type used:

160 MB/s	with JB or JX media
140 MB/s	with JA, JJ, JR, or JW media

The TS1130 Tape Drive can read and write the 3592-E05 format. Compared to the TS1120, which provides a native data rate of up to 100 MB/s, the TS1130, when writing in E05 format, achieves these data rates:

150 MB/s	with JB or JX media
140 MB/s	with JA, JJ, JR, or JW media

With E05 format, the TS1130 provides the same cartridge capacities as the TS1120. The TS1130 can reformat 3592-J1A and TS1120 media to TS1130, and TS1130 media to TS1120.

For further information regarding this tape drive, refer to 3.5, “The IBM System Storage TS1130 Tape Drive” on page 109.

12.2.2 Library control systems: Enhanced Frame Control Assembly

The *Enhanced Frame Control Assembly* is a 2n redundant power design, but with fewer components than the original frame control assembly found in earlier frame models. The Enhanced Frame Control Assembly has two redundant power supplies, which are fed directly by independent dual AC line cords. The assembly is constructed with hot-swappable, redundant parts, which (along with the dual AC line cords) remove the possibility of a single part causing failure. If one power supply fails, the remaining power supply provides all of the power to all of the library's elements.

The Enhanced Frame Control Assembly comes standard with models L23 and L53 and can be ordered as a feature code for models D23 and D53. The dual AC line cords are standard on models L23, D23, L53, and D53 and do not have to be ordered separately.

Medium Changer Assembly in the 3584 Tape Library

Integral to the enhanced frame control assembly power structure is the *Medium Changer assembly (MCA) unit*, a device located above the drives and the fixed power trays in models L23, D23, L53, and D53 frames. The MCA handles communication between host applications and the library, and it houses two Ethernet ports for connection to the IBM System Storage Tape Library Specialist Web interface, a master console, or both.

Refer to Figure 12-11 on page 335 for a view of the Medium Changer Assembly, identifying the locations of the two Ethernet ports. Use the ports as follows:

- ▶ Use Port A (identified as 1 in Figure 12-11 on page 335) to connect to the Tape Library Specialist Web interface.
- ▶ Use Port B (2) to connect to an optional TS3000 System Console (TSSC).

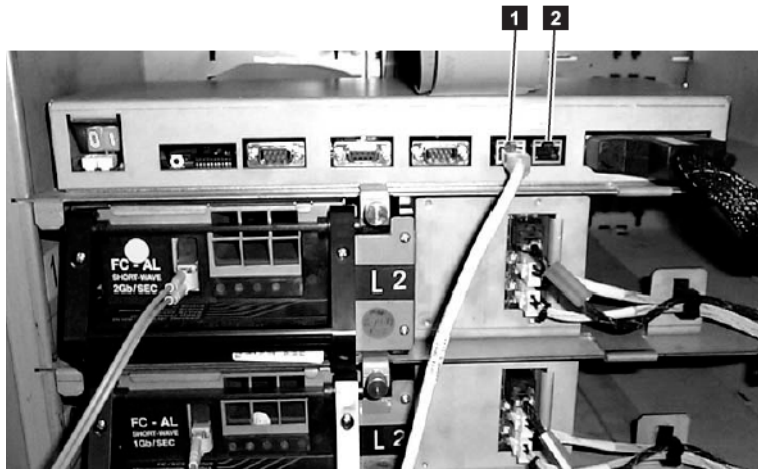


Figure 12-11 View of the Medium Changer Assembly identifying the two Ethernet ports

You can establish up to five Web sessions to the Tape Library Specialist by using one physical Ethernet port. If you have multiple Dxx frames, you can add an additional five connections per frame.

If Port A is connected to the Web and Port B is not connected to a TS3000 System Console (TSSC), service personnel can use Port B to connect a mobile computer to the Tape Library Specialist Web interface. A special Ethernet crossover cable is needed to make the connection.

You can also use Port B for the TSSC attachment with the Call Home feature of the TS3500 Tape Library, which is further described in 12.2.12, “Remote support” on page 345.

The *Call Home* feature retrieves library and drive logs (as well as other pertinent information) and saves them to the Remote Technical Assistance Information Network (RETAIN®) where they can be examined for both failure and maintenance analysis. In the past, this was done by using an analog modem attached to a serial port or by using an Ethernet port in a second frame that was connected to the TSSC. The second frame was necessary, because the TSSC required a private network that was separate from the client network. The dual Ethernet ports of the MCA make the Ethernet port in a second frame unnecessary.

Ethernet cables to the MCA can be routed through the top or bottom of the frame.

A library control system is required for a library to operate. Conventional libraries, such as the IBM 3494, use a single library controller that handles all of the different inputs and controller output commands. The IBM TS3500 Tape Library uses a system of distributed embedded controllers, each with its own processor:

Medium Changer Assembly (MCA) This controls powering up, handles all communications to the drives via RS-422, and communicates with the rest of the cards via the internal Controller Area Network (CAN) in the library. It has a serial interface for Call Home and two Ethernet interfaces: for the Web UI (port A) and the System Console (port B).

Operator Panel Controller (OPC) This controls all Operator Panel operations and the I/O station lock switch.

Accessor Controller Card (ACC) The master controller of the accessor mechanism. This has high level control of cartridge movement. The ACC issues commands to the MDA when X/Y motion is

required. It also controls the grippers and the barcode reader.

Motor Drive Assembly (MDA)

This controls fine movement by the accessor as directed by the ACC.

The four controllers are in different locations. The Operator Panel controller is located directly on the Operator Panel. The accessor and MDA are attached to the accessor. The MCA is located above the drives as seen in Figure 12-11 on page 335.

The advantages of a distributed control system are:

- ▶ Improved reliability:
 - Reduces single points of failure.
 - Smaller field-replaceable unit (FRU) components.
- ▶ Simplified library repair

Functionality is isolated to a single area of the library.
- ▶ Easier upgrades:
 - Distributed components only require power and communication wires.
 - Modular design for “building block” approach.
- ▶ More performance than a single library controller

Each major library component has its own processor.

12.2.3 Operator interface

The operator interface, located on the front of the frame (refer to Figure 12-2 on page 319), provides a set of indicators and controls that enables an operator to perform operations and determine library status. The panel, as shown in Figure 12-12 on page 337, consists of the library power switch, a power-on indicator, power switch door (L53 and L23 frames only), a touch-screen LCD and controller, and the controller for the I/O station. The Operator Panel controller is located inside the library behind the Operator Panel (number 11 in Figure 12-10 on page 331). It is a logic card that facilitates communication between the Operator Panel and the accessor controller. The Operator Panel controller posts status and information about the sensing and locking of the I/O station to the Operator Panel LCD.

The Operator Panel touch screen LCD consists of the touch keys area and the activity screen as shown in the expanded area of Figure 12-12 on page 337. The activity screen displays Ready on the touch screen when the library is ready (that is, when host applications can interact with the library). The first line on the screen shows the current level of library firmware and the panel screen number. The left field on the second line indicates that the library is either ready, not ready (not interacting with host applications), or initializing. The right field indicates the status of one or more I/O stations. The activity screen also shows the current activity in a large font and provides a history of preceding operations in a smaller font. Operations are listed from top to bottom with the most recent operations at the top. The activity screen automatically displays an error message when an error condition is detected. Refer to 12.10, “Operator displays and buttons” on page 372 for more information.

Security can be enabled on the operator interface. The Operator Panel is then password-protected, and a time interval can be set. You can also specify a time-out period that, when exceeded, causes the Operator Panel to lock.

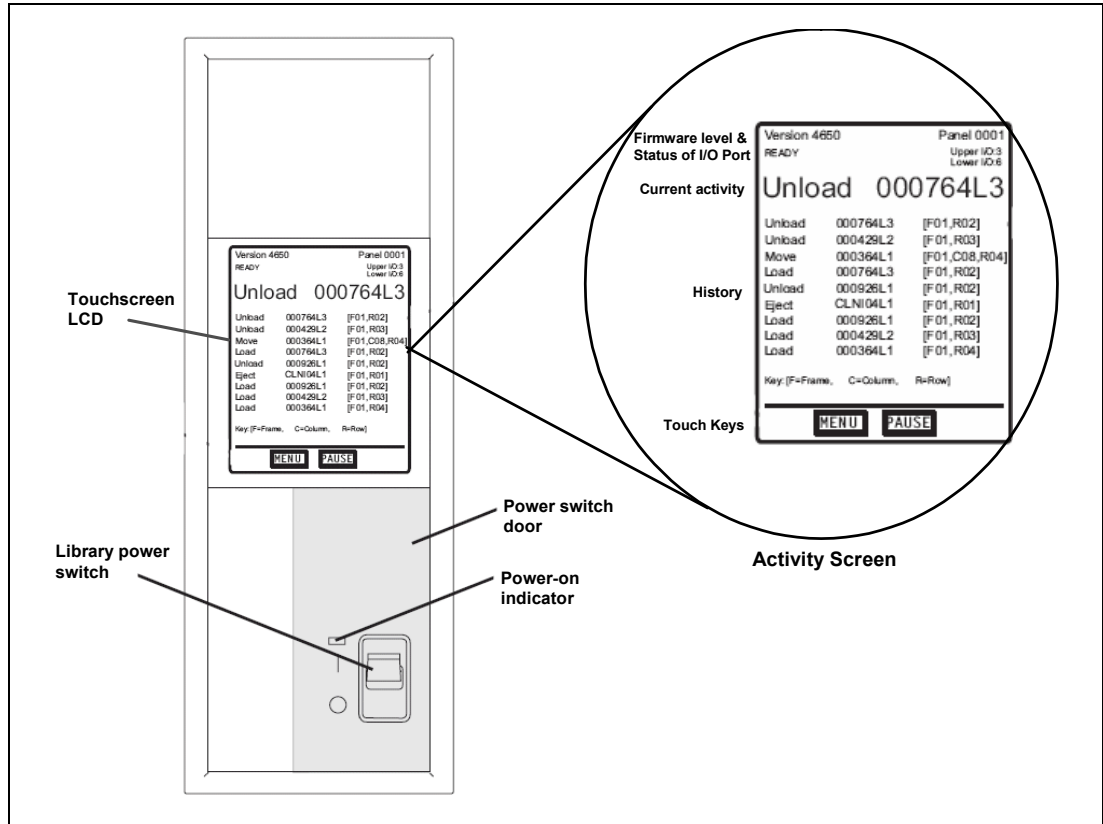


Figure 12-12 Operator Panel

12.2.4 Robotic cartridge accessor

The *cartridge accessor* is the assembly that moves tape cartridges between storage slots, tape drives, and the I/O station (number 3 in Figure 12-10 on page 331). The accessor assembly moves horizontally through the library frames using a rail system (number 2 in Figure 12-10 on page 331); it uses both the top and bottom rails.

The accessor assembly consists of an optimized dual gripper (number 4 in Figure 12-10 on page 331 and in more detail in Figure 12-13 on page 338) mounted on a vertical pole. The gripper can move up and down vertically and also rotates to access cartridge slots on both the back walls and front doors of the library frames. In libraries that mix drive types, the optimized dual grippers can house both Ultrium and 3592 tape cartridges. Thus, if one gripper fails, another gripper will act as backup to process a cartridge. The new, enhanced gripper is designed for the HD frame. A barcode reader is mounted on the accessor and can scan the cartridges in one frame in less than a minute.

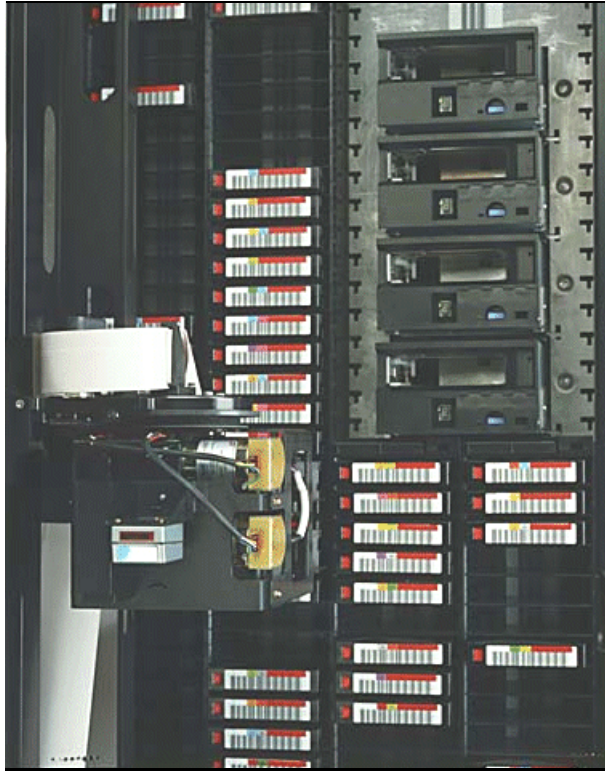


Figure 12-13 IBM TS3500 Tape Library accessor assembly

X-axis and Y-axis motion assemblies

These assemblies include a controller (circuit board) for the Controller Area Network interface, servo motor, pinion drive gear, and lead screw. These assemblies provide the motive force to move the accessor side to side (on the X-axis) and up and down (on the Y-axis). The controller part of this assembly is referred to as the *MDA*.

Pivot assembly

This group of parts provides a mounting platform for the gripper mechanism and the barcode reader. This assembly is capable of 180-degree rotation around the vertical axis.

Optimized dual gripper

This electromechanical device (mounted on the pivot assembly) gets or puts cartridges from or to a storage slot, tape drive, or I/O station. The gripper is independently controlled and can grip a single cartridge. There are two grippers on the pivot assembly (Gripper 1 and Gripper 2). The gripper installed in L53 or L23 can handle both LTO and 3592 tape cartridges. It can be changed without any tools and has been redesigned to eliminate weak points, therefore improving its lifetime. The cartridge presence sensor was also simplified. The original gripper in L32 must be replaced by ordering feature support (FC1608) in order to handle LTO and 3592 media.

Tip: The gripper installed in L53 or L23 can handle both LTO and 3592 tape cartridges, which provides gripper redundancy in a mixed LTO/3592 library.

Many libraries offer support for different drives and media, such as LTO, digital linear tape (DLT), or AIT. Typically, they use a universal gripper for cartridge handling; clam shell grippers are a common design approach. This universal gripper might decrease performance

and reliability, because a “catch-all” gripper cannot be optimized for each media type. The LTO (and also the 3592) cartridge was designed with automation in mind, and IBM was a key player in this effort. The cartridge contains automation handling features, such as the notches seen in Figure 12-14. The IBM TS3500 Tape Library gripper takes advantage of the handling features and uses hooks to handle the cartridge. This approach offers significant performance improvements as described in 12.3, “Performance” on page 352 and is more reliable than a catch-all gripper.

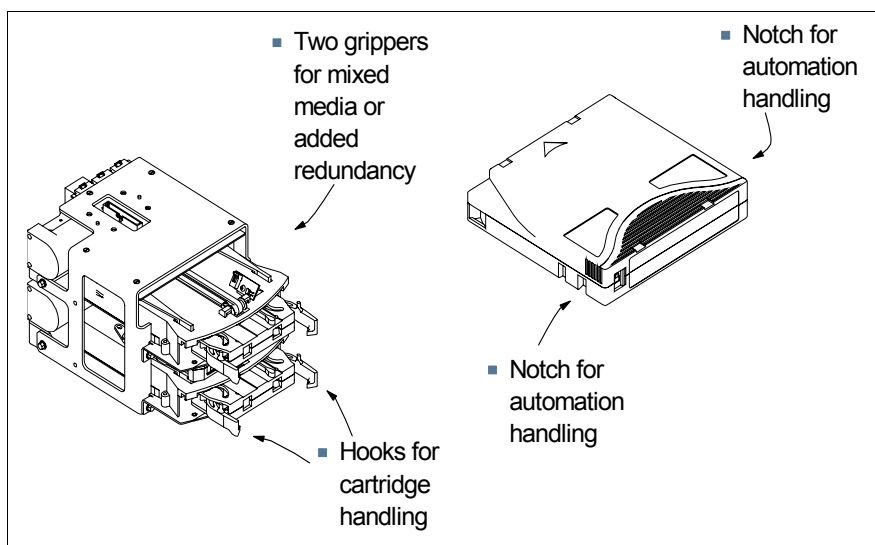


Figure 12-14 IBM TS3500 Tape Library gripper

The use of a dual-gripper accessor reduces the time taken to move cartridges in the library and can improve overall performance on large libraries. It increases redundancy and reliability. Note that library functions are controlled by host application software, and to make use of the dual gripper function, the software itself must be able to use two grippers simultaneously. If it does not, the library will function as though it had only a single gripper. If only one gripper is used at a time, the library periodically switches between both grippers to balance use.

Enhanced gripper for HD frame

The enhanced gripper for the HD frame has minor changes to the current gripper design. The current aluminum gripper plate is replaced by a plastic mold.

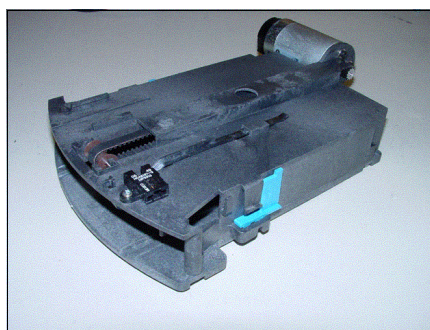


Figure 12-15 HD Gripper

Barcode reader

The barcode reader reads the barcode on a label that is attached to a cartridge or at the rear of every storage slot (which indicates an empty storage slot). The barcode reader is mounted on the pivot assembly and is used during inventories, audits, insertions, and inventory updates. The inventory is updated whenever the door is opened, and it determines whether cartridges have been added to, removed from, or moved within the library.

Because all storage slots have empty storage cell labels, the library can easily and quickly recognize whether there is a labeled cartridge or an empty storage slot in every location. This eliminates the need to reread or manually intervene in storage cells if no label is readable. Without this approach, the library cannot differentiate between a slot that is unlabeled, badly labelled, or empty.

Calibration sensor

This calibration sensor provides a means to locate certain positions within the library precisely during the calibration operation. The calibration sensor is mounted on the underside of gripper 1. (For the optimized dual gripper, the sensor is mounted on the top of gripper 2.) All positions are calculated from these locating positions.

12.2.5 Rail assembly

The cartridge accessor moves through the library on a rail assembly (number 2 in Figure 12-10 on page 331). The system consists primarily of a main rail assembly and support rail, and a trough for the power and control cable. The main rail assembly includes a main bearing way with a rack gear. Its support rail is an L-shaped rail that runs along the top of the frames and provides smooth transport for the cartridge accessor. The power and control cable is kept clear of the accessor in a covered trough at the bottom rear of the library.

12.2.6 Library-centric WWNN convention

Every device in a Storage Area Network (SAN) environment uses a unique worldwide node name (WWNN) for identification in the SAN. In a conventional library, if the drives are swapped, the WWNN is also changed, and therefore, you have to reconfigure both the SAN and the server. If you are using persistent binding on your server, a server restart is also necessary.

The IBM TS3500 Tape Library assigns the WWNNs to the drives. This technique is referred to as *library-centric worldwide names*. Every potential drive slot is assigned a unique worldwide name (WWN). If a drive is replaced, the new drive gets the same WWN as the old one. This is controlled by the MCA. Because of this library behavior, you can easily identify the position of the drive in the library by the WWNN. The last two digits represent the drive's location in the library. The last digit indicates the drive row, starting from 1, and the second to last digit indicates the frame, counting from 0. The remaining digits are encoded with the vendor ID and the library-specific data, ensuring that every drive has a unique WWNN. Figure 12-16 on page 341 shows the drive WWNNs in an IBM TS3500 Tape Library.

World Wide Node Names				Panel 0126
Key: [F=Frame, R=Row]				
[F1,R01]	5005	0763	0041	0001
[F1,R02]	5005	0763	0041	0002
[F1,R03]	5005	0763	0041	0003
[F1,R04]	5005	0763	0041	0004
[F1,R05]	5005	0763	0041	0005
[F1,R06]	5005	0763	0041	0006
[F1,R07]	5005	0763	0041	0007
[F1,R08]	5005	0763	0041	0008
[BACK]	[UP]	[DOWN]		

Figure 12-16 Drive WWNNs of an IBM TS3500 Tape Library

12.2.7 Control path failover

Alternate path support, currently available for AIX, Linux, Solaris, HP-UX, and Windows hosts, configures multiple physical control paths to the same logical library within the device driver and provides automatic failover to an alternate control path when a permanent error occurs on one path. This is transparent to the running application.

For example, consider a simple Multi-Path Architecture connection consisting of two HBAs in a host that are connected to a library with two or more drives (Figure 12-17 on page 342). Two drives have the control ports enabled. The two HBAs are connected to the first and second control port drives, respectively. This simple configuration provides two physical control paths to the library for redundancy if one path from an HBA to the library fails. When the server boots, each HBA detects a control port to the library, and two medium changer devices (smc0 and smc1) are configured. Each logical device is a physical path to the same library; however, an application can open and use only one logical device at a time, either smc0 or smc1.

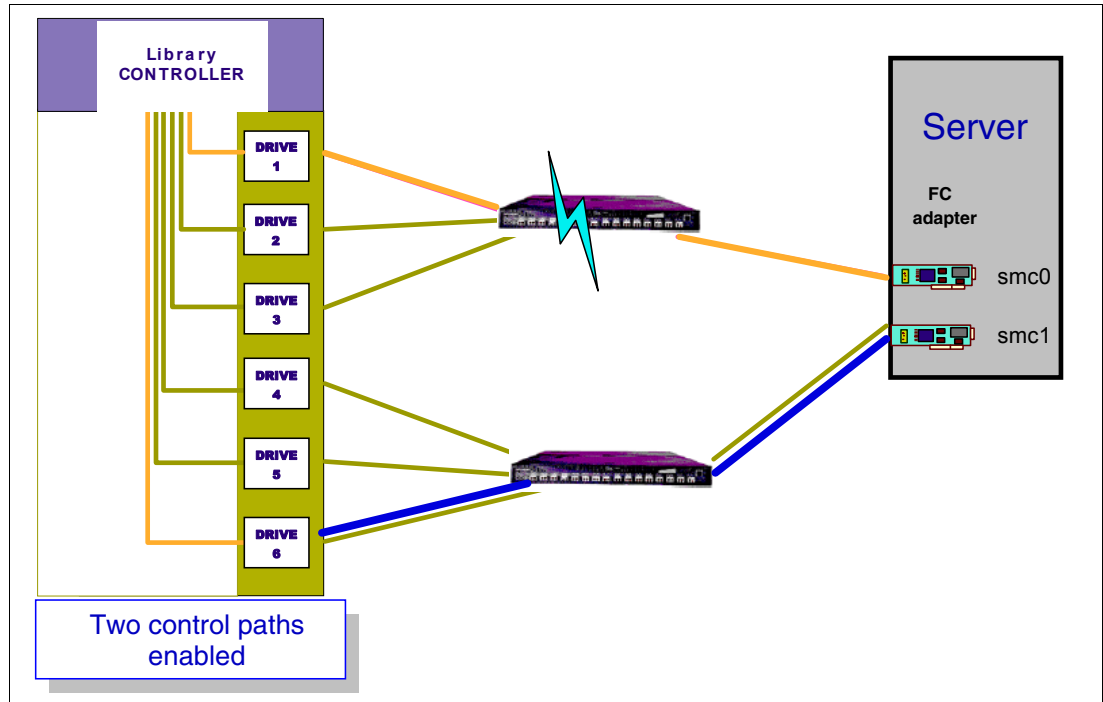


Figure 12-17 Redundant control paths to the library controller

Without the device driver alternate pathing support, if an application opens smc0 and a permanent path error occurs (because of an HBA, cable, switch, or drive control port failure), the current command to the library fails. It is possible to initiate manual failover by changing the device path to the alternate path (smc1), but this is a manual operation and the last failing command has to be resent.

When the alternate pathing support is enabled on both smc0 and smc1, the device driver configures them internally as a single device with multiple paths. The application can still open and use only one logical device at a time (either smc0 or smc1). If an application opens smc0 and a permanent path error occurs, the current operation continues on the alternate path without interrupting the application.

Activation of control path failover is done by entering a license key at the library Operator Panel. Control path failover is provided by an optional FC1680 for Lx2 frame models and requires the use of the IBM device driver. For Lx3 models, control path failover and data path failover are available with the optional Path Failover feature (FC1682).

12.2.8 Data path failover

Data path failover and load balancing exclusively support native Fibre Channel Ultrium and IBM 3592 Tape Drives in the IBM TS3500 Tape Library using the IBM device driver. Data path failover is now supported for AIX, Linux, HP, Solaris, and Windows hosts. Load balancing is supported for AIX, Linux, and Solaris. Refer to the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, for the current support and implementation details. Data path failover provides a failover mechanism in the IBM device driver, so that you can configure multiple redundant paths in a SAN environment. If a path or component fails, the failover mechanism is designed to provide automatic error recovery to retry the current operation using an alternate, preconfigured path without stopping the current job in progress. This improves flexibility in SAN configuration, availability, and management. When accessing a tape drive device that has been configured with alternate pathing across multiple host ports,

the IBM device driver automatically selects a path through the HBA that has the fewest open tape devices and assigns that path to the application. This autonomic self-optimizing capability is called *load balancing*. The dynamic load balancing support is designed to optimize resources for devices that have physical connections to multiple HBAs in the same machine. The device driver is designed to dynamically track the usage on each HBA as applications open and close devices and balance the number of applications using each HBA in the machine. This can help optimize HBA resources and improve overall performance. Further, data path failover provides autonomic self-healing capabilities similar to control path failover, with transparent failover to an alternate data path in the event of a failure in the primary host-side path.

Data path failover and load balancing for Linux and Solaris are provided by an optional feature (FC1681) for Lx2 models. Data path failover is included in the Path Failover feature (FC1682) for Lx3 models, which also includes control path failover.

Data path failover and load balancing support for AIX or for IBM 3592 tape drives do not require this feature.

12.2.9 Tape Library Specialist

The IBM TS3500 Tape Library's Web User Interface enables operators and administrators to manage storage devices from any location in an enterprise. The IBM TS3500 Tape Library Specialist enables direct communication with an IBM TS3500 Tape Library and provides a full range of user, operator, and administrator tasks, which can be executed remotely.

Firmware for the library and drives can be updated non-disruptively if using the Web User Interface. Note that nondisruptive library firmware updates require that a library control path using an LTO3 tape drive is used. LTO1 and LTO2 drives receive a SCSI Reset command during the firmware installation.

Multiple simultaneous Web clients

Each Ethernet-capable Medium Changer Assembly (MCA) on the IBM TS3500 Tape Library allows five simultaneous Tape Library Specialist users.

Individual Web login IDs and passwords

For the IBM TS3500 Tape Library, the Web User Interface supports a list of users who can access various areas of the Web User Interface. An administrator can create up to fifteen additional user IDs. Each user has a 30-character name, a 15-character login ID, a 15-character password, and an access level. The access level defines the level of Web access that the user is allowed. A maximum of five users can be signed on to the Specialist at the same time.

There are four access levels available:

- ▶ **Monitor:** Can view all physical and logical library data.
- ▶ **Service:** Can perform only service-related functions, such as update firmware, download logs, and view vital product data (VPD).
- ▶ **Superuser:** Can perform all tasks of a monitor or service role, plus change library settings and perform library operations. This role cannot change the password of others or enable or disable security.
- ▶ **Administrator:** Can perform all user management tasks.

Note that users can change their own password.

Multiple simultaneous Web clients and individual Web ID functions can be made available to existing IBM TS3500 libraries by upgrading to the latest firmware.

Customizable Web access

Customized Web access provides a way for the administrator or superuser to add roles with access to specific libraries and specific pages within the logical libraries for the Tape Library Specialist Web interface.

Like the standard roles that are delivered with the Tape Library Specialist, these custom roles can be assigned to multiple users. Customized Web access pages are not available unless Web security is enabled and password protection is turned on.

12.2.10 Expanded I/O station

L23 and L53 frames can have either a 16-slot 3592 or LTO cartridge input/output (I/O) station. An additional 16-slot I/O station can be ordered via FC1658 (for LTO) or FC1659 (for 3592).

A single frame cannot combine both the 3592 and LTO drives. However, in a library with mixed frame types, you can insert IBM 3592 cartridges into the lower I/O station of a Model L53 or L32 frame for transport (by the cartridge accessor) to a Model D23 or Model S24 (your library must contain an I/O station that will accept 3592 cartridges). Similarly, you can insert LTO Ultrium cartridges into the lower I/O station of a Model L23 for transport (by the cartridge accessor) to a Model D53, D32, or S54 (again, your library must contain an I/O station that can accept Ultrium cartridges).

Support for more than 32 I/O slots can be made available through *Virtual I/O*, a feature available with ALMS, which virtualizes storage slots to be used as I/O slots, also known as *Import/Export Elements (IEEs)*. For more information, refer to 12.5.2, “Virtual I/O” on page 360.

12.2.11 Reliability

The IBM TS3500 Tape Library is designed for high availability and reliability. Most essential components are redundant. These components have been described previously. Here is a summary of the high-availability features and components of the IBM TS3500 Tape Library:

- ▶ Redundant grippers

A failure of one gripper will cause the library to switch to a second gripper.
- ▶ Redundant accessors (optional):
 - Second library accessor operates simultaneously with the first accessor to service mount requests.
 - Designed to non-disruptively fail over to a redundant accessor when any component of either accessor fails.
- ▶ Redundant library and drive power

A single frame library contains one redundant power supply in the Enhanced Frame Controller, which provides power to the library robotics and the tape drives. The power requirements are distributed evenly over both power supplies under normal operating conditions, failing over to a single power supply if required.
- ▶ Redundant control and data paths:
 - Any LTO drive can be used as a library control path.
 - Automatic control path failover is currently available for AIX, Solaris, Red Hat and SuSE Linux, Windows, and HP-UX.

- Data path failover is currently available for AIX, HP-UX, Red Hat and SuSE Linux, Solaris, and Windows.
- ▶ Redundant copies of Vital Library Data:
 - Includes configuration data, calibration data, setup data, and so forth.
 - One node card contains the primary copy, and another node card contains a backup copy.
 - Backup and restore process is completely automated.
- ▶ Redundant copies of library firmware:
 - Each node card contains the firmware for every other processor card.
 - Component replacement is simplified.
 - Each node card contains two copies of operational firmware.
 - Protects the library from potentially harmful firmware update disruptions.
 - Helps reduce the risk of memory failures.
- ▶ Closed loop servo systems:
 - This includes horizontal motion, vertical motion, pivot motion, gripper extend, and retract motion.
 - Each servo system uses feedback.
 - Velocity and position are monitored.
 - This allows higher performance (as shown in Table 12-8 on page 353), and knowing velocity and position allows greater control.
 - Closed loop is more reliable.
 - Collisions and gripper damage can be avoided by monitoring position and velocity.

12.2.12 Remote support

This section describes the types of remote support that the TS3500 and its drives use to detect and solve problems.

Optional remote support is available for the TS3500 through its Call Home capability. The Call Home feature uses a modem connection and a master console to report failures that are detected by the library or a tape drive. Whenever a failure is detected, Call Home sends detailed error information to an IBM Support Center. Qualified Support Specialists will analyze the Call Home data and decide if an action is required as a result of that Call Home data. The library might also periodically send support information (such as configuration, library and drive code versions, and error logs) to IBM.

The Call Home feature of the TS3500 has two different, but related, capabilities:

Problem Call Home The TS3500 or one of its drives detects a problem, the library performs a Call Home operation to create a Problem Management Record (PMR) in the IBM Remote Technical Assistance Information Network (RETAIN), and information will be transferred to IBM for analysis of the problem.

Heartbeat Call Home On a scheduled basis (once a week or one hour after a code update has been completed), the TS3500 sends home (to IBM) the following files: a Machine Reported Product Data (MRPD) file, a library error log file, and a drive error log file. The MRPD file contains information about the machine (library), including the number of frames and drives, the model and serial number of each frame, the type and serial number of each drive, the code version of the library and each drive,

and any machine-detectable features, such as additional I/O stations, capacity expansion, and so forth.

Remote support through a modem

Optional remote support is available for the TS3500 through its Call Home capability through a no-charge feature (FC2710), which permits a single Tape Library with Call Home capability the remote support described previously.

Remote support through the TS3000

This section describes remote support to the TS3500 or 3584 Tape Library through a master console. A *master console* is a service tool that is present in most environments where one or more IBM tape storage devices, such as the IBM 3953 Tape System (3953-F05 Tape Frame and 3953-L05 Library Manager), are connected to a System z server (mainframe host). The TS3000 System Console (TSSC) provides the same functionality to attach a TS3500 or 3584 Tape Library that is connected to an Open Systems server.

When the TS3500 or 3584 Tape Library is in an environment that includes a master console, we recommend that the library perform the Call Home function through the master console instead of through a direct modem connection. This avoids the need for a dedicated analog phone line for the library's Call Home modem.

To perform a Call Home operation through a master console, the TS3500 or 3584 Tape Library sends Call Home information across a private Ethernet connection to the master console. The master console then performs the Call Home operation and sends the information to IBM RETAIN through the master console's modem connection.

For remote support through a master console, the Tape Library needs a minimum of two Ethernet ports: one port attached to your network for use by your administrator and one port attached to the private master console network for remote support. The library feature code (FC9217) provides an Ethernet cable for the remote support connection from the TS3500 to a master console.

Figure 12-18 on page 347 shows the flow of data in a configuration in which a single Master Console is supporting three Call Home-capable tape libraries.

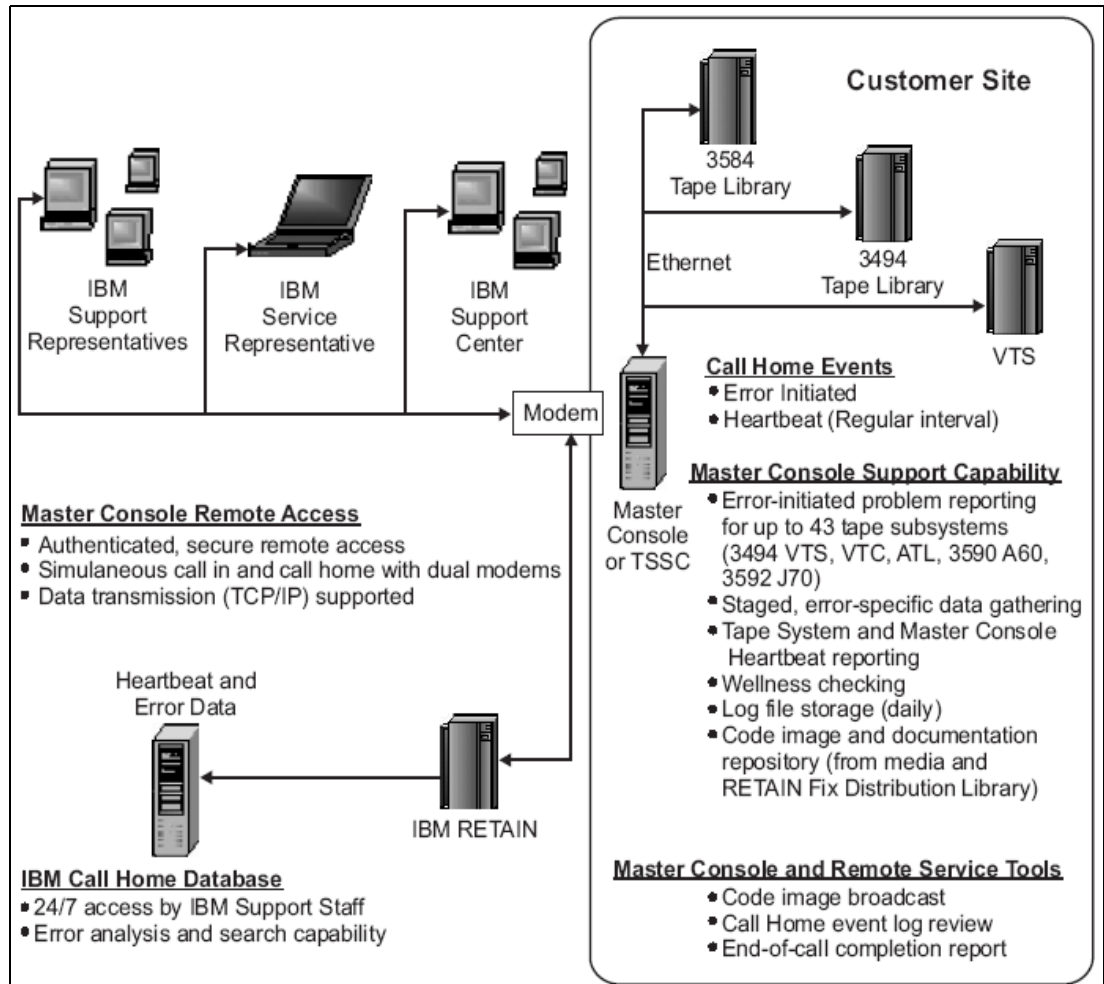


Figure 12-18 Flow of data from a Master Console supporting three Tape Libraries

A new feature code is available for the TS3000 System Console. Feature Code 2730 offers a 1U rack-mountable server and comes with a keyboard, display, mouse, and Ethernet switch.

Figure 12-19 on page 348 shows the rack-mountable TS3000 System Console.

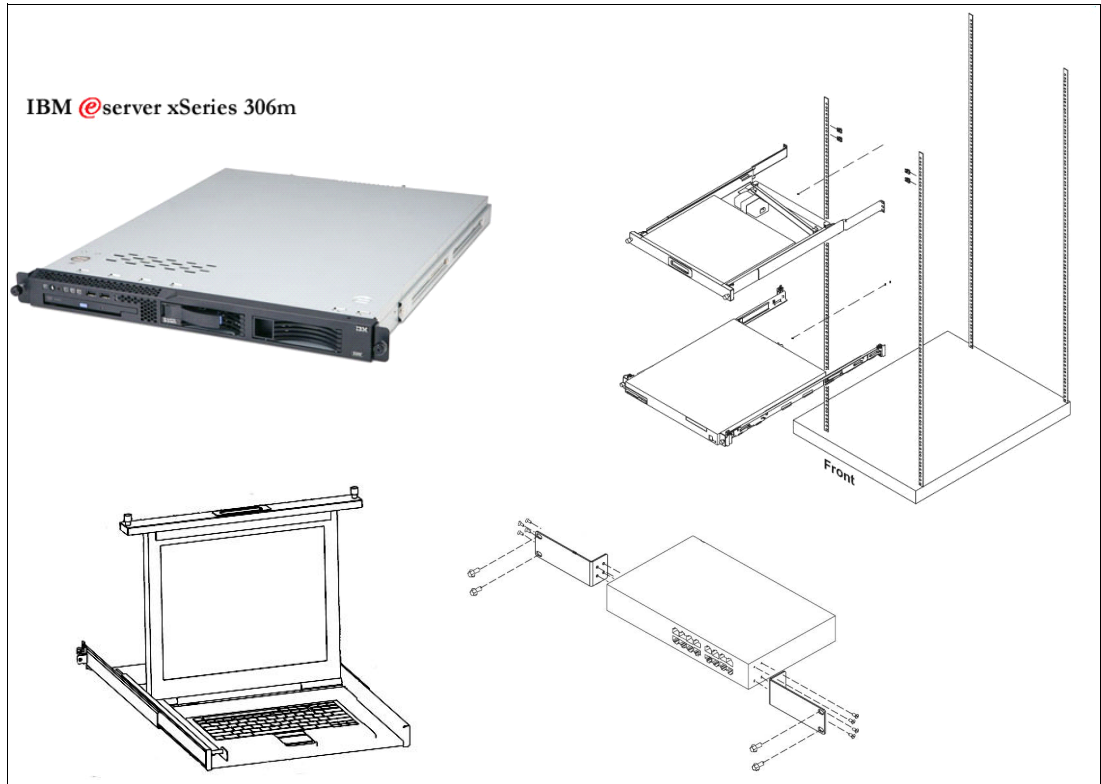


Figure 12-19 Rack-mountable TS3000 System Console

SNMP

Occasionally, the IBM TS3500 Tape Library might encounter a situation that needs to be reported, such as an open door that causes the library to stop. Because many servers can attach to the IBM TS3500 Tape Library by different attachment methods, the library provides a standard TCP/IP protocol called *Simple Network Management Protocol (SNMP)* to send alerts about conditions (such as an opened door) over a TCP/IP LAN network to an SNMP monitoring server. These alerts are called *SNMP traps*. Using the information supplied in each SNMP trap, the monitoring server (together with client-supplied software) can alert operations staff of possible problems or operator interventions that occur. Many monitoring servers (such as IBM Tivoli NetView®) can be used to send e-mail or pager notifications when they receive an SNMP alert.

The monitoring server must be loaded with systems management software that can receive and process the trap, or the trap will be discarded. SNMP trap support does not provide a mechanism for the operator to gather more information about a problem or to query the library about its current status.

If your systems management software includes an SNMP compiler, you might not need to manually interpret SNMP traps, but you will need the library's Management Information Base (MIB). The MIB contains units of information that specifically describe an aspect of a system, such as the system name, hardware number, or communications configuration. Obtain the MIB for the IBM TS3500 Tape Library from:

<ftp://ftp.software.ibm.com/storage/358x/3584>

For information about interpreting an SNMP trap or using SNMP MIBs to monitor your library, refer to the appropriate sections in the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

SMI-S support

This section describes how the IBM TS3500 Tape Library uses the Storage Management Initiative Specification (SMI-S) to communicate in a SAN environment.

To communicate with storage devices in a SAN environment, management software, such as the IBM TotalStorage Productivity Center (TPC), uses other software known as the Storage Management Initiative Specification (SMI-S) Agent for Tape. New with this release, the 3584 Tape Library provides native support for SMI-S. It is no longer necessary to run the SMI-S agent on a separate Linux machine. All the functions present in the proxy SMI-S agency have been replicated in this embedded version. The library Web user accounts are used for authentication. This is used in conjunction with secure socket layer (SSL) functionality.

The SMI-S Agent for Tape is designed to be compliant with the Storage Management Initiative Specification. The SMI-S is a design specification of the Storage Management Initiative (SMI) that was launched by the Storage Networking Industry Association (SNIA). The SMI-S specifies a secure and reliable interface that allows storage management systems to identify, classify, monitor, and control physical and logical resources in a Storage Area Network (SAN). The interface is intended as a solution that integrates the various devices to be managed in a SAN and the tools used to manage them. The SMI-S was developed to address the problems that many vendors face in managing heterogeneous storage environments. It creates a management interface protocol for multivendor storage networking products. By enabling the integration of diverse multivendor storage networks, the initiative is able to expand the overall market for storage networking technology.

The SMI-S v1.2 interface is embedded in the library when using the Ethernet port in an xx3 frame. Embedding the SMI-S interface simplifies the client environment and removes the performance bottle neck of the SNMP interface.

The embedded SMI-S agent provides the following profiles showed in Table 12-6.

Table 12-6 Embedded SIM-S Agent profiles

Profile	Subprofile	SMI-S Version
Server Profile	N/A	1.2
Storage Media Library		1.2
	Limited Access Port	1.2
	Chassis	1.2
	FC Port	1.2
	Software	1.2
	Physical Package	1.2

Figure 12-20 on page 350 shows you the SMI-S Agent panel view from the Web User Interface.

This page allows users to view and change the status of the Storage Management Initiative Specification (SMI-S) Agent on the tape library. The SMI-S Agent is the IBM implementation of the Common Information Model (CIM). The CIM is an interface standard that enables interoperability for hardware and software products (that might come from different manufacturers) in your enterprise's storage network environment. The CIM provides common protocols and data models that storage product manufacturers can use to ensure ease of both use and manageability of the storage network environment.

The SMI-S Agent operates on HTTP port 5988 and requires no credentials.

This release supports:

- ▶ Service Location Protocol (SLP)
- ▶ Storage media library profile
- ▶ TotalStorage Productivity Center (TPC)

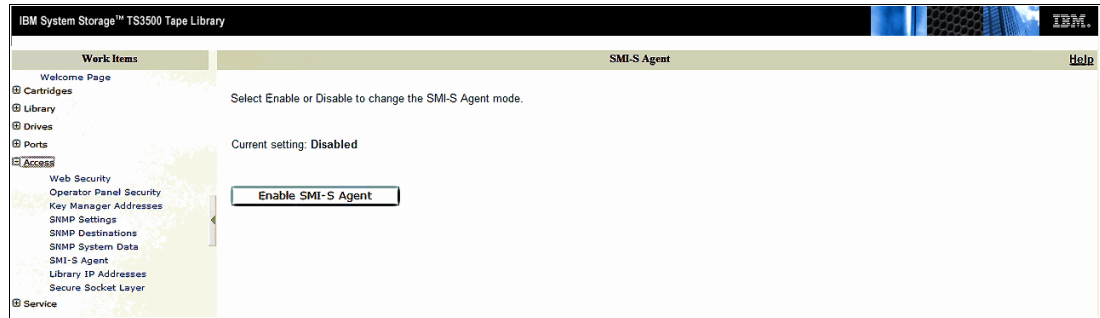


Figure 12-20 SMI-S Agent panel

The IBM TS3500 Tape Library can interoperate with SMI-S clients as shown in Figure 12-21.

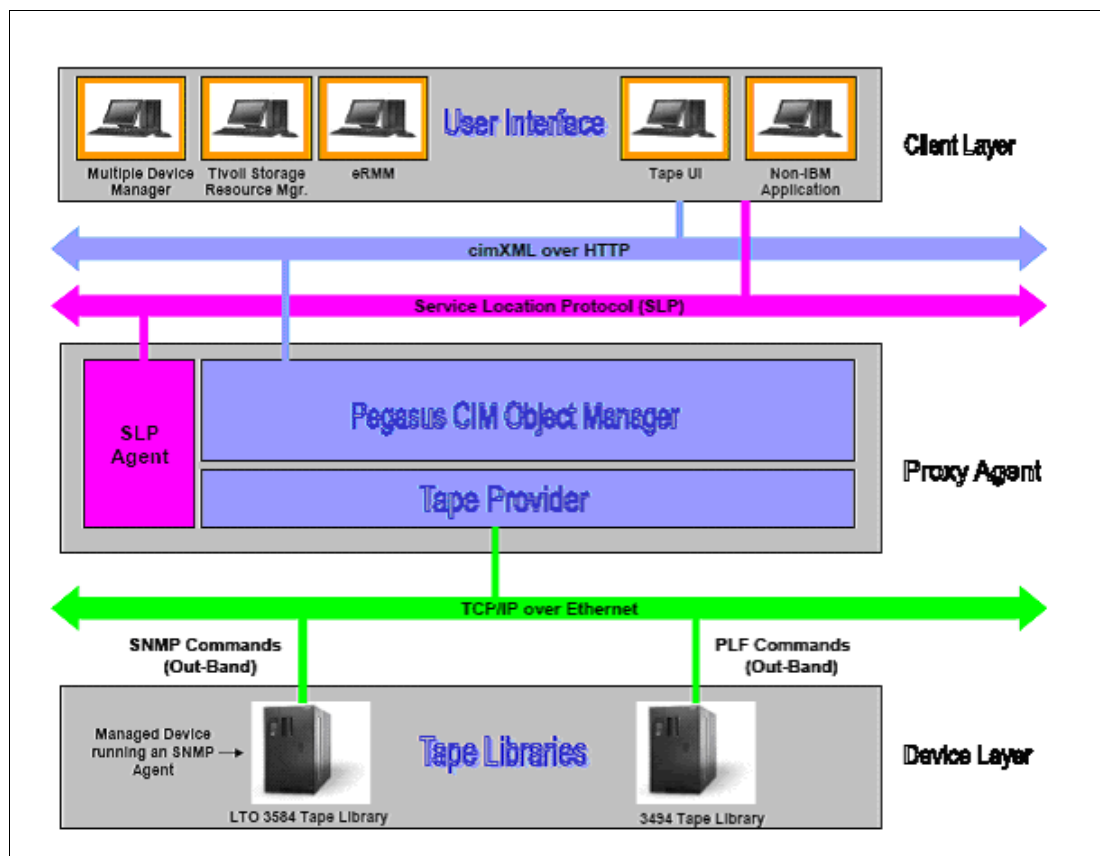


Figure 12-21 SMI-S support

The external Linux PC supports the following protocols:

- ▶ Server Profile SMI-I Version 2
- ▶ Storage Media Library Version 2:
 - Limited Access Port 1.1
 - Chassis 1.1
 - FC Port 1.1
 - Software 1.1
 - Physical Package 1.1

The TS3500 also provides detailed information regarding activity during the last 24 hours in four files that you can download by using the Web User Interface. Refer to “Enhanced data gathering and reporting” on page 400 for a detailed explanation.

12.2.13 Adding and removing cartridges

You can insert cartridges in the IBM TS3500 Tape Library in two ways.

The first method is to insert cartridges through the I/O station (refer to Figure 12-2 on page 319) that is located on the front door of the Lxx frame of the IBM TS3500 Tape Library. With this method, you can insert and remove cartridges from the library enclosure without interrupting library operation. The I/O station is controlled by the host application software that uses the library or from the Operator Panel. Insertion of cartridges into the I/O station alerts the application software, which registers the additional cartridges and their status in its database and then instructs the accessor to move the new cartridges into library slots. The slot location of each cartridge is held in the host application software database. A detailed description of how to insert cartridges can be found in the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

The second method to insert cartridges is to open the front door of a frame and bulk load the cartridges directly into empty storage slots. When the door is closed, the library will perform a cartridge inventory operation, which checks to determine whether each cartridge storage slot in the frame is empty or full and scans the cartridge barcode labels. When the library performs an automatic inventory in this way, the inventory will occur only for those frames whose doors had been opened.

A cartridge inventory operation occurs whenever you:

- ▶ Power on the library
- ▶ Issue the SCSI command **Initialize Element Status with Range**¹
- ▶ Select Inventory from the Manual Operations menu
- ▶ Select the appropriate menus from the Library Specialist Web interface
- ▶ Close the front door after manually accessing the library

When the library performs an automatic inventory because the front door was closed, the inventory occurs only for those frames whose doors have been opened. A door lock is provided to restrict physical access to cartridges in the library, which can be used to secure the cartridges and prevent unauthorized library access. Although the time required for the library to inventory cartridges is less than 60 seconds per frame, the door lock reduces the possibility of frames being opened in error and causing unnecessary inventory activity.

There is also a safety switch in the frame door (number 9 in Figure 12-10 on page 331) that shuts down the power to the cartridge accessor whenever the front door is opened.

¹ The TS3500 Tape Library tracks the logical location of all elements in the library by performing an automatic inventory as required (therefore, the SCSI Initialize Element Status command is allowed but ignored).

Removal of data cartridges can be performed not only by using your host application software, but also through the Tape Library Specialist or the Operator Panel. For a detailed description of how to remove cartridges, refer to the *IBM System Storage TS3500 Tape Library Operator Guide*, GA32-0560.

Cartridge Assignment Policy

The Cartridge Assignment Policy (CAP) of the IBM TS3500 Tape Library enables you to assign ranges of cartridge volume serial (VOLSER) numbers to specific logical libraries through the Tape Library Specialist. For more information, refer to “Cartridge Assignment Policy” on page 360.

Insert Notification

Insert Notification is an option that enables the IBM TS3500 Tape Library to monitor the I/O station for any new media that does not have a logical library assignment. Refer to “Insert Notification” on page 360.

12.3 Performance

The performance capability of a tape library solution depends on both the individual bandwidth capability of the drives and data bus and the speed of the robotic handling. The degree of importance for each of these elements depends on the quantity of data transferred during one operation. For example, when reading or writing large files (larger than 800 MB) to tape, then the data rate of the tape drive will be the overriding contributor to the speed of the operation. However, for reading or writing many small files (25 MB or less) to different tapes, the cartridge move and load times become the overriding contributor.

12.3.1 Elements that contribute to high performance capabilities

There are many elements that contribute to high performance.

Library bandwidth

You see the bandwidth of the IBM TS3500 Tape Library in Table 12-7 relating to the drive performance given in 2.5.2, “LTO performance” on page 80. Compressed drive performance can be calculated by assuming a compression ratio of 2:1 for LTO.

Table 12-7 IBM TS3500 Tape Library bandwidth

Tape drives	LTO Ultrium 1 native	LTO Ultrium 2 native	LTO Ultrium 3 native	IBM 3592 native	TS1120 native
72	3.9 TB/hr.	9.1 TB/hr.	20.7 TB/hr.	10.4 TB/hr.	29.5 TB/hr.
192	10.4 TB/hr.	24.2 TB/hr.	55.3 TB/hr.	27.6 TB/hr.	69.1 TB/hr.

Cartridge move time

Move time is the time that is required for the cartridge accessor to pick a cartridge from a random slot, move the cartridge to a drive, pivot (if required), and insert the cartridge into the drive. In a single-frame IBM TS3500 Tape Library, the typical time to move a cartridge from a cartridge storage slot to a tape drive, for example, is less than 2.7 seconds; for a six-frame configuration it only increases to 3.8 seconds; for the maximum 16 frames, the average move time is still only 6.2 seconds, as shown in Table 12-8 on page 353. For maximum

performance, as demonstrated in the table, drives must be centrally located and as close together as possible. The table does not apply to libraries that contain dual accessors.

Table 12-8 Library performance without dual accessor

Library configuration	Average move times with all drives in frame 1	Average move times with all drives in a central frame
One frame	2.7 seconds	N/A
Two frames	2.6 seconds	N/A
Four frames	3.3 seconds	2.9 seconds
Six frames	3.8 seconds	3.3 seconds
Eight frames	4.4 seconds	3.7 seconds
12 frames	5.3 seconds	4.3 seconds
16 frames	6.2 seconds	4.7 seconds

Mount throughput

Mount throughput is a measure of the overall capability of the cartridge accessor and tape drives. It is defined as the number of cartridges that the tape library can mount in one hour. A *mount*, often called the *mount/demount cycle*, involves removing the cartridge from a drive, returning it to its storage slot, collecting another cartridge from a random storage slot, moving it to the drive, and loading the cartridge into the drive.

Table 12-9 shows the mount throughput performance for the UltraScalable Tape Library with and without dual accessors. The table demonstrates that to maximize performance with dual accessors, each accessor must have drives centrally located in its preferred zone.

Table 12-9 Library mount throughput

Library configuration	Without dual accessor		With dual accessor	
	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame	Mounts per hour with all drives in frame 1	Mounts per hour with all drives in a central frame
One frame	550	N/A	N/A	N/A
Two frames	520	N/A	N/A	N/A
Four frames	410	430	N/A	1000
Six frames	350	380	N/A	900
Eight frames	310	350	N/A	800
12 frames	255	300	N/A	700
16 frames	215	260	N/A	600

Note: The dual accessor mount throughput assumes that the library is partitioned into at least two logical libraries so that each of the cartridges located in the two zones are mounted in drives within each zone with no accessor path overlap.

EXCHANGE MEDIUM command

Another method of increasing mount rate performance is using dual active grippers and the EXCHANGE MEDIUM command (as documented in *IBM System Storage TS3500 Tape Library SCSI Reference*, GA32-0561) to implement the exchange at cell algorithm. In this algorithm, a mount/demount cycle consists of the following series of operations:

1. Move to drive; unload cartridge into gripper 2.
2. Move to new cartridge; pick up cartridge with gripper 1.
3. Return cartridge in gripper 2 to the storage slot that was just vacated.
4. Move back to drive; load cartridge with gripper 1.

With the use of the floating home cell algorithm, cartridges are not returned to their original storage slots. Instead, the ejected cartridge is placed in the slot where the next mounted cartridge is located. Check with your backup software application for support.

Library inventory time

During normal use of the IBM TS3500 Tape Library for bulk loading of cartridges, the library will perform an inventory operation to check the (possibly new) content of the cartridge storage slots. During this time, the accessor is occupied scanning the barcode labels and empty slots.

The inventory process for the IBM TS3500 Tape Library is performed very efficiently, usually taking fewer than 60 seconds per frame.

12.3.2 Performance characteristics for HD frame

The inventory time for an HD frame can be considerably longer than existing frames because of the significant number of moves required to position each cartridge barcode label to be scanned. The following new requirements are introduced for the inventory process:

- ▶ The uppermost two rows of HD slots must be left empty during the initial bulk load of the frame. These rows provide an initial destination to begin a rolling inventory process in which cartridges are moved upward and scanned (nicknamed “roll-and-scroll”) with the process repeating for each column.
- ▶ Users must not manually insert cartridges into HD slots after the initial bulk load of the frame.
- ▶ Upon any frame door closure or power-on reset, the inventory process includes:
 - The library scans all Tier 0 and Tier 1 cartridges in the applicable frames and simultaneously performs a before-and-after comparison of each Tier 0 and Tier 1 cartridge VOLSER in order to determine if any slot was accessed (inserts or removals). Handling of unreadable barcode VOLSERS for Tier 0 and Tier 1 will work the same as the current “trust mode” (if unreadable, will assume that the HD slot has not been accessed).
 - For each HD column in which the number of HD slots determined to be accessed is less than or equal to a predetermined maximum, then only the affected HD slot is inventoried (shuffled and scanned) and their tier order is maintained with the unshuffle process.
 - For each HD column in which the number of HD slots determined to be accessed is greater than a predetermined maximum, then all HD slots in that column are inventoried using the roll-and-scroll process.
 - The library completes the roll-and-scroll inventory for all five columns in an HD frame in less than 45 minutes.

12.4 Upgrades and optional features

The IBM TS3500 Tape Library has a number of optional additional features. These features enhance the library by providing extra functions, additional capacity, higher reliability, and greater serviceability.

For more information about available features, refer to the sales manual for the IBM TS3500 Tape Library. You can access the sales manual at:

<http://www.ibm.com/common/ssi/0IX.wss>

12.5 ALMS

The Advanced Library Management System (ALMS) provides enhanced flexibility and capabilities for partitioning the IBM TS3500 Tape Library. ALMS virtualizes the SCSI element addresses while maintaining the approach of the Multi-Path Architecture and using SCSI-3 Medium Changer commands. Without ALMS, everything is based on the SCSI element address (location-centric), and partitioning is based on real cartridge slots and drive slots. With ALMS, there is no affinity between a real slot address and a SCSI element address reported to the server and used by the server. Instead, there is now an affinity with the VOLSER (volume serial numbers on the barcode label of the cartridge).

ALMS eliminates downtime when you add Capacity On Demand (COD) storage, add or remove logical libraries, or change logical library storage allocation. ALMS also reduces downtime when you add expansion frames, add or remove tape drives, or change logical drive allocation.

ALMS allows the following new capabilities on the IBM TS3500 Tape Library:

- ▶ Dynamic partitioning:
 - Storage slot pooling
 - Flexible drive assignment
- ▶ Add and remove storage capacity transparent to any host application
- ▶ Configure drives or Lxx storage capacity without taking the library offline
- ▶ Virtualize I/O slots to automatically manage the movement of cartridges between I/O station slots and storage slots

The IBM TS3500 Tape Library is compliant with the SCSI Medium Changer standard whether ALMS is enabled or not; when enabled, ALMS is completely transparent to the application. The SCSI Medium Changer can be thought of as a “location-centric” interface. The application controlling a SCSI Medium Changer device specifies a source and destination location for each request to move a cartridge. The traditional SCSI library does not have control of the cartridge locations; instead, the SCSI library just acts on behalf of the server.

There are four ALMS feature codes that you can use to purchase the ALMS, depending on the installed Lxx frame’s capacity:

- ▶ You can purchase Entry ALMS (FC1692) for an entry-capacity Lxx frame.
- ▶ You can purchase Intermediate ALMS (FC1693, which has a prerequisite of FC1692) for an intermediate-capacity Lxx frame.
- ▶ You can purchase Full ALMS (FC1694, which has a prerequisite of FC1693) for a full-capacity Lxx frame.
- ▶ Or, you can purchase ALMS (FC1690) for any capacity of Lxx frames.

For detailed information about Lxx frame capacity, refer to 12.1.2, “IBM TS3500 Tape Library frames L23 and D23” on page 323.

One of the previously listed Advanced Library Management System (ALMS) feature codes is required if you want to exploit either:

- ▶ Dual active accessor libraries (requires FC9040)
- ▶ System z attachment (requires FC9217)
- ▶ High Density frame (HD)

Restriction: ALMS is available only for the IBM TS3500 Tape Library and requires FC1690, FC1692, FC1693, or FC1694 for enablement.

12.5.1 Functional description

In this section, we give a functional description of the ALMS features.

Storage slot virtualization

The host view of a cartridge location is known as the *SCSI storage element address*. Without ALMS, the storage element address maps directly to a specific storage slot after the library is configured. With ALMS enabled, a given storage element address is no longer associated with a specific storage slot. Instead, storage slots are virtualized by dynamically associating them with element addresses, as required. An element address will be associated with a storage slot that is selected by the library, as cartridges are moved and inventoried. In the case of a storage element that is empty due to a move, that source element address will become unassociated. Association of storage element addresses is accomplished in a way that is completely transparent to the application software.

The number of storage element addresses for a logical library (as reported to the host application software) is selectable by changing the Maximum Number of Cartridges setting for that logical library using the Web User Interface (Tape Library Specialist). For each logical library, the default value for Maximum Number of Cartridges is the number of addressable storage slots that are installed in the library for that cartridge type at the time that ALMS is first enabled or, after ALMS is enabled, at the time that the logical library is created. The Maximum Number of Cartridges setting can be changed for each logical library, but the value must always be greater than or equal to the number of actual cartridges currently assigned to that logical library. It is possible to set Maximum Number of Cartridges to a value that is higher than the number of addressable storage slots installed at the time in order to allow future library capacity expansion to be transparent to the host application software; however, application performance might degrade slightly due to the greater number of addresses. Care must be taken to not exceed the license limitations of the host application software.

The starting element address for storage slots of each logical library will be x'400' (1024) plus the associated logical library number. For example, logical library 1 starts at x'401' (1025), logical library 2 starts at x'402', and so on (refer to Figure 12-22 on page 357). The reason that they do not all start at x'401' is because certain applications have to be able to differentiate between different logical libraries from the same physical library.

Drive assignment

Using the ALMS flexible drive assignment capability, any drive in any position within any frame can be assigned to any logical library without creating any gaps in drive addresses. Drive (data transfer) element addresses will still be mapped to specific drive locations when the drive is assigned, but any drive location can now be assigned to any logical library (intermix supported) using the Tape Library Specialist. Each drive added to a logical library will be assigned to the lowest available element address, regardless of drive location.

When ALMS is first enabled, the Data Transfer Element (DTE) addresses of all installed and assigned drives are not changed from their previous values. However, after ALMS is enabled, the DTE addresses for any newly installed and assigned drives no longer depend on the drive's position. Instead, the DTE address for any newly installed or assigned drive is determined by the sequence in which the drive is assigned to each logical library. After enabling ALMS, drives are assigned to logical libraries using the Drive Assignment page of the Tape Library Specialist.

Using this interface, the DTE address for the first drive assigned to a new logical library is 257 (x'101'); refer to Figure 12-22. The DTE address for any other drive assigned to a logical library is based on the next available DTE address in that particular logical library. The next available DTE address is the lowest available DTE address after the starting DTE address. (This will fill any gaps that are created when drives are unassigned and removed from a logical library.) When a drive is unassigned from a logical library using the Web interface, only that DTE address is made available for future usage, no other DTE addresses are affected.

The Drive Assignment page also supports the option to share a drive between two or more logical libraries. The drive will be assigned a DTE address in more than one logical library. Note that the DTE addresses that are assigned to a shared drive might differ by logical library.

By using the ALMS dynamic Drive Assignment capability, any drive in any position in any frame is available to be assigned to any logical library without creating gaps in DTE addresses.

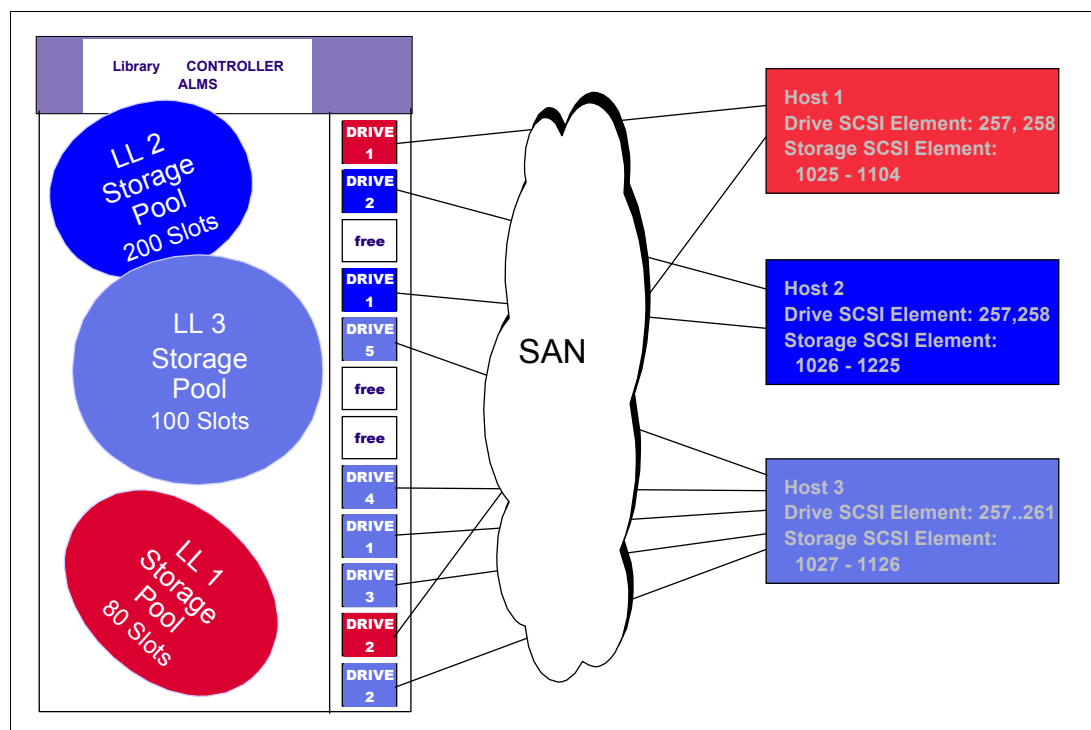


Figure 12-22 IBM TS3500 Tape Library with ALMS

Storage slot pooling

With ALMS, logical libraries can be added or deleted non-disruptively. All storage slots are first-come-first-served to each logical library based on cartridge insert operations. Therefore, storage slots are pooled as a shared resource such that changes to the capacity allocation for each logical library can occur without any downtime or administrator involvement whatsoever.

Indications of a full or nearly full physical library will continue to be provided via the Operator Panel, Tape Library Specialist, and SNMP traps.

The minimum logical library simply has a name and can be thought of as a file folder that has no content. Drives can be placed in the file folder using the Drive Assignment screen of the Tape Library Specialist. Cartridges can also be placed in the file folder, based on their volume serial (VOLSER) numbers and by using one of the following methods (in priority order):

- ▶ Migration from static partitioning (UI enablement of ALMS)
- ▶ Cartridge Assignment Policy (automatic at time of insertion)
- ▶ Insert Notification (Operator Panel selection at time of insertion)
- ▶ Software application move from I/O station (based on source of command)
- ▶ Manual assignment using the Tape Library Specialist

The VOLSER assignment and physical location of cartridges are stored in non-volatile RAM (both primary and backup copies).

Shared drive assignment

Certain clients require the ability to easily share a drive on an exception basis; for example, a drive might be required for a once-a-month job or as a temporary replacement for a failed drive. The Tape Library Specialist drive assignment UI supports the ability to assign a drive to multiple logical libraries. Therefore, each logical library will consist of dedicated drives and shared drives. Each logical library will map a drive element address to the location of both dedicated and shared drives.

This option reduces the requirement to configure and unconfigure the tape drive every time it is needed or not.

The Drive Assignment Web window supports the following point-and-click capabilities, which are nondisruptive to other logical libraries:

- ▶ Assign the drive
- ▶ Remove the drive assignment
- ▶ Reassign the drive

When a cartridge is mounted in a shared drive, the library will only accept a demount command requested via the source logical library; any demount command requested via other logical libraries will be rejected.

However, the data path to the tape drive itself is not protected by the library. Therefore, the administrator must ensure that shared drives are not accessed by the wrong application via the data path. One option to ensure that shared drives are not accessed by the wrong application via the data path is to use the SCSI reserve and release option on open and close. The device driver together with the application handles this option. On a device open, the application initiates a SCSI reserve through the tape device driver. No other server can now access the tape drive (except for commands, such as inquiry), ensuring that data is not overwritten by any other host or application. After the device is closed, the application must send a SCSI release to the tape drive. Most applications handle this option, but it is best to check with the backup software provider to confirm.

SAN zoning can also be used to prevent access to the same tape drives by different servers.

When a tape drive is shared by applications, any application using the drive has no knowledge of the other applications sharing the tape drive. Therefore, a cartridge might be loaded already and in use by application A, but if application B does not know it and tries to mount a cartridge in the same drive, application B gets a failure and the job that application B was executing fails. Several applications periodically scan all the tape drives and if they

recognize that there is a cartridge mounted without initiation from the application itself, the application considers this tape drive offline.

In any case, we recommend not allowing multiple applications to use shared tape drives concurrently. In other words, set tape drives offline (or in service mode) from the application whenever they are not in use by that application.

The sharing option is mainly intended for environments where certain drives are needed only occasionally and must be preconfigured for the application.

Important: An application that occasionally leaves cartridges in drives or periodically scans all configured drives is not a good candidate for sharing drives between logical libraries.

Eliminate downtime for total capacity changes

With ALMS enabled, the total library capacity (the number of addressable storage slots) can be changed transparently to each application, because the Maximum Number of Cartridges value is not affected by changes to the number of storage slots. The additional storage slots are simply new candidates to which to move cartridges upon insertion.

Furthermore, using the new Intermediate and Full Capacity on Demand capabilities of the TS3500 Tape Library models L23 and L53 requires no downtime at all for the change to total L-frame capacity.

Currently, up to 6887 slots are supported per single TS3500 library. Therefore, the limit of 15 active expansion frames is reduced as listed in Table 12-10. IBM plans to provide support for greater than 6887 cartridges in a future release that has been previewed.²

Table 12-10 TS3500 active frames

Number of active S24 frames	Number of active S54 frames	Limit of total active expansion frames
1	0	13 (reduce by 2)
0	1	13 (reduce by 2)
2	0	12 (reduce by 3)
0	2	11 (reduce by 4)
3	0	10 (reduce by 5)
0	3	9 (reduce by 6)
4	0	9 (reduce by 6)
0	4	7 (reduce by 8)
5	0	7 (reduce by 8)
0	5	5 (reduce by 10)
6	0	6 (reduce by 9)
0	6	Not supported
7	0	Not supported

² Previews provide insight into IBM plans and direction. Specific availability dates, ordering information, and terms and conditions will be provided when the product functionality is announced.

Cartridge Assignment Policy

The Cartridge Assignment Policy (CAP) of the IBM TS3500 allows you to assign ranges of cartridge volume serial (VOLSER) numbers to specific logical libraries through the Tape Library Specialist. When a cartridge is inserted into the I/O station, the Cartridge Assignment Policy will be used to attempt to associate the cartridge with a logical library. If the cartridge is not in the CAP and Insert Notification (discussed in the next section) is enabled, you can assign the cartridge to a logical library by using the Insert Notification process on the library's Operator Panel or keep the cartridge as unassigned and assign it later using the Tape Library Specialist. If the Insert Notification feature is not enabled, and the cartridge was not in the CAP, the cartridge will eventually be available to all hosts. Unassigned cartridges can also be assigned to a logical library by creating a new VOLSER range, and then performing a manual inventory to assign those cartridges through the Cartridge Assignment Policy.

The Cartridge Assignment Policy is media-type specific. It is based on the six most significant characters of the cartridge label. The ranges of VOLSERs do not include the media-type indicator (L3, L4, JA, JJ, and so forth), which means that two identical labels (except for the media-type indicator) can be assigned to two different logical libraries, for example, libraries that contain LTO or 3592 drives.

Note: The Cartridge Assignment Policy does not reassign an assigned tape cartridge. To reassign a cartridge, use the procedure for assigning cartridges to a logical library.

Insert Notification

Insert Notification is an option that enables IBM TS3500 to monitor the I/O station for any new media that does not have a logical library assignment. This feature can be enabled through the Operator Panel or through the Tape Library Specialist. With Insert Notification enabled, when new media is detected, the Operator Panel displays a message that asks you to select a logical library. Any unassigned cartridges in the I/O station will be assigned to the logical library that you select (and all other logical libraries will not be able to access the cartridges). The library includes an option to defer any assignment and there is a time-out period when the deferral will automatically take effect.

Note: When one or more 4 I/O station doors are installed, the Insert Notification cannot be enabled.

12.5.2 Virtual I/O

The IBM TS3500 Tape Library has I/O stations and I/O slots that enable you to import and export up to 32 cartridges at any given time. The I/O slots are also known as *import/export elements (IEEs)*. Virtual I/O (VIO) slots increase the quantity of available I/O slots by allowing storage slots to appear to the host as I/O slots. Storage slots that appear to the host as I/O slots are called *virtual import/export elements (VIEEs)*. The goal of virtual I/O slots is to reduce the dependencies between the system administrator and library operator so that each person performs their import and export tasks without needing the other person to perform any actions. With virtual I/O slots, the library automatically moves cartridges from the I/O stations to physical storage slots and from physical storage slots to the I/O stations.

With virtual I/O slots, you can configure up to 255 VIEEs per logical library. Each logical library will have a unique VIEE address space that is not accessible by other logical libraries. New logical libraries will, by default, be assigned the maximum number of virtual I/O slots, while logical libraries that were defined (before ALMS is enabled) initially have the number of physical I/O slots in the library.

Prior to virtual I/O slots, the IEE space was comprised of physical I/O station slots (10, 30, 16, or 32 depending on the frame model type) that were shared by all logical libraries. If the application or system administrator did not explicitly import the cartridges from the I/O station into library storage, the cartridges remain in the I/O station, which reduced the number of IEEs available to process imports and exports.

With virtual I/O slots, when cartridges are inserted into the I/O station, the library will work with the Cartridge Assignment Policy or Insert Notification to assign a cartridge to the correct logical library VIEE space, and cartridges will automatically be moved into library storage slots. If there is no Cartridge Assignment Policy assigned and Insert Notification is disabled for a particular cartridge, that cartridge will be inserted into the VIEE space of all logical libraries and automatically get moved into a library storage slot. The VIEE temporarily takes on the attributes of an IEE until a host moves the cartridge into a *storage element (StE)*. When the host move occurs, if the cartridge is in a storage slot, no physical move is needed, and the element transitions from a VIEE to an StE. Similarly, when a host exports a cartridge from an StE, the physical storage slot will be reported as a VIEE without moving the cartridge to the I/O station. The library will monitor when free space is available in the I/O station and move exported cartridges at the library's convenience.

If a cartridge cannot be assigned, this situation will be reported as *Assignment Pending*. This situation can occur if the assigned logical library does not have any available VIEE slots, or if all of the logical libraries do not have a common VIEE to share. To resolve this situation, either free up VIEE addresses so they are available in all libraries, or make a specific assignment of this cartridge to a logical library.

With VIO, there is an option to *Hide/Show Exports*. Show Exports, the default, shows a VIEE inventory of cartridges exported from the logical library. These cartridges then fill one of the VIEE slots for that logical library. Export Complete is shown when the exported cartridge is physically in an I/O station slot.

Selecting Hide Exports moves the exported cartridges to a library-maintained export queue, the VIEE is free immediately for other imports or exports, and the exported cartridge disappears from the host application's inventory data. Exporting a cartridge will be reported as Export in Progress if there is no available VIEE and will not complete until one is available. With Hide Exports, this situation will not occur.

Support for Virtual I/O slots is provided at library microcode level 5360 and higher and is enabled, by default, when ALMS is enabled. Existing clients who have already enabled ALMS on their IBM TS3500 Tape Library will have to install a newer level of library microcode that supports virtual I/O and then manually enable the virtual I/O slots.

12.5.3 Using ALMS in practice

So how will working with ALMS differ from working without ALMS? Let us imagine an environment in which there are two people who work with the Tape Library each day:

- ▶ The Media Operator who physically loads and unloads cartridges into the I/O station
- ▶ The Storage Application Administrator who configures the library and uses the application to move tapes in and out of the library

We now consider the steps necessary to move 30 cartridges in and out of a TS3500 Tape Library with a 16 port I/O station, both with and without ALMS.

Loading 30 cartridges into a library without ALMS

The Media Operator:

- ▶ Manually sorts the cartridges into groups for different logical libraries
- ▶ Loads 16 cartridges from one of the groups into the I/O station
- ▶ Responds to a prompt on the Operator Panel regarding assigning the cartridges to one of the logical libraries
- ▶ Contacts the Storage Application Administrator to request that the cartridges are moved into the library to create room for the remaining cartridges
- ▶ Waits until the I/O station is empty and then inserts the next group of cartridges
- ▶ And so on

In this scenario, the Storage Application Administrator must run the application commands to move cartridges into storage slots each time that the I/O station is filled.

Loading 30 cartridges into a library with ALMS

The Media Operator:

- ▶ Loads any 16 cartridges
- ▶ Watches the library move the cartridges into the body of the library as soon as the I/O station door is closed
- ▶ Loads the remaining cartridges
- ▶ Contacts the Storage Application Administrator to inform the Storage Application Administrator that the cartridges have been put in the library

In this scenario, the Storage Application Administrator must still run the application commands to move cartridges into storage slots. As far as the application is concerned, the cartridges are in I/O slots, not storage slots. You and I know that the cartridges are actually located in a slot in the body of the library that is masquerading as an I/O slot, or in ALMS terms, a *virtual* I/O slot. The application is blissfully unaware of this virtual I/O slot. When the application executes the command to move the cartridge from the I/O slot into a storage slot, there is no cartridge movement. Instead, ALMS changes the status of the slot from a virtual I/O slot to a storage slot, which happens in an instant.

Unloading 30 cartridges from a library without ALMS

The Storage Application Administrator:

- ▶ Determines how many I/O station slots are currently empty
- ▶ Uses the application to move the same number of cartridges into the I/O station
- ▶ Contacts the Media Operator and asks the Media Operator to remove the cartridges now to create empty slots
- ▶ Waits for confirmation from the Media Operator that the Media Operator has emptied the I/O station
- ▶ Uses the application to move the remaining cartridges into the I/O station
- ▶ Informs the Media Operator that there are additional cartridges to be unloaded and the Media Operator then removes the remaining cartridges

Unloading 30 cartridges from a library with ALMS

The Storage Application Administrator:

- ▶ Uses the application to move all the cartridges into the I/O station.
- ▶ Informs the Media Operator that there are 30 cartridges to be unloaded and the Media Operator then removes the cartridges present in the I/O station, closes the I/O station

door, and watches the remaining cartridges get immediately ejected. The last cartridges can then be removed.

In this scenario, the Storage Application Administrator does not need to be concerned when the I/O station fills. When it does fill, ALMS will change the status of the storage slots that contain the outstanding cartridges still in the body of the library to virtual I/O slots. From the viewpoint of the application, it has completed its job successfully. Actually, ALMS will move the remaining cartridges into the I/O station when the Media Operator has removed the cartridges that are currently present.

12.6 Environmental specifications

The IBM TS3500 Tape Library is a stand-alone tape subsystem consisting of one or more frames and capable of modular expansion to provide large capacities. The frames join end-to-end with the base frame on the left (viewed from the front) and the expansion frames extending to the right.

12.6.1 Physical dimensions

Table 12-11 indicates the physical dimensions of the IBM TS3500 Tape Library frames, and Table 12-12 gives their weights according to the number of installed drives, robotics, and tape cartridges.

Table 12-11 Physical dimensions

	Width	Depth	Height
L32 and D32	72.5 cm (28.5 in.)	152 cm (59.8 in.)	180 cm (70.9 in.)
L23, D23, L53, D53, and HA1	72.5 cm (28.5 in.)	121.2 cm (47.72 in.)	180 cm (70.9 in.)

Table 12-12 IBM TS3500 Tape Library weight

	Weight of base frame with 1 drive and 0 cartridges	Weight of base frame with 12 drives and maximum cartridges
L32	425 kg (937 lb.)	570 kg (1256 lb.)
D32	355 kg (784 lb.)	558 kg (1229 lb.)
L53	366 kg (806 lb.)	526 kg (1160 lb.)
D53	274 kg (604 lb.)	483 kg (1065 lb.)
L23	364 kg (802 lb.)	534 kg (1178 lb.)
D23	270 kg (596 lb.)	494 kg (1089 lb.)
HA1	261 kg (575 lb.)	N/A

Each frame has a set of casters and four leveling jackscrews. The nominal height from the bottom of the jackscrews to the top of the frame is 1840 mm (72.4 in.) and can be varied by ± 40 mm (± 1.6 in.). The shipping height of the IBM TS3500 Tape Library (on its casters and with jackscrews raised) is 1800 mm (70.9 in.).

Table 12-13 on page 364 gives physical specifications (such as height, width, depth, and weight) of models Sxx of the TS3500 Tape Library.

Table 12-13 Physical characteristics of the TS3500 Tape Library, Model Sxx

	S24 frame	S54 frame
Height of frame (on casters)	1800 mm (70.9 in.)	1800 mm (70.9 in.)
Width of frame with cover	782 mm (30.8 in.)	782 mm (30.8 in.)
Width of frame without covers ^a	725 mm (28.5 in.)	725 mm (28.5 in.)
Depth of frame (including front and rear doors)	1212 mm (47.72 in.)	1212 mm (47.72 in.)
Weight of base frame with 0 cartridges	285.8 kg (630 lb.)	290.3 kg (640 lb.)
Weight of frame with maximum cartridges	526.2 kg (1160 lb.) ^b	562.5 kg (1240 lb.) ^c

a. Frame width only. Additional interframe spacing of 30 mm (1.2 in.) is required.

b. Maximum 1000 3592 Tape Cartridges. The weight with cartridges assumes a cartridge weight of .242 kg (.534 lb.) for a standard 3592 Tape Cartridge. The actual weight of the library varies, depending on the configuration and cartridge capacity.

c. Maximum 1320 Ultrium Tape Cartridges. The weight with cartridges assumes a cartridge weight of .206 kg (.454 lb.) for a standard LTO Ultrium Tape Cartridge. The actual weight of the library varies, depending on the configuration and cartridge capacity.

When planning for the installation, consider the space implications in your computer room for the possibility of adding more frames in the future.

12.6.2 Floor requirements

Install the library on a raised or solid floor. The floor must have a smooth surface and, if raised, must not have ventilation panels beneath the leveling jackscrews. If carpeted, ensure that the carpet is approved for computer-room applications. To accommodate unevenness in the floor, you can raise or lower the leveling jackscrews to the following specifications:

- ▶ Maximum allowable variance must not exceed 7 mm (0.27 in.) per 76 mm (3 in.).
- ▶ Maximum out-of-level condition must not exceed 40 mm (1.6 in.) over the entire length and width of the library.

The floor on which the library is installed must be able to support:

- ▶ Up to 4.8 kilograms per square cm (68.6 lbs. per square inch) of point loads exerted by the leveling jackscrews
- ▶ Up to 211 kilograms per square meter (43.4 lbs. per square foot) of overall floor loading

The number of point loads exerted depends on the number of frames that make up the library. There are four point loads per frame (located at the corners of each frame).

12.6.3 Operating environment

The IBM TS3500 Tape Library is designed to operate in the following environment:

- ▶ Temperature: 16 - 32 C (61 - 89 F)
- ▶ Relative Humidity: 20% - 80%
- ▶ Wet Bulb: 23 C (73.4 F) maximum

12.6.4 Power and cooling specifications

Power and cooling for the IBM TS3500 Tape Library components are provided by the housing frame. Each base and expansion frame that contains drives has its own *frame control assembly (FCA)*, which receives power from a client-supplied outlet and, in turn, provides AC power to all tape drives within the frame. The FCA for the L32, L53, and L23 contains two DC power supplies; actually, only one DC power supply is needed to operate the entire library. Before support was provided for 16 frames, all additional FCAs in the D frame included one additional DC power supply for redundancy. With support for 16 frames, the additional FCAs in the D32 no longer have a default-installed DC power supply.

Additional DC power supplies can nevertheless be ordered or made available for extra frames, as explained in 12.2.2, “Library control systems: Enhanced Frame Control Assembly” on page 334.

The FCA is not required in expansion frames that contain no tape drives.

Each frame receives single-phase (200-240 V AC) power on its own power cord from a client-supplied outlet. Certain countries or regions require two-phase power to achieve the 200-240 V AC required by the frame.

A Dual AC Power feature (FC1901), supporting either 110 V AC or 220 V AC, is available for the IBM TS3500 Tape Library, providing two independent line cords that can be connected to two independent client branch circuits. A power switch connects to one of two client power feeds and passes all AC power to the frame from that feed. The switch monitors the AC line voltage from the feed that it is using and automatically switches to the alternate AC power feed if the incoming voltage drops below a preset level.

Table 12-14 lists the power requirements for the L53 and D53 frames.

Table 12-14 Power requirements for the IBM TS3500 Tape Library

Power requirements	Types of line cord	
	220 V AC line cord	110 V AC line cord
AC line voltage	200 to 240 V AC (nominal)	100 to 127 V AC (nominal)
AC line frequency	50 to 60 Hz	50 to 60 Hz
Nominal power	1.4 kW	1.2 kW
Line current	8.0 A	12.0 A
kVA	1.6 kVA	1.2 kVA
Heat output	4.8 kBTU/hr.	4.1 kBTU/hr.
Inrush current	200 A (peak for 1/2 cycle)	100 A (peak for 1/2 cycle)

Note: The values shown are for frames with 12 tape drives installed.

12.7 Host platforms and device drivers

The IBM TS3500 Tape Library is supported on many operating systems. For a current list of host software versions and release levels that support the TS3500 Tape Library, refer to:

<http://www-03.ibm.com/systems/storage/tape/>

12.7.1 Feature codes

The following no-charge specify feature codes indicate the server platform to which the IBM TS3500 Tape Library is attached. These features are used by IBM for device driver distribution:

- ▶ FC9210: Attached to HP-UX
- ▶ FC9211: Attached to Sun system
- ▶ FC9212: Attached to Windows system
- ▶ FC9213: Attached to other non-IBM system
- ▶ FC9215: Attached to Linux system
- ▶ FC9216: Attached to System z Linux system
- ▶ FC9400: Attached to System i
- ▶ FC9600: Attached to System p

You are not limited to one platform-attach feature, because the library can be attached to more than one of these platforms. You cannot add more than one of each feature; in other words, if you have two or more Windows servers, only one FC9212 is required.

Tip: The device driver is available for each operating system on this FTP site:

<ftp://ftp.software.ibm.com/storage/devdrv/>

12.7.2 Device driver installation

Install the IBM device drivers for the IBM TS3500 Tape Library as follows:

- ▶ If you intend to use the IBM TS3500 Tape Library with a commercial software application (such as VERITAS Backup Exec or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM TS3500 Tape Library.
- ▶ If you do not intend to use the IBM TS3500 Tape Library with a commercial software application, install the latest tape and medium device driver from the following Web site:

<ftp://ftp.software.ibm.com/storage/devdrv/>

Refer to the installation instructions in the *IBM Tape Device Drivers Installation and User's Guide*, GA27-2130.

Note: If you use the IBM TS3500 Tape Library with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, conflicts can occur over which driver controls the drive. Many examples are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

12.8 Storage applications

Software to exploit the IBM TS3500 Tape Library is not provided with the library. Additional software support is available through products that you must obtain separately from IBM, IBM Business Partners, or independent software vendors.

You will find details for each application that supports Ultrium and 3592 Tape Drives and attachment methods. You must also contact your storage application vendor for more information about specific versions and supported platforms. Several examples of third-party software applications with IBM LTO drives and libraries are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

12.9 IBM TS3500 Tape Library initial setup

The following sections describe several of the major items that are required to implement, manage, and operate the IBM Ultrium tapes and libraries. We do not cover all tasks, and we do not intend to cover all of the specific commands. For more details, refer to the *IBM System Storage TS3500 Tape Library Installation and Planning Guide*, GA32-0469, and for a practical installation with examples, *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

12.9.1 Tape Encryption overview

The 3592 Model E tape drives and the TS1040 Tape Drives both support Tape Encryption with all three encryption methods. You can encrypt all 3592 data cartridges including the WORM and the extended data cartridges when you are using the 3592 Model E tape drives. For encryption on the TS1040 Tape Drive, you must use Ultrium 4 data cartridges or WORM 4 cartridges.

The TS3500 supports the following three encryption methods:

- ▶ Application-Managed Encryption

The application controls the encryption process and generates and provides the encryption keys to the tape drives, for example, Tivoli Storage Manager.

- ▶ Library-Managed Encryption

The tape library controls the encryption process through the library interface. An external Encryption Key Manager (EKM) is needed for this method of encryption and is available for AIX, i5/OS, Linux, HP-UX, Sun Solaris, and Windows. The tape drive is communicating with the EKM through the library interface using TCP/IP.

- ▶ System-Managed Encryption

The encryption process is set up implicitly through each instance of the IBM device driver.

Encryption is available at no charge for the 3592 Model E tape drives for all encryption methods. The TS1040 supports Application-Managed Encryption (AME) at no charge. However, we recommend that you order FC9900 for AME as well.

Feature Code 1604 and FC9900 must be ordered when you are planning to implement Library-Managed Encryption (LME) or System-Managed Encryption (SME) with the TS3500.

Configuring and managing encryption is a client responsibility and not the responsibility of the IBM SSR. In certain instances, SSRs will be required to enable encryption at a hardware level when service access or service password-controlled access is required.

You can set up to four key manager TCP/IP addresses when LME is used as an encryption method.

Setting up encryption

Setting up or changing the encryption can only be done using the Web User Interface and not using the Operator Panel. Before you start configuring your encryption on the TS3500, the EKM must already be installed. The IBM EKM is the component that assists the 3592 Model E tape drives and the TS1040 in generating, protecting, storing, and maintaining encryption keys. The EKM R2 must be used when TS1040s are installed in a tape library.

Basic setup steps

To set up or change the encryption method for each 3592 Model E Tape Drive or TS1040, perform the following steps:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Library** → **Logical Libraries**. The Manage Logical Libraries window displays. For each logical library, the Encryption Method column indicates whether encryption is Library-Managed, System-Managed, Application-Managed, is assigned no method (None), or is unable to be set (N/A).
3. To set or change a drive's method of encryption, select the check box of the logical library to which the drive belongs. If you select multiple logical libraries with dissimilar encryption methods, the Encryption Method field displays Mixed, and no changes can be made.
4. If ALMS is not enabled, all logical libraries for a given media type must be selected in order for the Modify Encryption Method to be invoked.
5. From the Select Action drop-down box, select **Modify Encryption Method** and select **Go**. The Modify Encryption Method pop-up window displays.
6. In the Encryption Method field, select the type of encryption that you want.

If you select the System-Managed Encryption method when using 3592 Model E Tape Drive, the window displays the installed 3592 Model E tape drives and indicates whether they are encryption-capable. Select the encryption-capable drives that you want to become encryption-enabled, and then select **Apply**.
7. If the encryption method is Library-Managed Encryption, the Encryption Policy selections are:
 - Barcode (default)
 - Internal Label-Selective Encryption
 - Internal Label-Encrypt All. This selection is only used for Symantec Veritas NetBackup.

Note: The default setting of the Library-Managed Encryption method is to encrypt all cartridges in a logical partition.

Advanced Encryption Settings

The purpose of Advanced Encryption Settings is to allow only IBM Support personnel (under the direction of the drive development team) to provide a solution to an unforeseen problem or to support a unique configuration. This option is not intended for the client to use without the guidance of IBM Support.

Setting up the EKM addresses

The next step is to set one or more EKM addresses. You can create, modify, or delete a key manager address by using the Tape Library Specialist Web interface but not by using the Operator Panel. You can test a key manager address by using both the Web and the Operator Panel.

To set up the EKM addresses:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Access** → **Key Manager Addresses**. The Key Manager Addresses window is displayed.
3. Perform one of these actions:
 - To create a key manager address: From the Select Action drop-down box, select **Create**, and then, select **Go**. The Key Manager Create window displays. Enter the IP address and port of the key manager. Select **Apply**.
 - To change a key manager address: Select the key manager address that you want to change. From the Select Action drop-down box, select **Modify**, and then, select **Go**. The Key Manager Modify window displays. Enter any necessary changes in the IP Address or Port fields. Select **Apply**.
 - To delete a key manager address: Select the key manager address that you want to delete. From the Select Action drop-down box, select **Delete**, and then, select **Go**. The window displays the message, “Are you sure you want to delete this key manager entry?” Select **OK**. A pop-up window confirms the deletion. Select **Close**.

Operational topics

In the next steps, we explain how to determine which encryption method is used for a tape drive and to determine whether a data cartridge is encrypted or not. We start first with the tape drive.

Determine encryption method

You can view a drive’s method of encryption by using the Tape Library Specialist Web interface, but not by using the Operator Panel:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Library** → **Logical Libraries**. The Manage Logical Libraries window displays. For each logical library, the Encryption Method column indicates whether encryption is Library-Managed, Application-Managed, System-Managed, is assigned no method (None), or is unable to be set to encryption (N/A).
3. To view a drive’s method of encryption, select the check box of the logical library to which the drive belongs.
4. From the Select Action drop-down box, select **View Encryption Method**, and then, select **Go**. The View Encryption Method pop-up window displays.
5. Locate the entry in the Encryption Method field. To return to the previous window, select **Cancel**.
6. If the encryption method is Library-Managed Encryption, the Encryption policy selections are:
 - Barcode (default)
 - Internal Label-Selective Encryption. This selection is only used for Symantec Veritas NetBackup.
 - Internal Label-Encrypt All. This selection is only used for Symantec Veritas NetBackup.

Cartridge status

If you want to determine whether a data cartridge is encrypted:

1. Type the Ethernet IP address on the URL line of the browser and press Enter. The Welcome Page displays.
2. Select **Cartridges** → **Data Cartridges**. The Cartridges window displays.
3. Select whether the cartridges are in a frame or logical library, select how you want the cartridges to be sorted, and then, select **Search**. The page refreshes and displays a list of VOLSER ranges as links in the upper right. It also displays information about each cartridge in the library. If the library is installed with an encryption-enabled TS1120 Tape Drive or TS1040 Tape Drive, the window includes an Encryption column that indicates whether the cartridge is Encrypted, Not Encrypted, or Unknown. An Unknown cartridge is one that has not been previously mounted in a 3592 Tape Drive or TS1040 Tape Drive.

There are more options available for Tape Encryption. To find out all of the options for Tape Encryption, refer to the *IBM System Storage Tape Library Operator Guide*, GA32-0560.

The methods of encryption for the TS1120 and the TS1040 Tape Drives are different. If you want to learn more about the difference between the two encryption methods, go to 2.2, “Tape Encryption overview” on page 61.

Note: TS1120 Tape Drives that were manufactured before 8 September 2006 do not have the capability to encrypt data on the data cartridge. However, there is a chargeable upgrade available (FC5592) to upgrade the TS1120. This encryption capability includes drive hardware, as well as microcode additions and changes.

12.9.2 SCSI ID

The IBM TS3500 Tape Library uses Multi-Path Architecture, so it has no direct SCSI connection to a host system. When the host communicates with the library, it must send the communication via a control path to a drive designated as logical unit number 1 (LUN 1). A *control path* is the drive SCSI port through which a host system sends its commands to a logical library within the IBM TS3500 Tape Library. Refer to 2.5.7, “Multi-path architecture” on page 88 for an explanation of the concept of logical libraries. When you add multiple control paths to the IBM TS3500 Tape Library, any single, configured logical library can be accessed by multiple host systems.

Additional control paths also reduce the possibility that failure in one control path will cause unavailability of the entire library.

Note: The setup and SCSI configuration of the IBM TS3500 Tape Library are usually performed by an IBM SSR.

12.9.3 Element number

Element numbers identify the physical location within the library. This information is required mostly for storage applications, such as IBM Tivoli Storage Manager, which translate the device to a name that the robotic system understands.

In the IBM TS3500 Tape Library, each SCSI storage element is assigned a SCSI element address. A *SCSI storage element* is a physical location capable of holding a tape cartridge (such as an I/O slot, drive, or storage slot). The element numbering is grouped in:

- ▶ Tape drive sequence
- ▶ I/O station sequence

► Cartridge slot sequence

Note: The numbering is contiguous for the cartridge slot sequence. However, the addition, removal, or movement of one or more tape drives affects the element numbering of the cartridge slots.

Table 12-15 shows the element numbers for tape drives in each IBM TS3500 Tape Library frame up to six frames. For element numbers up to the maximum 16 frames, refer to the *IBM System Storage Tape Library Operator Guide*, GA32-0560.

Table 12-15 IBM TS3500 Tape Library tape drive element numbers

Drive number	Frame 1 (Lx3)	Frame 2 (Dx3)	Frame 3 (Dx3)	Frame 4 (Dx3)	Frame 5 (Dx3)	Frame 6 (Dx3)
1	257	269	281	293	305	317
2	258	270	282	294	306	318
3	259	271	283	295	307	319
4	260	272	284	296	308	320
5	261	273	285	297	309	321
6	262	274	286	298	310	322
7	263	275	287	299	311	323
8	264	276	288	300	312	324
9	265	277	289	301	313	325
10	266	278	290	302	314	326
11	267	279	291	303	315	327
12	268	280	292	304	316	328

Each element in the IBM TS3500 Tape Library (the cartridge storage slots, I/O storage slots, and tape drives) has two addresses:

- Physical address
- SCSI element address

When initiating an operation, such as moving a tape cartridge or performing manual cleaning, you can use the physical or logical address to specify a location in the library.

The physical address consists of frame, column, and row identifiers that define a unique physical location in the library. The address is represented as:

- *Fx,Cyy,Rzz* for a storage slot (where *F* equals the frame and *x* equals its number, *C* equals the column and *yy* equals its number, and *R* equals the row and *zz* equals its number)
- *Fx,Rzz* for a tape drive and I/O storage slot (where *F* equals the frame and *x* equals its number, and *R* equals the row and *zz* equals its number)

The SCSI element address consists of a bit and hex value that defines to the SCSI interface a logical location in the library. This logical address is represented as *xxxx (X'yyy')*, where *xxxx* is a bit value and *yyy* is a hex value. It is assigned and used by the host when the host processes SCSI commands. The SCSI element address is not unique to a storage slot, drive, or I/O slot; it varies, depending on the quantity of drives in the library.

For example, the storage slot address F2,C03,R22 means:

- ▶ F2: Frame 2 (first expansion frame)
- ▶ C03: Column 3 (second column from left on drive side)
- ▶ R22: Row 22 (22nd position down from the top of the column)

Each drive has a unique address to indicate its physical location. The drive address consists of two values: a frame number and a row number:

- ▶ Frame number: Represented as *Fx*, where *F* equals the frame and *x* equals its number. Regardless of whether any drives are installed, the frame number for the base frame is 1 and increments by one for each adjacent expansion frame.
- ▶ Row number: Represented as *Rzz*, where *R* equals the row and *zz* equals its number. The row number is 1 for the top drive position in the frame and increments by one for each row beneath the top drive. Regardless of whether drives are installed, the row numbering is the same for every frame.

A drive address of F2,R10 means frame 2 (that is, the first expansion frame), row 10 (tenth drive position from the top of the column).

Note: ALMS will virtualize a SCSI element address. Therefore, there is no relationship between physical location and SCSI element address if you use ALMS.

12.10 Operator displays and buttons

The IBM TS3500 Tape Library-Lxx operator display is a touch screen with integrated touch buttons. The display default setting returns to the basic main menu after five minutes of inactivity. The window has three sections (Figure 12-23 on page 373):

- ▶ Menu title and panel number
- ▶ Informational section
- ▶ Selectable buttons

Navigate through the Operator Panels by pressing the touch screen buttons:

- ▶ BACK: Will take you back to the previous window. You might need to press the BACK button several times to return to the main status window.
- ▶ UP and DOWN: If you are on a menu panel, these keys will navigate up and down in the current panel, scrolling one line when pressed once. If you keep the UP or DOWN keys pressed, scrolling will speed up. The longer you hold the keys, the faster the scrolling.
If you are selecting a value, the keys will increment or decrement the value.
- ▶ ENTER: The selected item is shown using reverse video. No action is processed until you press ENTER.

The default display is the Activity Status Display. The information in the Activity window is replaced automatically by an error message whenever the Ultrium tape library detects that:

- ▶ A permanent error has occurred.
- ▶ A drive requires cleaning, and automatic cleaning has been enabled.
- ▶ A drive requires cleaning, and no cleaning cartridge is present in the library.

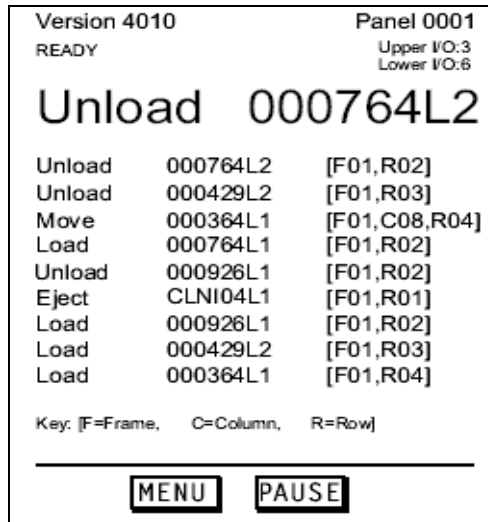


Figure 12-23 IBM TS3500 Tape Library-L32 operator display

Other commands or options will appear on various windows. From the main activity window, you can access the Library Main Menu by pressing MENU, or pause the library for a maintenance operation with the PAUSE key.

The PAUSE key causes the library to park the cartridge accessor in an area that gives clear access to the library's interior (if you need to open the front door). If you accidentally press the PAUSE key, wait for the 30 second time-out. The library will automatically resume operation.

Important: If you press the PAUSE key and open the front door, the library rejects requests for new operations.

When selecting a critical command, such as pressing PAUSE, a confirmation window displays with a text message with two keys, CONTINUE and CANCEL. The CONTINUE key proceeds and executes your command, and the CANCEL key returns to your previous window.

The windows on the Operator Panel fall into six categories:

Library status	Provides data about the accessor, cartridge locations, drives, and slots
Manual operations	Enables manual intervention, such as cartridge movements, cleaning, and inventory
Settings	Displays and changes configuration setup variables, such as cleaning mode, date, enabling and disabling drives, and virtual library configuration
Statistics	Reports usage data about the accessor, drives, and cleaning cartridges
Vital Product Data	(VPD) Describes the library, drives, and accessor, which includes information, such as the machine types, model numbers, serial numbers, and the level of firmware
Service	Places the library into service mode to carry out repairs or upgrades



Library management

In this chapter, we discuss the tools and technologies that you can use to perform initial and ongoing library configuration and maintenance and to monitor the technical health of the library. We provide an introduction to the Storage Management Initiative Specification (SMI-S), a standard that you can exploit to significantly reduce the effort associated with the management of storage devices, such as disk arrays, SAN fabric devices, and more recently, tape libraries.

In addition, we discuss management features unique to specific tape library models.

13.1 Library management overview

For the purposes of this chapter, we define *library management* to include the tasks associated with initially configuring a tape library and then performing the ongoing tasks necessary to maintain technical health. We are not discussing operational tasks, such as loading and unloading cartridges. This chapter therefore describes the tools available (rather than describing each of the management tasks in detail) to assist you in performing the following tasks. These tasks are general and do not necessarily apply to all libraries:

- ▶ *Configuration customization*, which includes the following tasks:
 - Defining logical libraries
 - Defining a network address for the library Ethernet interface
 - Bringing drives and logical libraries online and offline
 - Defining how many characters to use in the VOLSER
 - Defining user IDs to use to access the Web interface or Operator Panel
 - Enabling automatic tape drive cleaning
- ▶ *Configuration viewing*, which includes displaying the following information regarding the library configuration:
 - Drive information, such as serial numbers, worldwide names (WWNs), and which cartridges are loaded
 - Cartridge inventory
 - I/O slot occupancy
 - Logical library configuration
- ▶ *Displaying error messages*. Seeing which error messages have been recorded by library components and tape drives
- ▶ *Alerting error messages*. Sending error messages to another location for attention, which can occur by e-mail or Simple Network Management Protocol (SNMP)
- ▶ *Updating firmware*. Keeping library and drive firmware up-to-date

13.2 Management tools and technologies

In this section, we introduce the tools and technologies that you can use to assist with library management:

- ▶ Operator Panel
- ▶ Web User Interface
- ▶ TapeAlert
- ▶ SNMP
- ▶ SMI-S
- ▶ IBM TotalStorage Tape Diagnostic Tool (ITDT)
- ▶ IBM Ultrium Device Driver

13.2.1 Operator Panel

The Operator Panel is the Liquid Crystal Display (LCD) on the front of each library. You control it by pressing buttons or it can be touch-sensitive. You perform the majority of tape management tasks directly via the Operator Panel. Note that the menu items available are different on different models of tape libraries. To confirm exactly which menu options a particular library displays, refer to the relevant Setup and Operator Guide.

Typical features available through the Operator Panel on most IBM tape libraries include:

- ▶ Library configuration:
 - Setting the network address
 - Bringing drives online and offline
 - Changing the mode of the library from random to sequential (TS2900, TS3100, TS3200, and TS3400)
 - Configuring logical libraries (TS3100, TS3200, TS3400, TS3310, and TS3500)
 - Configuring the library to send an e-mail with the error conditions (TS2900, TS3100, TS3200, TS3400, and TS3310)
 - Configuring the library to send error conditions as SNMP traps (TS2900, TS3100, TS3200, TS3400, TS3310, and TS3500)
- ▶ Viewing configuration details. Displaying information regarding:
 - Firmware levels for the library and the drives
 - Library inventory
 - Drive serial numbers
 - The number of empty slots and occupied slots
 - Cartridges in the I/O slots
- ▶ Diagnostics:
 - Displaying error logs
 - Running diagnostic routines to test the library and tape drives
- ▶ Control:
 - Unlocking the I/O station
 - Moving cartridges
 - Performing an inventory

Table 13-1 summarizes the management tasks that are available through the Operator Panel.

Table 13-1 Summary of management capabilities available with the Operator Panel

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Yes	Yes	Yes	No ^a	No ^b

a. Although the Operator Panel does not perform alerting, configuration to e-mail or send SNMP traps is performed here.

b. Strictly speaking, this functionality is somewhat available on certain libraries, but it is not the recommended approach.

Most management tasks can be performed through the Operator Panel. However, the inherent drawback is that someone must be physically present to activate the panel and view the output (directing a colleague over the phone to operate the panel and read back what that person sees generally yields unsatisfactory results). With tape libraries often located remotely from those people who manage them, the Operator Panel is often inadequate in meeting the needs of Library Managers. It is, however, the main interface used by IBM Support Service Representatives (SSRs).

The remainder of the tools and technologies introduced in this chapter provide remote management capability.

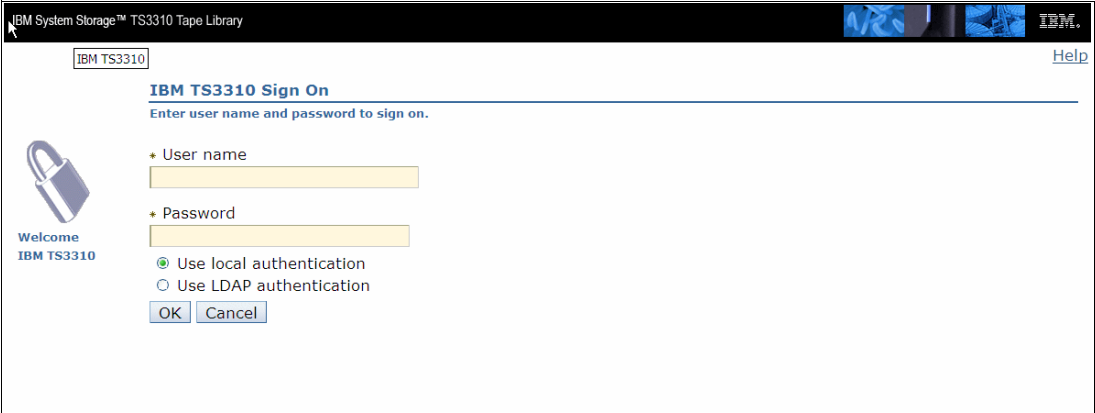
13.2.2 Web User Interface

The remote management of tape libraries through a Web User Interface (Web UI) is a standard feature of all currently marketed IBM Tape Libraries. Note that the menu options and even the style of the Web UI differ between different library models. However, they offer broadly similar functionality. Use of the Web UI is implemented by configuring an IP address through the Operator Panel. In addition, user IDs and passwords can be defined with different access levels.

Note: Each tape library ships with a default administrative user ID and password (admin/secure) for accessing the Web UI. Change this default immediately after defining the network address.

Also, be aware that restricting access to the Web UI is optional on earlier tape libraries. We strongly recommend that restricting access is always enabled.

Display the Web UI sign-on in a window by entering the Web address into your browser, as shown in Figure 13-1.



The screenshot shows a web browser window titled "IBM System Storage™ TS3310 Tape Library". The page has a black header bar with the IBM logo on the right. Below the header, the page content is white. On the left, there is a blue padlock icon and the text "Welcome IBM TS3310". In the center, the heading "IBM TS3310 Sign On" is followed by the instruction "Enter user name and password to sign on.". There are two input fields: "User name" and "Password", both with a small blue plus icon to their left. Below these fields are two radio buttons: "Use local authentication" (which is selected) and "Use LDAP authentication". At the bottom of the form are "OK" and "Cancel" buttons. A "Help" link is visible in the top right corner of the page content area.

Figure 13-1 The Web User Interface sign-on window for the TS3310

After signing on, a menu appears that offers broadly the same functionality as that provided by the Operator Panel. The window in Figure 13-2 on page 379 shows summary information and the fully expanded menu available on the TS3310 Tape Library.

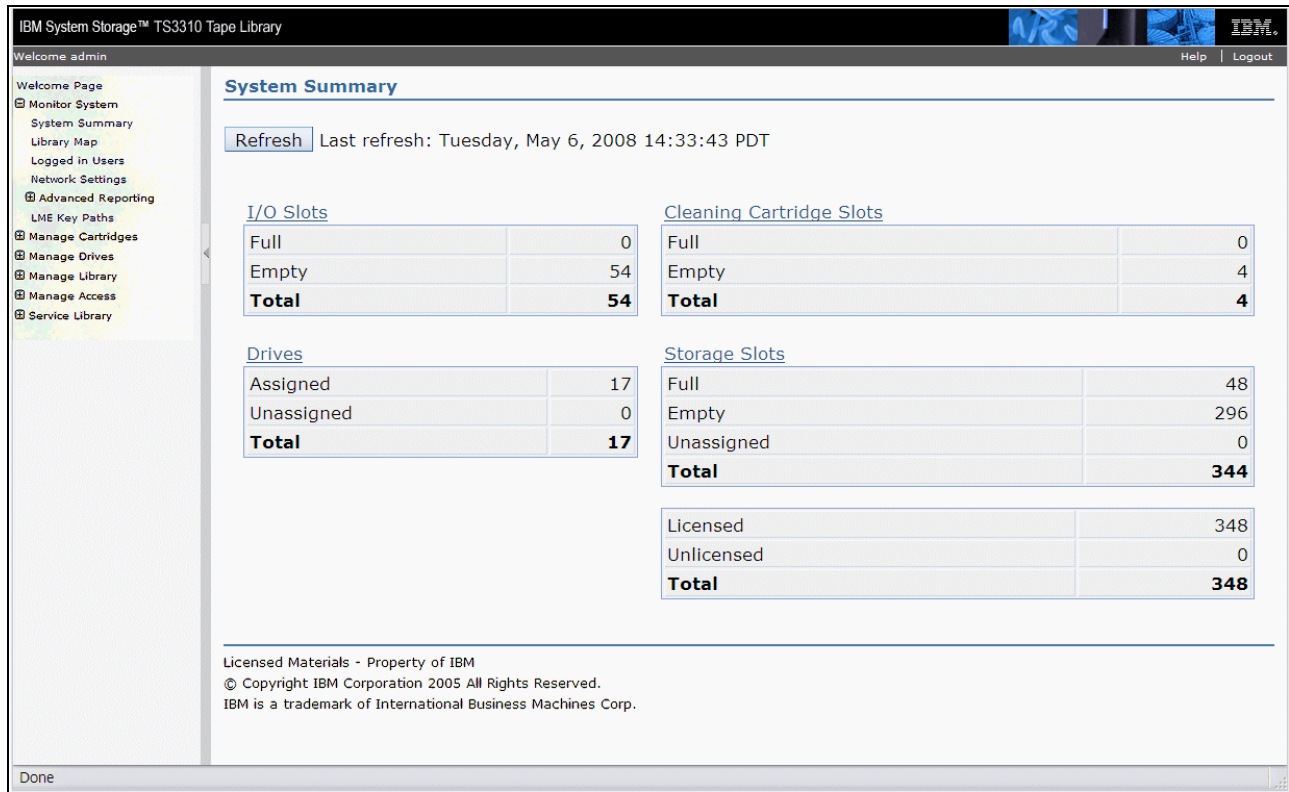


Figure 13-2 Web User Interface menu and System Summary display

Although the Web UI and Operator Panel functionality are similar, certain library models can have specific functionality that is only available through the Web UI. For example:

- ▶ The TS2900 Tape Autoloader:
 - User Access configuration
 - Event notification configuration
 - Key Path Diagnostics
 - Download Library Logs
 - Encryption
 - Reset Library/Drive
- ▶ TS3100 and TS3200 Tape Libraries:
 - Event notification configuration
 - Error log configuration
 - Library restart
 - Encryption
 - Library firmware upgrade (only possible via the Web UI)
- ▶ TS3310 Tape Library:
 - Library firmware upgrade (only possible via the Web UI)
 - Advanced Reporting
- ▶ TS3400 Tape Library:
 - Encryption
 - Event notification configuration
 - Error log configuration

- ▶ The TS3500 Tape Library:
 - Advanced Library Management System (ALMS) configuration
 - Detailed logs regarding the mount history, drive statistics, Fibre Channel port statistics (available with library firmware 5500), and library statistics (available with library firmware 6xxx) can be downloaded.

This list is not meant to be comprehensive. Check the documentation shipped with each library to confirm the functionality available through the Web UI for specific library models.

To summarize the management functionality that is available through the Web UI, refer to Table 13-2.

Table 13-2 Summary of management capabilities available with the Web User Interface

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Yes	Yes	Yes	No. Although the Operator Panel does not perform alerting, configuration to e-mail or send SNMP traps is performed here.	Yes

The Web UI is clearly a comprehensive tool. We recommend that every library is network-connected to take advantage of the facilities available. Indeed, certain functionality just outlined is *only* available via the Web UI, making this tool indispensable.

13.2.3 TapeAlert

All IBM Ultrium Tape Libraries are compatible with TapeAlert technology, which provides error and diagnostic information about the drives and the library to the server to which the drives are connected. *TapeAlert* is an industry standard that defines status conditions and problems experienced by devices, such as tape drives, autoloaders, and libraries. The standard enables a TapeAlert-aware application, such as Tivoli Storage Manager, to read TapeAlert messages (called *flags*) from a tape drive via the SCSI bus. The server reads the flags from Log Sense Page 0x2E.

For a full list of the possible flags, refer to the appendix of the relevant Setup and Operator Guide.

TapeAlert Messages and Tivoli Storage Manager

In Tivoli Storage Manager, you can set tape alert messages to be on or off by using the Tivoli Storage Manager Administration command **set tapealertmsg on** or **set tapealertmsg off**. You can query tape alert messages by using the **query tapealertmsg** command.

TapeAlert has only three severity levels:

- ▶ Critical
- ▶ Warning
- ▶ Informational

Certain critical messages result in ANRxxxxS, while others use ANRxxxxE, depending on the text. Examples of each warning type are:

- ▶ ANRxxxxS Device /dev/rmt1, volume VOL123 has issued the following Critical TapeAlert: Your Data is at risk. 1. Copy any data you require from this tape. 2. Do not use the tape again. 3. Restart the operation with a different tape.
- ▶ ANRxxxxE Device /dev/lb0, volume NONE has issued the following Critical TapeAlert: The library has a problem with the host interface. 1. Check the cables and cable connections. 2. Restart the operation.
- ▶ ANRxxxxW Device /dev/lb0, volume NONE has issued the following Warning TapeAlert: A hardware failure of the library is predicted. Call the library supplier helpline.
- ▶ ANRxxxxI Device /dev/mto, volume MYVOL1 has issued the following Informational TapeAlert: You have tried to load a cartridge of a type which is not supported by this drive.

If you monitor Tivoli Storage Manager events using the Tivoli Enterprise Console® or SNMP, you can also monitor IBM Ultrium tape libraries indirectly by enabling tape alert messaging as just described within Tivoli Storage Manager.

Table 13-3 Summary of management capabilities available with TapeAlert

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	No	Yes	No

TapeAlert is a technology inherent to IBM Ultrium tape drives to permit sending tape and library alerts to servers connected to the tape library. It is especially useful if you are already monitoring your servers and applications, such as Tivoli Storage Manager, because this effectively means that the tape libraries and drives are also monitored by default.

13.2.4 SNMP

Simple Network Management Protocol (SNMP) forms part of the Internet protocol suite as defined by the Internet Engineering Task Force. Originally developed in 1988, the protocol can support monitoring of network-attached devices for any conditions that warrant administrative attention. The protocol has been developed from its original inception as Version 1 to Version 2 and Version 3.

Managed devices (*agents*) can send SNMP “traps” or “notifications” (essentially alerts concerning a change in state) to an SNMP Manager, such as IBM Tivoli NetView, from which multiple network devices can be monitored and managed.

The details of exactly what conditions can cause alerts are described in a *Management Information Base (MIB)*. A MIB is a formal description of a set of network objects that can be managed using SNMP. This file must be loaded into the SNMP Manager so that the notifications received can be correctly interpreted.

Library configuration information can be requested with an SNMP Manager. This is achieved using a MIB Browser, which runs an SNMP WALK command to retrieve all managed object values.

The TS2900 Tape Autoloader, TS3100, TS3200, TS3310, TS3400, and TS3500 Tape Libraries support SNMP. For the TS3500 library, you can find the MIB file at:

<ftp://ftp.software.ibm.com/storage/358x/3584/>

For the other tape libraries, go to:

<http://www-01.ibm.com/systems/support/storage/>

Table 13-4 is a summary of the management capabilities that are available with SNMP.

Table 13-4 Summary of management capabilities available with SNMP

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	Yes	No ^a	Yes	No

a. Errors are always alerted to be viewed remotely.

13.2.5 SMI-S

As storage technologies become increasingly affordable, the demand for storage hardware has also increased. As a consequence, the workload associated with managing this expanding infrastructure is also increasing. The task of staying in control of tape libraries, SAN switches, and disk arrays from a variety of vendors, each with their own unique management tools, naturally becomes a greater challenge.

It is against this background that the Storage Networking Industry Association (SNIA), a vendor neutral organization, defines standards-based management for storage devices. The goal of using a single tool to permit management of storage devices from a wide variety of vendors is only possible if those storage devices conform to an agreed to management interface. The SNIA has defined an interface for just this purpose, the Storage Management Interface Specification (SMI-S). If a device conforms to SMI-S, Resource Management Applications that use the SMI-S, such as the IBM TotalStorage Productivity Center, are able to manage aspects of those storage devices that are defined in that version of the SMI-S.

SMI-S 1.2 has been defined for library management, and Storage Working Groups in SNIA are now working on the next releases of SMI-S to broaden the scope of the interface. This permits a greater range of common functionality to be managed centrally from a common interface. SMI-S is, therefore, always an evolving standard.

Products that conform to SMI-S can be submitted to the SNIA to demonstrate that they pass conformance tests that are defined by the Storage Working Groups in the SNIA. You can view a list of providers of products that can demonstrate conformance at the following Web site:

<http://www.snia.org/ctp/conformingproviders>

IBM tape libraries and SMI-S

IBM has achieved official conformance for the management of the TS3310 and TS3500 Tape Libraries, which is achieved by implementing "SMI-S Agent for Tape" on a Linux system. The Agent acts as an interface between the Resource Management Application and one or multiple TS3310 and TS3500 Tape Libraries.

In addition, the TS3310 Tape Library natively supports SMI-S 1.2. The SMI-S support is embedded within the library. The tape library passed the SNIA conformance testing, and this tape product is now listed on the SNIA Web site.

The 3494 has very limited support for SMI-S. However, certain library details can be seen in the IBM Resource Management Application, the IBM TotalStorage Productivity Center (TPC). In addition, you can start the Web User Interface from within TPC.

Although no other IBM Tape Libraries support SMI-S, it is still possible to list unsupported libraries in a Storage Resource Manager and then initiate the Web User Interface.

IBM TotalStorage Productivity Center (TPC)

TPC is a suite of storage infrastructure management software that can centralize, automate, and simplify the management of complex and heterogeneous storage environments. It can improve storage capacity utilization and improve administration efficiency. TPC brings together in a single interface the management of storage devices, fabric, data, and now with the TPC V3.3 release, TPC supports TS3500, 3494, TS3310, and any SMI-S compliant tape subsystems.

TPC provides the following capabilities:

Device discovery	Tape libraries, disk, and fabric devices can be automatically discovered to facilitate TPC configuration.
Topology viewer	This viewer displays how storage elements are connected, for example, which tape drives are connected to which ports on a SAN switch.
Configuration display	The current configuration and utilization of storage devices can be viewed.
Monitoring	Thresholds can be set that will trigger actions; for example, if a file's system utilization expands beyond 90%, a script can be run to increase the size.
Alerting	Conditions, such as SNMP traps issued from managed devices, can be logged and can optionally cause another action to be initiated, for example, sending the event to a Tivoli Enterprise Console.
Management	Devices can be manually configured from within the TPC, such as the SAN Volume Controller.

For further information regarding TPC, refer to *IBM TotalStorage Productivity Center V3.1: The Next Generation*, SG24-7194, and *TotalStorage Productivity Center V3.3 Update Guide*, SG-7490.

Tape library management through TPC

TPC can display all information that is currently defined in SMI-S 1.2. The next few pages show windows available within TPC to demonstrate the configuration and status information that is currently viewable. Note that SMI-S 1.2 does not include the concept of logical libraries or virtual I/O slots, so this information cannot be displayed. Note also that SMI-S 1.2 is limited to *displaying* configuration information, not *changing* configuration information. You can change configuration information by starting the Web User Interface from within TPC. Alerts from SNMP traps are logged and displayed in TPC, but it is not yet possible to initiate actions as a result of those traps, for example, to forward the error condition to a Tivoli Enterprise Console.

To provide a better appreciation of tape library management within TPC, we display several of the windows that you view when working with the Tape Manager. TPC provides a menu on the left of the window that provides the capability to work with different classes of storage devices. As you can see in Figure 13-3, this includes:

- ▶ Data Manager
- ▶ Data Manager for Databases
- ▶ Data Manager for Chargeback
- ▶ Disk Manager
- ▶ Fabric Manager
- ▶ Tape Manager

Tape Manager is used to drill down to view all of the tape libraries and to work with them. Our demonstration begins with selecting the Tape Manager menu (Figure 13-3).

Selecting tape libraries

This first window is viewed by selecting tape libraries under the Tape Manager. In this demonstration environment, only one library is being managed, and this library is identified on the right along with its current status, number of tape drives, and cartridges. The Element Manager refers to the Web User Interface.

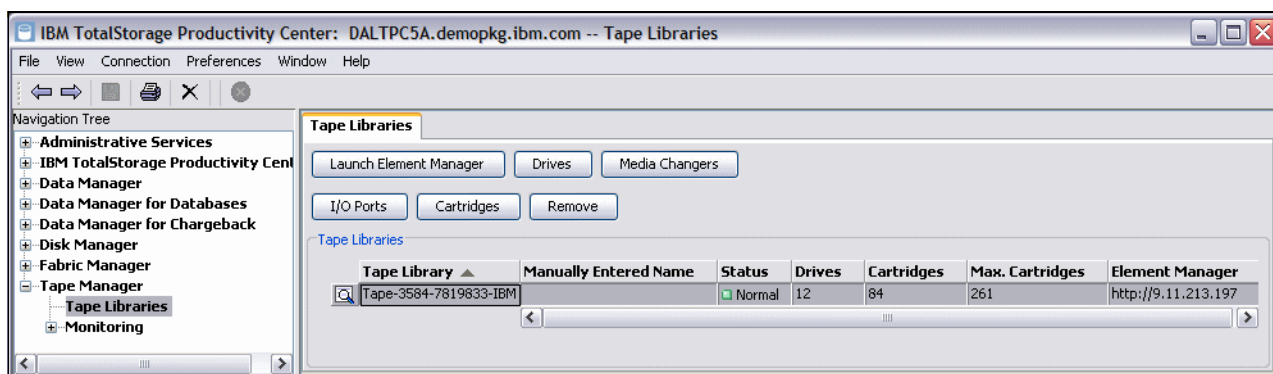


Figure 13-3 TPC window showing a list of tape libraries managed

The following pages show the windows displayed when selecting:

- ▶ The magnifying glass to the left of the tape libraries in the list (a short list of one tape library in this example)
- ▶ The Drives button
- ▶ The Media Changers button
- ▶ The I/O Ports button
- ▶ The Cartridges button

Selecting the magnifying glass

Figure 13-4 on page 385 provides further details concerning this library, including the option to update fields, for example, to include contact details for on-site staff.

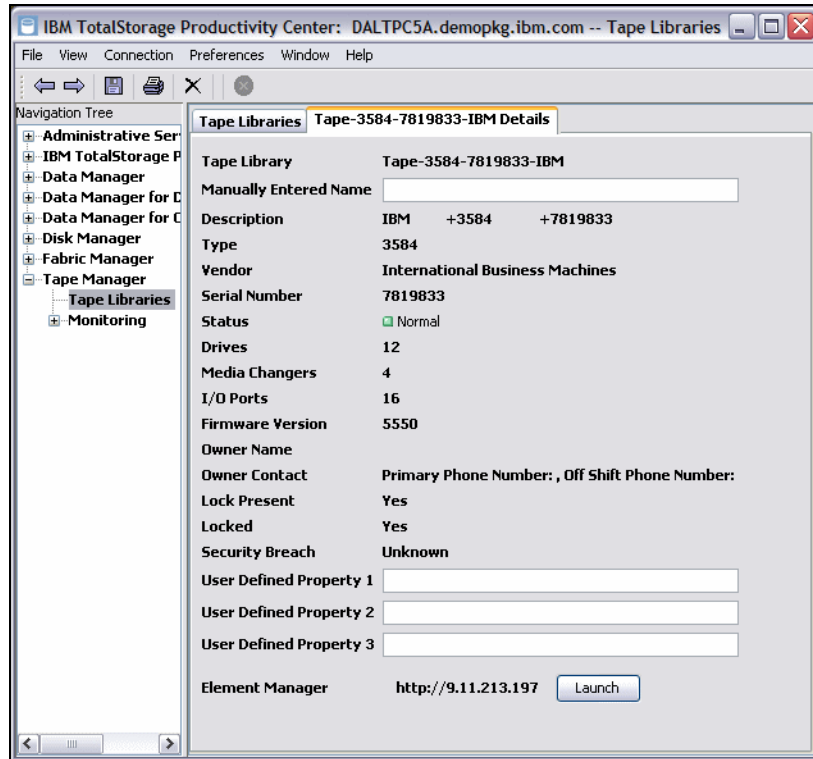


Figure 13-4 TPC window showing tape library details

Selecting drives

Figure 13-5 shows information, such as the status for each drive, the number of mounts performed by the drive, and firmware levels.

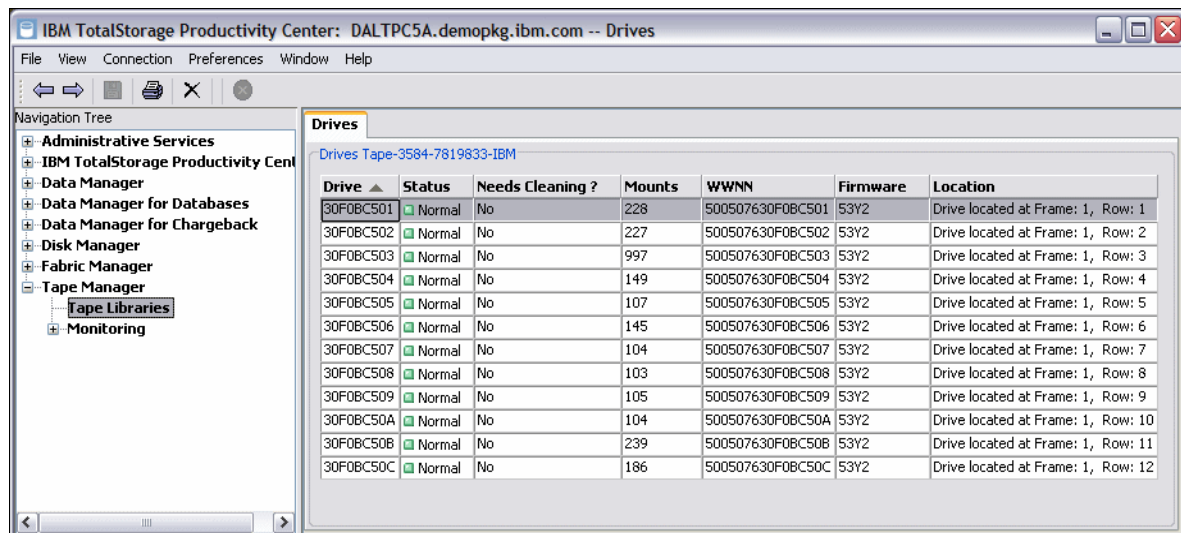


Figure 13-5 TPC window shown when selecting drives

Selecting media changers

Figure 13-6 lists all the media changers available for a library. Each of these media changers provides an independent path that you can use to control the library. Define redundant paths, per logical library, in order to allow control of the library in the event of a path failure.

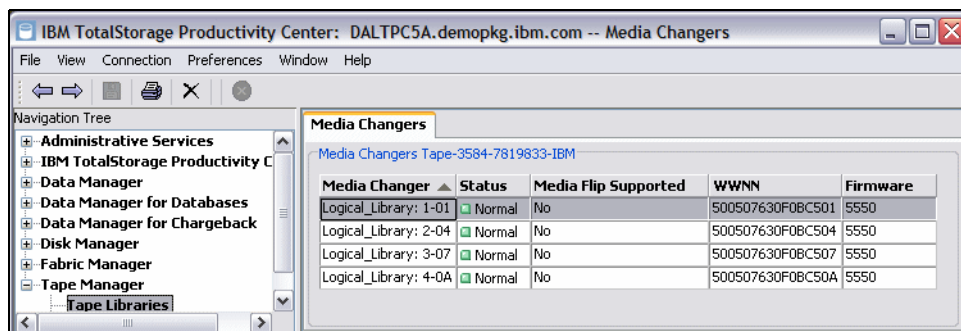


Figure 13-6 TPC window shown when selecting media changers

Selecting I/O ports

Figure 13-7 shows each I/O port in the library and its location.

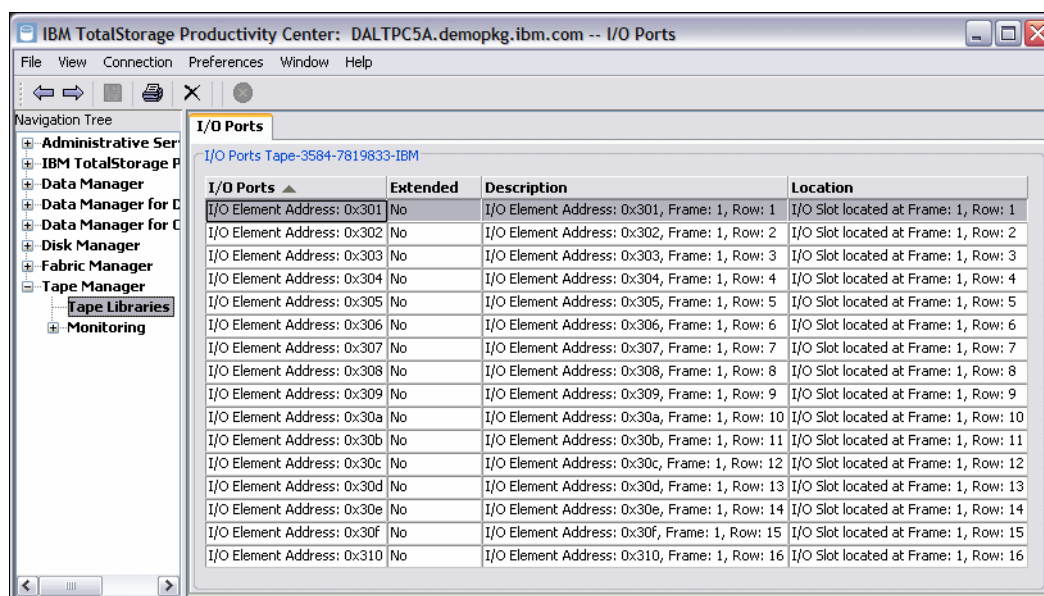


Figure 13-7 TPC window shown when selecting I/O ports

Selecting cartridges

To conclude this demonstration, we can see the inventory of the library and the location of each cartridge in that inventory in Figure 13-8 on page 387.

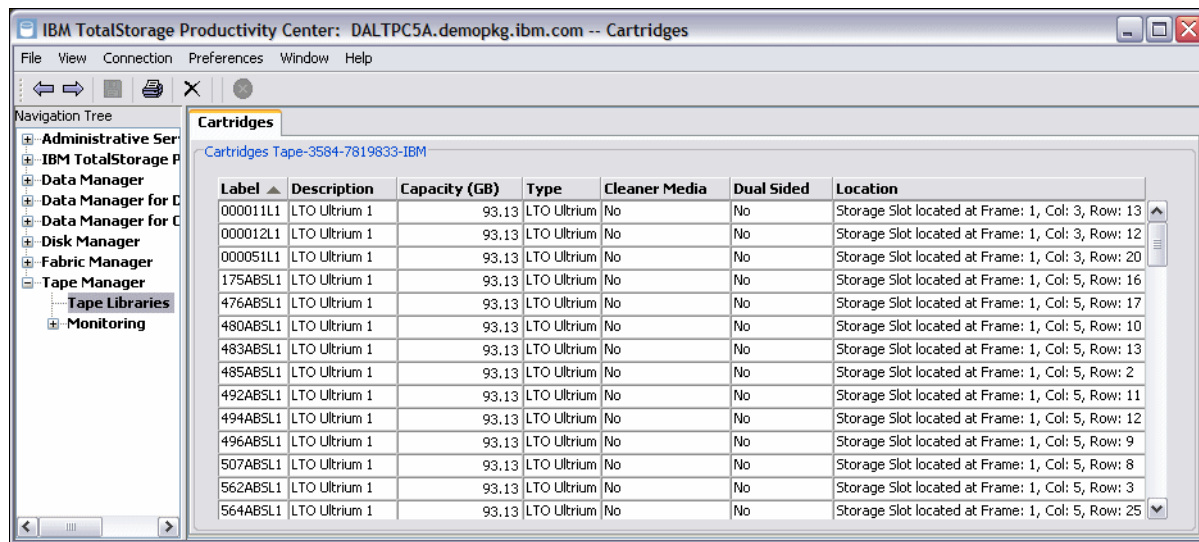


Figure 13-8 TPC Windows shown when selecting cartridges

Table 13-5 is a summary of the management capabilities.

Table 13-5 Summary of management capabilities available using SMI-S and TPC

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	Yes	Yes, we can view SNMP traps issued by the library, but not read the detailed drive and library logs on the library itself. Although, you can access these via the Web UI, which you can start from within TPC.	Yes, that is, we can view SNMP traps sent to TPC.	No

13.2.6 IBM TotalStorage Tape Diagnostic Tool (ITDT)

A newly designed command line tool, ITDT Standard Edition (SE) Version 2.0, and a new ITDT Graphical Edition (GE) for Windows operating system users, provide a quick and simple means to:

- Update firmware of IBM tape drives, autoloaders, and libraries
- Retrieve an IBM tape drive dump
- Retrieve logs of IBM tape autoloaders and libraries
- Perform IBM tape drive diagnostics
- Check system performance and IBM tape drive compression capability

Using ITDT on the server connected to your tape library is the recommended way to upgrade drive firmware on all IBM Linear Tape-Open (LTO) tape libraries due to its speed and ease of use. The tool does not require any special device drivers and is supported on Windows, AIX, Linux, and Solaris platforms.

ITDT Standard Edition V2.0 supports the IBM Ultrium Tape Drive and the 3592 models J1A and 3592 models E tape drives. Here, we show you a list of the supported tape products:

- ▶ 3580 Ultrium Tape Drive (Generation 3 and 4)
- ▶ Ultrium Tape Drives T800/F, T800V, T1600/F
- ▶ TS1030 Model F3A and F3B tape drives
- ▶ TS1040 Ultrium Model F4A Tape Drive
- ▶ TS2230/TS2240 Tape Drive Express
- ▶ TS2340 Tape Drive Express
- ▶ TS1120 Enterprise Tape System
- ▶ TS1130 Enterprise Tape System
- ▶ TS2900 Tape Autoloader
- ▶ TS3100 and TS3200 Tape Library Express
- ▶ TS3310 Tape Library
- ▶ TS3400 Tape Library
- ▶ TS3500 Tape Library

Note: Use ITDT Standard Edition V1.2 for the following tape products:

- ▶ 3580 Ultrium Tape Drive (Generation 3 and 4)
- ▶ Ultrium Tape Drives T200/F, T400/F, T800/F, T800V, T1600/F
- ▶ 3581 Ultrium Tape Autoloader
- ▶ 3581-2U Ultrium Tape Autoloader
- ▶ 3582 and 3583 Ultrium Scalable Tape Library

The ITDT Standard Edition V2.0 is supported on the following operating systems:

- ▶ Microsoft Windows Server 2003 (32-bit IX86)
- ▶ AIX 5L 5.2, 5.3, and 6.1 (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (32-bit IX86)
- ▶ Linux systems with Kernel 2.6, glibc 2.2.5, and later (64-bit System p)
- ▶ Linux systems with Kernel 2.6, glibc 2.3.3, and later (64-bit System z)
- ▶ Solaris 9 and 10 (64-bit SPARC)
- ▶ HP-UX Version 11i v1 and v2 (PA-Risc and Itanium)
- ▶ i5/OS Version 5 Release 3 and Version 5 Release 4 (System i), only tape drives

Note: Use ITDT Standard Edition V1.2 for existing operating systems, Microsoft Windows 2000 Server, SP4 (32-bit IX86), Linux systems with Kernel 2.4, glibc 2.2.5, and later (32-bit IX86 and 64-bit System p). You can download the ITDT-SE V1.2 from the following link:

http://www-1.ibm.com/support/docview.wss?rs=547&context=STCVQ6Y&dc=D410&uid=ssg1S4000338&loc=en_US&cs=utf-8&lang=en

Using ITDT Standard Edition (SE)

After you enter `itdt` at the command line, the information shown in Figure 13-9 displays.

```
IBM Tape Diagnostic Tool Standard Edition - V2.0.0 Build 001

Entry Menu

[S] Scan for tape drives

[H] Help
[Q] Quit program

Notes:
- During a test, user data on the cartridge will be erased!
- Make sure no other program is accessing the devices used by ITDT!
- A device scan may take several minutes in some cases!

- Q + Enter will always close this program.
- H + Enter will display a Help page.

<[H] Help | [Q] Quit | Command >
```



Figure 13-9 Initial window displayed after starting ITDT

When you enter `S`, a scan starts that finds and displays for selection all IBM LTO devices. Non-IBM devices are not displayed. After the scan is complete, a window similar to the one shown in Figure 13-10 displays.

```
IBM Tape Diagnostic Tool Standard Edition - Device List

Host Bus ID LUN Model Serial Ucode Changer [#]
+-----+-----+-----+-----+-----+-----+-----+-----+
| 0 | 3 | 0 | 1 | 0 | ULTRIUM-TD2 | 1110078510 | 53Y3 | |
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |
| 11 | | | | | | | | | |
+-----+-----+-----+-----+-----+-----+-----+

[S] Scan [T] Test [D] Dump [F] Firmware Update
[E] Encryption [W] Full Write [U] Tape Usage [I] Manual Inspect

<[H] Help | [Q] Quit | Line # | Command >
```

Figure 13-10 ITDT window listing devices discovered during the scan

As you can see, you can select five possible actions:

- [S] Scan** This action initiates another SCSI bus scan to seek further devices.
- [T] Test Device** This action exercises and tests a tape drive.
- [D] Firmware Dump** This action dumps the memory into two files. The dumps require special tools for analysis, so this option is only of value if an IBM Service Support Representative (SSR) asks you to provide dumps.
- [F] Firmware Update** This action initiates a Firmware Update. For library firmware update, use the Web User Interface.
- [E] Encryption** This action is used to verify if data on the medium is indeed encrypted. This action is not used to provide a Write and Read test. This is supported on LTO4 and 3592 models E tape drives. The drive must be encryption-enabled, Encryption Key Manager must be installed and operational, and the Encrypted data cartridge must be used for test.
- [W] Full Write** This option is used to help to detect if there are system performance bottlenecks or any system compression issue. This test writes an entire cartridge with the compression ON. A blank cartridge must be used, because all data on it will be overwritten.
- [U] Tape Usage** This option retrieves and displays tape statistical data and error counters.
- [I] Manual Inspect** Use this option if directed by an SSR. It provides a general interface for reporting problems for devices that are not automatically detected.

Downloading ITDT

To download ITDT-SE, ITDT-GE, and instructions for using the tools, visit the following Web site and search for ITDT:

<http://www-03.ibm.com/servers/storage/support/>

Table 13-6 shows a summary of ITDT-SE and ITDT-GE capabilities.

Table 13-6 Summary of management capabilities available using ITDT-SE and ITDT-GE

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	No, but you can test tape drives.	No	Yes

As you can see, ITDT-SE or the ITDT-GE, are principally valuable as a tools for updating tape drive firmware. Indeed, IBM recommends this tool for drive firmware updates because of its speed and ease of use.

Using ITDT Graphical Edition (GE)

The ITDT-GE Version 2.0 tool is a guided user interface version for Microsoft Windows users. At the time that this book was written, Microsoft Windows XP and Microsoft Windows Server 2003 (IX86, 32-bit) are the only supported operating systems. IBM Tape Diagnostic Tool - Graphical Edition (ITDT-GE) can run extended diagnostics on tape drives quickly, retrieve error logs from tape drives, and perform a firmware update on tape drives or libraries. There are no dedicated diagnostics for the library robotics with this release, but testing tape drives inside libraries is supported.

ITDT-GE offers the following features:

- ▶ Simple program installation
- ▶ Device scan with device list retrieval
- ▶ Enhanced tape drive test
- ▶ Additional tests to be run against tape drives
- ▶ Dump retrieval for tape drives and libraries
- ▶ Firmware update for tape drives and libraries
- ▶ Tape driver independence

ITDT-GE supports diagnostics for:

- ▶ IBM Ultrium 3580 Tape Drive (Generation 3 and 4)
- ▶ IBM Ultrium Tape Drives T800/F, T800V, T1600/F
- ▶ IBM System Storage 3588/TS1030 model F3A and F3B Tape Drive
- ▶ IBM System Storage 3588/TS1040 model F4A Tape Drive
- ▶ IBM System Storage 3580 Half-Height/TS2230/TS2240 Tape Drive Express
- ▶ IBM System Storage TS2340 Tape Drive Express
- ▶ IBM 3592/TS1120 Enterprise Tape System
- ▶ IBM 3592/TS1130 Enterprise Tape System
- ▶ IBM System Storage 3572/TS2900 Tape Autoloader
- ▶ IBM System Storage 3573/TS3100 and TS3200 Tape Library Express
- ▶ IBM System Storage 3576/TS3310 Tape Library
- ▶ IBM System Storage 3577/TS3400 Tape Library
- ▶ IBM System Storage 3584/TS3500 Tape Library

ITDT-GE is an application based on Java. You need to install Java before using ITDT-GE on your Windows systems. You can download the latest Java version from the following Web links:

<http://www.ibm.com/java>

<http://www.java.com>

ITDT-GE offers a series of functions in a Graphical User Interface that are the same as the functions in the ITDT-SE version using the command line. Here, we show you the suite of functions offered, and we will show you examples of the GUI panels that you see on your Windows servers when ITDT-GE is installed and started.

The functions allowed in the ITDT-GE Version 2.0 are:

Scan	From this option, you scan and find all the tape devices and medium changers that are configured and available. Refer to Figure 13-11 on page 392.
ITDT-GE Tests	This function has a pull-down menu from which you can run Standard, Full Write, and Encryption tests. These tests are identical to the tests that are described in “Using ITDT Standard Edition (SE)” on page 389. Refer to Figure 13-12 on page 393 and Figure 13-13 on page 393.
ITDT-GE Dump and Logs	Through a pull-down menu, this function gives you two options that allow you to retrieve a dump from a single tape device and save the dump to a specific file or view the tape usage of a single tape device using the Tape Usage Log option. Refer to Figure 13-14 on page 394.
ITDT-GE Firmware Update	This option is also identical to the Update Firmware of the ITDT Standard Edition, viewed in a GUI format. Refer to Figure 13-16 on page 395.

Next, we show you several examples of the IBM Tape Diagnostic Tool Graphical Edition (ITDT-GE) Graphical User Interface (GUI) panels. We do not show all of the available panels but only a few of them to provide you with a general overview. In Figure 13-11, you see the ITDT-GE panel when the Scan option is selected.

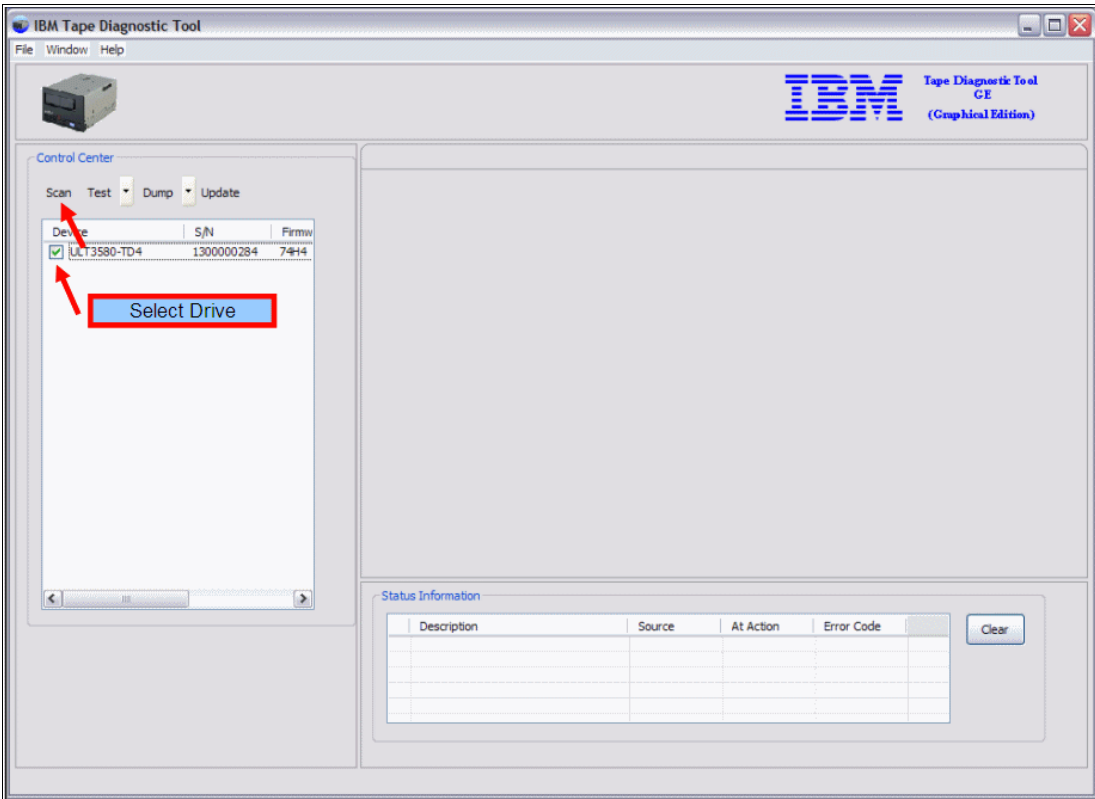


Figure 13-11 ITDT-GE Scan tape devices

Figure 13-12 on page 393 and Figure 13-13 on page 393 show you the ITDT-GE Test panels.

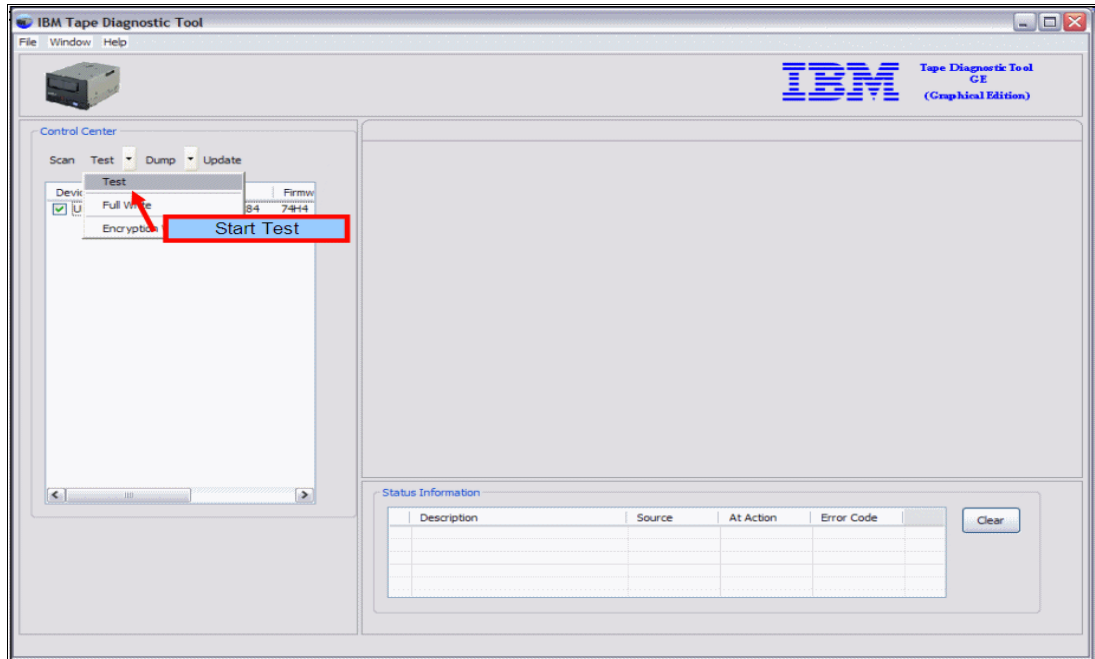


Figure 13-12 ITDT-GE Test menu

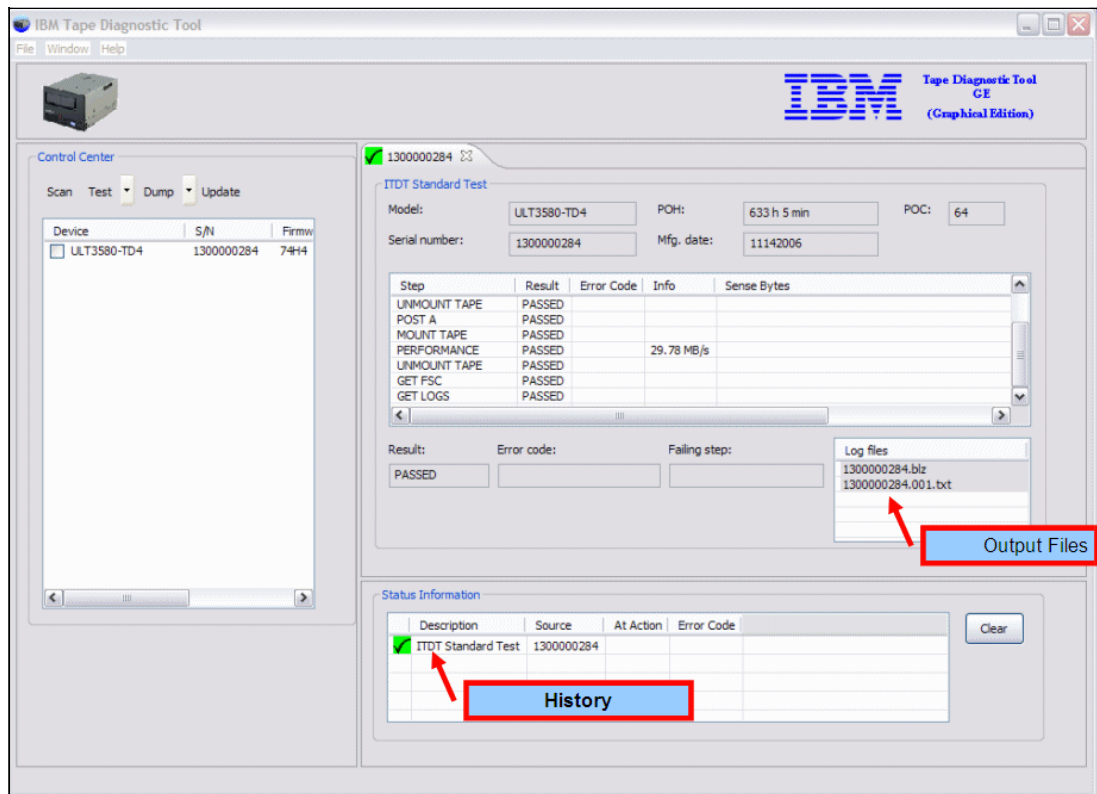


Figure 13-13 ITDT-GE Test results menu

In Figure 13-14 on page 394 and Figure 13-15 on page 394, you see the ITDT-GE Dump and Tape Usage Log panels.

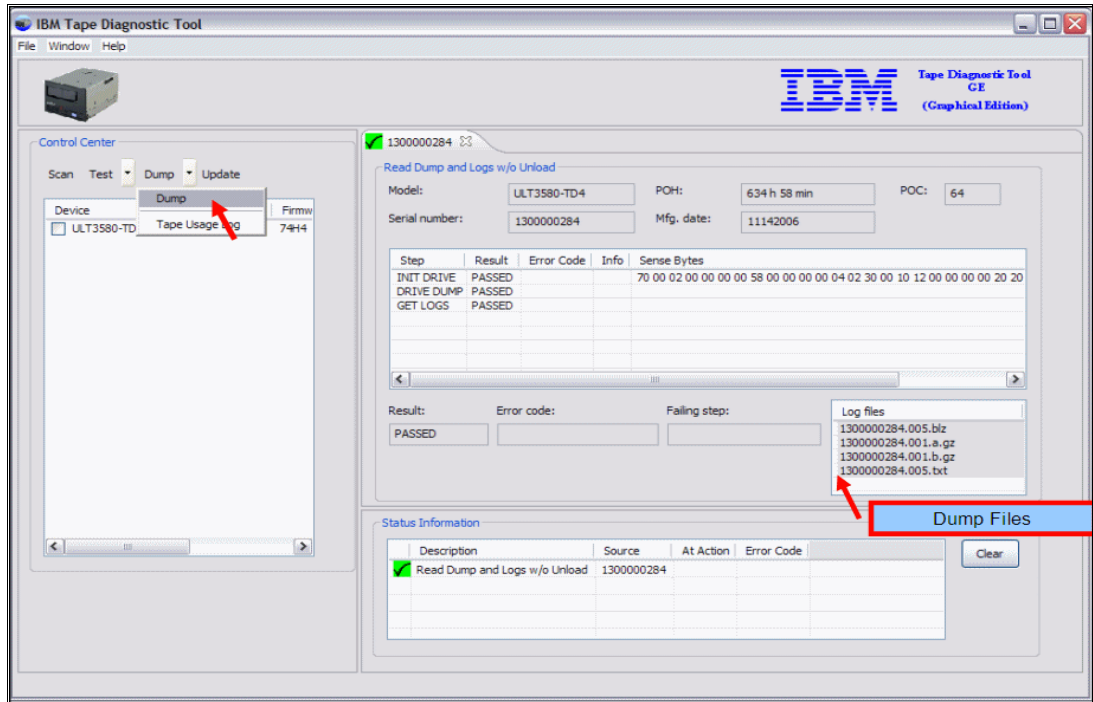


Figure 13-14 ITDT-GE Retrieve Dump panel

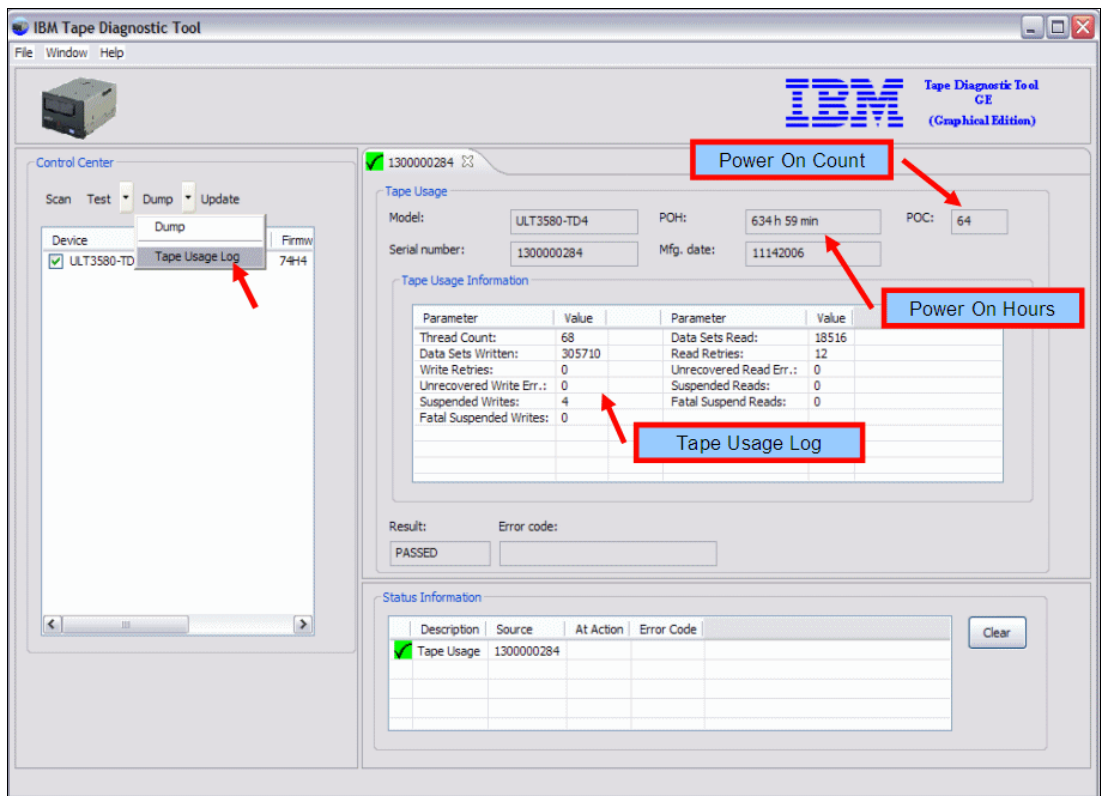


Figure 13-15 ITDT-GE Tape Usage Log panel

Next, Figure 13-16 on page 395 shows you the ITDT-GE Update Firmware panel.

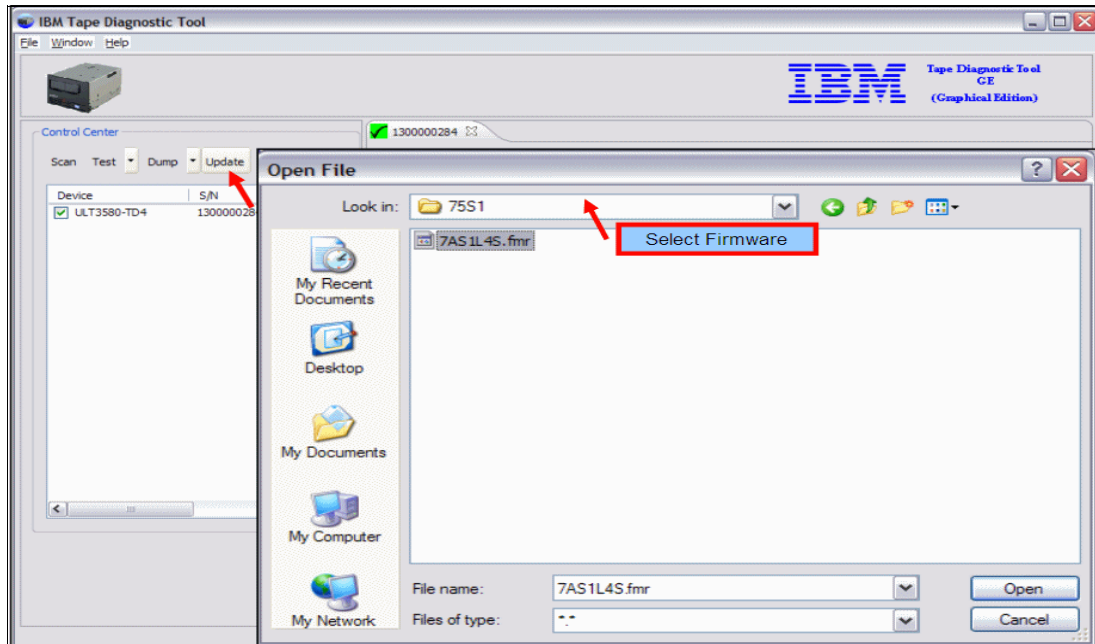


Figure 13-16 ITDT-GE Update Firmware panel

13.2.7 IBM Ultrium Device Driver

The IBM Ultrium tape and medium changer device drivers are designed specifically to take advantage of the features provided by the IBM Ultrium tape drives and medium changer devices. The goal is to give applications access to the functions required for basic tape functions, such as backup and restore, and medium changer operations, such as cartridge mount and demount, as well as to the advanced functions needed by full tape management systems, such as Tivoli Storage Manager. Whenever possible, the driver is designed to take advantage of the device features transparently to the application.

In addition to the functionality just outlined, the IBM Ultrium Device Driver provides the following capabilities that are relevant to tape library management:

- ▶ Control path and data path failover configuration
- ▶ Tape utility program
 - Tape drive service aids:
 - Tape dump
 - Firmware load
- ▶ Error logging and the automatic dump facility

You can find a complete description of all IBM Ultrium Device Driver functionality for AIX, Linux, HP-UX, Solaris, and Windows platforms in the *IBM Tape Device Driver Installation and Users Guide*, GA27-2130.

Control path and data path failover configuration

Prior to enabling alternate pathing support with the device driver, the appropriate path failover feature code must be installed in the tape library.

Systems with multiple paths to a tape or changer device are labelled as primary or alternate. In the case of AIX, you can define up to 16 paths and enable them for path failover. The steps required to enable path failover depend upon the platform. Refer to the *IBM Tape Device Driver Installation and Users Guide*, GA27-2130, for specific instructions.

The IBM tape utility program

Installed with the device driver is a tape utility program, which is called tapeutil in AIX and Solaris, IBMtapeutil in Linux, and ntutil in Windows, that exercises or tests the functions of the tape device and the device driver. It also performs basic tape and medium changer operations. The tape utility program provides two versions: the interactive interface and the command-line interface.

You can use the tape utility program to access tape drive service aids from within the interactive interface. Among other things, this tape utility program provides facilities to:

- ▶ Force a microcode dump
- ▶ Load firmware
- ▶ Perform error log analysis

Prior to the availability of ITDT, using tapeutil often provided the simplest means of performing these tasks. However, these tasks are performed more elegantly now with ITDT.

Note: Use of tapeutil does *not* require root access, unlike ITDT.

Error logging and the automatic dump facility

The device driver provides error logging on most platforms to the system log. On AIX, each error is logged with an associated error label and error ID, which identify the type of error:

TAPE_ERR1	Tape media error.
TAPE_ERR2	Tape hardware error.
TAPE_ERR4	SCSI adapter detected error.
TAPE_ERR5	Unknown error.
RECOVERED_ERROR	Temporary tape hardware or media error.
TAPE_DRIVE_CLEANING	Tape drive needs cleaning.
DEV_DUMP_RETRIEVED	Device dump retrieved.

The error is then further described with the Detail Data option. An explanation of the numerous fields is in the *IBM Tape Device Driver Installation and Users Guide*, GA27-2130; however, these logs are generally analyzed by technical support staff.

The AIX device driver provides an automatic dump facility for IBM Ultrium tape drives. Whenever a check condition occurs and the sense data indicates a dump is available, the device driver reads the dump from the device and stores it in the /var/adm/ras directory. A maximum of three dumps for each device is stored in this directory as:

Atape.rmtx.dump1
Atape.rmtx.dump2
Atape.rmtx.dump3

In this dump name, x is the device number, for example, rmt0. When the device is first configured, the dump name is set to dump1. If more than three dumps occur, the driver starts over at dump1; therefore, it always keeps the last three dumps.

The device driver also creates an entry in the AIX error log labeled “DEV_DUMP_RETRIEVED” when an automatic dump was either attempted and failed or was successful. Technical Support might ask for these dumps.

Trace facility

Technical Support might ask you to use this tool also. You can manually start and stop traces via the command line. The command is operating system-dependent and is documented with the **trace** and **trcstop** commands.

Table 13-7 summarizes the management capabilities available with the IBM Ultrium Device Driver.

Table 13-7 Management capabilities available using the IBM Ultrium Device Driver

Set configuration	Display configuration	View errors	Send error alerts	Update firmware
No	No	Yes, you can view tape errors by Error log analysis.	Yes, tape drive errors are sent to the System error log.	Yes

ITDT has largely superseded tapeutil in terms of tape drive management. However, the logging of errors to the System log and the creation of automatic dumps are useful facilities to aid in the detection and resolution of tape drive errors.

13.2.8 Summary of management capabilities

Table 13-8 summarizes the management capabilities available with each tool or technology.

Table 13-8 Management capabilities available with each tool or technology

Tool or technology	Set configuration	Display configuration	View errors	Send error alerts	Update firmware
Operator Panel	Yes	Yes	Yes	No	No
Web UI	Yes	Yes	Yes	No	Yes
TapeAlert	No	No	No	Yes	No
SNMP	No	Yes	No	Yes	No
SMI-S	No	Yes	Yes	Yes	No
IBM Ultrium Device Driver	No	No	Yes	Yes	Yes
ITDT-SE	No	No	No	No	Yes
ITDT-GE	No	No	No ^a	No	Yes

a. You can see displayed Sense Bytes data during the tests, while using the ITDT-GE.

13.3 Library-specific management capabilities

The management of IBM Ultrium Tape Libraries is similar between models; however, certain models have additional features. This section discusses certain differences among the models.

13.3.1 TS2900

Characteristics of the TS2900 include:

- ▶ Error messages can be e-mailed.
- ▶ SNMP is supported.
- ▶ Library firmware can be updated via the Web User Interface.
- ▶ The EKM Key Path Diagnostics.
- ▶ It has an LCD Operator Panel controlled by buttons on the right side of the Operator Panel.

13.3.2 TS3100

Characteristics of the TS3100 include:

- ▶ Error messages can be e-mailed.
- ▶ Library firmware can be updated via Web or tapeutil.
- ▶ SNMP is supported.

13.3.3 TS3200

Characteristics of the TS3200 include:

- ▶ Error messages can be e-mailed.
- ▶ Library firmware can be updated via the Web or tapeutil.
- ▶ SNMP is supported.

13.3.4 TS3310

Characteristics of the TS3310 include:

- ▶ Error messages can be e-mailed.
- ▶ Library firmware can be updated via the Web or tapeutil.
This is the only library whose firmware cannot be updated by ITDT.
- ▶ SNMP is supported.
- ▶ Native SMI-S support is provided.
- ▶ It has a color touch-sensitive Operator Panel.
- ▶ Errors are grouped as Operator Intervention Messages in the Control Panel and Web UI.

13.3.5 TS3400

Characteristics of the TS3400 include:

- ▶ Error messages can be e-mailed.
- ▶ Library firmware can be updated via the Web User Interface.
- ▶ It has an LCD Operator Panel controlled by buttons on the right side of the Operator Panel.

13.3.6 TS3500

Characteristics of the TS3500 include:

- ▶ Error messages cannot be e-mailed.
- ▶ Library firmware can be updated via ITDT, tapeutil, or Web UI.
- ▶ SNMP is supported.
- ▶ SMI-S 1.2 conformance with “SMI-S Agent for Tape” is provided.
- ▶ Non-disruptive library firmware update is provided, which means that there is no need to bring the library down during the firmware update. This function is available with firmware level 6xxx.
- ▶ Non-disruptive drive firmware update is available with firmware level 5500 or higher, but it is significantly slower than via ITDT.
- ▶ Advanced Library Management System can only be configured through the Web UI.

Call Home

The TS3500 Tape Library can call an IBM Support Center when an error occurs. The library reports codes indicating the replacement parts that might be required and the urgency of the problem. The library can also periodically send support information, such as configuration, library and drive code versions, and error logs, to IBM.

The TS3500 Call Home feature has two different, but related, capabilities:

- ▶ Problem Call Home

The TS3500 or one of its drives detects a problem, and the library performs a Call Home operation to create a RETAIN Problem Management Record (PMR). This is a single page of text data that enables the Support Center or the SSR to access an action plan and a list of parts called *field-replaceable units* (FRUs).

- ▶ Heartbeat Call Home

On a scheduled basis (once a week or one hour after a code update has been completed or a power cycle), the TS3500 sends home (to IBM) the following files: a Machine Reported Product Data (MRPD) file, a library error log file, and a drive error log file. The MRPD file contains information about the machine (library), including the number of frames and drives, the model and serial number of each frame, the type and serial number of each drive, the code version of the library and each drive, and any machine-detectable features, such as additional I/O stations, capacity expansion, and so forth.

A test call home can also be initiated from the Operator Panel.

When a Problem Call Home or a Heartbeat Call Home is initiated, the TS3500 also sends data files that might be helpful to Support Center personnel. In the case of a Heartbeat Call Home, the library also sends the library error log and drive error log. In the case of a Problem Call Home, the library sends any trace files that might be related to the problem.

Call Home is provided by a no-charge FC2710 (Remote Support Facility), which provides a modem and cable 15.2 m (50 ft.). The client must provide an analog phone line to use the Call Home feature. This phone line needs to be within 15.2 m (50 ft.) of the library. Refer to 12.2.12, “Remote support” on page 345 for further details regarding Call Home.

Enhanced data gathering and reporting

There are four files that you can download from the TS3500, which provide detailed information regarding activity during the last 24 hours:

Library Statistics.csv

Contains information about the maximum cartridge residency, mount and eject times, average cartridge residency, mount and eject times, and total cartridge inserts, mounts, and ejects. The information is provided for each hour of a 24-hour period and for each logical library. Download via the Web UI by selecting **Manage Library** → **By Logical Library**, and then, select the download link.

or

Directly from the library:

http://LibraryName/FS/LIBLG_01_LP.csv

Note that the library statistics are only available with Lx3 models.

Drive Statistics.csv

Contains information about each drive's last mount; only installed drives are shown in the drive statistics log. Download via the Web UI by selecting **Manage Drives** → **Drive Summary**, and then, select the download link.

or

Directly from the library:

http://LibraryName/FS/LIBLG_01_DS.csv

Port Statistics.csv

Contains Fibre Channel port information about the last mount; only installed drives with Fibre Channel ports are shown in the port statistics log. Download via the Web UI by selecting **Manage Ports** → **Fibre Channel Summary**, and then, select the download link.

or

Directly from the library:

http://LibraryName/FS/LIBLG_01_PS.csv

Mount history.csv

Includes statistics about the last 100 cartridges that were demounted in the library and information about the TS1120 Tape Drives (at firmware level 16E4 or later) or TS1130 Tape Drives, which is derived from the customer-centric Statistical Analysis and Reporting System (ccSARS). Download via Web UI by clicking **Manage Cartridges** → **Data Cartridges**, and then, select the download link.

or

Directly from the library:

http://LibraryName/FS/LIBLG_01_CS.csv

The Web User Interface provides a detailed help function that explains the details of each file. You can also find a detailed description of each of the files in a white paper accessible from the Tape Systems Resource Library at the following Web site:

<http://www-03.ibm.com/servers/storage/tape/resource-library.html>

13.4 Best practices

This is a list of library management recommendations:

- Connect every library to your network to take advantage of the Remote Management capability and use the Web UI. This is the only way to access certain functionality on each library, and it provides an extremely effective means of monitoring and managing the library.

- ▶ Keep the library and drive firmware up-to-date. Not only do firmware updates correct errors, but they add functionality to both the Operator Panel menus and the Web UI. If you encounter a library or drive error and need to place a call with IBM Support, it is likely they will ask you to upgrade to the latest firmware if you have not already done so. Achieving resolution is assisted by already being up-to-date with firmware levels.
- ▶ Securing Web access to the TS3500 Web UI must be enabled. It is already enabled on the other library models, which means that you need a login and password to access the Web UI.
- ▶ If your library is located in an insecure area, you must secure access to the Operator Panel by requiring that users log in.
- ▶ Install ITDT on your server and use it to upgrade the drive firmware. This is the fastest way to update drive firmware on all tape libraries.
- ▶ Use the nondisruptive library firmware update available via the Web UI on the TS3500 rather than using ITDT (which requires bringing the library offline).
- ▶ Use Call Home if you have an IBM TS3500 Tape Library. The service is free (you only need to provide an analog line) and provides an extremely effective means of monitoring the library.
- ▶ Take advantage of data and control path failover and load balancing with the optional features that provide path failover for all operating systems that use the IBM Tape Device Driver.
- ▶ Ensure that the operating environment meets the specifications documented in the Setup and Operator Guide. In addition to temperature and humidity tolerances, ensure that the library is located in an area free of airborne particulate matter.

And while we have your attention:

- ▶ Only use supported media. IBM Ultrium Tape Drives are very reliable, but the use of uncertified media can damage drives. We, the authors of this book, have personal experience of tape drives needing replacement after they were used with unsupported media. Indeed, the use of unsupported media can invalidate your maintenance contract. For a list of certified media, refer to:
<http://www-03.ibm.com/systems/storage/media/>
- ▶ Pack cartridges with care prior to transport. Handle cartridges just as you handle hard disk drives. It is important that they are protected from contaminants (any particulate matter whatsoever) and are packed to avoid shaking. The edges of tapes get damaged if the cartridges are dropped or allowed to move in the packing cases during transport. The IBM Ultrium technology implementation is designed to tolerate minor edge damage, but inadequate packing will result in irrecoverable damage. For more information, refer to:
ftp://ftp.software.ibm.com/common/ssi/rep_sp/n/TSB00180USEN/TSB00180USEN.PDF



Part 3

Previous IBM Tape Libraries

In this part, we describe previous versions of IBM tape libraries and autoloaders for the installation of Linear Tape-Open (LTO) tape drives.



IBM TotalStorage 3580 Tape Drive

The IBM TotalStorage 3580 Tape Drive is the smallest in the family of IBM Ultrium tape solutions. It is an external, stand-alone, Small Computer System Interface (SCSI)-attached tape drive that attaches to System i, System p, System x, RS/6000 SP, and other UNIX and PC servers supporting OS/400, IBM AIX, Sun Solaris, HP-UX, Microsoft Windows NT®, Microsoft Windows 2000 Server, Microsoft Windows Server 2003, and Red Hat and SUSE LINUX using a supported SCSI adapter.

The IBM TotalStorage 3580 Tape Drive is a cost-effective solution for save-and-restore and archiving functions, and it provides an excellent migration path from SDLT, 1/4-inch, 4 mm, or 8 mm tape drives.

14.1 Model description

The IBM 3580 (Figure 14-1 and Figure 14-2) is a large-capacity, high-performance Ultrium tape drive available in four model types, depending on the capacity and SCSI¹ interface required.



Figure 14-1 IBM 3580 model L23/H23 Tape Drive



Figure 14-2 IBM 3580 model L33/L3H

The available IBM 3580 models are:

- ▶ IBM 3580-L23: Ultrium 2 drive with Low-Voltage Differential (LVD) Ultra2 SCSI attachment that connects to LVD fast/wide adapters
- ▶ IBM 3580-H23: Ultrium 2 drive with High-Voltage Differential (HVD) Ultra SCSI attachment that connects to HVD fast/wide adapters
- ▶ IBM 3580-L33 and IBM 3580-L3H: Ultrium 3 drive with Low-Voltage Differential (LVD) Ultra SCSI attachment that connects to LVD fast/wide adapters

The IBM 3580-L33 and IBM 3580-L3H are functionally identical; the only difference is the IBM 3580-L3H is an Express Model, which is part of the Express Portfolio™.

¹ Refer to "Interfaces" on page 55 for an explanation of HVD and LVD.

Note: The IBM Express Portfolio is a set of IBM offerings for IBM Business Partners in Small and Medium Business. For details, refer to the Web site:

http://www.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html

The IBM 3580-L23 and H23 use the Ultrium 2 LTO cartridge, which has a capacity of 200 GB (400 GB with 2:1 compression), and are capable of sustaining a data rate of up to 35 MB/s (uncompressed).

The IBM 3580-L33 and L3H use the Ultrium 3 LTO cartridge, which has a capacity of 400 GB (800 GB with 2:1 compression), and are capable of sustaining a data rate of up to 80 MB/s (uncompressed).

Note: Although the IBM 3580 provides the capability for high tape performance, other components of the system might limit the actual performance achieved. Also, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

14.2 Feature codes

The IBM 3580 can be ordered with the following feature codes (Table 14-1). We have not included the various cabling options; refer to the product publications for detailed information about configuring and ordering cables.

Table 14-1 IBM 3580 feature codes

Feature code	Description	Comments
7003	19-inch Rack Mount Kit	N/A
8001	One 100 GB data cartridge	Plant only; refer to 14.9, "Media" on page 411 for details.
8101	One 200 GB data cartridge	Plant only; refer to 14.9, "Media" on page 411 for details.
8301	One 400 GB data cartridge	Plant only; refer to 14.9, "Media" on page 411 for details.
8002	One cleaning cartridge	Plant only; refer to 14.9, "Media" on page 411 for details.
8723	Rack mount kit	N/A

14.3 SCSI attachment

The Ultrium 3 IBM 3580-L33/L3H is an LVD drive.

For Ultrium 2, the SCSI interface (HVD or LVD) on each IBM 3580 is chosen by selecting the appropriate model number.

The IBM 3580 can be attached to pSeries, IBM RS/6000, xSeries, iSeries, AS/400, other Intel, HP-UX, and Sun systems that support Ultra/Wide SCSI HVD and Ultra2 Wide SCSI LVD interface specifications. The interface that you choose will depend on the available adapter in the host, which must be of the same type as the drive interface.

The IBM 3580 also might be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM marketing representative for a current list of supported Open Systems configurations and software vendors, or go to:

<http://www.ibm.com/servers/storage/tape/3580/interop.html>

14.4 SCSI cabling

A SCSI cable is required for each IBM 3580 connection to a SCSI bus. For Ultrium 2 IBM 3580 drives, a single 2.5 m (6.6 ft.) SCSI cable is available as a no-charge feature; if an alternate length is required, it must be included in the initial order. A SCSI terminator is included with each drive.

An *interposer* (a connector that matches the pin pattern of the host adapter to the pin pattern of the cable) also might be required for attachment to particular server adapters.

14.4.1 Cables (Ultrium 1 and Ultrium 2)

A single SCSI cable is available as a no-charge feature (either FC9702 or FC9703) specified only with the initial IBM 3580 order. It is not orderable as a miscellaneous equipment specification (MES) for installation later. Feature FC9702 supplies a 2.5 m (6.6 ft.) universal SCSI cable with HD68 connectors at each end; feature FC9703 supplies a VHDCI connector at one end and HD68 at the other.

Additional SCSI cables are available as optional features on the IBM 3580 for LVD and HVD attachment to host adapters.

The following cables have an HD68 connector at each end:

- ▶ Feature FC5301: 0.4 m (1.3 ft.) SCSI cable
- ▶ Feature FC5302: 2.5 m (6.6 ft.) SCSI cable
- ▶ Feature FC5305: 5 m (16.4 ft.) SCSI cable
- ▶ Feature FC5310: 10 m (32 ft.) SCSI cable
- ▶ Feature FC5318: 18 m (59.1 ft.) SCSI cable
- ▶ Feature FC5325: 25 m (82.0 ft.) SCSI cable

These cables have a VHDCI connector at one end and an HD68 connector at the other end:

- ▶ Feature FC5602: 2.5 m (6.6 ft.) SCSI cable
- ▶ Feature FC5604: 4.5 m (14.8 ft.) SCSI cable
- ▶ Feature FC5610: 10 m (32 ft.) SCSI cable
- ▶ Feature FC5620: 20 m (65.6 ft.) SCSI cable
- ▶ Feature FC5625: 25 m (82 ft.) SCSI cable

14.4.2 Cables (Ultrium 3)

The following Ultra2 SCSI cables are available as optional features for attaching the IBM 3580 to servers and other adapters. A SCSI differential terminator is included with each tape drive.

These cables are available with a VHDCI connector on one end and an HD68 connector on the other end:

- ▶ Feature FC5602: 2.5 m (6.6 ft.) VHDCI/HD68 SCSI Cable
- ▶ Feature FC5604: 4.5 m (14.8 ft.) VHDCI/HD68 SCSI Cable
- ▶ Feature FC5610: 10 m (32 ft.) VHDCI/HD68 SCSI Cable

14.4.3 Interposers (Ultrium 1 and Ultrium 2 only)

An interposer might be required to connect host adapters that do not have HD68 connectors to the SCSI cables. The following chargeable interposers are available:

- ▶ Ultrium 1 only, FC2895 interposer to connect System i adapter FC6501.
- ▶ Ultrium 1 and Ultrium 2, FC5099 interposer to connect a mini-68-pin VHDCI connector to the 68-pin HD68 connector on the SCSI cable. The interposer (a 0.3 m (11 in.) cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.
- ▶ Ultrium 1 and Ultrium 2, FC5098, Inline HVD SCSI Terminator, is required when attaching to Hewlett-Packard V-Class systems with adapter A4800A.

14.4.4 SCSI length limitations

The overall LVD SCSI cable length is limited to 25 m (82 ft.) using point-to-point interconnection. If using multi-drop interconnection, the overall LVD SCSI cable length is limited to 12 m (39.4 ft.). The stub length at each device must not exceed 0.1 m (0.33 ft.).

The overall HVD SCSI cable lengths are limited to 25 m (82 ft.) using point-to-point or multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 ft.).

14.5 Environmental specifications

The IBM 3580 is designed to be placed on or beside the attached host server or installed in a standard 19-inch rack.

14.5.1 Physical dimensions

The IBM 3580 is a relatively small single tape drive enclosure:

- ▶ Width: 17.1 cm (6.73 in.)
- ▶ Depth: 33.3 cm (13.1 in.)
- ▶ Height: 14.6 cm (5.75 in.)
- ▶ Maximum weight: 6.6 kg (14.6 lbs.)

14.5.2 Operating environment

The IBM 3580 can be installed in a normal office environment and does not need to be in a specialized machine room. Refer to the product publications for specific information.

14.6 Host platforms and device drivers

The following no-charge specify feature codes indicate the server platform to which the IBM 3580 is attached:

- ▶ FC9210: Attached to HP-UX
- ▶ FC9211: Attached to Sun system
- ▶ FC9212: Attached to Windows NT or Windows 200x system
- ▶ FC9213: Attached to other non-IBM system
- ▶ FC9215: Attached to Linux system
- ▶ FC9400: Attached to AS/400 system
- ▶ FC9600: Attached to RS/6000

A *device driver* is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3580). Sometimes, the driver code is supplied as part of the operating system code (for example, in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The IBM 3580 is shipped with device drivers to support Ultrium 1, Ultrium 2, and Ultrium 3 drives in the following operating environments at the minimal levels shown:

- ▶ AIX 5L Versions 5.1, 5.2, 5.3, and higher
- ▶ Sun Solaris 7, 8, and 9
- ▶ Windows NT 4.0 with Service Pack 6 or later
- ▶ Windows 2000 build 2195 or later
- ▶ Windows Server 2003 build 3790 or later
- ▶ HP-UX 11.0, 11.i, or 11.i v2
- ▶ OS/400 V5R1, V5R2, or V5R3
- ▶ Red Hat Advanced Server 3, SUSE LINUX Enterprise Server 8 or 9

For the current list of supported operating systems and host adapters, refer to:

<http://www.ibm.com/servers/storage/tape/3580/interop.html>

Tip: The device driver CD or diskette that is shipped with the IBM 3580 might not contain the device drivers with the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:

<ftp://ftp.software.ibm.com/storage/devdrv/>

14.6.1 Device driver installation

Install the IBM device drivers for the IBM 3580 as follows:

- ▶ If you intend to use the IBM 3580 with a commercial software application (such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3580.
- ▶ If you do not intend to use the IBM 3580 with a commercial software application, install the tape and medium device driver from the CD that is shipped with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

Note: If you use the IBM 3580 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions from the application's vendor. Otherwise, if the application supplies its own driver code, conflicts can occur over which driver controls the drive. *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502, give examples of using the Ultrium drives.

14.7 Storage applications

The software to manage the IBM 3580 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, IBM Business Partners, or independent software providers. A list of compatible software is available at the Web site:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application, including Ultrium support and specific Ultrium models and attachment methods. You can also contact your storage application vendor for more detailed information about supported versions and platforms.

14.8 Performance considerations

For best performance, IBM recommends that you attach only one tape drive per SCSI bus. This might not be a realistic objective, but minimizing the number of devices per bus will improve performance. Attaching other SCSI devices on the same SCSI bus as the IBM 3580 might affect the performance of those devices.

iSeries configurators allow only one drive per input/output port for maximum performance. Installing more than one Ultrium tape drive on an I/O port might affect the system performance.

Although the compression technology can increase the amount of data stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

14.9 Media

One Ultrium cleaning cartridge and one Ultrium data cartridge are included with each IBM 3580 drive order². With the initial order, you can order additional data and cleaning cartridges as chargeable features for the IBM 3580:

- ▶ FC8101 provides a single 200 MB Ultrium 2 Data Cartridge.
It is a chargeable feature, and you can order a maximum of five.
- ▶ Feature FC8301 provides a single 400 MB Ultrium 3 Data Cartridge.
It is a chargeable feature, and you can order a maximum of five.
- ▶ Feature FC8002 provides a single Ultrium Cleaning Cartridge.
It is a chargeable feature, and you can order a maximum of five.
- ▶ Feature FC8001 provides a single 100 MB Ultrium 1 Data Cartridge.
It is a chargeable feature, and you can order a maximum of five.
Note: This feature has been withdrawn from marketing.

Subsequent to the initial order, you can order additional supplies from the IBM media business or from a third-party media vendor. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497 for details about ordering supplies and cartridges, with or without labels.

14.10 IBM 3580 Ultrium Tape Drive initial setup

In this section, we discuss the major items required to implement, manage, and operate the IBM 3580 Tape Drives. We do not cover all of the tasks, nor do we intend to cover all of the specific commands. For more details, refer to *IBM 3580 Ultrium Tape Drive Setup, Operator and Service Guide*, GA32-0415; *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*, GA32-0460; *IBM TotalStorage 3580 Tape Drive Setup, Operator, and Service Guide*, GC26-7708; *Implementing IBM Tape in Linux and Windows*, SG24-6268; and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

² All media and cleaning cartridges are warranted separately from the IBM 3580.

14.10.1 SCSI ID

If you attach multiple IBM 3580 SCSI devices in the same chain, they need to each use different SCSI IDs starting with the lowest number on the first device as depicted in Figure 14-3. The last device of that SCSI chain must have a valid terminator. The SCSI ID setup button is located at the rear of the IBM 3580.

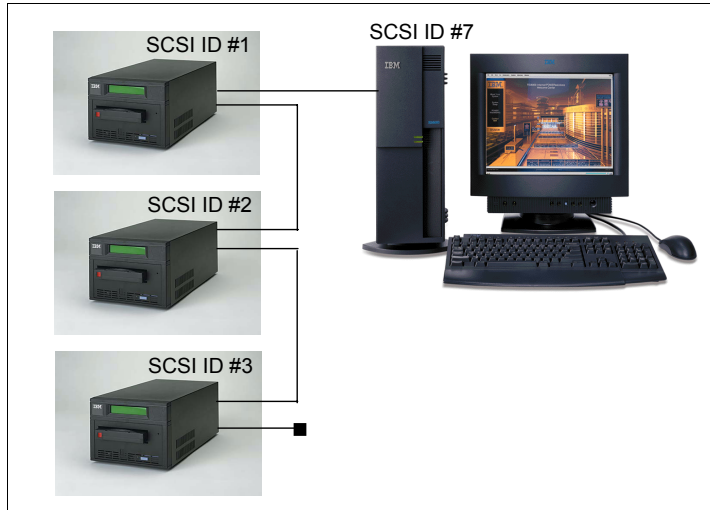


Figure 14-3 SCSI ID setup example

14.11 Operator displays and buttons

The IBM 3580-L23 and IBM 3580-H23 have a simple operating interface consisting of:

- ▶ A status light
- ▶ A message display
- ▶ A single character display
- ▶ An unload push button

The IBM 3580-L33 and IBM 3580-L3H have a simple operating interface consisting of:

- ▶ A status light
- ▶ A single character display
- ▶ An unload push button
- ▶ A power on/off push button

14.11.1 Status light

The status light (labeled 2 in Figure 14-4 on page 413 and Figure 14-5 on page 414) provides information about the state of the IBM 3580. The light can be either green or amber (yellow), and, when lit, either solid or flashing. These are the possible conditions of the status light and an explanation of what each condition means:

- ▶ Off: The IBM 3580 Tape Drive has no power or is powered off.
- ▶ Green/solid: The IBM 3580 Tape Drive is idle, or if C displays simultaneously in the single-character display (see label 3 in Figure 14-4 on page 413 or Figure 14-5 on page 414), it needs cleaning.
- ▶ Green/flashing: The IBM 3580 is reading or writing data, rewinding the tape, locating data on the tape, or unloading the tape.

- ▶ Amber (Yellow)/solid: The IBM 3580 is in maintenance mode or is running power-on self-test diagnostic routines.
- ▶ Amber/flashing: The IBM 3580 requires service or is updating firmware. Note the code on the single-character display. Refer to the Setup and Operator Guides (GA32-0415 for Ultrium1, GA32-0460 for Ultrium 2, or GC26-7708 for Ultrium 3).

14.11.2 Message display (Ultrium 1 and Ultrium 2 only)

The message display (labeled 4 in Figure 14-4 and Figure 14-5 on page 414) is a liquid crystal display (LCD) that provides information about the status of the tape drive and error conditions.

The message display consists of two rows, with 20 characters available in each row. During operation, the IBM 3580 Tape Drive continuously queries the drive and updates the display with status messages. When in an idle (non-operating) state, the tape drive displays the following messages:

```
Ultrium Tape Drive
Drive Empty
```

14.11.3 The single-character display

The IBM 3580 features a light-emitting diode (LED) display (labeled 3 in Figure 14-4 and Figure 14-5 on page 414). The LED presents a single-character code for:

- ▶ Error conditions and informational messages
- ▶ Diagnostic or maintenance functions (while in maintenance mode only)

For the list of messages, refer to the Setup and Operator Guides (GA32-0415 for Ultrium 1, GA32-0460 for Ultrium 2, or GC26-7708 for Ultrium 3).

If multiple errors occur, the code with the highest priority (represented by the lowest number) displays first. When the error is corrected, the code with the next highest priority displays, and so on, until no errors remain.

The single-character display is blank during normal operation of the IBM 3580 Tape Drive.

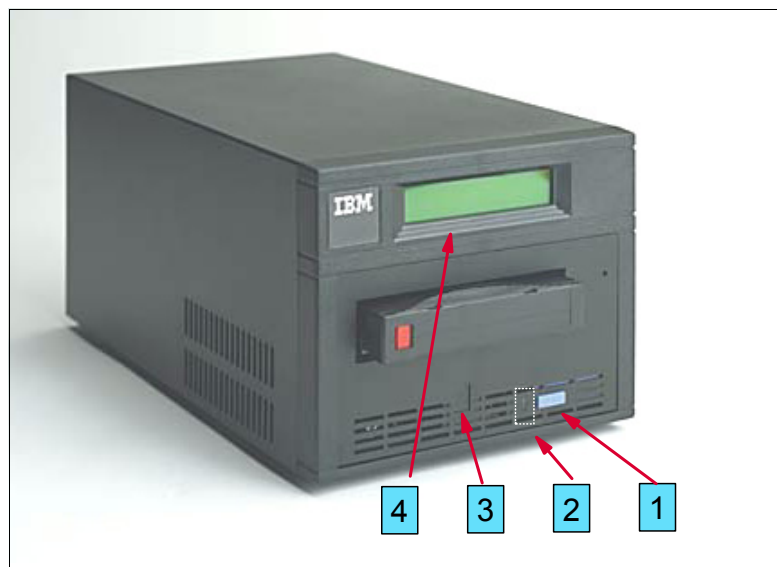


Figure 14-4 Front view of the IBM 3580 model L11/L13/L23 or H11/H13/H23 Tape Drive

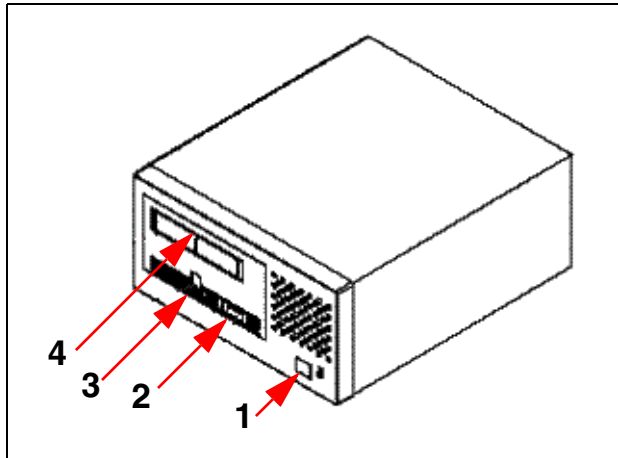


Figure 14-5 Front view of the IBM 3580-L33/L3H Tape Drive

14.11.4 Unload push button

The unload push button enables you to perform several functions. You can:

- ▶ Rewind the tape in the cartridge and eject the cartridge from the tape drive.
- ▶ Enter or exit maintenance mode or perform diagnostic or maintenance functions.
- ▶ Scroll through the maintenance menus.
- ▶ Execute a panic reset.

Important: If you press the Unload button during operation, the IBM 3580 ends the current job, and the IBM 3580 unloads and ejects the tape cartridge.

14.11.5 Power push button (Ultrium 3)

The Power push button (labeled 1 in Figure 14-5) turns the tape drive on or off. The button is located on the front panel. When the Power Button is in the off position, the primary electrical power within the enclosure is still active. To remove all electrical power to the enclosure, unplug the power cord at the rear of the drive from the receptacle.

14.12 Drive cleaning

All IBM Ultrium tape drives have an integrated cleaning mechanism that brushes the head at cartridge load time and again when unloading a cartridge. Along with this, the drives have a cleaning procedure that uses a special cleaning cartridge.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

Clean the drive head in the IBM 3580 whenever C displays on the single-character display and the status light is solid green. IBM does not recommend that you clean the drive head on a periodic basis; only when C displays.

To clean the head, insert the cleaning cartridge into the tape load compartment. The tape drive performs the cleaning automatically. The cleaning cycle takes less than two minutes. When the cleaning is finished, the drive ejects the cartridge.

Important: If you insert a cleaning cartridge when the drive does not need cleaning or if you insert a cleaning cartridge that has expired, the drive automatically ejects the cartridge.

14.13 Firmware upgrade

Drive firmware is best updated using the driver's application interface, SCSI or Fibre Channel.

There are tools readily available to facilitate this process. The recommended tool, the IBM Totalstorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. To download ITDT and instructions for using the tool, visit:

<http://www-03.ibm.com/servers/storage/support/>

ITDT is available for multiple platforms. You can use other tools, such as ntutil and TapeUTIL, for drive firmware updates. The library also supports drive firmware update by creating and using an Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware is:

1. Download the latest drive firmware to your host computer by visiting:

<http://www-1.ibm.com/servers/storage/tape/lto/>

Note: Carefully select the correct firmware, because there is different firmware for Fibre Channel drives, SCSI drives, and also LTO1, LTO2, and LTO3 drives.

2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Using ITDT to update drive firmware

A newly designed tool, ITDT, has multiple functional capabilities and is a quick, convenient, and efficient method for performing drive firmware updates. As a note, ITDT performs drive dump retrievals as well. Below are several capabilities of this tool:

- ▶ Firmware update capability via SCSI is available to all IBM LTO tape drives.
- ▶ The tool does not require any special device drivers.
- ▶ The tool is available for most major platforms (Windows, AIX, SUN, Linux, and NetWare).
- ▶ The tool is capable of uploading drive dump files.
- ▶ The tool's primary function is thoroughly testing a drive. However, if the library is online to the server/host where the tool resides, ITDT communicates with the drive through the library to load and unload a test cartridge, therefore exercising several library functions.
- ▶ The tool scans the SCSI bus, finds all IBM LTO devices, and displays them for selection. The tool does not display or allow for selection any non-IBM device.
- ▶ Each function has a Help selection, which explains the required syntax, as well as a brief description of the particular function.
- ▶ A readme text file is posted with the .exe for a thorough explanation of initial tool download information from the Web, as well as an explanation of tool capabilities.
- ▶ The tool is currently a command line tool that you start by simply typing the executable name, itdt, from the directory where the tool exists.

Other methods for updating drive firmware

When updating drive firmware by using SCSI or Fibre Channel, the procedure varies, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard, or Microsoft).

If you use an IBM tape device driver, you can update drive firmware by using the `tapeutil` or `ntutil` tools. The *IBM Tape Device Driver Installation and Users Guide*, GA27-2130, explains these tools.

If you use a non-IBM tape device driver, refer to the relevant documentation.



IBM TotalStorage 3581 Tape Autoloader

Note: All models of the IBM TotalStorage 3581 Tape Autoloader: IBM 3581-L17/H17, IBM 3581-L13/H13, and IBM 3581-L23/H23 were withdrawn from marketing in October 2004. A newer IBM 3581 with a 2U form factor offers a single Ultrium 2 tape drive and storage for up to eight tape cartridges. We describe it in Chapter 16, “IBM TotalStorage 3581 2U Tape Autoloader” on page 435.

The IBM TotalStorage 3581 Tape Autoloader is an external, single-drive, Small Computer System Interface (SCSI)-attached stand-alone or rack-mounted autoloader that attaches to System i, AS/400, System p, RS/6000, System x, Microsoft Windows NT, Microsoft Windows 2000 Server, Windows Server 2003, Sun Solaris, HP-UX, and Linux systems using a SCSI adapter.

The IBM TotalStorage 3581 Tape Autoloader uses a single IBM LTO Ultrium tape drive. The autoloader contains seven tape slots¹ providing a media capacity of up to 700 GB (1.4 TB with 2:1 compression) per autoloader and is capable of sustaining a data rate of up to 15 MB/s (uncompressed).

¹ When the optional barcode reader is installed, the cartridge capacity is reduced to six.

15.1 Model description

There are six separate model types of the IBM TotalStorage 3581 Tape Autoloader, depending on the capacity and required SCSI² interface.



Figure 15-1 IBM TotalStorage 3581 Tape Autoloader

The six models are:

- ▶ *IBM 3581-L17* and *IBM 3581-L13*: Seven cartridge slots and a .7 TB native data capacity with a Low-Voltage Differential (LVD) Ultra2 SCSI attachment that connects to LVD fast/wide adapters.
- ▶ *IBM 3581-H17* and *IBM 3581-H13*: Seven cartridge slots and a .7 TB native data capacity with a High-Voltage Differential (HVD) Ultra SCSI attachment that connects to HVD fast/wide adapters.

The IBM 3581-L17, -L13, -H17, and -H13 all use the same Ultrium 1 LTO cartridge, which has a capacity of 100 GB (200 GB with 2:1 compression) and are capable of a sustained data rate of up to 15 MB/s (uncompressed).

The IBM 3581-L17 and IBM 3581-L13 are functionally identical, as are the IBM 3581-H17 and IBM 3581-H13. The only difference is that the IBM 3581-L13 and the IBM 3581-H13 have a three-year Client Element Exchange warranty.

- ▶ *IBM 3581-L23* and *IBM 3581-H23*: Seven cartridge slots and a 1.4 TB native data capacity with a Low-Voltage Differential (LVD) Ultra160 SCSI attachment (IBM 3581-L23) or a High-Voltage Differential (HVD) Ultra SCSI attachment (IBM 3581-H23).

The IBM 3581-L23 and IBM-H23 both use the same Ultrium 2 LTO cartridge, which has a capacity of 200 GB (400 GB with 2:1 compression), and are capable of a sustained data rate of up to 35 MB/s (uncompressed). IBM Ultrium 2 Tape Drives can read and write original LTO Ultrium Data Cartridges at original Ultrium 1 capacities and with an improved performance of up to 20 MB/s native data transfer rate (40 MB/s with 2:1 compression).

Note: Although the IBM TotalStorage 3581 Tape Autoloader provides the capability for high tape performance, other components of the system might limit the actual performance achieved. Also, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

² Refer to “Interfaces” on page 55 for an explanation of HVD and LVD.

Feature codes

The IBM 3581 can be upgraded with the following feature codes (Table 15-1). We have not included the various cabling options; refer to the product publications for detailed information about configuring and ordering the IBM TotalStorage 3581 Tape Autoloader.

Table 15-1 IBM 3581 feature codes

Feature code	Description	Comments
7003	5U rack mount option	Plant or field install
7004	Barcode reader	N/A
8001	One 100 GB data cartridge	Plant only; refer to 15.9, "Media" on page 425 for details.
8101	One 200 GB data cartridge	Plant only; refer to 15.9, "Media" on page 425 for details.
8002	One cleaning cartridge	Plant only; refer to 15.9, "Media" on page 425 for details.
9210	Attached to HP-UX	N/A
9211	Attached to Sun Solaris system	N/A
9212	Attached to Windows system	N/A
9213	Attached to other non-IBM system	N/A
9215	Attached to Linux system	N/A
9400	Attached to i5/OS or OS/400 system	N/A
9600	Attached to AIX system	N/A

15.1.1 Access mode

The IBM 3581 can be operated in sequential or random-access mode. In sequential mode, the IBM 3581 loads cartridges one after another, controlled by the hardware when it receives the unload command from the host server. In random-access mode, the IBM 3581 relies on application software for cartridge management.

15.1.2 SCSI devices

Although it has only a single tape drive, the 3581 appears as two SCSI devices on the SCSI bus. In other words, the autoloader and the drive have separate SCSI addresses.

The IBM 3581 only operates on a single path, and control of the autoloader is handled by a single server. Connection to multiple servers can be achieved when using SAN technology and appropriate application software for cartridge management, such as IBM Tivoli Storage Manager.

15.1.3 Adding and removing cartridges

The IBM 3581 does not have a cartridge I/O station. To insert and remove cartridges from the slots, you have to open the autoloader door. The IBM TotalStorage 3581 Tape Autoloader can contain up to seven tape cartridges, as labeled in Figure 15-2:

1. Five cartridges in the front, slots 1 through 5 (referred to as *front slots*)
2. Two cartridges in the rear, slots 6 and 7 (referred to as *rear slots*)

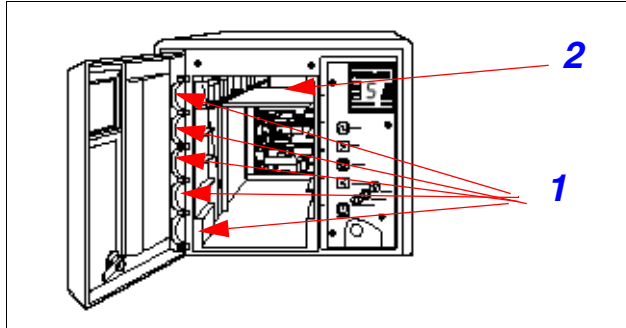


Figure 15-2 IBM 3581 cartridge slots

15.1.4 Operation

The IBM 3581 autoloader is designed for easy, unattended operation. An optional barcode reader makes tape inventory tasks more efficient. Indicators on the operator's panel provide information about:

- ▶ Power
- ▶ Autoloader and drive activity
- ▶ Error status
- ▶ Message information

Push buttons provide display, mode, and power controls.

15.2 SCSI attachments

The SCSI interface (HVD or LVD) on each IBM TotalStorage 3581 Tape Autoloader is chosen by selecting the appropriate model number (H17/13/23 or L17/13/23).

The IBM TotalStorage 3581 Tape Autoloader can be attached to pSeries, IBM RS/6000, xSeries, iSeries, AS/400, other Intel, HP-UX, and Sun systems that support Ultra/Wide SCSI HVD and Ultra2 Wide SCSI LVD interface specifications. The interface that you choose depends on the available adapter in the host, which must be of the same type as the drive interface.

SCSI cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code must also be specified.

The IBM TotalStorage 3581 Tape Autoloader might also be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM marketing representative for a current list of supported Open Systems configurations and software vendors.

15.3 SCSI cabling

A SCSI cable is required for each IBM 3581 connection to a SCSI bus. A single 2.5 m (8.2 ft.) SCSI cable is available as a no-charge feature; if an alternate length is required, it must be included in the initial order. A SCSI terminator is included with each autoloader. An interposer (a connector that matches the pin pattern of the host adapter to the pin pattern of the cable) might also be required for attachment to particular server adapters.

15.3.1 Cables

A single SCSI cable is available as a no-charge feature (FC9702 or FC9703) only with the initial IBM 3581 order. These no-charge features cannot be ordered later as a miscellaneous equipment specification (MES); however, the same cables can be ordered later as chargeable MES upgrades using FC5302 and FC5602. FC9702 supplies a 2.5 m (8.2 ft.) SCSI cable with HD68 connectors at each end; FC9703 differs in that one end has a VHDCI connector.

Additional SCSI cables are available as optional features on the IBM 3581 for LVD and HVD attachment to host adapters:

- ▶ FC5301: 0.4 m (1.3 ft.) SCSI cable
- ▶ FC5302: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5305: 5 m (16.4 ft.) SCSI cable
- ▶ FC5310: 10 m (32.8 ft.) SCSI cable
- ▶ FC5318: 18 m (59.1 ft.) SCSI cable
- ▶ FC5325: 25 m (82.0 ft.) SCSI cable

The cables can be used with an HVD Ultra SCSI bus or LVD Ultra2 SCSI bus and have an HD68 connector on each end. A SCSI terminator is included with each IBM 3581.

The following cables differ in that they have a VHDCI connector at one end:

- ▶ FC5602: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5604: 4.5 m (14.8 ft.) SCSI cable
- ▶ FC5610: 10 m (32.8 ft.) SCSI cable
- ▶ FC5620: 20 m (65.6 ft.) SCSI cable
- ▶ FC5625: 25 m (82.0 ft.) SCSI cable

15.3.2 Interposers

An interposer is required to connect host adapters that do not have HD68 connectors to the SCSI cables. The following chargeable interposers are available:

- ▶ FC2895 interposer to connect iSeries adapter FC6501.
- ▶ FC5099 interposer to connect a mini-68-pin VHDCI connector to the 68-pin HD68 connector on the SCSI cable.

This interposer (a 0.3 m (11.8 in.) cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other end.

15.3.3 SCSI length limitations

The IBM 3581 has one SCSI ID for the drive and one for the loader, so the SCSI interconnection is multi-drop. This means that the overall LVD SCSI cable length is limited to 12 m (39.4 ft.). The stub length at each device must not exceed 0.1 m (0.33 ft.).

The overall HVD SCSI cable lengths are limited to 25 m (82 ft.) using multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 ft.).

15.4 Upgrades and optional features

The IBM 3581 H17/13/23 and L17/13/23 are single tape drive autoloaders and cannot be upgraded to any other models.

Two additional optional features are available:

- ▶ FC7003: 5U Rack Mount Option

The IBM 3581 can be installed as a stand-alone single unit, or two units can be mounted side-by-side in a standard 19-inch rack, requiring 5 EIA units of rack space. This chargeable feature provides the necessary hardware to mount the autoloader in the rack.

- ▶ FC7004: Barcode Reader

This optional chargeable feature enables the IBM 3581 autoloader to read cartridge information contained in a barcode label on the IBM Ultrium cartridges. User-installed application software provides the inventory management functions enabled by the barcode reader feature.

Note: Installing FC7004 reduces the autoloader capacity to six data cartridges. The barcode reader connects to the interface connector on the inside top panel of the IBM 3581. This location prevents you from using cartridge storage slot 1 (refer to Figure 15-2 on page 420). When you install the barcode reader, you reduce the capacity of the autoloader to six cartridge storage slots. The front storage slots are still numbered 1 through 5, but the autoloader's menu functions and the server's application software cannot select or use slot 1. This is illustrated when, with the barcode reader installed, the operator LOAD SLOT function uses storage slots 2 and 3 as the cartridge source locations to load slots 6 and 7; without the barcode reader installed, the LOAD SLOT function uses storage slots 1 and 2 as the source locations. Refer to Figure 15-2 on page 420 for slot locations.

15.5 Environmental specifications

The IBM 3581 is a medium-sized desktop or stand-alone unit that optionally can be integrated into a standard 19-inch rack for space optimization. Two IBM 3581s can be installed side-by-side in a rack using 5 EIA space units.

15.5.1 Physical dimensions

The IBM 3581 models H17/13 and L17/13 are medium-sized single tape drive autoloaders:

- ▶ Width: 21.9 cm (8.62 in.)
- ▶ Depth: 58.1 cm (22.87 in.)
- ▶ Height: 19.0 cm (7.48 in.)
- ▶ Maximum weight: 13.0 kg (28.7 lbs.)

15.5.2 Operating environment

The IBM 3581 can be installed in a normal office environment and does not need to be in a specialized machine room.

15.6 Host platforms and device drivers

These no-charge specify feature codes indicate the server platform to which the IBM 3581 is attached:

- ▶ FC9210: Attached to HP-UX
- ▶ FC9211: Attached to Sun system
- ▶ FC9212: Attached to Windows NT system
- ▶ FC9213: Attached to other non-IBM system
- ▶ FC9215: Attached to Linux system
- ▶ FC9400: Attached to i5/OS or OS400 system
- ▶ FC9600: Attached to AIX system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3581). Sometimes the driver code is supplied as part of the operating system code, such as in OS/400, sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

Ultrium 1

The IBM TotalStorage 3581 Tape Autoloader ships with device drivers to support Ultrium 1 drives in the following operating environments at the minimal levels shown:

- ▶ AIX Versions 4.3.2 or later
- ▶ Sun Solaris 2.6, 7, and 8
- ▶ Windows NT 4.0 with Service Pack 6
- ▶ Windows 2000 Server (build 2195 or greater)
- ▶ Windows Server 2003
- ▶ HP-UX 11.0
- ▶ OS/400 V4R4

Ultrium 2

The IBM TotalStorage 3581 Tape Autoloader ships with device drivers to support Ultrium 2 drives in the following operating environments at the minimal levels shown:

- ▶ OS/400 V5R1, or later
- ▶ AIX V5.1, or later
- ▶ Sun Solaris 7, 8, or 9
- ▶ Microsoft Windows 2000 Server (build 2195 or greater)
- ▶ Microsoft Windows Server 2003 (build 3790 or greater)
- ▶ HP-UX 11.0, HP-UX 11i (64-bit), and HP-UX 11i v2
- ▶ Linux distributions: Red Hat Advanced Server 3, SuSE LINUX Enterprise Server 8 or 9

Tip: The device driver CD or diskette that ships with the IBM 3581 might not contain the device drivers with the most recent level or the device drivers for all supported systems. Therefore, you need to always check the following FTP site for the latest device drivers:

<ftp://ftp.software.ibm.com/storage/devdrv/>

15.6.1 Device driver installation

Install the IBM device drivers for the IBM 3581 as follows:

- ▶ If you intend to use the IBM 3581 with a storage management application (such as Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3581.
- ▶ If you do not intend to use the IBM 3581 with a commercial software application, install the tape and medium device driver from the CD that ships with the autoloader. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

Note: If you use the IBM 3581 with a commercial software application, IBM recommends that you install an IBM-supplied device driver *only* if instructed to do so in the application vendor's installation instructions. Otherwise, if the application supplies its own driver code, conflicts can occur over which driver controls the tape subsystem. Many examples of using the LTO drives are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

15.7 Storage applications

The software to manage the IBM 3581 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, IBM Business Partners, or independent software vendors. A list of compatible software is available at:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 1 and Ultrium 2 support and specific Ultrium models and attachment methods. You can also contact your storage application vendor for more detailed information about specific versions and supported platforms.

15.8 Performance considerations

For best performance, we recommend that you attach only one tape drive per SCSI bus. This might not be a realistic objective, but minimizing the number of devices per bus will improve performance. Attaching other SCSI devices on the same SCSI bus as the IBM 3581 drive can affect the performance of those devices.

iSeries configurators allow only one drive per input/output port for maximum performance. Installing more than one Linear Tape-Open (LTO) tape drive on an I/O port can affect the system performance.

Although the compression technology can increase the amount of data stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

15.9 Media

One Ultrium cleaning cartridge and one Ultrium data cartridge are included with each autoloader order³. With the initial order, additional data and cleaning cartridges were available as chargeable features for the IBM 3581:

- ▶ FC8001 provides a single 100 MB Ultrium Data Cartridge.
It is a chargeable feature, and a maximum of seven can be ordered.
- ▶ FC8101 provides a single 200 MB Ultrium Data Cartridge.
It is a chargeable feature, and a maximum of 20 can be ordered.
- ▶ FC8002 provides a single Ultrium Cleaning Cartridge.
It is a chargeable feature, and a maximum of three can be ordered.

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497 for details about ordering supplies and cartridges, with or without labels.

15.10 IBM 3581 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3581. It does not cover all tasks, and we do not intend to list all of the specific commands. For more details, refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461; *Implementing IBM Tape in Linux and Windows*, SG24-6268; and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

15.10.1 SCSI ID

The IBM 3581 consists of two SCSI devices: the autoloader and the drive. The default settings for the SCSI IDs as displayed on the message display panel are LdR Id 1⁴ (for the autoloader) and dRV Id 3 (for the drive). Depending on your requirements, you might need to change the SCSI ID default settings for your installation. When setting a SCSI ID:

- ▶ Do not select an ID that is already in use.
- ▶ Do not select the SCSI ID of the server SCSI adapter card. The SCSI ID of the server SCSI adapter card is usually higher than any device on the SCSI bus. Generally, the SCSI ID for the server adapter is set to 7.
- ▶ Do not use F, because it is reserved for internal use by the SCSI library.
- ▶ Unless you choose another operation, the IBM 3581 times out 30 seconds after each operation, and LdR REAdY appears in the message display (label 1 in Figure 15-3 on page 427).
- ▶ Functions and messages in the message display can only be scrolled forward. To select a previously viewed function, continue to scroll through the choices until the function that you want appears on the message display.
- ▶ As with the IBM 3580, the IBM 3581 can be part of a SCSI chain. The same rules apply for SCSI addresses as for the IBM 3580.

Refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461, for details about determining and changing SCSI IDs.

³ All media and cleaning cartridges are warranted separately from the IBM TotalStorage 3581 Tape Autoloader.

⁴ The message display panel displays a D as a lower case letter so we have shown the message as it appears.

15.10.2 Element numbers

Element numbers (also called *element addresses*) identify the physical location within the autoloader. This information is required by storage management applications, such as IBM Tivoli Storage Manager.

Table 15-2 shows the three types of elements in the IBM 3581.

Table 15-2 IBM 3581 element numbers

Element	Element number
Picker (media transport element)	57 hexadecimal
Tape drive (data transfer element)	52 hexadecimal
Storage element	01 - 07 hexadecimal

The IBM 3581 has one storage element for each of the cartridge storage slots.

A host application controls movement within the autoloader by issuing one of these SCSI commands:

- ▶ **MOVE MEDIUM:** This SCSI command tells the autoloader to move a cartridge from the source element to the destination element. The elements are identified using the element numbers that are shown in Table 15-2. So, for example, a MOVE MEDIUM command can be issued to tell the library to move a cartridge from the picker to the drive.
- ▶ **POSITION TO ELEMENT:** This positions the picker to a specified element number.

15.10.3 Operator displays and buttons

Management of the IBM 3581 is performed by using the status lights, message display panel, and push buttons on the control panel behind the front door.

Status lights

The IBM 3581 has three status lights on the Operator Panel (label 2 in Figure 15-3 on page 427):

- ▶ **POWER:** The green POWER light comes on whenever you turn on the power.
- ▶ **ACTIVITY:** The amber ACTIVITY light indicates robotic or drive activity. A slowly blinking light indicates robotic activity; a rapidly blinking light indicates drive activity.
- ▶ **ALARM:** The red ALARM light comes on whenever an error occurs. To resolve the error, refer to the *Setup and Operator Guide*, GA32-0457.

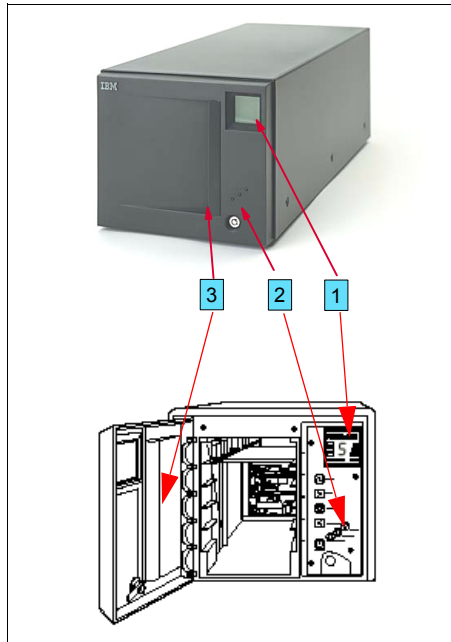


Figure 15-3 IBM 3581 front view

15.10.4 Message display

The IBM 3581 has a one-line, 10-character front panel with a liquid crystal display (LCD) that provides operational information, as well as diagnostics and messages.

The LCD message display (label 1 in Figure 15-3) provides information about the status of the IBM 3581 and any error conditions. When in an idle (non-operating) state, the autoloader message panel displays LdR REAdY. In addition, the following characters (shown in Figure 15-4 on page 428) can appear on the left side of the display:

DC	Indicates that data compression is selected on the drive
WP	Indicates that a write-protected data cartridge is loaded in the drive
CT	Indicates that the drive head needs to be cleaned

The large field in the center of the display indicates the number of the storage slot from which the picker removed a cartridge for loading into the drive. Whenever an error occurs, E displays in this field, and the error message is displayed on line 1.

The activity bars on the right (in conjunction with the activity light) indicate robotic and drive activity:

- ▶ The bottom bar blinks when no activity is taking place.
- ▶ A slow interval between the bars appearing and disappearing indicates robotic activity.
- ▶ A fast interval between the bars appearing and disappearing indicates drive activity.

The seven numeric fields at the bottom of the display indicate the current cartridge inventory. Each field will appear only if a cartridge is present in that storage slot, as shown in Figure 15-4 on page 428.



Figure 15-4 IBM 3581 message display

15.10.5 Drive status messages

During operation, the IBM 3581 places messages about the drive's status in the message display. These messages can appear:

CLEANING	The drive is cleaning the head with the cleaning cartridge.
EJECTING	The drive is unloading the tape.
ERASING	The drive is erasing the tape.
LOADING	The drive is loading the tape.
LOCATING	The drive is locating the position on the tape.
READING	The drive is reading from the tape.
REWINDING	The drive is rewinding the tape.
WRITING	The drive is writing to the tape.

If an error occurs during operation, the IBM 3581 halts the current operation and displays an error code in the message display. The following list provides the most common error codes and gives a description of each error code:

CT FAILED	Cleaning tape failed to clean drive.
DEST FULL	The destination location was full.
DRIVE BUSY	The drive is busy and cannot unload the tape.
DRIVE FULL	The drive was full.
DRIVE PGRM	The attempt to set drive parameters failed.
DRIVE POST	The drive failed its Power-On Self Test (POST).
FRONT SLOT	A front slot sensor was not tripped.
FRONT TAPE	A front tape sensor was not tripped.
LDR INIT	The autoloader was unable to complete its initialization.
PCKR EMPTY	The picker was empty.
PCKR FULL	The picker was full.
REAR SLOT	A rear slot sensor was not tripped.
REAR TAPE	A rear tape sensor was not tripped.
ROBOT POST	The robotics failed its Power-On Self Test (POST).
SRC EMPTY	The source location was empty.
SLOT EMPTY	No slot beam was detected.
PWR SWITCH	The front power switch was pressed.
SLOT FULL	A cartridge was already in the slot.

This list is not complete. Refer to the *Setup and Operator Guide* for the full error list.

15.10.6 Control buttons

The control buttons are push buttons on the Operator Panel that let you interact with the menus on the message display (Figure 15-5 on page 430):

MODE	Scrolls through the commands that you can use to operate the IBM 3581 (label 1 in Figure 15-5 on page 430)

NEXT	Highlights the next item or value in the currently displayed menu (label 2 in Figure 15-5 on page 430)
SELECT	Selects the currently displayed operation (label 3 in Figure 15-5 on page 430).
PREVIOUS	Highlights the previous item or value in the currently displayed menu (label 4 in Figure 15-5 on page 430).

To operate a button, press and release it. You can use the control buttons to:

- ▶ Load a tape cartridge into a drive (LOAD DRV)
- ▶ Eject a tape cartridge from the drive and put it into the storage slot from which it was loaded (EJECT DRV)
- ▶ Load slot 6 from slot 1, or load slot 7 from slot 2 (LOAD SLOT)
- ▶ Move a cartridge from slot 6 to slot 1 or from slot 7 to slot 2 (EJECT SLOT)
- ▶ Eject a tape cartridge that was left in the media picker into an empty destination slot (EJECT PCKR)
- ▶ Set the SCSI ID of the autoloader or the drive (SET SCSI)

Note: The procedure for loading slots 1 through 5 differs from loading slots 6 and 7. If you are loading seven cartridges, load slots 6 and 7 first. Refer to “Inserting a Cartridge into Slots 6 and 7” of the chapter “Operating the IBM 3581 Tape Autoloader” in *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461, which also contains a complete list of commands.

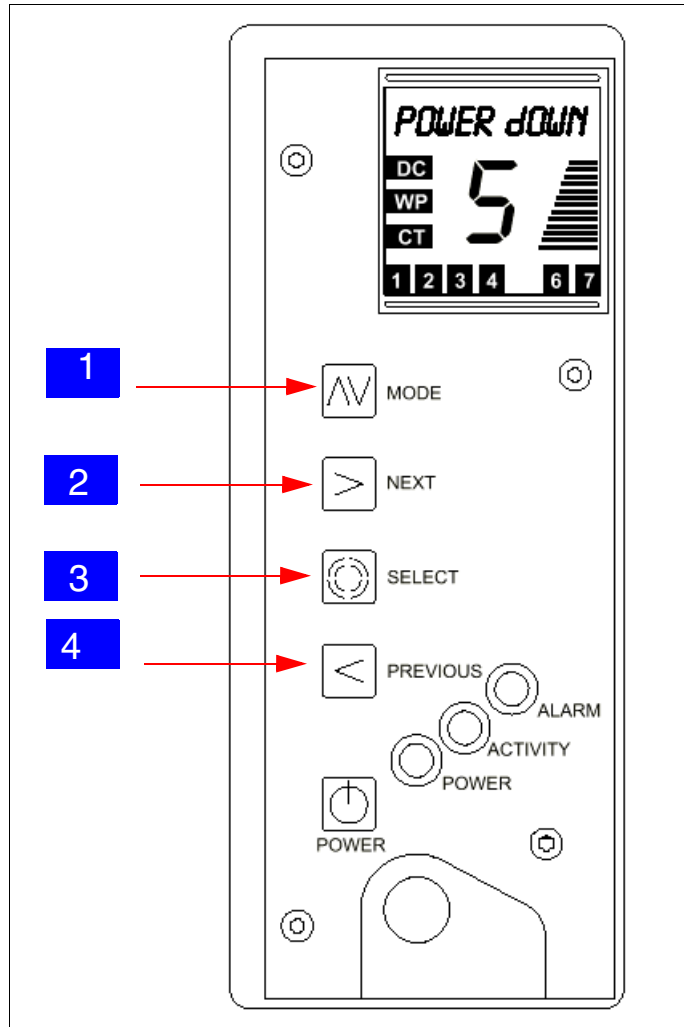


Figure 15-5 IBM 3581 Operator Panel

15.10.7 Operating modes

The IBM 3581 operates in both random access mode (in which the server's application software manages the cartridges) and sequential access mode (in which the autoloader's firmware manages the cartridges).

Change between random and sequential mode through the Diagnostic Menus.

Select CHG MODE to toggle between the random access and sequential access modes. The IBM 3581 can operate in either mode:

- ▶ In random access mode, the autoloader allows the server's application software to select any data cartridge in any order. You can logically divide cartridge usage to satisfy particular data storage needs. For example, you can assign one or more cartridges to specific data functions (such as certain directories or network servers), or you can assign specific cartridges to individual users or groups (such as Sales or Engineering).
- ▶ In sequential access mode, all cartridges present are considered to be a single volume. The autoloader's firmware predefines the selection of the cartridges. After initialization, the firmware causes the autoloader to always load the first cartridge found (counting from 1 through 7) into the drive. After the server's application software has filled this cartridge and

unloaded the drive, the autoloader automatically returns the cartridge to its storage slot and loads the next cartridge in order. Empty storage slots are ignored. The autoloader continues this process until the volume is full.

Note: While in sequential access mode, the autoloader's robotics are not logically connected to the SCSI bus and do not respond to SCSI commands.

To change the mode of operation:

1. Ensure that **LdR REAdY** appears on the message display.
2. Press and hold **NEXT** and then **MODE** until **dIAG MENU** displays (approximately five seconds).
3. Press and hold **MODE** until **CH M0dE** appears on the message display.
4. Press **SELECT** to display the current mode of operation.
5. Press **NEXT** or **PREVIOUS** to toggle the mode between **SEQUENTIAL** and **RANdOM**.
6. Choose the mode that you want and press **SELECT**. **CYCLE PWR** blinks on the message display. If you changed to random mode, **LdR REAdY** then displays; if you changed to sequential mode, **SEQ REAdY** then displays.
7. To activate the new mode of operation, cycle power (turn off, then turn on) to the IBM 3581.

The complete list of mode setup commands is in the *Operator and Setup Guide*.

15.11 Drive cleaning

All IBM Ultrium tape drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. There is also a cleaning procedure using a special cleaning cartridge.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or an IBM-approved cleaning cartridge.

The IBM 3581 internal tape drive determines when the head needs to be cleaned and alerts you by displaying **CT** on the message display (label 1 in Figure 15-3 on page 427). This is the *only* occasion when a cleaning cartridge needs to be used. The IBM 3581 supports three methods of cleaning the drive:

- ▶ **Host cleaning:** Host cleaning enables the server software to detect the need to clean an Ultrium Tape Drive and to control the cleaning process. The cleaning cartridge must be stored in one of the available storage slots within the 3581.
- ▶ **Automatic cleaning (AUTOCLEAN):** Automatic cleaning enables the 3581 to automatically respond to any tape drive's request for cleaning and to begin the cleaning process. Automatic cleaning makes the cleaning process transparent to any host application using the autoloader. If the server application does not support the host cleaning function, use the autoclean function.
- ▶ **Manual cleaning:** Manual cleaning requires you to select a menu option from the autoloader's display. Manual cleaning is always supported, regardless of whether host cleaning or automatic cleaning is enabled or disabled.

In all methods, the autoloader performs the cleaning after you unload the data cartridge from the drive and before the next load.

Note: Whenever you enable host application cleaning or the autoloader's autoclean function, the tape capacity of the autoloader is reduced to six tapes without the barcode reader and to five cartridges with the barcode reader feature installed. The extra slot is used for storing the cleaning cartridge within the IBM 3581.

You can find proper instructions for cleaning the IBM 3581 in "Performing Diagnostic and Maintenance Functions" in the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

15.12 Firmware upgrade

There are tools readily available to facilitate this process. The recommended tool, the IBM TotalStorage Tape Diagnostic Tool (ITDT), is available on the IBM Web site and requires no special device drivers. To download ITDT and the instructions for using the tool, visit:

<http://www-03.ibm.com/servers/storage/support/>

ITDT is available for multiple platforms. Other tools, such as ntutil and tapeutil, can also be used for drive firmware updates. The library also supports drive firmware update by creating and using a Field Microcode Replacement (FMR) cartridge.

The recommended method to update drive firmware is:

1. Download the latest drive firmware to your host computer by visiting:

<http://www-1.ibm.com/servers/storage/tape/lto/>

Important: Be careful to select the correct firmware. There is different firmware for Fibre Channel drives and SCSI drives, in addition to different firmware for LTO1, LTO2, and LTO3 drives.

2. Update all SCSI and Fibre Channel drives in the library by using ITDT.

Using ITDT to update drive firmware

A newly designed tool, ITDT, is a tool with multiple functional capabilities and is a quick, convenient, and efficient method for drive firmware updates. As a note, you can also perform drive dump retrievals with the tool. Several of the capabilities of this tool are:

- ▶ Firmware update capability via SCSI to all IBM LTO tape drives.
- ▶ The tool does not require any special device drivers.
- ▶ The tool is available for most major platforms (Windows, AIX, SUN, Linux, and NetWare).
- ▶ The tool is capable of uploading drive dump files.
- ▶ The tool's primary function is thoroughly testing a drive. However, if the library is online to the server or host where the tool resides, ITDT will communicate with the drive through the library to load and unload a test cartridge, thereby, exercising library functions.
- ▶ The tool scans the SCSI bus to find and display for selection all IBM LTO devices. The tool does not display or allow for selection any non-IBM device.
- ▶ Each function has a Help selection, which explains the required syntax, as well as a brief explanation of the particular function.

- ▶ A readme text file is posted with the .exe file for a thorough explanation of initial tool download information from the Web, as well as an explanation of tool capabilities.
- ▶ The tool is currently a command line tool that you start by simply typing the executable name, itdt, from the directory where the tool is located.

Other methods for updating drive firmware

When updating drive firmware by using the SCSI or Fibre Channel, the procedure varies, depending on whether you use an IBM tape device driver or a non-IBM tape device driver (such as a driver from Sun, Hewlett-Packard, or Microsoft).

If using an IBM tape device driver, drive firmware can be updated using the tapeutil or ntutil tools. These tools are explained in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430.

If using a non-IBM tape device driver, refer to the relevant documentation.



IBM TotalStorage 3581 2U Tape Autoloader

The IBM TotalStorage 3581 2U Tape Autoloader (IBM 3581 2U) is a desktop or rack-mountable unit (requiring two rack units, therefore “2U”) that operates in automatic, sequential, or random mode and comes equipped with a robotic interface that moves tape cartridges to and from the drive and a cartridge carousel.

The IBM TotalStorage 3581 2U Tape Autoloader offers high capacity, performance, and technology designed for the midrange Open Systems environment. It also constitutes an excellent tape storage solution for clients with existing digital linear tape experience or requiring high performance automated tape backup.

Optional features include a Remote Management Unit (RMU) and a barcode reader (BCR).

16.1 Description

The IBM TotalStorage 3581 2U Tape Autoloader (Figure 16-1 on page 437) uses the IBM Ultrium 2 and Ultrium 3 drives for fast data transfer and reliability in automated library services. The Ultrium 2 cartridge has a native capacity of 200 GB. The Ultrium 3 cartridge has a native capacity of 400 GB.

The IBM TotalStorage 3581 2U Tape Autoloader has an eight-cartridge capacity. With an IBM Ultrium 2 drive, the native media capacity is 1.6 TB (3.2 TB with 2:1 compression) with a sustained data rate up to 35 MB/s (uncompressed). With an IBM Ultrium 3 drive, the native media capacity is 3.2 TB (6.4 TB with 2:1 compression) with a sustained data rate up to 80 MB/s (uncompressed) with Ultrium 3 media.

The IBM TotalStorage 3581 2U Tape Autoloader attaches to a variety of server and operating system platforms. (Refer to 16.6, “Host platform and device drivers” on page 446.)

The four models of the IBM TotalStorage 3581 2U Tape Autoloader are:

- ▶ The IBM TotalStorage 3581 2U Tape Autoloader Model L28:
 - The IBM 3581-L28 has an Ultrium 2 drive and a Low-Voltage Differential (LVD) Ultra 160 SCSI attachment that connects to LVD fast/wide adapters.
 - Using the optional High-Voltage Differential (HVD) converter (FC3104), a SCSI LVD to HVD converter/expander converts the autoloader’s LVD to HVD.
- ▶ The IBM TotalStorage 3581 2U Tape Autoloader Model F28
The IBM 3581-F28 has an Ultrium 2 drive and a 2 Gbps native switched fabric Fibre Channel attachment.
- ▶ The IBM TotalStorage 3581 2U Tape Autoloader Model L38/L3H
The IBM 3581-L38 has an Ultrium 3 drive and a LVD Ultra 160 SCSI attachment that connects to LVD fast/wide adapters.
- ▶ The IBM TotalStorage 3581 2U Tape Autoloader Model F38/F3H
The IBM 3581-F38 has an Ultrium 3 drive and a 2 or 4 Gbps Native Switched Fabric Fibre Channel attachment.

The IBM 3581-L38 and IBM 3581-L3H are functionally identical. The IBM 3581-F38 and IBM 3581-F3H are functionally identical. The only difference is that the IBM 3581-L3H and IBM 3581-F3H are Express Models and are part of the IBM Express Portfolio.

Note: The IBM Express Portfolio is a set of IBM offerings for Business Partners in Small and Medium Business. For details, refer to the Web site:

http://www.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html



Figure 16-1 IBM TotalStorage 3581 2U Tape Autoloader

The autoloader's robotic system includes an I/O door, a cartridge carousel with eight cartridge slots, and a cartridge loader. The I/O door allows the importing or exporting of a single cartridge to or from the autoloader. The cartridge carousel encircles the Ultrium 2 or 3 drive and positions the specified cartridge slot in front of the tape drive. A robotic cartridge loader moves the cartridges between the cartridge slots and the tape drive. (See Figure 16-2.)

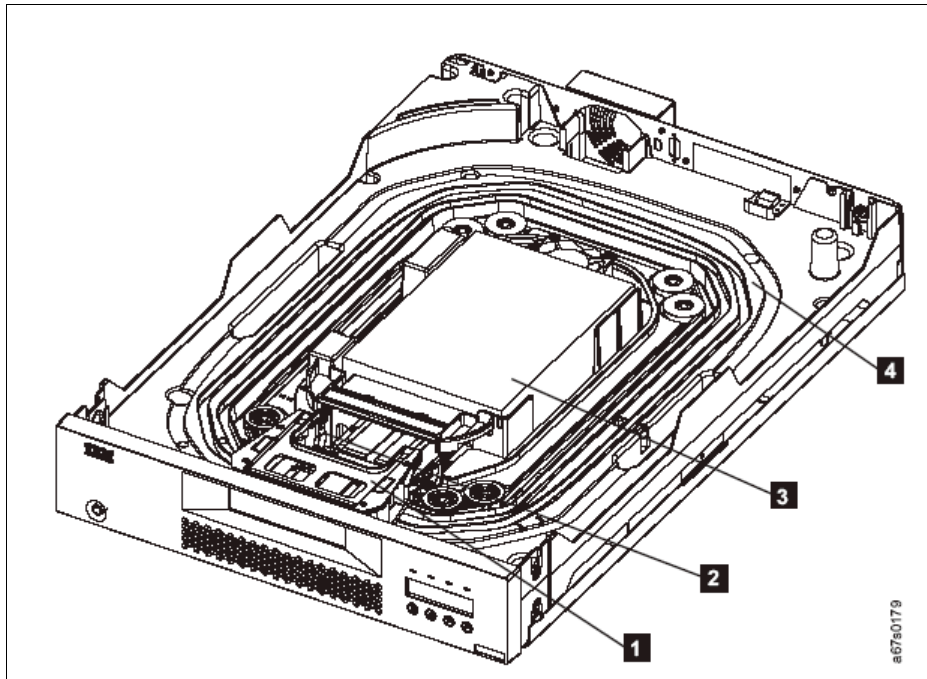


Figure 16-2 Interior components with one cartridge slot

The numbers in Figure 16-2 refer to the following components:

1. Cartridge slot

Each cartridge is installed in a cartridge slot to ensure that the cartridge is properly aligned for insertion into the tape drive.

2. Cartridge loader

The cartridge loader moves cartridges between the cartridge slots and the tape drive. When a cartridge slot is positioned in front of the drive, the loader grips the sides of the cartridge and slides it forward or backward between the slot and drive. The loader then releases the cartridge and pushes it firmly into the drive or slot.

3. Ultrium 2 or Ultrium 3 Tape Drive (LVD or Fibre Channel)

The autoloader contains one LVD (IBM 3581 L28/L38/L3H) or Fibre Channel (IBM 3581 F28/F38/F3H) Ultrium tape drive. The Ultrium 2 IBM 3581 L28/F28 provides a sustained data transfer rate of 35 MB/s (compressed) and can store up to 200 GB of uncompressed information on a single data cartridge (400 GB, assuming an average compression ratio of 2:1). The Ultrium 3 IBM 3581 L38/F38/L3H/F3H provides a sustained native data transfer rate of 80 MB/s and can store up to 400 GB of uncompressed information on a single data cartridge (800 GB, assuming an average compression ratio of 2:1).

4. Carousel

The carousel stores up to eight Ultrium 3, Ultrium 2, or Ultrium 1 data cartridges. The carousel consists of a drive chain, guides, and gears that move the cartridges into position in front of the drive.

16.1.1 IBM 3581-L28/F28 (Ultrium 2) characteristics

Next, we list the characteristics of the IBM 3581-L28/F28 (Ultrium 2).

Digital speed matching

The IBM 3581 performs dynamic speed matching to adjust the drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This capability offers the dual benefit of reducing the number of backhitch repositions and improving throughput performance.

Power management

The power management function controls the drive's electronics to be either completely turned off or to be in a low-power mode. These power modes occur only when the circuit functions are not needed for drive operation.

Channel calibration

The IBM 3581-L28/F28 channel calibration feature allows for customization of each Read/Write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and Read/Write head characteristics.

The autoloader also presents the following characteristics:

- ▶ Separate writing of multiple file marks

Separate writing of multiple file marks causes any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark. This feature has two advantages:

- First, it can improve performance if a subsequent append overwrites somewhere after the first file mark.
- Second, a write of multiple file marks typically indicates a point where an append operation might occur after the first of these file marks. This change prevents the need to rewrite datasets containing client data and the first file mark in cases where this type of an append occurs.

- ▶ Large internal buffer

The Ultrium 2 tape drive has a 64 MB internal data buffer.

- Fast cartridge fill times (refer to Table 16-1)

Table 16-1 Data cartridge fill times

Tape drive	Cartridge fill time (sustained data rate)	
	Ultrium 2 cartridge (200 GB)	Ultrium 1 cartridge (100 GB)
Ultrium 2	1 hr. 44 min.	1 hr. 29 min.
	(122.8 GB/hr.)	(71.0 GB/hr.)

- Fast data access, rewind, and load times (Table 16-2)

Table 16-2 Data access, rewind, and load times

Action	Ultrium 2 tape drive
Cartridge load time	15 seconds
Maximum rewind time	80 seconds
Average file access time	49 seconds

16.1.2 IBM 3581-L38/L3H/F38/F3H (Ultrium 3) characteristics

The Ultrium 3 Tape Drive offers the following significant improvements over the Ultrium 2.

Increased performance

Maximum tape drive throughput data rate performance is more than doubled, up to 80 MB/s native data transfer rate. Data tracks are now written 16 at a time. IBM Ultrium 3 Tape Drives can read and write, at 8 data tracks at a time, Linear Tape-Open (LTO) Ultrium 2 Data Cartridges at Ultrium 2 capacities and rates. IBM Ultrium 3 Tape Drives can read LTO Ultrium 1 Data Cartridges at Ultrium 1 capacities with improved rates.

Note: Although the IBM 3581 2U provides the capability for excellent tape performance, other components of the system can limit the actual performance achieved. Also, whereas the compression technology used in the tape drive can typically double the amount of data that can be stored on the media, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

Larger capacity

The tape cartridge capacity is doubled over the Ultrium 2 Data Cartridge up to 400 GB native physical capacity (800 GB with 2:1 compression) with the use of the IBM TotalStorage LTO Ultrium 400 GB Data Cartridge. This is achieved by increasing the linear density, the number of tape tracks, and the media length. The tape itself is an advanced metal particle tape developed to help provide durability and capacity.

Ultrium 2 cartridge compatibility

The Ultrium 3 Tape Drive can read and write on Ultrium 2 cartridges.

SCSI Ultra160 LVD attachment

The Model L38 comes with a SCSI Ultra160 LVD attachment for connection to a wide spectrum of Open Systems servers. It is supported on AIX, OS/400, i5/OS, Sun Solaris, HP-UX, Microsoft Windows 2000 Server, Windows Server 2003, Linux, and other Open Systems.

Fibre Channel attachment

The Model F38 comes with a native switched fabric 2 Gbps Fibre Channel attachment. It is supported on AIX, OS/400, Sun Solaris, HP-UX, Microsoft Windows 2000 Server, Windows Server 2003, Linux, and other Open Systems.

Larger internal data buffer

There is a 128 MB internal data buffer in the Ultrium 3 Tape Drive as compared to a 64 MB internal data buffer in the Ultrium 2 Tape Drive.

Graceful dynamic braking

In the event of power failure, reel motors are designed to maintain tension and gradually decelerate instead of stopping abruptly, which helps reduce tape breakage, stretching, and loose tape wraps during a sudden loss of power.

Other IBM LTO Ultrium features enhanced in Ultrium 3

Additional features includes:

- ▶ Servo and track layout technology

There are 704 data tracks in Ultrium 3 as compared to 512 data tracks in Ultrium 2. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

- ▶ Magneto Resistive (MR) head design

Use of flat lap head technology in MR heads for Ultrium 3 helps minimize contact, debris accumulation, and wear on the tape as it moves over the Read/Write heads.

- ▶ Digital speed matching

The Ultrium 3 Tape Drive is designed to perform dynamic speed matching (at one of five speeds: 40, 50, 60, 70, or 80 MB/s) to adjust the drive's native data rate as closely as possible to the net host data rate (after data compressibility has been factored out). This helps reduce the number of backhitch repositions and improve throughput performance on Ultrium 3 ranges from 40 to 80 MB/s as compared to 17.5 to 35 MB/s on Ultrium 2.

- ▶ Robust drive components optimized for automation environments

To help enhance reliability and prolong the life of the drive, it was designed using several of the most robust components available, such as an all metal clutch, steel ball bearings in the loader, robust leader block design, and a single circuit card.

- ▶ Power management

The Ultrium 3 Tape Drive power management function is designed to control the drive electronics to be either completely turned off or to be in a low power mode when the circuit functions are not needed for drive operation.

- ▶ Adaptive read equalization

The drive is designed to automatically compensate for dynamic changes in readback signal response.

- ▶ Dynamic amplitude asymmetry compensation

Readback signals are designed to dynamically optimize for linear readback response from magneto resistive read head transducers.

- **Separate writing of multiple file marks**

Separate writing of multiple file marks is designed to cause any write command of two or more file marks to cause a separate data set to be written containing all file marks after the first file mark. This feature has two advantages: it helps improve performance if a subsequent append overwrites somewhere after the first file mark, and write of multiple file marks typically indicates a point where an append operation might occur after the first of these file marks. This change helps prevent having to rewrite datasets containing client data and the first file mark if this type of an append occurs.

- **LTO Data Compression (LTO-DC)**

The Ultrium 3 uses LTO-DC, which is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithm. LTO-DC is an extension of Adaptive Lossless Data Compression (ALDC) and an improvement over previous IBM lossless compression algorithms. The IBM-patented “Scheme-Swapping” compression is designed to look ahead at incoming data to determine the most efficient storage method (either ALDC or pass-through mode) to help provide optimal data compression and increased data throughput.

- **LTO Cartridge Memory (LTO-CM)**

Contained within the LTO Ultrium data cartridge is the LTO-CM, which is a passive, contactless silicon storage device that is physically a part of the cartridge. The LTO-CM is used to hold information about that specific cartridge, the media in the cartridge, and the data on the media. The storage capacity of the LTO-CM is 4096 bytes. Communication between the drive and the LTO-CM is via a low-level RF field transmitted by the drive to the cartridge.

- **Statistical Analysis and Reporting System (SARS)**

The Ultrium 3 Tape Drive uses SARS to help isolate failures between media and hardware. The SARS uses the cartridge performance history saved in the CM module and the drive performance history kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the more likely cause of failure. The SARS can cause the drive to request a cleaner tape, to mark the media as degraded, and to indicate that the hardware has degraded.

With support for LTO Ultrium-format tape data cartridges, the IBM 3581 provides an excellent migration path from digital linear tape (DLT or SDLT), 1/4-inch, 4 mm, or 8 mm tape drives.

16.2 Feature codes

You can order the IBM TotalStorage 3581 2U Tape Autoloader and upgrade it with the following features.

Table 16-3 Feature codes for the IBM 3581 2U

Feature code	Description	Comments
1660	RMU	N/A
3104	HVD Converter Kit	3581-L28 only
5096	SC-LC Fibre Cable Interposer	N/A
5099	VHDCI/HD68 Cable Interposer	N/A
7003	Rack Mount Option	N/A
7004	Barcode Reader	N/A
8002	Cleaning Cartridge	Plant only
8101	1 200 GB Ultrium 2 Data Cart	Plant only
8301	1 400 GB Ultrium 3 Data Cart	Plant only

Barcode reader (BCR)

The BCR reads barcode labels and sends the label IDs to the server (host) and to the Remote Management Unit (RMU), if installed. The barcode reader is installed at the back of the unit so that it does not affect the slot capacity of the unit.

Remote Management Unit (RMU)

The Remote Management Unit (RMU) provides remote access to the autoloader over a network. The autoloader can be attached to the network through a 10/100 Ethernet port located on the RMU. Any server (host) can access the autoloader if it has a Web browser installed and the IP address of the autoloader is known.

HVD converter

The HVD converter is a SCSI LVD to HVD converter/expander. It converts the autoloader's low voltage differential (LVD) to wide high voltage differential (HVD). This enables LVD peripherals to be used on an HVD bus. The converter can also be used to reshape poor quality LVD signals and allow additional cable length.

Rack Mount Kit

The Rack Mount Kit supplies the necessary mounting hardware to install the autoloader in a 19-inch rack.

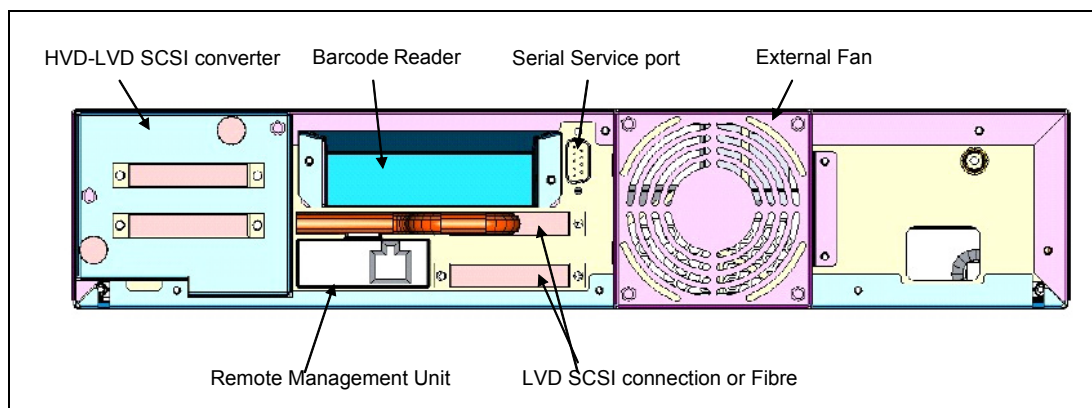


Figure 16-3 Back view of the IBM 3581 2U

16.3 Access modes

The IBM TotalStorage 3581 2U Tape Autoloader can operate in two modes, automatic or sequential:

- **Automatic mode**

Automatic mode is the default setting. It enables the autoloader to switch between sequential and random modes depending on the SCSI command received. In automatic mode, sequential mode is activated when the autoloader is powered on. When the autoloader receives a MOVE MEDIUM, READ ELEMENT STATUS, or an INITIALIZE ELEMENT STATUS command, sequential mode is disabled and random mode becomes active. The autoloader will switch back to sequential mode with every OCP-initiated LOAD or UNLOAD command.

- **Sequential mode**

In sequential mode, the autoloader's firmware predefines the selection of the cartridges. After initialization, the firmware causes the autoloader to select the first available cartridge found (counting from 1 through 8) for loading into the drive. If AUTOLOAD MODE is set to ON, the first cartridge will load automatically. Otherwise, the OCP's LOAD CARTRIDGE command must be executed. After the server's (host's) application software fills this cartridge with data and issues an UNLOAD command, the autoloader returns the cartridge to its storage slot and loads the next cartridge in order. Empty storage slots are ignored. The autoloader continues this process until all cartridges have been filled with data.

Note: While in sequential mode, the autoloader's robotics are not logically connected to the SCSI bus and do not respond to SCSI commands.

Associated with sequential mode are LOOP MODE and AUTOLOAD MODE:

- **Loop mode**

LOOP MODE can be used with sequential mode. Sequential mode with LOOP MODE turned ON loads the cartridge in slot 1 after the cartridge in slot 8 has been filled and sent back to its home slot. This allows endless backup operations without user interaction.

- **Random mode**

In random mode, the autoloader allows the server's (host's) application software to select any data cartridge in any order.

16.4 Physical attachments

The IBM 3581 2U features LVD Ultra160 SCSI and 2 Gb Fibre Channel interfaces, attaching to System p, System i, System x, System z (Fibre Channel only), RS/6000, AS/400, Sun, and HP-UX systems. Native device driver support is available for AIX, OS/400, Windows NT, Windows 2000 Server, Windows Server 2003, Sun Solaris, HP-UX, and Linux. Refer to 16.6, "Host platform and device drivers" on page 446 for more details.

SCSI cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code also must be specified.

The IBM 3581 2U might be compatible with other servers, operating systems, and SCSI adapters. Contact your local IBM marketing representative for a current list of supported Open Systems configuration and software vendors, or go to:

<http://www.ibm.com/servers/storage/tape/3581/interop.html>

16.4.1 SCSI cabling

A SCSI or Fibre cable is required to attach the IBM 3581 2U to the server host bus adapter. At least one Fibre cable must be specified on the initial plant order. A SCSI cable and terminator are supplied with IBM 3581-L38. An interposer or interposers might be required for attachment to various server adapters. Additional SCSI cables are available as optional features on the IBM 3581-L28 for LVD and HVD attachment to host adapters.

Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface.

SCSI cables

The following cables are available for SCSI LVD attachment of the IBM 3581 2U.

These cables come with HD68 connectors on both ends (Ultrium 2 only):

- ▶ FC5302: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5305: 5 m (16.4 ft.) SCSI cable
- ▶ FC5310: 10 m (32.8 ft.) SCSI cable
- ▶ FC5325: 25 m (82 ft.) SCSI cable
- ▶ FC9702: 2.5 m (8.2 ft.) SCSI cable (plant only)

These cables have a VHDCI connector on one end and an HD68 connector on the other end:

- ▶ FC5602: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5604: 4.5 m (14.8 ft.) SCSI cable
- ▶ FC5610: 10 m (32.8 ft.) SCSI cable
- ▶ FC5625: 25 m (82 ft.) SCSI cable (Ultrium 2 only)
- ▶ FC9703: 2.5 m (8.2 ft.) SCSI cable (Ultrium 2 and plant only)

Interposer

An interposer is required to connect a SCSI cable with HD68 connectors to a VHDCI connector. There is one interposer available: FC5099 VHDCI/HD68 interposer to connect a mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other end.

SCSI length limitations

SCSI length limitations apply, depending on the connection type:

- ▶ HVD connections

Total HVD SCSI cable lengths are limited to 25 m (82 ft.) using point-to-point (that is, one host connected to only one tape drive), or multi-drop interconnection (that is, one host connected to more than one tape drive on the same SCSI bus). Stub length at each device must not exceed 0.2 m (0.66 ft.).

- ▶ LVD connections

Total LVD SCSI cable length is 12 m (39.4 ft.) due to an internal multi-drop interconnection. Stub length at each device must not exceed 0.1 m (0.33 ft.).

16.4.2 FC cabling

A Fibre Channel cable is required to attach an IBM 3581 2U to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components. The IBM LTO Ultrium 2 and Ultrium 3 Fibre Tape Drive come with an LC Duplex connector.

FC cables

Features available for Fibre Channel cables and their respective lengths are:

- ▶ FC5907: 7 m (23.0 ft.) SC-LC Fibre Channel Cable - Ultrium 2 only
- ▶ FC5922: 22 m (72.0 ft.) SC-LC Fibre Channel Cable - Ultrium 2 only
- ▶ FC5961: 61 m (200.1 ft.) SC-LC Fibre Channel Cable - Ultrium 2 only
- ▶ FC6005: 5 m (16.4 ft.) LC-LC Fibre Channel Cable
- ▶ FC6013: 13 m (42.7 ft.) LC/LC Fibre Channel Cable - Ultrium 3 only
- ▶ FC6025: 25 m (82.0 ft.) LC-LC Fibre Channel Cable
- ▶ FC6061: 61 m (200.1 ft.) LC-LC Fibre Channel Cable - Ultrium 2 only

Interposer

A interposer might be required to connect a fibre cable with LC Duplex connectors to another SC Duplex connector. The following interposer is available: FC5096 Interposer SC-LC Fibre.

16.5 Specifications

The IBM TotalStorage 3581 2U Tape Autoloader is a stand-alone, medium-sized library unit that can be placed on a desk or in a rack. It requires two Electronic Industries Association (EIAs) of rack space. Table 16-4 shows the physical specifications. Table 16-5 shows the power specifications. Table 16-6 shows the acoustic specifications. Table 16-7 on page 446 shows the environmental specifications.

Table 16-4 Physical specifications for the IBM 3581 2U

Physical specifications		
	Desktop version	Rack mount version
Width	321 mm. (16.6 in.)	483 mm. (19 in.)
Depth	665 mm. (26.2 in.)	864 mm. (34 in.)
Height	86 mm. (3.4 in.)	89 mm. (3.5 in.)
Weight	Approximately 12.5 kg. (27.56 lbs.) maximum without Rack Mount Kit	

Table 16-5 Power specifications for the IBM 3581 2U

Power specifications	
AC line voltage	100 to 240 Vac
Line frequency	50 to 60 Hz auto-ranging
Line current at 100 Vac	1.3 A
Line current at 240 Vac	0.7 A
Maximum heat output	100 watts (86 KCAL/hr.)

Table 16-6 Acoustic specifications for the IBM 3581 2U

Acoustic Specifications		
Maximum noise level	Idling	Operating
	60 db (6.3 bels)	62 db (6.5 bels)

Table 16-7 Environmental specifications for the IBM 3581 2U

Environmental specifications				
Environmental factor	Power on	Power off ^a	Storage ^b	Shipment
Temperature	+10°C to +35°C	+10°C to +43°C	1°C to 60°C	-40°C to +60°C
Temperature Variation	10°C/Hr. max	10°C/Hr. max	10°C/Hr. max	10°C/Hr. max
Relative humidity (non-condensing)	15% to 85%	10% to 90%	10% to 90%	10% to 90%
Wet Bulb (max)	26°C	27°C	29°C	29°C
Altitude	0 to 3048 m (10000.3 ft.)	0 to 2500 m (8202.4 ft.)	0 to 2500 m (8202.4 ft.)	0 to 12192 m (40001.3 ft.)

a. Indicated values are valid for the unpacked unit with no data cartridge. If there is a cartridge with the unit either inside or out, the "Power On" specification must apply to the "Power Off" situation.

b. Indicated values are valid for the packaged unit. The storage period must not exceed three years. The limits are for the ambient temperature within 1 m (3.3 ft.) from the packaged unit.

Note: The operating environment of the autoloader must not conflict with the media storage requirements. While the autoloader might be capable of operating at elevated temperatures for an extended period of time, the temperature can shorten the useful life of media that is stored in the autoloader. If media is stored in the autoloader for more than 10 hours, the storage temperature requirements for media need to met. You can assume that media stored in the autoloader will be 2 degrees higher than ambient room temperature when the autoloader is powered on.

16.6 Host platform and device drivers

The following no-charge feature codes indicate the server platform to which the IBM TotalStorage 3581 2U Tape Autoloader is attached:

- ▶ FC9210 attached to HP-UX system
- ▶ FC9211 attached to Sun systems
- ▶ FC9212 attached to Windows systems
- ▶ FC9213 attached to Non-IBM systems
- ▶ FC9215 attached to Linux systems
- ▶ FC9216 attached to zSeries Linux (F38 model only)
- ▶ FC9400 attached to an i5/OS or OS/400 system
- ▶ FC9600 attached to an AIX system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3581 2U). Sometimes, the driver code is supplied as part of the operating system code, such as in OS/400, sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library is shipped with the device drivers to support the following operating environments at the minimal levels shown:

- ▶ OS/400 V5R1 or later
- ▶ AIX V5.1, 5.2, or later
- ▶ Sun Solaris 7, 8, or 9
- ▶ Microsoft Windows NT Server 4 SP6 or later
- ▶ Microsoft Windows 2000 (build 2195 or greater)
- ▶ Microsoft Windows Server 2003 (build 3790 or greater)
- ▶ HP-UX 11.0, HP-UX 11i (64-bit), and 11i V2
- ▶ Linux distributions:
 - Red Hat Enterprise Linux 3
 - SuSE LINUX Enterprise Server 8 or 9

Host software versions and release levels that support the IBM 3581 2U are listed at:

<http://www.ibm.com/servers/storage/tape/3581/interop.html>

16.6.1 Device driver installation

Install the IBM device drivers for the IBM 3581 2U as follows:

- ▶ If you intend to use the IBM 3581 2U with a commercial software application (such as VERITAS Backup Exec or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3581 2U.
- ▶ If you do not intend to use the IBM 3581 2U with a commercial software application, install the tape and medium device driver from the CD that ships with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which ships on the CD with the driver code.

Tip: The device driver CD that ships with the IBM 3581 2U might not contain the device drivers with the most recent level or the device drivers for all supported systems.

16.7 Media

One Ultrium Cleaning Cartridge and one Ultrium 200 GB Data Cartridge are included with each order. Additional data and cleaner cartridges are optional and have to be ordered, as needed, using the appropriate feature codes:

- ▶ FC8002 provides a single Ultrium Cleaning Cartridge: maximum of 5 cleanings
- ▶ FC8101 provides a single 200 GB Ultrium 2 Data Cartridges: maximum of 20 cleanings
- ▶ FC8301 provides a single 400 GB Ultrium 3 Data Cartridges: maximum of 5 cleanings

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 497 for details about ordering supplies and cartridges, with or without labels.

16.7.1 Media compatibility

Ultrium 2

The Ultrium 2 Tape Drive is compatible with the cartridges of its predecessor, the Ultrium 1 Tape Drive. Cartridge compatibility for the Ultrium 2 Tape Drive is as follows:

- ▶ Reads and writes Ultrium 2 format on Ultrium 2 cartridges
- ▶ Reads and writes Ultrium 1 format on Ultrium 1 cartridges

- ▶ Does not write Ultrium 2 format on Ultrium 1 cartridges
- ▶ Does not write Ultrium 1 format on Ultrium 2 cartridges

Ultrium 3

The Ultrium 3 Tape Drive is compatible with the cartridges of its predecessors, the Ultrium 2 and Ultrium 1 Tape Drives. Cartridge compatibility for the Ultrium 3 Tape Drive is as follows:

- ▶ Reads and writes Ultrium 3 format on Ultrium 3 cartridges
- ▶ Reads and writes Ultrium 2 format on Ultrium 2 cartridges
- ▶ Reads Ultrium 1 format on Ultrium 1 cartridges
- ▶ Does not write Ultrium 3 format on Ultrium 2 cartridges
- ▶ Does not write Ultrium 2 format on Ultrium 3 cartridges

16.8 IBM 3581 2U initial setup

The following section covers several of the major items required to implement, manage, and operate the IBM 3581 2U. It does not cover all tasks, and we do not intend to cover all of the specific commands. For more details, refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

16.8.1 SCSI ID

The IBM 3581 2U drive must be assigned a unique ID to be recognized by and to be able to communicate with the server (host). The IBM 3581 2U comes with a default SCSI ID 2 for the drive. The SCSI ID can be changed by using the Operator Control Panel (OCP). When the IBM 3581 2U is the last device on the SCSI string, be sure that the proper SCSI terminator is installed; for example, when the optional HVD converter is installed, the HVD terminator needs to be installed.

16.8.2 Storage element addressing

Storage element addresses (also called *element numbers*) identify the physical location within the IBM 3581 2U. This information is needed, for example, when testing the IBM 3581 2U with ntutil. Table 16-8 shows the storage element addresses and indexes.

Table 16-8 IBM 3581 2U element numbers and element indexes

Element	Element number (hex)	Element indexes
Cartridge Slot 1	1 (1h)	1
Cartridge Slot 2	2 (2h)	2
Cartridge Slot 3	3 (3h)	3
Cartridge Slot 4	4 (4h)	4
Cartridge Slot 5	5 (5h)	5
Cartridge Slot 6	6 (6h)	6
Cartridge Slot 7	7 (7h)	7
Cartridge Slot 8	8 (8h)	8
Cartridge Loader and carousel	82 (52h)	N/A
Tape Drive	86 (56h)	N/A

16.8.3 Operator Control Panel

The Operator Control Panel (OCP) is an interface between the operator and the IBM 3581 2U. Refer to Figure 16-4. All changes can be performed using the OCP. The OCP can be password-protected. The default setting of the IBM 3581 2U is OFF.

The OCP contains four light-emitting diodes (LEDs), a display, and four push buttons.

The four LEDs contain status information about:

READY/ACTIVITY	(green) Turns on any time the autoloader is powered on and able to function. This LED blinks whenever there is autoloader or tape drive activity.
CLEAN DRIVE	(amber) Turns on when the tape drive needs to be cleaned. This LED will turn off after the drive is cleaned.
MEDIA Important	(amber) Turns on when there has been a failure that indicates that there is a piece of media that is bad, marginal, or invalid. This LED will turn off when all marginal and invalid cartridges have been exported from the autoloader.
ERROR	(red) Turns on when there is an unrecoverable tape drive or autoloader failure. This LED turns on at the same time that the error message is displayed on the window and remains on until the error state is resolved.



Figure 16-4 IBM 3581 2U Operator Control Panel

Two menus are available when using the Operator Control Panel: the Online menu and the Offline menu.

Online menu

After powering on the autoloader, the Online Menu is available (refer to Figure 16-5 on page 450). The Online Menu contains the Information Menu and Go Offline.

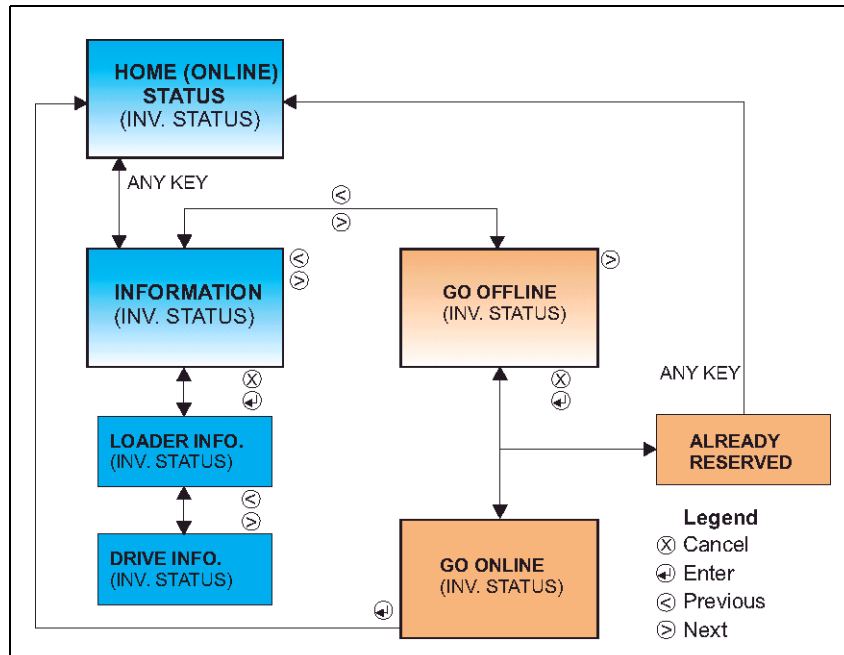


Figure 16-5 3581 2U Online Menu

Offline menu

After logging on from an RMU or going offline from the OCP, the user has access to the Offline Menu. The contents of the Online Menu depend on whether you are logging on with a SCSI (IBM 3581-L28/L38/L3H) or a native Fibre Channel (IBM 3581-F28/F38/F3H) drive. Refer to Figure 16-6 and Figure 16-7 on page 452.

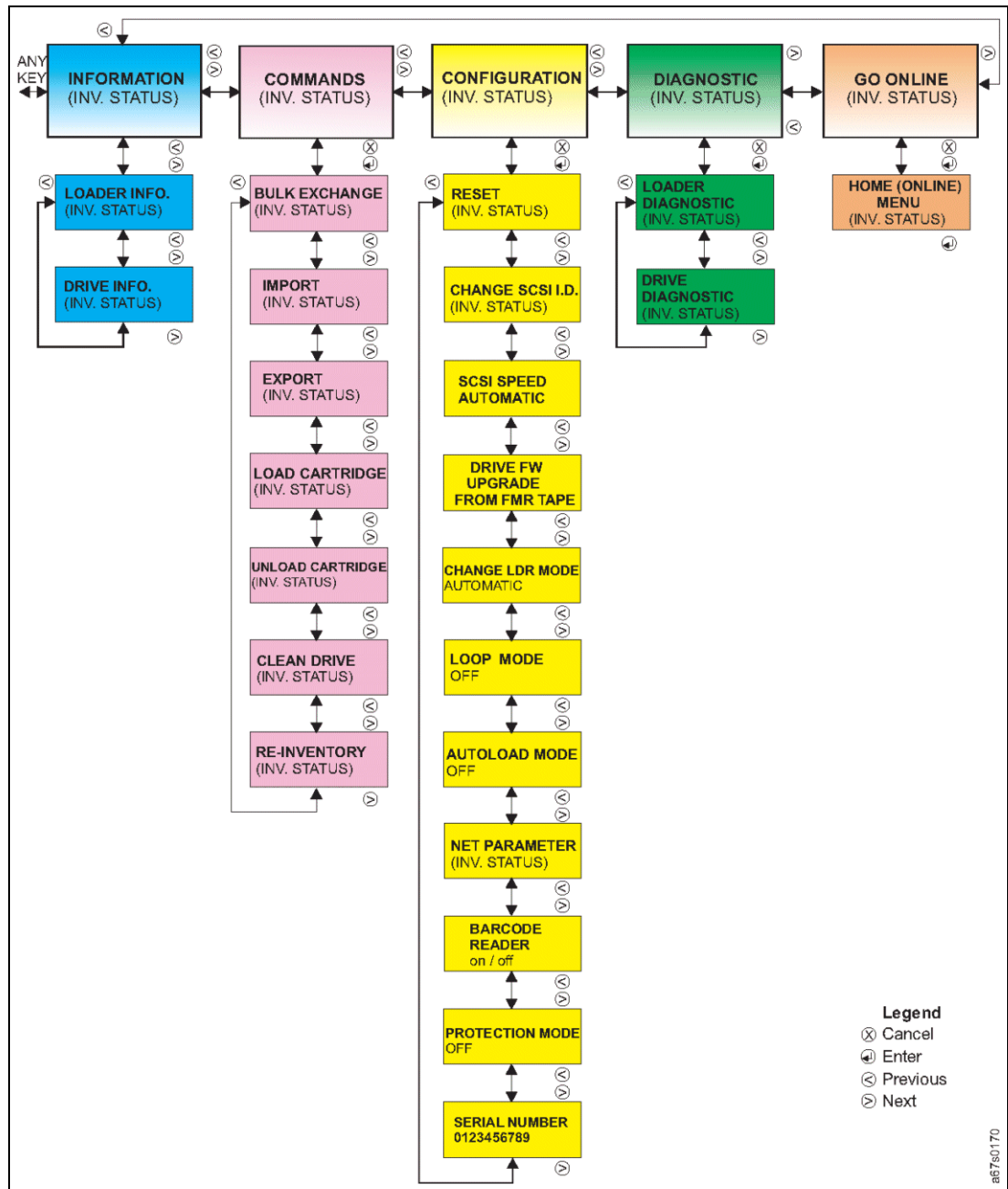


Figure 16-6 3581 2U Online Menu: SCSI drive

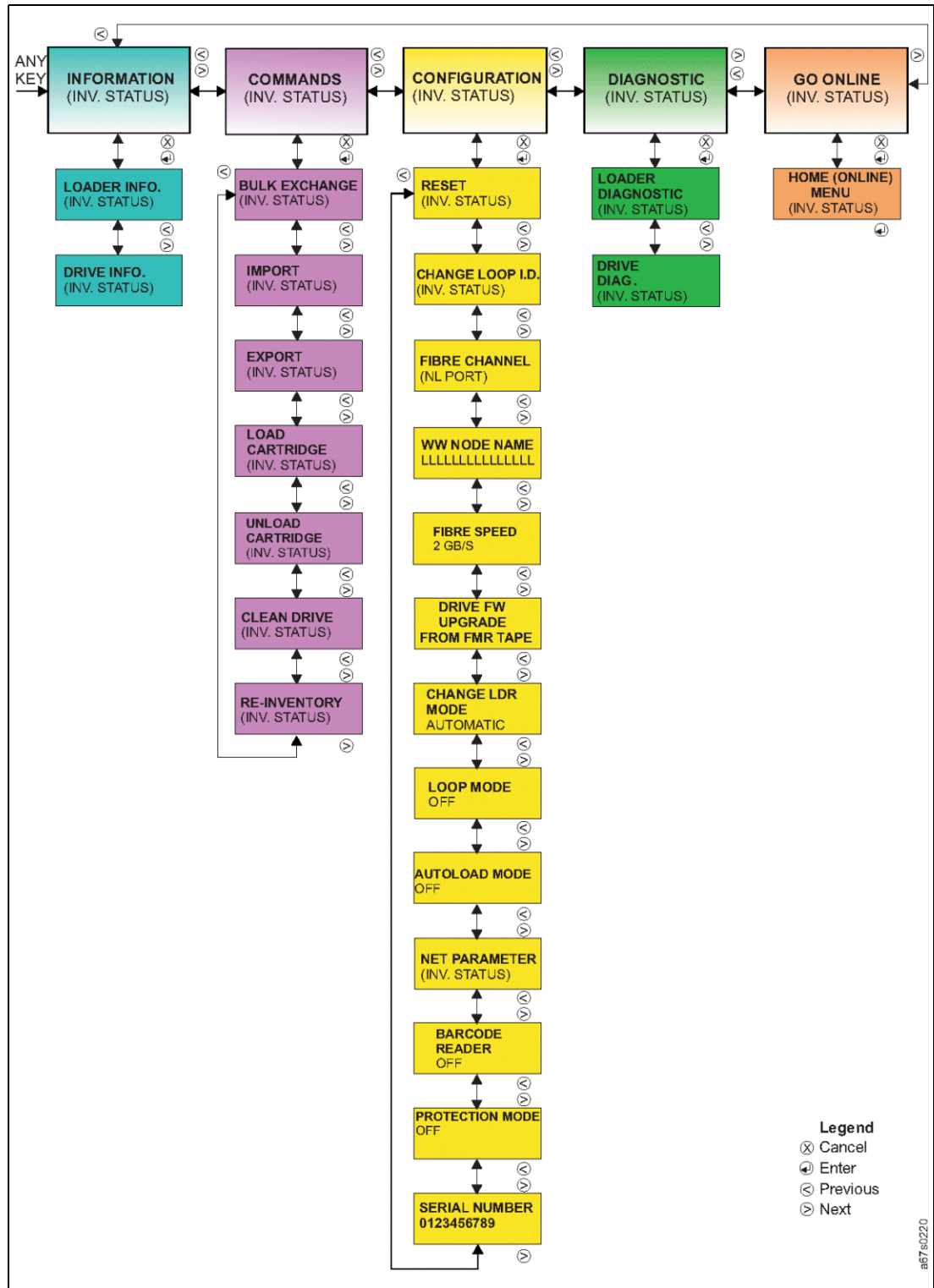


Figure 16-7 3581 2U Offline Menu: Fibre Channel drive

Each menu is accessible through the Operator Control Panel push buttons. Refer to the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470, for all menu items.

16.9 Firmware upgrades

At installation time, you must make sure that the current firmware is installed on your IBM LTO tape drives and library. Because the IBM 3581 2U is designated as a Client Setup Machine, it is the client's responsibility to have the current firmware installed. Determine the latest level of firmware available from the IBM Technical Support Web sites:

<http://www.ibm.com/servers/storage/support/lto/3581-2u/>
<ftp://index.storsys.ibm.com/358x/>

The following methods can be used for upgrading the firmware:

- ▶ Using the serial interface and a communication program, such as HyperTerminal (Windows).
This method must be used when the optional RMU is not installed.
- ▶ Using the optional RMU interface.
The RMU uses the Ethernet interface for upgrading the firmware.
- ▶ Using ntutil, tapeutil, or both.
Ntutil and tapeutil use the SCSI interface or Fibre Channel interface for upgrading the firmware. The ntutil and tapeutil utilities are both part of the IBM driver.
- ▶ Using LTO-TDX
This tool, LTO-TDX, is an alternative method for downloading LTO drive firmware across the SCSI bus or Fibre Channel. In addition, this tool can be used to upload LTO drive error dumps. The tool supports all IBM LTO Generation 1 and Generation 2 SCSI and Fibre Channel drives. The tool *will not* support any other manufacturer's LTO drive.
- ▶ Follow the instructions for updating your firmware in the *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470.

Note: AS/400, iSeries, and System i clients can update the autoloader and drive firmware using the serial interface. The Field Microcode Replacement (FMR) upgrade function is not supported on the IBM 3581 2U.

Only the *drive* firmware can be updated with the LTO-TDX tool.

The LTO-TDX is supported on Windows, Linux, and NetWare operating systems. The LTO-TDX tool can be downloaded from:

<ftp://ftp.software.ibm.com/storage/358x/tools/>



IBM TotalStorage 3582 Tape Library

The IBM TotalStorage 3582 Tape Library (IBM 3582) is an entry-level tape library that can accommodate one or two Ultrium 2 or Ultrium 3 drives, shown in Figure 17-1 on page 456. It is a high-performance, reliable, scalable tape subsystem. Designed for tape automation, you can attach the IBM TotalStorage 3582 Tape Library to iSeries, pSeries, zSeries Linux, xSeries, Intel (running Windows or Linux), Sun SPARC, Hewlett-Packard, and other Open Systems using SCSI or Fibre Channel attachment. It uses the IBM Ultrium tape drives for fast data transfer and reliability in automated library service. Each aspect of the library subsystem has been optimized for repeated, reliable unattended tape handling.

17.1 Model description

The IBM 3582 can have one or two IBM Ultrium 2 or Ultrium 3 tape drives. Ultrium 2 has a native data transfer rate of 35 MB/s and a cartridge capacity of 200 GB, while Ultrium 3 supports 80 MB/s and 400 GB native. The drives feature data compression hardware using an adaptation of the Lempel-Ziv class 1 (LZ-1) data compression algorithm that provides an effective 2:1 compression rate.

The IBM 3582 has one I/O slot plus additional cartridge capacity of 23 slots (24 slots in all), allowing a native capacity of 4.8 TB/9.6 TB of uncompressed data (with Ultrium 2/3 drives respectively). With compression (assuming 2:1), the IBM 3582 can store 9.6 TB/19.2 TB of data (with Ultrium 2/3 drives). These capacities assume that the I/O slot has been configured as an additional storage slot, increasing the overall library capacity.

The IBM 3582 is an excellent high-performance, entry-level choice for entry-level and midrange systems.



Figure 17-1 IBM TotalStorage 3582 Tape Library

The IBM TotalStorage 3582 Tape Library supports all three Ultrium 2 drive types: Ultrium 2 Low-Voltage Differential (LVD), Ultrium 2 High-Voltage Differential (HVD), and Ultrium 2 FC, as well as the two Ultrium 3 types: Ultra 160 LVD and FC. The drives can be intermixed. The IBM 3582 comes standard with Multi-Path Architecture and the ability to partition the library into two logical libraries. The library can be configured as a stand-alone unit or mounted in an industry-standard 19-inch rack. Additional optional features include control path failover in AIX, Windows, HP-UX, Solaris, and Linux environments, and a Remote Management Unit/Specialist (RMU) for remote library management. LTO1 tape cartridges are also supported for read-only access. Table 17-1 shows a summary of the IBM 3582.

Table 17-1 IBM 3582 model summary

Model	Cartridge slots	Data capacity (native)	Data capacity (compressed)	IBM Ultrium tape drives
3582-L23	23 ^a	4.6 TB LTO2 9.2 TB LTO3	9.2 TB LTO2 18.4 TB LTO3	1-2

a. The one I/O station slot can be assigned as an additional storage slot. If this is done, the library native capacity is 4.8 TB/9.6 TB and compressed capacity is 9.6 TB/19.2 TB.

17.1.1 Tape drives

The IBM 3582 can use the Ultrium 2 and Ultrium 3 drives.

It is mandatory to have at least one IBM Ultrium drive installed in the IBM 3582. An additional Ultrium drive can be added at the initial order or as a field upgrade performed by the client.

The drives can be any mixture of LVD, HVD, or Fibre Channel. The drives are ordered for plant or field installation using chargeable feature codes. Plant installation will be one or two drives of the same type; however, field installation allows any mixture of available drives.

For an Ultrium 3 initial order:

- ▶ FC8033 provides one IBM Ultrium 3 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI Connection.
- ▶ FC8035 provides one IBM Ultrium 3 tape drive with a native 2 Gb Fibre Channel Connection.

Table 17-2 on page 460 shows other feature codes, including those feature codes used to order Ultrium 2 drives.

Each IBM Ultrium tape drive contains the electronics and logic for reading and writing data, control of the tape drive, management of the data buffer, and error recovery procedures. All tape drives are packaged as a common assembly that is a field-replaceable unit (FRU), which is designed for quick removal and replacement.

17.1.2 Cartridge storage

As well as the installed tape drives, the library enclosure contains cartridge storage slots, arranged in two rows. The row toward the front of the library is made of two removable magazines of seven slots each. The row toward the rear of the library contains nine slots (Figure 17-3 on page 458). The magazines are designed so that tape cartridges can only be inserted in the proper orientation. Once inserted, the tape cartridges will be retained in the magazine so that they remain in place even when the magazine is inverted and shaken lightly. The magazines can only be inserted one way into the mounting columns in the library.

In Figure 17-2, one magazine is loaded, and the other magazine is removed.



Figure 17-2 IBM 3582 seven-slot magazines

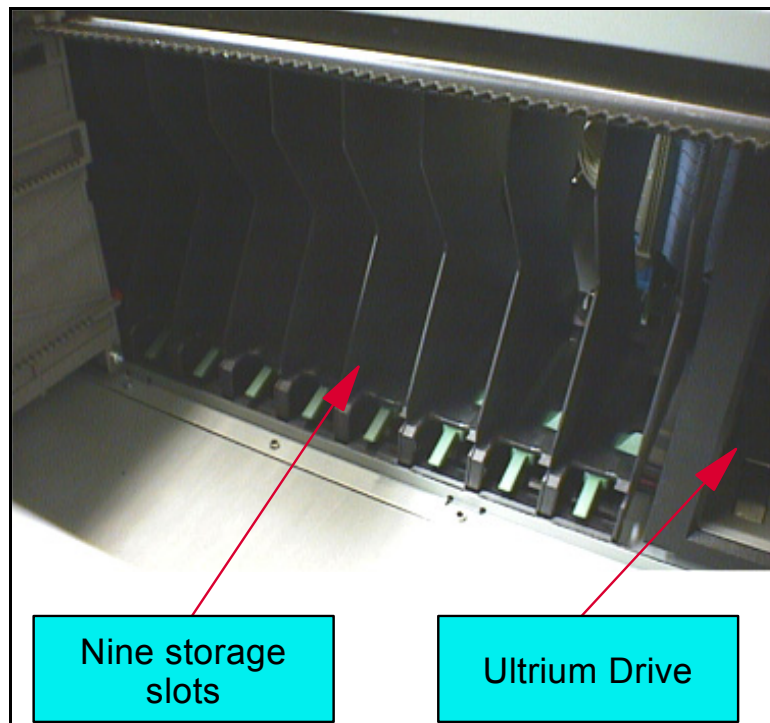


Figure 17-3 IBM 3582 rear-mounted storage slots

17.1.3 Barcode scanner

A barcode scanner is provided as standard with the IBM 3582, and it does not affect the slot capacity. The barcode scanner is used during the inventory process to locate all cartridges inserted into the library. This action is repeated every time that the front door is opened to ensure that the inventory is updated if a cartridge has been manually added, moved, or removed while the door was open.

17.1.4 I/O station

This facility enables the insertion and ejection of cartridges without interrupting the normal operation of the library. There is a single-slot I/O station where a cartridge can be inserted or ejected by opening the I/O station door.

17.1.5 Robotic system

In conjunction with the library control microcode, the robotic system identifies and moves cartridges between the storage slots, tape drives, and the I/O station. It has a number of components:

- ▶ A cartridge picker for placing cartridges in storage slots, tape drives, or the I/O station
- ▶ A barcode scanner used to set up the library initially when it identifies the types of storage arrays and tape drives installed in the library, and in normal operation for reading the external labels on the cartridges, when it locates and categorizes all cartridges installed in the library
- ▶ X-axis and Z-axis drive motors for moving the picker assembly inside the library enclosure

17.1.6 Library control and operation

The library control unit contains the electronics and logic for autochanger operations. It controls all operations in the IBM 3582, including the interaction between the library and operators. The control unit Licensed Internal Code creates and maintains the library configuration, the physical location of the robotic system, and the inventory of cartridges. The database is kept in the flash memory of the library control hardware.

Requests issued from the server result in cartridge movement in the library. The primary requests issued are for mounting and demounting cartridges to and from the tape drives and for inserting and ejecting cartridges. The host has records of the physical location of a cartridge in the library, and the physical location is also managed by the library.

In addition to requesting movement of cartridges in the library, the host can obtain status, performance, configuration information, and information about the cartridges stored in the IBM 3582.

Each cartridge must have a machine- and operator-readable external barcode label to identify a media cartridge in the library during initial inventory and any time that a cartridge is added to the library. The library stores the physical location of the cartridge in an inventory database based on the cartridge label. All host application requests for operations involving movement or use of a cartridge need only reference the physical location of the cartridge (using an element number as described in 17.10.3, “Identifying library location element numbers” on page 466) for the library to perform the request.

17.1.7 Operator Panel

An LCD operator control panel on the front of the machine provides status information and menu options. From this panel, the operator can initiate actions, such as moving and loading tape cartridges or invoking diagnostics.

17.1.8 Maintenance

The cartridge storage slots, cartridge picker, and tape drives are accessed for maintenance purposes by opening the front door of the library. The tape drives, power supplies, and host interface board are reached from the back of the library.

17.2 Feature codes

The IBM 3582 can be ordered and upgraded with the feature codes shown in Table 17-2 on page 460. We have not included the various cabling options or options referring to LTO2; refer to the product publications for detailed information about configuring and ordering.

Table 17-2 IBM 3582 feature codes

Feature code	Description	Comment
1660	RMU/Specialist	Required for FC
1680	Control Path Failover	N/A
1681	Data Path Failover	Ultrium 3 FC only
2200	Stand-alone Kit	N/A
7003	Rack Mount Kit	N/A
8002	One cleaning cartridge	Plant only; refer to 17.8, "Media" on page 464 for details
8033	Ultrium 3 LVD drive	N/A
8035	Ultrium 3 Native FC drive	N/A
8034	Ultrium 3 LVD drive	Client setup
8036	Ultrium 3 Native FC drive	Client setup
8103	Ultrium 2 LVD drive	N/A
8104	Ultrium 2 HVD drive	N/A
8105	Ultrium 2 Native FC drive	N/A
8203	CSU Ultrium 2 LVD drive	Client setup
8204	CSU Ultrium 2 HVD drive	Client setup
8205	CSU Ultrium 2 Native FC drive	Client setup
8305	Five Ultrium 3 data cartridges	N/A
8320	20 Ultrium 3 data cartridge	N/A
9210	Attached to HP-UX	N/A
9211	Attached to Sun	N/A
9212	Attached to Windows	N/A
9213	Attached to other non-IBM	N/A
9215	Attached to Linux	N/A
9216	Attached to zSeries Linux	N/A
9400	Attached to iSeries, AS/400	N/A
9600	Attached to pSeries AIX	N/A

17.3 Physical attachments

The IBM 3582 can be attached to iSeries, pSeries, IBM RS/6000, xSeries, zSeries Linux, Intel, Sun, and HP systems that support the Ultra/Wide SCSI HVD, Ultra2 Wide SCSI LVD, and Fibre Channel interface.

SCSI or Fibre Channel cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code also must be specified.

The IBM 3582 might be compatible with other servers, operating systems, SCSI adapters, and HBAs. Contact your local IBM marketing representative for a current list of supported Open Systems configuration and software vendors, or go to:

<http://www.ibm.com/servers/storage/tape/3582/interop.html>

17.4 Cabling

Cables are required to attach tape drives in the IBM 3582 to each server connection (up to the number of tape drives installed). An interposer also might be required for attachment to various server adapters. One or more of the following Fibre Channel or SCSI cables must be specified on the IBM 3582.

The following specifications are primarily for the Ultrium 3 devices. There might be other options available for the Ultrium 2. Refer to the product publications for detailed information about configuring and ordering.

17.4.1 Fibre Channel cables

A Fibre Channel cable is required to attach an IBM 3582 with the Fibre Drive feature (FC8035 or FC8036) to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components. The IBM LTO Ultrium 3 Fibre Tape Drive (FC8035 or FC8036) comes with an LC Duplex connector.

Features available for Fibre Channel cables, and their respective lengths, are:

- ▶ FC5907: 7 m (22.11 ft.) SC-LC Fibre Channel Cable
- ▶ FC5913: 13 m (42.7 ft.) SC-LC Fibre Channel Cable (LTO2 only)
- ▶ FC5922: 22 m (72.2 ft.) SC-LC Fibre Channel Cable
- ▶ FC5961: 61 m (200.1 ft.) SC-LC Fibre Channel Cable
- ▶ FC6005: 5 m (1.6 ft.) LC-LC Fibre Channel Cable
- ▶ FC6013: 13 m (42.7 ft.) LC-LC Fibre Channel Cable (LTO2 only)
- ▶ FC6025: 25 m (82 ft.) LC-LC Fibre Channel Cable
- ▶ FC6061: 61 m (200.1 ft.) LC-LC Fibre Channel Cable

17.4.2 SCSI cables

A SCSI cable is required to attach an IBM 3582 with an IBM LTO Ultrium 3 LVD Tape Drive feature (FC8033 or FC8034) to each server connection (up to the number of tape drives installed). At least one SCSI cable must be specified on the initial plant order. A SCSI terminator is included with each IBM Ultrium Tape Drive. An interposer or interposers may be required for attachment to various server adapters. Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface. An interposer may also be required for attachment to various server adapters.

The IBM LTO Ultrium 3 Tape Drives come with an HD68 connector for SCSI attachment. Features for specifying SCSI cables available for LVD Ultra160 SCSI attachment, and their respective lengths, are as follows for LTO3 attachments.

Cables with HD68 connector on both ends:

- ▶ FC5302: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5305: 5 m (16.5 ft.) SCSI cable (LTO2 only)
- ▶ FC5310: 10 m (33 ft.) SCSI cable

The following cables differ in that they have a VHDCI connector at one end.

Cables with a VHDCI connector on one end and an HD68 connector on the other end:

- ▶ FC5602: 2.5 m (8.2 ft.) SCSI cable
- ▶ FC5604: 4.5 m (14.5 ft.) SCSI cable
- ▶ FC5610: 10 m (33 ft.) SCSI cable

17.4.3 Interposers

An interposer may be required to connect a Fibre cable with LC Duplex connectors to another SC Duplex connector. The following interposer is available:

- ▶ FC5096: Interposer SC-LC Fibre

An interposer may be required to connect a SCSI cable with HD68 connectors to another connector. The following interposer is available

- ▶ FC5099: VHDCI/HD68 cable/interposer

This interposer (a 0.3 m (11.8 in.) cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

17.4.4 SCSI length limitations

The overall LVD SCSI cable length is limited to 25 m (82 ft.) using point-to-point interconnection. If using multi-drop interconnection, then the overall LVD SCSI cable length is limited to 12 m (39.4 ft.). The stub length at each device must not exceed 0.1 m (0.33 ft.).

17.5 Environmental specifications

The IBM TotalStorage 3582 Tape Library is a standalone, medium-sized library unit that can be placed on a desk or in a rack.

The IBM 3582 has one or two drives and 23 cartridge slots, plus a single-slot I/O station. The physical dimensions are:

- ▶ Width: 45.5 cm (17.9 in.)
- ▶ Depth: 66.0 cm (26.0 in.)
- ▶ Height: 19.4 cm (7.7 in.) for a stand-alone library on casters
- ▶ Maximum weight: 30.3 kg (66.7 lb.) with two drives
- ▶ 4 EIA units high (if rack-mounted)

17.6 Host platforms and device drivers

The following no-charge codes indicate the server platform to which the IBM 3582 is attached:

- ▶ FC9210: Attached to HP-UX
- ▶ FC9211: Attached to Sun system
- ▶ FC9212: Attached to Windows 2000 Server or Windows Server 2003 system
- ▶ FC9213: Attached to other non-IBM system
- ▶ FC9215: Attached to Linux system
- ▶ FC9216: Attached to System z Linux system
- ▶ FC9400: Attached to System i or AS/400 system
- ▶ FC9600: Attached to System p or RS/6000 system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3582). Sometimes the driver code is supplied as part of the operating system code (such as in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library is shipped with the device drivers to support the following operating environments at the minimal levels shown:

- ▶ AIX 5L or V5.1
- ▶ Solaris 8 or 9
- ▶ Windows 2000 Server (build 2195)
- ▶ Windows Server 2003 (build 3790)
- ▶ HP-UX 11.0 or 11.i (64-bit)
- ▶ OS/400 V5R1 or later
- ▶ Linux distributions: Red Hat Enterprise Linux Version 3 or SUSE LINUX Enterprise Server 8

For a detailed list of currently supported operating systems and host adapters, refer to:

<http://www.ibm.com/servers/storage/tape/3582/interop.html>

Tip: The device driver CD or diskette that ships with the IBM 3582 might not contain the device drivers with the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:

<ftp://ftp.software.ibm.com/storage/devdrv/>

17.6.1 Device driver installation

Install the IBM device drivers for the IBM 3582 as follows:

- ▶ If you intend to use the IBM 3582 with a commercial software application (such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker), refer to that application's installation instructions to install the device driver and configure the IBM 3582.
- ▶ If you do not intend to use the IBM 3582 with a commercial software application, install the tape and medium device driver from the CD that is shipped with the drive. Refer to the installation instructions in *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

Note: If you use the IBM 3582 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, then conflicts can occur over which driver controls the drive. Many examples using Ultrium drives are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

17.7 Storage applications

The software for managing the IBM 3582 is not provided with the library. It is not really feasible to use the IBM 3582 without additional application software to manage the slots and cartridge inventory. Additional software support is available through library management software products, which can be obtained separately from IBM, IBM Business Partners, or independent software providers. A list of compatible software is available at this Web site (look for product details and interoperability):

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 2 and Ultrium 3 support and specific Ultrium models and attachment methods. Contact your storage application vendor for more detailed information about specific versions and supported platforms.

17.8 Media

An Ultrium cleaning cartridge and a pack of 5 or 20 Ultrium 3 data cartridges can be included with the 3582 order¹. Additional Ultrium 3 or Ultrium 2 data and cleaning cartridges can be ordered as chargeable features for the IBM 3582. Refer to the product publications for further information about ordering:

- ▶ FC8305 provides a five-pack 400 GB Ultrium 3 Data Cartridge.
Up to five features can be ordered. The cartridges come with a barcode label, but it is not affixed.
- ▶ FC8002 provides a single Ultrium Cleaning Cartridge.
It is a chargeable feature, and a maximum of five features can be ordered.
- ▶ FC8320 provides a pack of twenty 400 GB Ultrium 3 Data Cartridges
Up to four features can be ordered. The cartridges come with a barcode label, but it is not affixed.

Subsequent to the initial order, additional supplies may be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, "IBM LTO Ultrium and 3592 media" on page 497 for details about ordering supplies and cartridges, with or without labels.

17.8.1 Ultrium 2 media

These feature codes are required to order Ultrium 2 media (plant install) with your IBM 3582:

- ▶ FC8101 provides a five-pack 200 GB Ultrium 2 Data Cartridge.
Up to four FC8101 features can be ordered. The cartridges come with a barcode label but it is not affixed.
- ▶ FC8002 provides a single Ultrium Cleaning Cartridge.
It is a chargeable feature, and a maximum of five can be ordered.
- ▶ FC8110 provides a pack of twenty 200 GB Ultrium Data Cartridges with unattached barcode labels. A maximum of four can be ordered.

¹ All media and cleaning cartridges are warranted separately from the IBM 3582.

17.9 Installation and performance considerations

When attaching to an iSeries, only one drive per input/output port is allowed for maximum performance. Installing more than one Ultrium tape library on an I/O port may affect drive performance.

Installing more than one Ultrium drive on a SCSI bus can affect tape drive performance. For optimal performance, we recommend that no more than one IBM Ultrium drive is attached to an individual SCSI bus.

Intermixing other SCSI devices on the same SCSI bus as the IBM 3582 can affect the performance of those devices.

While IBM Ultrium tape drives provide the capability for high tape performance, other components of the system can limit the actual performance achieved. The compression technology used in the tape drive can typically double the amount of data that can be stored on the media; however, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

The IBM 3582 has Multi-Path Architecture; refer to 2.5.7, “Multi-path architecture” on page 88 for more information. This means the library can be logically divided into two separate physical libraries with one drive each, a seven-slot magazine each, and a pre-determined number of slots in the rear storage area of the IBM 3582. If the I/O slot is defined, it can be shared.

17.10 IBM 3582 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3582 Tape Library. It does not cover all tasks and we do not intend to cover all of the specific commands. For more details, refer to the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.

17.10.1 Fibre Channel

Ultrium Fibre Channel drives offer a 2 Gbps interface with 200 MB/s, serial-communications technology capable of interconnecting when separated by as much as 10 km (7 miles). You can establish Fibre Channel connections between Fibre Channel ports that reside in the library, one or more servers, and the network interconnecting them. The network can consist of elements, such as switches, hubs, bridges, and repeaters used in the interconnection.

Each library Fibre Channel tape drive must have a Fibre Channel Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel topology. Table 17-3 lists the default Fibre Channel Loop IDs and AL_PAs for each drive in the library. The Fibre Channel Loop IDs are given in decimal format, and the AL_PA values are given in hexadecimal format.

Table 17-3 Fibre Channel IDs

Drive	Fibre Channel Loop ID	AL_PA
1	17	X'CC'
2	18	X'CB'

You can change a Fibre Channel Loop ID by using the library's Operator Panel or RMU. Using a method called hard addressing, the drive then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Fibre Channel Loop ID values range between 0 and 125. The higher the number of the Fibre Channel Loop ID (and AL_PA), the lower the priority of the device in the loop.

You can also specify Fibre Channel Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called *soft addressing*. To dynamically arbitrate the AL_PA, specify a Fibre Channel Loop ID of 126 or 127.

17.10.2 SCSI ID

The IBM 3582 has one or two SCSI devices/addresses: the two drives. The default settings for the SCSI IDs are 0 and 1. Depending on your requirements, you might have to change the SCSI ID default settings for your installation.

The IBM 3582 uses a path through one or more of the tape devices to access the tape library robot. The tape device is LUN 0, and the library robot will be LUN 1. A SCSI ID does not have to be set for the library robot.

The IBM 3582 is a SCSI target device, and it can be connected to a single-ended, Low Voltage Differential or High Voltage (Ultrium 2 only) Differential SCSI bus. The SCSI bus must be terminated, and a terminator is shipped with each drive.

17.10.3 Identifying library location element numbers

To manipulate the media within the library, the host must reference each movement with source and target designations. This is done via element addressing, which specifies precisely which slots within the library are to be used. Table 17-4 shows the element addressing scheme used for the unpartitioned IBM 3582.

Table 17-4 IBM 3582 element numbering

Column	Element numbers
Picker	1
I/O station	16
Drives	256 - 257
Storage	4096 - 4116

Drives are addressed left to right.

The I/O station is a single slot. Storage slots are addressed from left to right, front first and then back.

17.11 Operator displays and buttons

Normally, the host issues commands to the IBM 3582 Tape Library. Operator control is provided via the Operator Panel. The operator is responsible for:

- ▶ Starting the IBM 3582 Tape Library
- ▶ Shutting down the IBM 3582 Tape Library
- ▶ Handling media

Refer to the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458, for general procedures.

17.11.1 Operator Panel

The Operator Panel provides communication between the operator and the IBM 3582. Visual indications and push buttons enable the operator to control the IBM 3582.

As shown in Figure 17-4, the IBM 3582 Operator Panel has two areas:

- Operator Panel Keyboard

The Operator Panel Keyboard is a five-button keypad that lets you control the library operations interactively. Using the Operator Panel, you can set library options, check library status, and diagnose errors.

- Operator Panel Display

The Operator Panel Display is an LCD on the library front panel that is used to display icons and text.



Figure 17-4 IBM 3582 Operator Panel

Menu options

Figure 17-5 on page 468 shows the layout of the menu options on the Operator Panel.

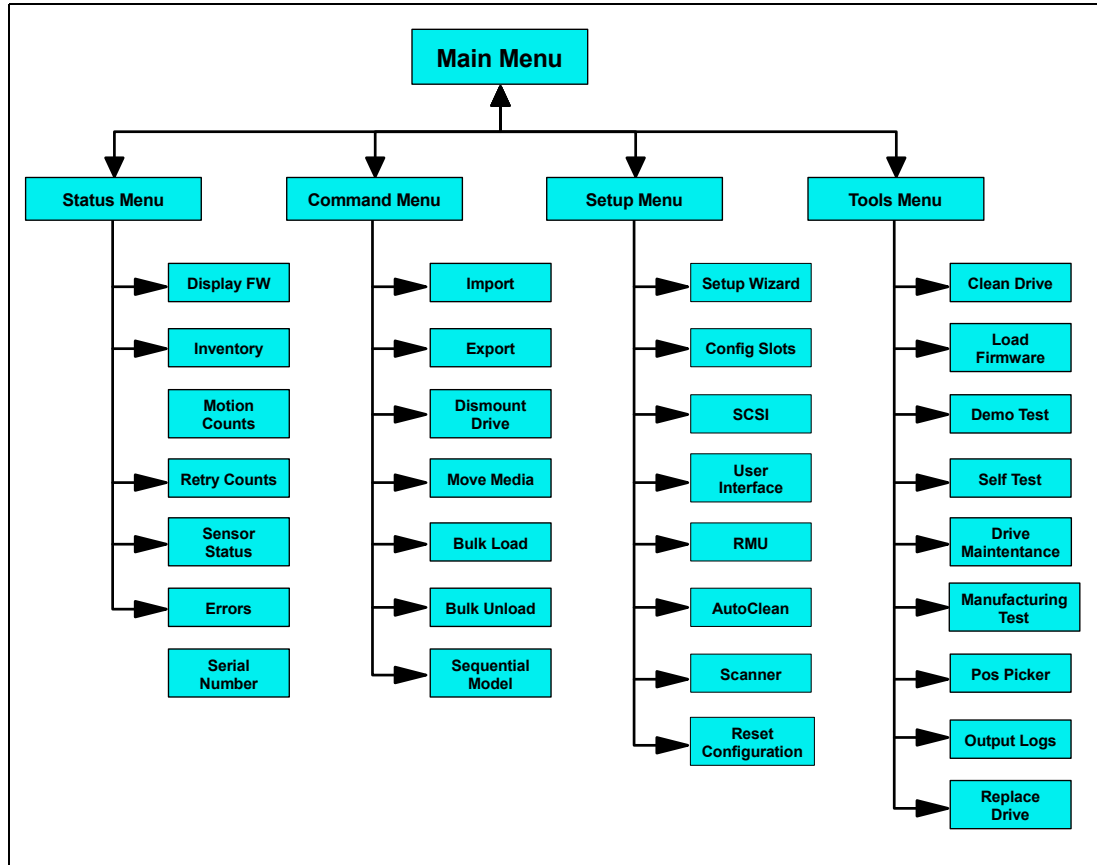


Figure 17-5 IBM 3582 top-level menu options

Each menu is accessible through the Operator Panel push buttons. The complete layout can change with the installed firmware. Refer to the Operator section of the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458, for details for all menu items.

Using commands that require an offline state

Some commands require that the library be in an offline state. If any such commands are attempted while the library is in an online state, the operator will be requested to take the library offline.

Operator intervention message

If a problem causes an operator intervention message to appear, refer to the Troubleshooting and Diagnostics section in the *IBM Total Storage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.

17.12 Library mode

The library operates in one of two modes: random mode or sequential mode.

Sequential mode is used with applications that recognize the tape drives, but not the medium changer. Tape cartridge locations and loading are managed by the library, and data is written to tapes in the order in which they are stored in the library.

Random mode is used with applications that recognize the medium changer and drives. The application manages the tape loading, slot positioning, and the order in which cartridges are used.

Libraries usually are set up using random mode.

17.13 Drive cleaning

All of the IBM Ultrium Tape Drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. Drives also have a cleaning procedure that uses a special cleaning cartridge, if this becomes necessary.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or a cleaning cartridge that is approved by IBM.

A specially labeled IBM LTO Ultrium Cleaning Cartridge must be ordered with each IBM 3582 Tape Library. The drive determines when the drive head needs to be cleaned and alerts you by displaying CT on the message display. Additional preventive cleaning is discouraged.

17.14 Firmware upgrades

Each IBM Ultrium tape drive and tape library contains IBM Licensed Internal Code, often referred to as *firmware*. At installation time, you must make sure that the current firmware is installed on your IBM LTO tape drives and library. Because the IBM 3582 is designated as a Client Setup Machine, it is the client's responsibility to have the current firmware installed. Determine the latest level of firmware available from the IBM Technical Support Web site:

<http://www.ibm.com/servers/storage/support/lto/3582/index.html>

Click the **Download** tab, and click **Firmware**. Follow the instructions for updating your firmware in the *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458.



IBM TotalStorage 3583 Tape Library

The IBM TotalStorage 3583 Tape Library is a high-performance, reliable, scalable tape subsystem. Designed for tape automation, the IBM TotalStorage 3583 Tape Library (IBM 3583) can be attached to iSeries, pSeries, xSeries, zSeries, AS/400, RS/6000, Intel, HP, and Sun systems that support Small Computer System Interface (SCSI) High-Voltage Differential (HVD), SCSI Low-Voltage Differential (LVD), and Fibre Channel (FC) interfaces.

It uses IBM Ultrium tape drives for fast data transfer and reliability in automated library service. Each aspect of the library subsystem has been optimized for repeated, reliable unattended tape handling. Multiple-drive models provide additional enhanced functions, such as fast data transfer, simultaneous backup, concurrent Read/Write operations, control path failover, and fault tolerance. The Multi-Path Architecture enables a single library to be shared by multiple homogeneous or heterogeneous applications.

18.1 Model description

The IBM 3583 houses from one to six IBM Ultrium tape drives, which can have a native data transfer rate of up to 80 MB/s and a cartridge capacity of up to 400 GB, depending on whether it is an Ultrium 1, Ultrium 2, or Ultrium 3 drive. Any combination of the different Ultrium drives can be installed. (Note that the Ultrium 1 tape drive was withdrawn from marketing on 1 October 2004.) Figure 18-1 shows the IBM TotalStorage 3583 Tape Library.



Figure 18-1 IBM TotalStorage 3583 Tape Library

The drives feature data compression hardware using an IBM adaptation of the Lempel-Ziv class 1 (LZ-1) data compression algorithm, which provides an effective data rate of up to 160 MB/s and a cartridge capacity of up to 800 GB (with 2:1 compression) on IBM Ultrium 3 400 GB media.

The IBM 3583 models feature cartridge capacities of 18, 36, and 72 cartridges; that is, capacities of 7.2 TB, 14.4 TB, and 28.8 TB of uncompressed Ultrium 3 data. With compression (assuming 2:1), the largest model of the IBM 3583, the Model L72, can store 57.6 TB of Ultrium 3 data.

The IBM 3583 comes standard with remote library management, Multi-Path Architecture, and the ability to partition the library into three logical libraries. The library can be configured as a stand-alone unit or can be mounted in an industry-standard 19-inch rack. Additional optional features include control path failover for AIX, HP-UX, Solaris, Windows, and Linux when using the IBM tape device driver. The IBM 3583 comes in three models. The major difference between the models is the number of storage cells shipped with the initial order:

- ▶ *IBM 3583 Model L18* is supplied with space for 18 cartridges.
- ▶ *IBM 3583 Model L36* is supplied with space for 36 cartridges.
- ▶ *IBM 3583 Model L72* is supplied with space for 72 cartridges.

The models are summarized in Table 18-1 on page 473.

Table 18-1 IBM 3583 model summary

Model	Cartridge slots	Native data capacity with Ultrium 2	Native data capacity with Ultrium 3	IBM Ultrium Tape Drives
L18	18 ^a	3.6 TB	7.2 TB	1-6
L36	36 ^b	7.2 TB	14.4 TB	1-6
L72	72 ^c	14.4 TB	28.8 TB	1-6

a. Plus one I/O station slot

b. Plus one I/O station slot

c. Including 12 I/O station slots

The model numbering is an indication of how many cartridge slots were originally shipped with the model. However, all of the IBM 3583 models are the same physical size, and the two smaller models, L18 and L36, can be field-upgraded to hold up to 72 cartridges by the addition of upgrade features. The effect of these upgrades is shown in Table 18-3 on page 481.

18.1.1 Tape drives

The IBM 3583 libraries support the IBM Linear Tape-Open (LTO) Ultrium 3 tape drives, as well as the Ultrium 2 and Ultrium 1 tape drives. All types of tape drives and cartridges can be resident in the same IBM 3583 frame. It is mandatory to have at least one IBM Ultrium drive installed in any of the libraries. Up to five more drives can be added either on the initial order or as field upgrades.

The installed drives can be any mixture of Low Voltage Differential (LVD), High Voltage Differential (HVD) (Ultrium 1 and 2 only), or 2 Gbps switched fabric Fibre Channel-attached up to a total of six. LVD-interfaced and HVD-interfaced drives cannot be connected on the same SCSI bus. The drives are ordered for plant or field installation using chargeable feature codes:

- ▶ FC8033 provides one IBM Ultrium 3 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI interface.
- ▶ FC8035 provides one IBM Ultrium 3 tape drive with a Fibre Channel Interface.
- ▶ FC8103 provides one IBM Ultrium 2 tape drive with a Low Voltage Differential (LVD) Ultra160 SCSI interface.
- ▶ FC8104 provides one IBM Ultrium 2 tape drive with a High Voltage Differential (HVD) Ultra/Wide SCSI interface.

Note: Ultrium 1 tape drive features FC8003 and FC8004 (together with the FC8005 SAN Data Gateway Module) can be used with the IBM 3583, but these features were withdrawn from marketing as of 1 October 2004.

Each IBM Ultrium tape drive contains the electronics and logic for reading and writing data, control of the tape drive, management of the data buffer, and error recovery procedures. All tape drives are packaged as a common assembly that is a field-replaceable unit (FRU), designed for quick removal and replacement. The cartridge capacities are unaffected by the number of drives installed.

18.1.2 Cartridge storage

As well as the installed tape drives, the library enclosure contains cartridge storage slots that are arranged in columns (from one to four including the I/O column, depending on the library model). Each of the storage columns has provision for an additional fixed slot located at the top of each column. This slot is reserved for future use.

The tape cartridges are stored in removable magazines, which are installed into the columns in the library (three magazines to each column). The magazines are designed so that tape cartridges can only be inserted in the proper orientation. After they are inserted, the tape cartridges will be retained in the magazine so that they remain in place even when the magazine is inverted and shaken lightly. The magazines can only be inserted one way into the mounting columns in the library.

18.1.3 Barcode reader

A barcode reader is provided as standard with all IBM 3583 models, and it does not affect the slot capacity of the libraries. The barcode reader is used during the inventory process to locate all cartridges inserted in the library. This action is repeated every time that the front door is opened to ensure that the inventory is updated, in case a cartridge has been manually added, moved, or removed while the door was open.

18.1.4 I/O station

This facility allows the insertion and ejection of cartridges without interrupting the normal operation of the library. There are two types of I/O station:

- ▶ The single-cartridge station, where one cartridge can be inserted or ejected by opening the I/O station door.
- ▶ The 12-cartridge station, where 12 cartridges are contained in two removable magazines. The cartridges can be inserted or ejected by opening the I/O station door.

Models L18 and L36 have the single-cartridge I/O station for tape cartridges and can be upgraded to a 12-cartridge station by FC8012. This feature also adds six data cartridge slots below the I/O station. The 12-element I/O station can be configured as data storage. (See Table 18-3 on page 481.) The model L72 has the 12-cartridge station installed as standard equipment.

18.1.5 Robotic system

In conjunction with the library control microcode, the robotic system identifies and moves cartridges between the storage slots, tape drives, and the I/O station. It has a number of components:

- ▶ A cartridge picker for placing cartridges in storage slots, tape drives, or the I/O station
- ▶ A barcode reader used to set up the library initially when it identifies the types of storage arrays and tape drives installed in the library; and in normal operation for reading the external labels on the cartridges, when it locates and categorizes all cartridges installed in the library
- ▶ A picker assembly for mounting the cartridge picker and the barcode scanner
- ▶ Y-axis and Z-axis drive motors for rotating the picker assembly, and moving it vertically, inside the library enclosure

18.1.6 Library control and operation

The library control unit contains the electronics and logic for autochanger operations. It controls all operations in the IBM 3583 libraries, including the interaction between the library and operators. The control unit Licensed Internal Code creates and maintains the library configuration, the physical location of the robotic system, and the inventory of cartridges. The database is kept in the flash memory of the library control hardware.

Requests issued from the server result in cartridge movement in the library. The primary requests issued are for mounting and dismounting cartridges to and from the tape drives and for inserting and ejecting cartridges. The host has records of the physical location of a cartridge in the library, and the physical location is also managed by the library.

In addition to requesting movement of cartridges in the library, the host can obtain status, performance, configuration information, and information about the cartridges stored in the IBM 3583.

Each cartridge must have a machine-readable and operator-readable external barcode label to identify a media cartridge in the library during initial inventory and any time that a cartridge is added to the library. The library stores the physical location of the cartridge in an inventory database based on the cartridge label. All host application requests for operations involving movement or use of a cartridge need only reference the physical location of the cartridge (using an element number as described in 18.11.4, “Element numbers” on page 488) for the library to perform the request.

18.1.7 Operator Panel

An LCD operator control panel on the front of the machine provides status information and menu options. From this panel the operator can initiate actions such as moving and loading tape cartridges or invoking diagnostics.

18.1.8 Remote Management Unit

A *Remote Management Unit* (RMU) comes standard in every IBM 3583. The RMU provides an Ethernet 10/100 port so that the library can be configured as a TCP/IP device on the network. Library status can be sent to the network as Simple Network Management Protocol (SNMP) traps. The IBM Tape Library Specialist enables network access (via Web browser) to the library for more detailed status and control. All library Operator Panel functions can be accessed using this Web interface.

18.1.9 Library partitioning

The IBM 3583 Multi-Path Architecture (see 2.5.7, “Multi-path architecture” on page 88 for more information) enables homogeneous or heterogeneous Open Systems hosts to share the library’s robotics without storage management middleware or a dedicated server acting as a library manager.

The library can be partitioned into as many as three logical libraries in order to share the library among various software platforms and applications (such as Windows Server 2003 and UNIX). Partitioning in this way means that they can share the library robotics independently of each other. Each logical library has its own distinct drives, cartridge storage slots, and control paths. If the application supports it, both Ultrium 2 and 3 drives and media are allowed in the same logical library. Cartridges under library control are not shared between logical libraries and they are *not* allowed to be moved between logical libraries. Input/output (I/O) slots are shared on a first-come-first-served basis.

For more information about the multi-path and partitioning capabilities of the IBM 3583, refer to the library partitioning sections in these books:

- ▶ *Implementing IBM Tape in Linux and Windows*, SG24-6268
- ▶ *Implementing IBM Tape in UNIX Systems*, SG24-6502

18.1.10 Control path failover

For enhanced availability, you can use control path failover. This optional feature provides automatic control path failover to a pre-configured redundant control path in the event of a loss of a host adapter or control path drive, without stopping the current job in progress. With control path failover installed, the alternate control path can include another HBA, SAN, or library control path drive. Support is provided under AIX, Linux, HP-UX, Windows, and Solaris for both SCSI and Fibre Channel attachments when the IBM tape device driver is used.

18.1.11 Data path failover and load balancing

Data path failover exclusively supports native Fibre Channel Ultrium 3 or Ultrium 2 drives in the IBM 3583 using the IBM tape device driver for AIX, Linux, and Solaris. Load balancing exclusively supports native Fibre Channel Ultrium 3 or Ultrium 2 drives in the IBM 3583 using the IBM tape device driver for AIX and Linux. It is not supported for Solaris.

Data path failover is designed to provide a failover mechanism in the IBM device driver, which enables you to configure multiple redundant paths in a SAN environment. In the event of a path or component failure, the failover mechanism is designed to automatically provide error recovery to retry the current operation using an alternate, pre-configured path without stopping the current job in progress. This allows you flexibility in SAN configuration, availability, and management.

18.1.12 SAN Data Gateway Module

The SAN Data Gateway Module (FC8005) functions as an interface between LVD SCSI Ultrium 1 tape drives (FC8003) in the library and Fibre Channel devices on the SAN. It provides attachment support for Fibre Channel interfaces using a Shortwave Gigabit Interface Convertor (GBIC) with SC connectors. The SAN Data Gateway Module is managed over the IP network. It has an Ethernet 10/100 interface with an RJ-45 connector.

Note: Ultrium 1 tape drive features FC8003 and FC8004 together with the FC8005 SAN Data Gateway Module will still work with the IBM 3583, but they were withdrawn from marketing as of 1 October 2004.

18.1.13 Maintenance

The cartridge storage slots, cartridge picker, and tape drives are accessed for maintenance purposes by opening the front door of the library. The tape drives, power supplies, and host interface board are accessed from the back of the library for maintenance.

18.2 Feature codes

The IBM 3583 can be ordered and upgraded with the feature codes in Table 18-2 on page 477. We have not included the various cabling options (see 18.4, “Cabling” on page 478), or all LTO2 options; refer to the product publications for detailed information about configuring and ordering.

Table 18-2 IBM 3583 feature codes

Feature	Description	Comment
1450	Multi-path - Field Specify	Field only
1660	RMU/StorWatch Specialist	Included as standard
1680	Control Path Failover	Automatic control path failover to a pre-configured redundant control path in the event of the loss of a host adapter or control path drive, without stopping the current job in progress
1681	Data Path Failover	Ultrium 3 FC only
8002	IBM Ultrium Cleaning Cartridge	N/A
8033	LTO Ultrium 3 LVD Drive	N/A
8035	LTO Ultrium 3 Native FC Drive	N/A
8006	Rack mount option	N/A
8007	18-slot Tape Storage Column	Adds 18 slots Maximum: - Model L18: two - Model L36: one
8008	Redundant power module	Redundant dc power module
8305	5-pack IBM Ultrium 3, 400 GB Data Cartridges	Plant only. Refer to 18.9, "Media" on page 483 for details
8320	20-pack IBM Ultrium 3, 400 GB Data Cartridges	Plant only. Refer to 18.9, "Media" on page 483 for details
8012	12-cartridge I/O station	Adds 18 slots in the door (12 of them can be used for nondisruptive exchange of cartridges) Maximum: - for L18 and L32: one - standard on L72
8013	6-cartridge magazine	Plant only
8103	LTO Ultrium 2 LVD Drive	N/A
8104	LTO Ultrium 2 HVD Drive	N/A
8105	LTO Ultrium 2 Fibre Drive	N/A
8110	20-pack of IBM Ultrium 200 GB Data Cartridges	Plant only. Refer to 18.9, "Media" on page 483 for details.
9210	Attached to HP-UX	N/A
9211	Attached to Sun	N/A
9212	Attached to Windows	N/A
9213	Attached to other non-IBM	N/A
9215	Attached to Linux system	N/A
9216	Attached to zSeries Linux systems	N/A
9400	Attached to AS/400	N/A

Feature	Description	Comment
9450	Multi-path - Plant Specify	Plant only
9600	Attached to AIX	N/A

18.3 Physical attachments

In each of the different IBM 3583 models, the interface (LVD, HVD, or Fibre Channel) on each of the drives is chosen by selecting the appropriate drive type indicated by feature code numbers (Table 18-2 on page 477).

The IBM 3583 can be attached to the iSeries, pSeries, xSeries, zSeries, AS/400, RS/6000, RS/6000 SP systems, Netfinity® and non-IBM servers, workstations, and personal computers that support the Ultra/Wide SCSI HVD, Ultra 160 SCSI LVD, and Fibre Channel (FC) interface.

SCSI or FC cables and appropriate interposers, as required, must be ordered for attachment to a server. A power cord feature code must also be specified.

The IBM 3583 might be compatible with other servers, operating systems, and adapters. Contact your local IBM representative for a current list of supported configurations. You can also refer to the Interoperability Matrix (List of Supported Servers) on this Web site:

<http://www.ibm.com/servers/storage/tape/3583/interop.html>

Another resource is the IBM TotalStorage Fibre Channel HBA Search Tool site:

<http://knowledge.storage.ibm.com/servers/storage/support/hbasearch/interop/hbaSearch.do>

18.4 Cabling

Cables are required to attach tape drives in the IBM 3583 to each server connection (up to the number of tape drives installed).

An interposer might also be required for attachment to various server adapters. One or more of the following Fibre Channel or SCSI cables must be specified on the IBM 3583.

The following specifications are primarily for the LTO3 drives. There might be other options available for the LTO2 drives. Refer to the product publications for detailed information about configuring and ordering.

18.4.1 Fibre Channel cables

Additional FC cables are available as optional features on the IBM 3583 for Fibre Channel attachment to host Fibre Channel adapters, Fibre Channel switches, or other Fibre Channel components.

A Fibre Channel cable is required to attach an IBM 3583 with the Fibre Drive feature to host Fibre Channel adapters, Fibre Channel Switches, or other Fibre Channel components. The IBM LTO Ultrium 3 Fibre Tape Drive (FC8035) comes with an LC Duplex connector. The IBM LTO Ultrium 2 Fibre Tape Drive (FC8105) also comes with an LC Duplex connector.

Features available for Fibre Channel cables, and their respective lengths, are:

- ▶ FC5907: 7 m (22.11 ft.) SC-LC Fibre Channel Cable
- ▶ FC5913: 13 m (42.7 ft.) SC-LC Fibre Channel Cable
- ▶ FC5922: 22 m (72.2 ft.) SC-LC Fibre Channel Cable
- ▶ FC6005: 5 m (16.5 ft.) LC-LC Fibre Channel Cable
- ▶ FC6013: 13 m (42.7 ft.) LC-LC Fibre Channel Cable
- ▶ FC6025: 25 m (82 ft.) LC-LC Fibre Channel Cable

18.4.2 SCSI cables

A SCSI cable is required to attach an IBM 3583 with an IBM LTO Ultrium 3 LVD Tape Drive feature (FC8033) to each server connection (up to the number of tape drives installed). At least one SCSI cable must be specified on the initial plant order. A SCSI terminator is included with each IBM Ultrium Tape Drive. An interposer or interposers might be required for attachment to various server adapters. Clients are responsible for selecting and ordering the correct cables and interposers to match the IBM LTO Ultrium SCSI interface and the server SCSI interface.

The IBM LTO Ultrium 3 drives come with an HD68 connector for SCSI attachment. Features for specifying SCSI cables available for LVD Ultra160 SCSI attachment, and their respective lengths, are:

- ▶ Cables with an HD68 connector on both ends:
 - FC5302: 2.5 m (8.2 ft.) SCSI cable
 - FC5305: 5 m (16.5 ft.) SCSI cable
 - FC5310: 10 m (33 ft.) SCSI cable
- ▶ Cables with a VHDCI connector on one end and an HD68 connector on the other end:
 - FC5602: 2.5 m (8.2 ft.) SCSI cable
 - FC5604: 4.5 m (14.5 ft.) SCSI cable
 - FC5610: 10 m (33 ft.) SCSI cable

18.4.3 Interposers

An interposer might be required to connect a Fibre cable with LC Duplex connectors to another SC Duplex connector. The Interposer SC-LC Fibre interposer (FC5096) is available.

An interposer might be required to connect a SCSI cable with HD68 connectors to another connector. The following interposer is available: FC5099 - VHDCI/HD68 cable/interposer. This interposer (a 0.3 m (11.8 in.) cable) has a male mini-68-pin VHDCI connector on one end and a female 68-pin HD68 connector on the other.

18.4.4 Terminator

An inline terminator is required when attaching the IBM 3583 to Hewlett-Packard V-Class systems with adapter A4800A. The following inline terminator is available: FC5098, Inline HVD SCSI Terminator.

18.4.5 Cable length limitations

The native Fibre Channel drive and the SAN Data Gateway Module are capable of 2 Gbps speed. They automatically switch to a 1 Gbps speed if they are attached to a 1 Gbps HBA, switch, or other Fibre Channel components. At 2 Gbps, the maximum cable length is limited to 300 m (984 ft.), and at 1 Gbps to 500 m (1640 ft.).

The overall LVD SCSI cable length is limited to 25 m (82 ft.) using point-to-point interconnection (for example, one host connected to only one tape drive). If using multi-drop interconnection (such as one host connected to more than one tape drive on the same SCSI bus), the overall LVD SCSI cable length is limited to 12 m (39.4 ft.). The stub length at each device must not exceed 0.1 m (0.33 ft.).

The overall HVD SCSI cable lengths are limited to 25 m (82 ft.) using point-to-point or multi-drop interconnection. The stub length at each device must not exceed 0.2 m (0.66 ft.).

18.5 Upgrades and optional features

You can add MES features to each model type in the IBM 3583 family in order to add capacity in terms of drives and cartridge cells and to add the 12-cartridge I/O station. This effectively takes the place of model upgrades because no upgrades are available for the IBM 3583 series.

In other words, you cannot “upgrade” an IBM 3583-L18 to an IBM 3583-L36 or L72. Similarly, an IBM 3583-L36 cannot be “upgraded” to an IBM 3583-L72.

18.5.1 Upgrade features

You can expand any IBM 3583 model to the maximum capacity of the largest model (L72) with the addition of MES features.

Adding drives

You can add IBM LTO Ultrium drives to any library model to a maximum of six drives in total. The drives can be LVD, HVD, or Fibre in any combination. To install an LVD drive, add FC8103 (Ultrium 2) or FC8033 (Ultrium 3), to add an HVD drive add FC8104 (Ultrium 2), and to add a Fibre drive, add FC8105 (Ultrium 2) or FC8035 (Ultrium 3).

Adding cartridge capacity

You can add an additional 18 tape cartridge slots to either of the smaller IBM 3583 models using FC8007. You can add one or two of these features to model L18 (for a total of 36 or 54 cartridge slots), and you can add one feature to model L36 (to total 54 cartridge slots).

You can install a 12-cartridge I/O station to models L18 and L36 by adding FC8012. This feature accommodates the 12 cartridges in two six-slot cartridge magazines that are accessed by opening the I/O station door. In addition to the two magazines, this feature supplies six additional fixed slots in the library door for a total of 18 additional slots. This feature in combination with FC8007 provides the maximum slot capacity and function for the two smaller IBM 3583 models.

Table 18-3 on page 481 shows how to upgrade the capacity of 3583-L18 and 3583-L36 libraries by adding extra 18-slot tape storage columns (FC8007) and by adding the 12-cartridge I/O station (FC8012). You can set up the 12-cartridge I/O station as storage slots or I/O slots.

Table 18-3 IBM 3583 capacity upgrades

3583 model	Single cartridge I/O station	12 cartridge I/O station FC8012 defined as storage	12 cartridge I/O station FC8012 defined as I/O
L18	18 storage 1 I/O	36 storage 0 I/O	24 storage 12 I/O
L18 with one FC8007 (18 slot option)	36 storage 1 I/O	54 storage 0 I/O	42 storage 12 I/O
L18 with two FC8007 (18 slot option)	54 storage 1 I/O	72 storage 0 I/O	60 storage 12 I/O
L36	36 storage 1 I/O	54 storage 0 I/O	42 storage 12 I/O
L36 with one FC8007 (18 slot option)	54 storage 1 I/O	72 storage 0 I/O	60 storage 12 I/O
L72 (FC8012 is default)	not available	72 storage 0 I/O	60 storage 12 I/O

18.5.2 Optional features

Two optional features are available:

- ▶ FC8006, rack mount option: The IBM 3583 libraries can be installed either standalone or in a standard EIA 19-inch rack. They occupy the full width of the rack and require 14 units of rack space (62.2 cm or 24.5 in.). This is the chargeable feature that provides the necessary hardware to mount the library in the rack.
- ▶ FC8008, redundant power module: This chargeable feature supplies a redundant DC power module for clients requiring an extra level of backup protection. You can order one of these features per library.

18.6 Environmental specifications

The IBM 3583 is a standalone, medium-sized library unit that can be placed in a rack or on the floor.

IBM 3583 models have from one to six drives and up to 72 cartridge slots. The physical dimensions are:

- ▶ Width: 48.1 cm (18.9 in.)
- ▶ Depth: 73.5 cm (28.9 in.)
- ▶ Height: 68.5 cm (27.0 in.) for a standalone library on casters
- ▶ Maximum weight: 116.6 kg (257 lb.) with six drives and 72 cartridges

18.7 Host platforms and device drivers

The following no-charge specify feature codes indicate the server platform to which the IBM 3583 is attached:

- ▶ FC9210: Attached to HP-UX
- ▶ FC9211: Attached to Sun system
- ▶ FC9212: Attached to Windows system

- ▶ FC9213: Attached to other non-IBM system
- ▶ FC9215: Attached to Linux system
- ▶ FC9216: Attached to zSeries Linux system
- ▶ FC9400: Attached to iSeries system
- ▶ FC9600: Attached to pSeries or RS/6000 system

A device driver is additional code on the host server platform that enables it to recognize and talk to a peripheral device (in this case, the IBM 3583). Sometimes the driver code is supplied as part of the operating system code (for example, in OS/400), sometimes a software patch is required, and sometimes the driver is installed separately from a CD or diskette (either an operating system CD or provided with a vendor application).

The library ships with the device drivers to support the following operating environments at the minimal levels shown:

- ▶ AIX 5L V5.1
- ▶ Solaris 8 or 9
- ▶ Windows 2000 Server (build 2195)
- ▶ Windows Server 2003 (build 3790)
- ▶ HP-UX 11.0 or 1.1 (64-bit)
- ▶ OS/400 V5R1 or later
- ▶ Linux distributions: Red Hat Enterprise Linux Version 3 or SuSE LINUX Enterprise Server 8

For a detailed list of currently supported operating systems and host adapters, refer to:

<http://www.ibm.com/servers/storage/tape/3583/interop.html>

Tip: The device driver CD or diskette that ships with the IBM 3583 might not contain the device drivers at the most recent level or the device drivers for all supported systems. Always check the following FTP site for the latest device drivers:

<ftp://ftp.software.ibm.com/storage/devdrv/>

18.7.1 Device driver installation

Install the IBM device drivers for the IBM 3583 as follows:

- ▶ If you intend to use the IBM 3583 with a commercial software application, such as IBM Tivoli Storage Manager, VERITAS Backup Exec, or EMC Legato NetWorker, refer to that application's installation instructions to install the recommended device driver and configure the IBM 3583.
- ▶ If you do not intend to use the IBM 3583 with a commercial software application, install the tape and medium device driver from the CD that ships with the drive. Refer to the installation instructions in the *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, which is supplied on the CD with the driver code.

Note: If you use the IBM 3583 with a commercial software application, IBM recommends that you install any IBM-supplied device driver only if instructed to do so in the installation instructions supplied by the vendor of the application. Otherwise, if the application supplies its own driver code, conflicts can occur over which driver controls the drive. Many examples of using the Ultrium drives are given in *Implementing IBM Tape in Linux and Windows*, SG24-6268, and *Implementing IBM Tape in UNIX Systems*, SG24-6502.

18.8 Storage applications

The software to manage the IBM 3583 is not provided with the libraries. Additional software support is available through library management software products that must be obtained separately from IBM, IBM Business Partners, or independent software vendors. A list of compatible software is available at:

http://www.ibm.com/servers/storage/tape/lto/lto_isv.html

You will find details for each application including Ultrium 1, 2, and 3 support, and specific Ultrium models and attachment methods. You must also contact your storage application vendor for more detailed information of specific versions and platforms supported.

18.9 Media

An Ultrium cleaning cartridge and a pack of 20 Ultrium 3 data cartridges can be included with the 3583 order¹. Additional Ultrium 3 or Ultrium 2 data and cleaning cartridges can be ordered as chargeable features for the IBM 3583. Refer to the product publications for further information about ordering:

- ▶ FC8002 provides a single Ultrium Cleaning Cartridge.
This is a chargeable feature. A maximum of three features can be ordered.
- ▶ FC8320 provides a pack of twenty 400 GB Ultrium 3 Data Cartridges.
The cartridges come with a barcode label, but it is not affixed.

Subsequent to the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor using the product number IBM 3589. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497 for details about ordering supplies and cartridges, with or without labels.

18.9.1 Ultrium 2 media

These feature codes are required if you need to order Ultrium 2 media with your IBM 3583:

- ▶ FC8101 provides a single 200 GB Ultrium 2 Data Cartridge.
The cartridges come with a barcode label but it is not affixed.
- ▶ FC8110 provides a pack of twenty 200 GB Ultrium Data Cartridges with unattached barcode labels. A maximum of five can be ordered.

Note: All of the media features are available only with the initial order. They cannot be ordered as an MES feature. After the initial order, additional supplies can be ordered from the IBM media business or a third-party media vendor. Refer to Appendix A, “IBM LTO Ultrium and 3592 media” on page 497 for details about ordering supplies and cartridges, with or without labels.

18.10 Installation and performance considerations

When attached to an System i, only one drive can be configured per input/output port (IOP) for maximum performance. Installing more than one Ultrium tape library on an IOP might affect drive performance.

¹ All media and cleaning cartridges are warranted separately from the IBM 3583.

Installing more than one Ultrium drive on a SCSI bus can affect tape drive performance. For optimal performance, we recommend that no more than one IBM Ultrium drive is attached to an individual SCSI bus.

Intermixing other SCSI devices on the same SCSI bus with the IBM 3583 can affect performance of those devices.

Although the IBM Ultrium tape drives provide the capability for high tape performance, other components of the system might limit the actual performance achieved. The compression technology used in the tape drive can typically double the amount of data that can be stored on the media; however, the actual degree of compression achieved is highly sensitive to the characteristics of the data being compressed.

The weight of the IBM 3583, depending on the number of drives and cartridges, may be up to 116.6 kg (257 pounds). Mounting more than one library in a rack can create a tipping hazard. We advise clients to take safety precautions when mounting the libraries in the racks.

18.11 IBM 3583 initial setup

The following section covers some of the major items required to implement, manage, and operate the IBM 3583. It does not cover all tasks and we do not intend to cover all of the specific commands. For more details, refer to the chapter “Determining SCSI and FC IDs” in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

18.11.1 Fibre Channel

Ultrium Fibre Channel drives have a 2 Gbps interface with 200 MB/s, serial-communications technology capable of interconnecting when separated by as much as 10 km (7 miles). You can establish Fibre Channel connections between Fibre Channel ports that reside in the library, one or more servers, and the network interconnecting them. The network can consist of elements, such as switches, hubs, bridges, and repeaters used in the interconnection.

Each library Fibre Channel tape drive must have a Fibre Channel Loop ID and corresponding Arbitrated Loop Physical Address (AL_PA) to communicate in a Fibre Channel topology. Table 18-4 lists the default Fibre Channel Loop IDs and AL_PAs for each drive in the library. The Fibre Channel Loop IDs are given in decimal format and the AL_PA values are given in hexadecimal format.

Table 18-4 Fibre Channel IDs

Drive	Default FC Loop ID	Default AL_PA
1	0	X'EF'
2	1	X'E8'
3	2	X'E4'
4	3	X'E2'
5	4	X'E1'
6	5	X'E0'

You can change a Fibre Channel Loop ID by using the library's Operator Panel or the RMU. Using a method called *hard addressing*, the drive then automatically selects the corresponding AL_PA, which is the identifier that devices use to communicate. Valid Fibre Channel Loop ID values range between 0 and 125. The higher the number of the Fibre Channel Loop ID (and AL_PA), the lower the priority of the device in the loop.

You can also specify Fibre Channel Loop IDs that allow the drive to dynamically arbitrate the AL_PA with other Fibre Channel devices on the loop. This method avoids conflicts over the address and is called *soft addressing*. To dynamically arbitrate the AL_PA, specify a Fibre Channel Loop ID of 126 or 127.

18.11.2 SCSI ID and LUN assignment

The SCSI ID and LUN assignment in the IBM 3583 depends on whether the multi-path feature is installed. The IBM 3583 consists of up to seven SCSI devices: the library and up to six drives.

If the multi-path feature is installed, the Logical Unit Number (LUN) for the tape drive is always LUN 0, and the LUN for the Medium Changer device is always LUN 1. All other LUNs are invalid addresses. The default SCSI IDs for the drives are 1 through 6.

Note: The Medium Changer SCSI ID is the same as the SCSI ID for the first drive. You can enable additional drives to optionally provide Medium Changer (LUN 1) addressing by configuring more than one logical library or by enabling additional control paths.

If the multi-path feature is not installed, the IBM 3583 uses a separate SCSI device address for the robot so you will have to define a SCSI ID for the tape library unit. In this case, the LUNs for both the library and the tapes are always LUN 0. The default settings for the SCSI IDs are 6 for the library and 0 through 5 for the drives. Depending on your requirements, you might need to change the SCSI ID default settings for your installation.

Note: Do not use SCSI ID F, because it is reserved for internal use by the SCSI library. SCSI ID 7 is also often used by the host SCSI adapter.

The IBM 3583 is a SCSI target device and can be connected to a single-ended LVD or HVD SCSI bus. Both ends of the bus must be terminated and a terminator is shipped with each drive. The design of an IBM 3583 enables the SCSI type (single-ended, LVD, or HVD) to be configured at the client site via a switch located on the SCSI Interface PCBA.

18.11.3 Identifying library locations

The convention in Table 18-5 is used to identify the coordinates of each library element (storage, slots, or drives).

Table 18-5 IBM 3583 storage slot coordinates

First digit	Second digit	Third digit
Column	Magazine	Row

The columns are numbered from 1 to 5 starting from the I/O station column and continuing clockwise (see Figure 18-2 on page 486).

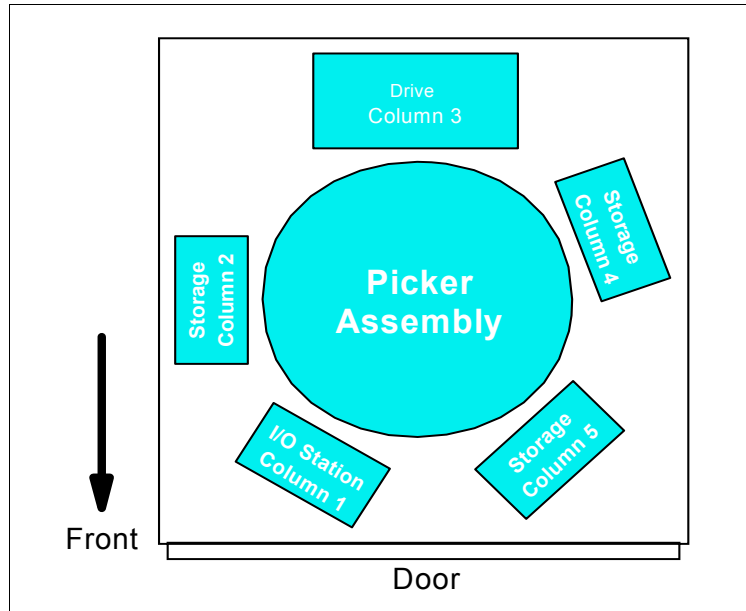


Figure 18-2 IBM 3583 storage columns: Top view

Figure 18-3 on page 487 follows this legend:

- ▶ The magazines within each column are designated A to C from top to bottom (label 1).
- ▶ The rows within each magazine are numbered from 1 to 6 from top to bottom (label 2).
- ▶ The drives within the drive column are designated from A to F from bottom to top (label 3).
- ▶ The fixed slots in the storage columns (label 4) are reserved for future functions.

So, to illustrate this convention, consider the coordinates:

1-A-6

These coordinates refer to the slot found in column 1, the topmost of the three magazines, and the bottom slot within that magazine.

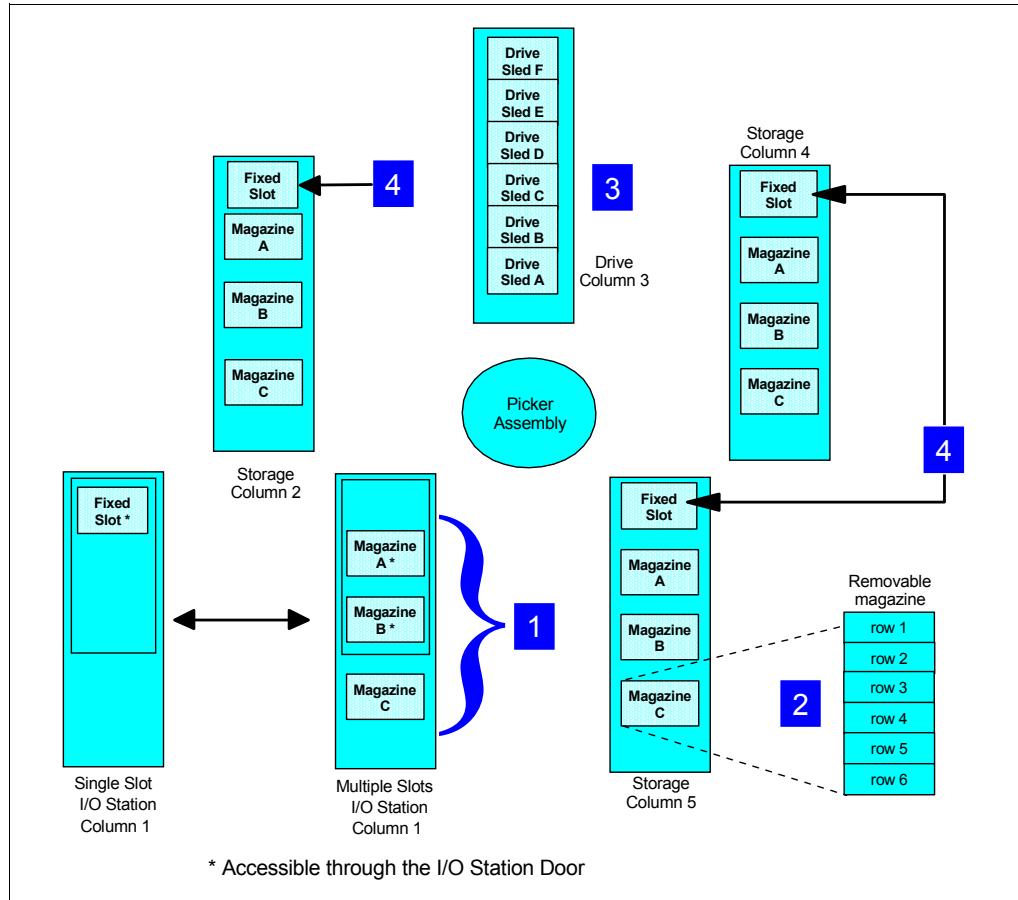


Figure 18-3 IBM 3583-L72 location logical view

Figure 18-4 shows the IBM 3583 with a view of the front door opened showing I/O station column 1. This diagram also shows a good view of the 12-slot I/O station option.



Figure 18-4 IBM 3583 front view, open door

Note: The only components accessible in a nondisruptive mode are the magazines located in the I/O station door (label 1 in Figure 18-4).

18.11.4 Element numbers

To manipulate the media within the library, the host must reference each movement with source and target designations. This is done via element addressing, which specifies precisely which slots within the library to use. Table 18-6 shows the basic element addressing scheme used for the IBM 3583.

Table 18-6 IBM 3583 element numbering

Column	Element numbers (in hexadecimal)
Picker	1h (1)
Single-Slot I/O station	10h (16)
Multi-Slot I/O station	10h - 1Bh (16 - 27)
Drives	100h - 105h (256 - 261)
Storage	1000h - 1047h (4096 - 4167)

Drives are addressed from bottom to top.

The I/O station is addressed from top to bottom. Storage slots are addressed from top to bottom, column by column.

For additional details, refer to the Appendix “Element Addressing” in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

18.12 Operator Panel and RMU

Normally, the host issues commands to the IBM 3583. Operator control is provided via the Operator Panel or via the Tape Library Specialist Web interface on the Remote Management Unit (RMU). The operator is responsible for:

- ▶ Starting the IBM 3583
- ▶ Shutting down the IBM 3583
- ▶ Handling media
- ▶ Updating firmware
- ▶ Cleaning drives

For more about operator tasks, refer to “Operating Procedures” in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

18.12.1 Operator Panel

The Operator Panel provides communication between the operator and the IBM 3583. Visual indications and push buttons enable the operator to control the IBM 3583.

As shown in Figure 18-5 on page 489, the IBM 3583 Operator Panel has six discrete areas:

- ▶ The I/O station status area provides constant information about the I/O station (label 1 in Figure 18-5 on page 489). The information provided states whether the I/O station is locked. The status of the I/O door and a physical representation of an occupied I/O station slot are indicated by a blacked-out area.
- ▶ The library status area displays informational status, such as the library’s online or offline status, and the library reports status or messages to solicit operator intervention (label 2 in Figure 18-5 on page 489).

- ▶ The message area displays six lines of text, graphic representations, or a combination of both (label 3 in Figure 18-5). Each text line can be up to 20 characters long. The display communicates interactive dialogs, special messages, alerts, and library configurations. More details are in “Using the Operator Panel Menu” in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.
- ▶ The drive status area (label 4 in Figure 18-5) provides constant information about the drives, such as:
 - Presence of tape drive (illustrated by a black outlined box for each drive)
 - Power to the tape drive
 - Cleaning requirements
 - Compression
 - Write protection
 - Tape activity (read, write, load, unload, and so forth)
 - Error codes
- ▶ The soft keys reference the push buttons located beneath them. They are used to perform the commands displayed in the soft keys area and to move through the various displays of the Operator Panel (label 5 in Figure 18-5).
- ▶ Push buttons (label 6 in Figure 18-5) are the actual physical buttons that perform the commands referred to by the soft keys located above each one of them.

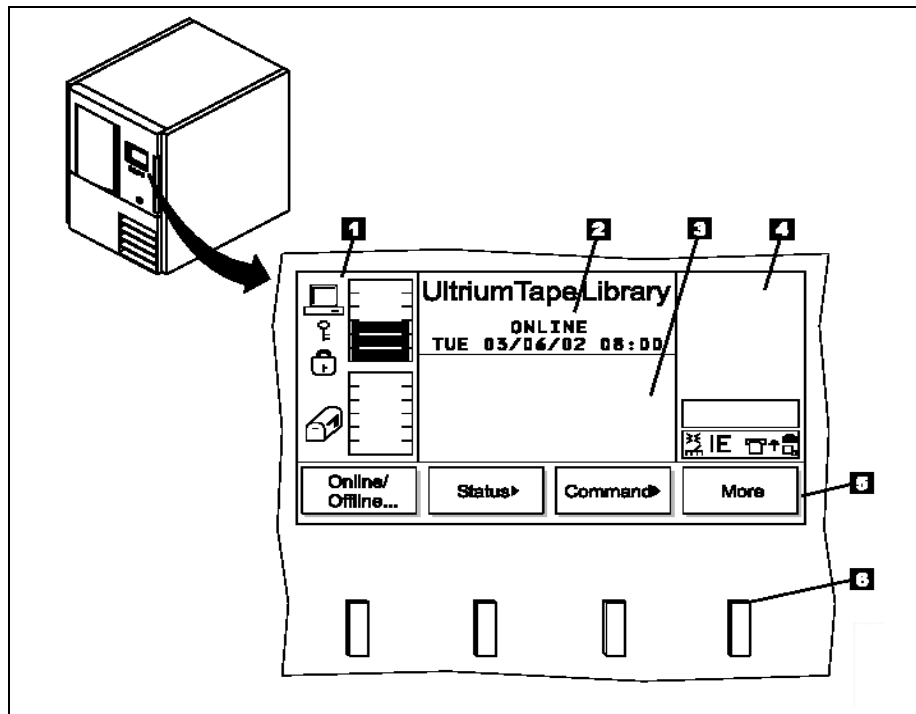


Figure 18-5 IBM 3583 Operator Panel

Menu options

Each menu is accessible through the Operator Panel push buttons. Figure 18-6 on page 490 shows the flow chart of the IBM 3583 library menu options. For more information about these functions, refer to the “Operating Procedures” chapter in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

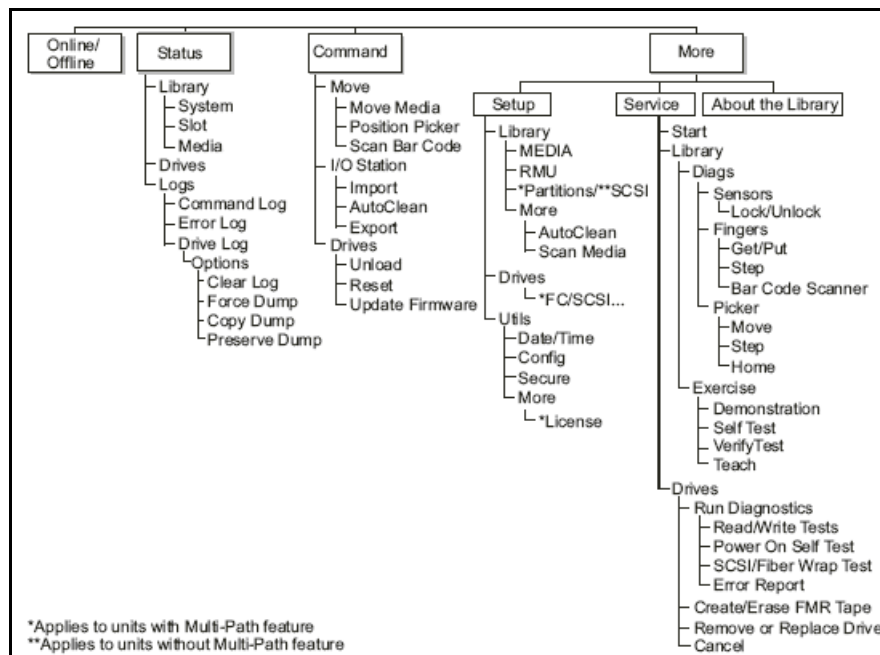


Figure 18-6 IBM 3583 flow chart of library functions

Menu guidelines

All of the menus and their options are grouped according to function. As shown in Figure 18-7, some options are followed by special characters, based on the following system:

- ▶ A keyword leading to another menu is suffixed by a small black arrow.
- ▶ A keyword leading to a dialog box is suffixed with three closely spaced dots.
- ▶ A keyword leading to an immediate action has no suffix.

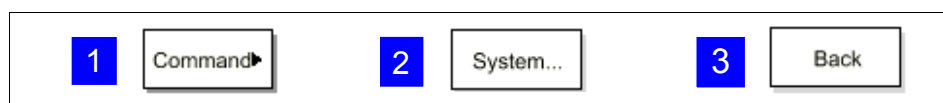


Figure 18-7 IBM 3583 soft key symbols

- ▶ Most fields on the menus, submenus, dialogs, and screens are read-only. Fields that are writable are shown in reverse video (Figure 18-8).

Figure 18-8 IBM 3583 Operator Panel: Input field

Note: The information menus are not updated dynamically. To view changes, reselect the menu that was changed.

Using commands that require an offline state

Some commands require that the library is in an offline state. If any such commands are attempted while the library is in an online state, the operator will be requested to take the library offline.

Operator intervention message

If a problem causes an operator-intervention message to appear, refer to “Operator Intervention Messages” in the Error Messages appendix of the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

18.12.2 RMU with Tape Library Specialist

The Remote Management Unit (RMU) provides remote access to the IBM 3583 over a network. You can attach the library to the network through a 10/100 Ethernet port on the RMU. All available functions are accessible without the need of a dedicated server or separate software. You can access the library through any server on the network by entering the IP address or IP name in a Web browser. The Operator Panel page of the Ultrium Tape Library Specialist Web interface is protected by a password and is a direct interface to the Operator Panel of the attached library.

As shown in Figure 18-9 on page 492, the IBM 3583 Tape Library Specialist Web interface has three discrete frames:

- ▶ The left navigation frame (label 1 in Figure 18-9 on page 492) contains hyperlinks where you can log out the current user, display a brief description of the tabs from the center navigation frame, open the library's online documentation, download the SNMP MIB file, display contact information for technical support, and display the current version of the RMU firmware.
- ▶ The center navigation frame (label 2 in Figure 18-9 on page 492) has tab-style hyperlinks for Status information, Configuration, Firmware, Diagnostics file, Operator Panel, and Logs. If you select a tab other than the Status tab, then you have to enter a logon name and password.
- ▶ The top information frame (label 3 in Figure 18-9 on page 492) contains information for you to identify the tape library that you are remotely managing. The frame shows the URL identifier and library type. The URL identifier is the host name given to the library during initial configuration. The library type is the ID string of the library and is taken from standard inquiry data.

More details are covered in Operator Panel and RMU section in the *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411.

Initial setup of the RMU is done using the Operator Panel, and you must establish password protection from the first logon.



Figure 18-9 IBM 3583 TotalStorage Specialist Web interface

18.13 Random access

The library operates in random access mode, which means that you can access any cartridge in any sequence. This mode normally requires software that generates commands that are sent to the library. The server's application software manages the cartridges (and therefore the data). Refer to 18.8, "Storage applications" on page 483.

18.14 Drive cleaning

All of the IBM Ultrium Tape Drives have an integrated cleaning mechanism that brushes the head at load time and again when unloading a cartridge. Along with this, drives have a cleaning procedure using a special cleaning cartridge, in case this becomes necessary.

Important: When cleaning the drive head, use only the IBM LTO Ultrium Cleaning Cartridge or a cleaning cartridge that is approved by IBM.

With each IBM 3583, a specially labeled IBM LTO Ultrium Cleaning Cartridge is supplied to clean the drive head. The drive determines when the head needs to be cleaned and alerts you by displaying CT on the message display. Any additional preventive cleaning is discouraged.

18.15 Firmware upgrades

Each IBM Ultrium tape drive and tape library contains IBM Licensed Internal Code, often referred to as *firmware*. At installation time, you must make sure the current firmware is installed on your IBM LTO tape drives, library, and RMU. Because the IBM 3583 is designated as a Client Setup Machine, it is the client's responsibility to have the current firmware installed. Determine the latest available level by clicking **Firmware** at:

<http://www.ibm.com/servers/storage/support/lto/3583/downloading.html>

Follow the instructions for updating your firmware in the “Operating Procedures” chapter in *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411, or from:

http://www.ibm.com/servers/storage/support/lto/ltofaqs_updatefw.html



Part 4

Appendixes



A

IBM LTO Ultrium and 3592 media

When an IBM Tape Library is ordered, it is supplied with one Ultrium data cartridge or one 3592 data cartridge and one cleaning cartridge at no charge. Each member of the IBM 35xx and TS3xxx Tape Library family has different media features and rules that apply when placing the order. The following information will assist you in ordering additional media.

If you want to order media for your Ultrium or 3592 tape drives, go to this Web site:

<http://www-03.ibm.com/servers/storage/media/distributors/index.html>

Select your geographic location and your country, and a list of authorized distributors is presented.

Refer to “Features available with IBM hardware initial order” on page 498 for a list of additional features for IBM LTO Ultrium and 3592 supply data cartridges with barcode labels that are separately delivered to the data cartridges. The actual value of barcode labels cannot be predetermined. For cartridges with predefined barcode labels and predetermined barcode values, order cartridges from a authorized dealer. Refer to Table A-9 on page 509.

The media suppliers can supply tape cartridges from various manufacturers or offer a choice of brands. The tape cartridges that you use must be manufactured by a qualified Linear Tape-Open (LTO) media company to meet the LTO standards.

Features available with IBM hardware initial order

The following media features are available for inclusion with the initial hardware order. Note that all media and cleaning cartridges are warranted separately from the IBM Ultrium hardware.

IBM TotalStorage 3581 2U Tape Autoloader (Models L38 and F38): Ultrium 3

These chargeable features provide media with the IBM 3581 Ultrium 2 Tape Drive and are available only with the initial order:

- ▶ FC8301 provides a single 400 GB Ultrium data cartridge. A maximum of 20 is allowed.
- ▶ FC8002 provides a single Ultrium cleaning cartridge. A maximum of five is allowed.

IBM System Storage TS2230 Tape Drive

Because the TS2230 Tape Drive is an Express model, a part number is used instead of a feature code: Part number 95P2020 provides a pack of five Ultrium 3 data cartridges.

IBM System Storage TS2240 Tape Drive

Because the TS2240 Tape Drive is an Express model, a part number is used instead of a feature code: Part number 95P2020 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS2340 Tape Drive

Because the TS2340 Tape Drive is an Express model, a part number is used instead of a feature code: Part number 95P4278 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS2900 Tape Drive

Because the TS2900 Tape Drive is an Express model, a part number is used instead of a feature code:

- ▶ Part number 95P4278 provides a pack of five Ultrium 4 data cartridges.
- ▶ FC8002 provides a single Ultrium cleaning cartridge. For the High Volume sellers, the cleaning cartridge must be ordered using part number 23R7008.

IBM System Storage TS3100 Tape Library

The TS3100 Tape Library can be an Express model so a part number can be used or a feature code can be used when ordering data cartridges:

- ▶ Part number 95P2020 provides a pack of five Ultrium 3 data cartridges.
- ▶ Feature code 8405 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS3200 Tape Library

These chargeable features provide media with the TS3200 Tape Library and are available with the initial order:

- ▶ Feature code 8305 provides a pack of five 400 GB Ultrium 3 data cartridges.
- ▶ Feature code 8405 provides a pack of five Ultrium 4 data cartridges.

IBM System Storage TS3310 Tape Library

See “IBM 3589 LTO Ultrium tape cartridges” on page 499 for more information about ordering tape cartridges.

IBM System Storage TS3400 Tape Library

No feature code is available for ordering data cartridges at the initial order.

IBM System Storage TS3500 Tape Library

For ordering media supplies for the TS3500 Tape Library, go to “IBM 3589 LTO Ultrium tape cartridges” on page 499 and “IBM 3599 tape cartridges” on page 503.

IBM 3589 LTO Ultrium tape cartridges

To ensure that the IBM Ultrium Tape Drive conforms to the IBM specification for reliability, IBM recommends that you use only IBM LTO Ultrium tape cartridges. IBM TotalStorage LTO Ultrium Data Cartridges cannot be interchanged with the media used in other IBM non-LTO Ultrium tape products.

Table A-1 shows the generations of IBM TotalStorage Ultrium data cartridges identified by color.

Table A-1 LTO Ultrium data cartridges identified by color

Data cartridge	Case color
Ultrium 4 WORM	Green top; platinum (silvery gray bottom)
Ultrium 4	Green
Ultrium 3 WORM	Blue top; platinum (silvery gray bottom)
Ultrium 3	Blue
Ultrium 2	Purple
Ultrium 1	Black

All four generations contain 1/2-inch, dual-coat, metal-particle tape. Table A-2 shows the native capacity of Ultrium data cartridges.

Table A-2 Native capacity of the Ultrium data cartridges

Data cartridge	Native data capacity
Ultrium 4 WORM	800 GB (1600 GB at 2:1 compression)
Ultrium 4	800 GB (1600 GB at 2:1 compression)
Ultrium 3 WORM	400 GB (800 GB at 2:1 compression)
Ultrium 3	400 GB (800 GB at 2:1 compression)
Ultrium 2	200 GB (400 GB at 2:1 compression)
Ultrium 1	100 GB (200 GB at 2:1 compression)

Cartridge compatibility

Table A-3 shows the compatibility of all four generations of Ultrium cartridges in an Ultrium 4 tape drive.

Table A-3 Ultrium data cartridge compatibility with an Ultrium 4 tape drive

IBM Ultrium Tape Drive	IBM TotalStorage LTO Ultrium Data Cartridge			
	800 GB (Ultrium 4)	400 GB (Ultrium 3)	200 GB (Ultrium 2)	100 GB (Ultrium 1)
Ultrium 4	Read/Write	Read/Write	Read only	N/A
Ultrium 3	N/A	Read/Write	Read/Write	Read only
Ultrium 2	N/A	N/A	Read/Write	Read/Write
Ultrium 1	N/A	N/A	N/A	Read/Write

Model description and ordering media supplies

We have put together two tables where you can easily find the media description and several ways to order the media.

Table A-4 on page 501 lists the twelve models of the IBM TotalStorage Tape Media 3589 for use with IBM Ultrium tape drives. IBM 3589 now supports VOLSER labels with embedded radio-frequency identification (RFID)-enabled barcode labels, which store and allow remote retrieval of VOLSER information. RFID labels contain a 216-bit unique pre-programmed field and a 256-bit user-defined field. These RFID labels are designed to work with most standard asset tracking and management software.

The following selection of 3589 models include a 20-pack of labeled LTO Ultrium data cartridges and write-once read-many (WORM) data cartridges. These cartridges support RFID labels and are used in LTO Ultrium Tape Drive products:

Model 002	100 GB labeled Ultrium tape cartridges
Model 006	200 GB labeled Ultrium tape cartridges
Model 008	400 GB labeled Ultrium tape cartridges
Model 010	800 GB labeled Ultrium tape cartridges
Model 028	400 GB labeled Ultrium WORM tape cartridges
Model 032	800 GB labeled Ultrium WORM tape cartridges

With the media identifier, the following type of cartridge is identified:

- ▶ Media identifier L1 is an Ultrium 1 cartridge.
- ▶ Media identifier L2 is an Ultrium 2 cartridge.
- ▶ Media identifier L3 is an Ultrium 3 cartridge.
- ▶ Media identifier L4 is an Ultrium 4 cartridge.
- ▶ Media identifier LT is a WORM cartridge.

Table A-4 3589 media

Model	Description	Media identifier	Feature code
3589-02	IBM Ultrium 1 cartridge (100 GB) with Labels (20-pack)	L1	FC2020
3589-03	IBM Ultrium 1 cartridge (100 GB) without Labels (20-pack)	L1	FC3020
3589-06	IBM Ultrium 2 cartridge (200 GB) with Labels (20-pack)	L2	FC6020
3589-07	IBM Ultrium 2 cartridge (200 GB) without Labels (20-pack)	N/A	FC7020
3589-08	IBM Ultrium 3 cartridge (400 GB) with Labels (20-pack)	L3	FC0820
3589-09	IBM Ultrium 3 cartridge (400 GB) without Labels (20-pack)	N/A	FC0920
3589-10	IBM Ultrium 4 cartridge (800 GB) with Labels (20-pack)	L4	FC1020
3589-11	IBM Ultrium 4 cartridges without Labels (20-pack)	N/A	FC1120
3589-28	IBM Ultrium 3 WORM cartridge (400 GB) with Labels (20-pack)	LT	FC2820
3589-29	IBM Ultrium 3 WORM cartridge (400 GB) without Labels (20-pack)	N/A	FC3920
3589-32	IBM Ultrium 4 WORM cartridge (800 GB) with Labels	LT	FC3220
3589-33	IBM Ultrium 4 WORM cartridge (800 GB) without Labels	N/A	FC3320

Table A-5 shows another way of presenting the 3589 media and links to the Internet, as well as telephone numbers for ordering the 3589 media.

Table A-5 Media supplies

Supply item	Methods of ordering
IBM TotalStorage LTO Ultrium 800 GB Data Cartridge Barcode labels are pre-applied to cartridges.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 010. Specify the VOLSER characters that you want. Order as part number 96P1470 (color label) or 96P1471 (black and white label) through an IBM-authorized distributor. Specify the VOLSER characters that you want.
IBM TotalStorage LTO Ultrium 800 GB Data Cartridge Order VOLSER labels separately.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 011. Specify the VOLSER characters that you want. Order as part number 24R1922 through an IBM-authorized distributor. Specify the VOLSER characters that you want.
5-PACK IBM TotalStorage LTO Ultrium Data Cartridge	Order as part number 95P2020 through an authorized IBM Business Partner. Specify the VOLSER characters that you want.

Supply item	Methods of ordering
IBM TotalStorage LTO Ultrium 400 GB Data Cartridge Barcode labels are pre-applied to cartridges. This media can be used with Ultrium 3 drives (Read/Write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 009. Specify the VOLSER characters that you want. Order as part number 96P1470 (color label) or 96P1471 (black and white label) through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media Or, call 1-888-IBM-MEDIA. Specify the VOLSER characters that you want.
IBM TotalStorage LTO Ultrium 400 GB Data Cartridge Order VOLSER labels separately. This media can be used with Ultrium 3 drives.	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 008. Order as part number 24R1922 through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media Or, call 1-888-IBM-MEDIA. Specify the VOLSER characters that you want.
IBM Ultrium 3 400 GB WORM Tape Cartridge (with attached labels) IBM TotalStorage 3589 Model 028/Feature Code 2820 is a 20-pack of WORM cartridges labeled with starting Volume serial information and, optionally, packed in individual jewel cases. Attached labels have been preprinted with a barcode that ends with LT, where L stands for LTO, and T identifies the cartridge as a WORM cartridge. This media can be used with Ultrium 3 drives.	Order by Machine Type/Model and Feature Code through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media If you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.
IBM Ultrium 3 400 GB WORM Tape Cartridge (without attached labels) IBM TotalStorage 3589 Model 029/Feature Code 2920 is a 20-pack of WORM cartridges packed in individual jewel cases with unattached blank labels. This media can be used with Ultrium 3 drives (Read/Write).	Order by Machine Type/Model and Feature Code through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media If you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.

Supply item	Methods of ordering
IBM TotalStorage LTO Ultrium 200 GB Data Cartridge Barcode labels are pre-applied to cartridges. This media can be used with LTO2 drives (Read/Write) and LTO3 drives (Read/Write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 006. Specify VOLSER characters you want. Call 1-888-IBM-MEDIA.
IBM TotalStorage LTO Ultrium 200 GB Data Cartridge Order VOLSER labels separately (see "Ordering barcode labels" on page 508). This media can be used with LTO2 drives (Read/Write) and LTO3 drives (Read/Write).	Order the cartridge from your IBM Marketing Representative or any authorized IBM Business Partner by specifying Machine Type 3589 Model 007. call 1-888-IBM-MEDIA.
IBM LTO Ultrium 100 GB Data Cartridge Order VOLSER labels separately (see "Ordering barcode labels" on page 508). This media can be used with LTO1 drives (Read/Write), LTO2 drives (Read/Write), and LTO3 drives (read only).	Order as part number 08L9120 through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media if you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.
IBM TotalStorage LTO Ultrium Cleaning Cartridge Universal cleaning cartridge for use with Ultrium 1, Ultrium 2, and Ultrium 3 drives. VOLSER labels are included.	Order as part number 08L9120 through an IBM-authorized distributor. For the closest distributor, visit the Web at: http://www.ibm.com/storage/media if you do not have Internet access, order the cartridge from any authorized IBM Business Partner or your IBM Marketing Representative. Call 1-888-IBM-MEDIA.

IBM 3599 tape cartridges

This section provides information about ways of ordering media supplies, including feature codes and part numbers for ordering media supplies for 3592 tape drives. Selected media supplies can be ordered using feature codes when purchasing a 3592 drive. This is the pack-in method of ordering, and the media will be shipped with the hardware order. Not all media types are available with this method.

The 3599 Tape Media method is available for ordering all types of data and cleaning cartridges. This method is typically used for ordering larger quantities and for ordering initialized and pre-labeled cartridges. Media supplies can also be ordered using part numbers through IBM-authorized distributors.

Model description

For clients who order media using the 3599 Tape Media method, IBM TotalStorage Enterprise Tape Media 3599 provides the ability to order unlabeled, pre-labeled, initialized, and bulk-packaged tape data cartridges in a wide variety of combinations, and cleaning cartridges for the 3592-J1A, TS1130, and TS1120 Tape Drives.

Cartridge capacity is dependent on the recording format of the tape drive writing the cartridges. The 3592-J1A writes in FMT1 mode, the 3592-E05 can write in either EFMT1 or EFMT2 format. and 3592 models E06 and EU6 can write in EFMT3 and in EFMT2 format. Models E05 and Ex6 can also write in an encrypted format which does not change the capacity of the cartridge compared to the non-encrypted format. The TS1120 writes in EEFMT2-encrypted format, and the TS1130 writes in EEFMT2 and EEFMT3.

The IBM 3592 Enterprise Tape Cartridge has a native capacity of 700 GB when formatted for EFMT3, 500 GB when formatted for EFMT2, and 300 GB when formatted for EFMT1.

The IBM 3592 Extended Tape Cartridge has a native capacity of 1000 GB in EFMT3 format or 700 GB in EFMT2 format. This cartridge is not supported with 3592-J1A drives.

The IBM 3592 Economy Tape Cartridge has a native capacity of 128 GB in EFMT3 format, 100 GB in EFMT2 format, and 60 GB in EFMT1 format. Capacities of data cartridges can be increased through data compression, with the actual compression and capacity depending upon the specific data. Write Once Read Many (WORM) cartridges are also available in all three capacities.

With the 3599 Tape Media method of ordering, model numbers are used to identify the cartridge types, and feature code combinations are used to specify the quantities, labeling, and initialization options. IBM 3599 supports VOLSER labels with embedded radio-frequency identification (RFID)-enabled barcode labels, which store and allow remote retrieval of VOLSER information. RFID labels contain a 216-bit unique pre-programmed field and a 256-bit user-defined field. These RFID labels work with most standard asset tracking and management software.

You have to order cartridges either labeled or labeled and initialized in order to obtain cartridges with the RFID labels. Refer to Table A-6 for additional details.

Table A-6 3599 media feature description

Media type	3599 Model	Format L=Labeled I= Initialized	External Media ID		RFID label	Quantity 20-pack Feature Code	Description
			Yes ^a	No ^b			
JA	011	L + I ^{c, d}	FC 9030	FC 9031	Yes	FC1020	3592 Enterprise Tape Cartridge with labeling and initialization
	012	L			Yes	FC2020	3592 Enterprise Tape Cartridge with external volume labels only
	013	Not L + I	N/A	N/A	N/A	FC3020	3592 Enterprise Tape Cartridge without labels or initialization

Media type	3599 Model	Format L=Labeled I= Initialized	External Media ID		RFID label	Quantity 20-pack Feature Code	Description
			Yes ^a	No ^b			
JB	014	L + I ^{c, d}	FC 9032	FC 9034	Yes	FC4020	3592 Extended Tape Cartridge with labeling and initialization
	015	L			Yes	FC5020	3592 Extended Tape Cartridge with external volume labels only
	016	Not L + I	N/A	N/A	No	FC6020	3592 Extended Tape Cartridge without labeling or initialization
JJ	E11	L + I ^c	FC 9050	FC 9051	Yes	FC1120	3592 Economy Tape Cartridge with labeling and initialization
	E12	L			Yes	FC1220	3592 Economy Tape Cartridge with external volume label only
	E13	Not L + I	N/A	N/A	No	FC1320	3592 Economy Tape Cartridge without labels or initialization
JR	E21	L + I ^c	FC 9042	FC 9043	Yes	FC3120	3592 Economy Tape Cartridge (WORM) with labeling and initialization
	E22	L			Yes	FC3220	3592 Economy Tape Cartridge (WORM) with external volume labels only
	E23	Not L + I	N/A	N/A	No	FC3320	3592 Economy Tape Cartridge (WORM) without labels or initialization

Media type	3599 Model	Format L=Labeled I= Initialized	External Media ID		RFID label	Quantity 20-pack Feature Code	Description
			Yes ^a	No ^b			
JW	021	L + I ^c	FC 9040	FC 9041	Yes	FC2120	3592 Enterprise Tape Cartridge (WORM) with labeling and initialization
	022	L			Yes	FC2220	3592 Enterprise Tape Cartridge (WORM) with external volume labels only
	023	Not L + I	N/A	N/A	No	FC2320	3592 Enterprise Tape Cartridge (WORM) without labels or initialization
JX	024	L + I ^e	FC 9044	FC 9045	Yes	FC2420	3592 Extended Tape Cartridge (WORM) with labeling and initialization
	025	L			Yes	FC2520	3592 Extended Tape Cartridge (WORM) with external volume labels Only
	026	Not L + I	N/A	N/A	No	FC2620	3592 Extended Tape Cartridge (WORM) without labels or initialization
JA	017	L + I	FC 7005	FC 7006	No	N/A	5-pack 3592 Cleaning Cartridges, 50 uses

a. The Media Identifier feature is required for cartridges in order to have an RFID label.

b. If the cartridges are to be used on a Silo Compatible Tape Drive Frame 3592 Model C20, order the FC described to provide the Cartridge without Media ID Letters.

c. FC9080 is related to EFMT1 format (3592-J1A), FC9081 is for EFMT2 format (3592-E05), and FC9082 is for EFMT3 format (3592-Ex6).

d. FC9060 ships cartridges pre-initialized to 20% of total capacity of the cartridge. FC9062 provides for a single partition of approximately 80% of total capacity with the first 20% of capacity having fast record access characteristics.

e. Only FC9081 (E2 Format) and FC9082 (E3 Format) are supported.

Table A-7 lists the data cartridges and media supplies that you can order for the 3592 tape drives. You can use one of the followings methods to order the cartridges:

- ▶ Order by part number through an IBM-Authorized distributor. For the closest distributor, visit the Web at:
<http://www.ibm.com/storage/media>
- ▶ If you do not have Internet access, order the cartridges from any authorized IBM Business Partner or your IBM Marketing Representative.
- ▶ Call 1-888-IBM-MEDIA.

Table A-7 Media supplies for the 3592 drive

Supply item	Media ID	Part number
IBM 3592 Enterprise Tape Cartridge	JB	25R9830
IBM 3592 Enterprise Tape Cartridge	JA	18P7534
IBM 3592 Economy Tape Cartridge	JJ	24R0316
IBM 3592 Enterprise Cartridge WORM	JX	23R9831
IBM 3592 Enterprise Cartridge WORM	JW	18P7538
IBM 3592 Economy Cartridge WORM	JR	24R0317
IBM TotalStorage Enterprise Data Cartridge 3592 cleaning, 50 uses	JA	18P7535

Labeling service

This service applies to IBM 3589 and IBM 3599 media types that have labels as described in the previous two sections.

There are six characters in the VOLSER, and IBM provides specific codes to allow you the flexibility to choose where to begin the volume range that you require. The sixth character is always a zero character (0), because your volume serial range must always begin at a 0 boundary for labeling, and the labels supplied are sequential. So, for example, if you order 20 cartridges, the first cartridge will be labeled with a sixth digit of 0, and the twentieth cartridge will be labelled with a sixth digit of 9.

The character identifier features are four-digit feature numbers of the form *9nnn*, composed as:

- ▶ The first digit, 9, means the feature carries no charge.
- ▶ A second digit of 1, 2, 3, 4, or 5 indicates which character in the VOLSER this feature is specifying (1st, 2nd, 3rd, 4th, or 5th).
- ▶ The third and fourth digits range from 00 through 35, where 00 through 09 represent the characters 1 through 9, and 10 through 35 represent the characters A through Z.

Choose the first 1, 2, 3, 4, or 5 digits by using the feature numbers as follows:

- ▶ First alphanumeric digit (0 to 9 or A to Z): use FC9100 (0) to FC9135 (Z).
- ▶ Second alphanumeric digit (0 to 9 or A to Z): use FC9200 (0) to FC9235 (Z).
- ▶ Third alphanumeric digit (0 to 9 or A to Z): use FC9300 (0) to FC9335 (Z).
- ▶ Fourth numeric digit (0 to 9): use FC9400 (0) to FC9409 (9).
- ▶ Fifth numeric digit (0 to 9): use FC9500 (0) to FC9509 (9).
- ▶ Sixth numeric digit is set to 0 as standard.
- ▶ Seventh and eighth characters of the VOLSER are set based on media type. Refer to the Media Identifier column in Table A-4 on page 501 and “Labeling service” on page 507.

If you do not specify a feature code, the supplied starting character will be a zero. Therefore, if you specify features for the first three characters as ABC but no more, the sequence of labels will begin ABC000.

Two specific features indicate requirements for colored labels:

- ▶ FC9077 specifies a white background.
- ▶ FC9022 specifies a colored background for the alpha characters.

If you specify FC9022, you can choose from 10 available colors as shown in Table A-8.

Table A-8 Color specify feature codes for the IBM 3599

Alpha prefix background	Feature code	Alpha prefix background	Feature code
Red	9003	Orange	9008
Yellow	9004	Pink	9009
Light green	9005	Dark green	9010
Light blue	9006	Light orange	9011
Gray	9007	Purple	9012

Ordering barcode labels

You can order barcode labels from one of the following authorized suppliers. Refer to Table A-9 on page 509.

Table A-9 Authorized suppliers of custom barcode labels

In the Americas	In Europe and Asia
EDP/Colorflex 2550 West Midway Boulevard Broomfield, CO 80020-1633 U. S. A. Telephone: 800-432-1337 or 303-666-2160 http://www.colorflex.com/Ai/Home.asp	EDP Europe, Ltd. 43 Redhills Road South Woodham Ferrers Chelmsford, Essex CM3 5UL U. K. Telephone: 44 (0) 1245-322380 http://www.edpeurope.com/media_labelling.h tm
Dataware 7570 Renwick Houston, TX 77081 U. S. A. Telephone: 800-426-4844 http://www.datawarelabels.com/	Dataware Labels Europe Heubergstrasse 9 D-83052 Bruckmuhl-Gotting Germany Telephone: 49 806-29455 http://www.datawarelabels.com/
NetC P. O. Box 320784 Fairfield, CT 06432 U. S. A. Telephone: 203-372-6382 http://www.netc11c.com/	NetC Europe Ltd Town Farm Bungalow North Curry Taunton Somerset U. K. TA3 6LX Telephone: 44 (0) 1823 491439 http://www.netclabels.co.uk
	NetC Asia Pacific Pty Ltd Locked Bag 14 Kenthurst NSW Australia 2156 Telephone: 61 (0) 2 9654 8272 http://www.netclabels.com.au



B

IPv6

The TS3500, TS3400, TS3310, TS3200, TS3100, Tape Libraries, TS2900 Tape Autoloader, and TS1120 Model C06 Controller support both IPv4 and IPv6 transportation. In this appendix, we introduce:

- ▶ IPv6 concept and address format compared with IPv4
- ▶ IPv6 supported list of Tape Library products
- ▶ An example of configuration of IPv4 and IPv6 on the TS3100 Tape Library

IPv6 introduction

Internet Protocol Version 6 (IPv6) is a network layer for packet-switched Internetworks. It is designated as the successor of IPv4, the current version of the Internet Protocol, for general use on the Internet.

By the early 1990s, it was clear that the change to a classless network introduced a decade earlier was not enough to prevent IPv4 address exhaustion and that further changes to IPv4 were needed. By the beginning of 1992, several proposed systems were being circulated and by the end of 1992, the Internet Engineering Task Force (IETF) announced a call for white papers (RFC 1650) and the creation of the "IP, the Next Generation" (IPng Area) of working groups.

IPng was adopted by the Internet Engineering Task Force on 25 July 1994 with the formation of several "IP Next Generation" (IPng) working groups. By 1996, a series of RFCs were released defining IPv6, starting with RFC 2460.

IPv4 and IPv6 address formats

The primary change from IPv4 to IPv6 is the length of network addresses. IPv6 addresses are 128 bits long (as defined by RFC 4291), whereas IPv4 addresses are 32 bits; where the IPv4 address space contains roughly 4 billion addresses, IPv6 has enough room for 340 undecillion unique addresses.

An IPv4 address has the following format: $x . x . x . x$ where x is called an octet and must be a decimal value between 0 and 255. Octets are separated by periods. An IPv4 address must contain three periods and four octets.

Examples of valid IPv4 addresses include:

- ▶ 1 . 2 . 3 . 4
- ▶ 01 . 102 . 103 . 104

An IPv6 address can have two formats:

- ▶ Normal: Pure IPv6 format
- ▶ Dual: IPv6 plus IPv4 formats (not used in this release)

Normal IPv6 address

An IPv6 (Normal) address has the following format: $y : y : y : y : y : y : y : y$ where y is called a segment and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons - not periods. An IPv6 normal address must have eight segments; however, a short form notation can be used by the Tape Library Specialist Web interface for segments that are zero or those segments that have leading zeros. The short form notation cannot be used from the Operator Panel.

Examples of valid IPv6 (Normal) addresses:

- ▶ 2001 : db8 : 3333 : 4444 : 5555 : 6666 : 7777 : 8888
- ▶ 2001 : db8 : 3333 : 4444 : CCCC : DDDD : EEEE : FFFF
- ▶ :: (implies all eight segments are zero)
- ▶ 2001: db8: : (implies that the last six segments are zero)
- ▶ :: 1234 : 5678 (implies that the first six segments are zero)
- ▶ 2001 : db8: : 1234 : 5678 (implies that the middle four segments are zero)

- 2001:0db8:0001:0000:0000:0ab9:C0A8:0102 (This can be compressed to eliminate leading zeros, as follows: 2001:db8:1::ab9:C0A8:102)

An IPv6 (Dual) address combines an IPv6 and an IPv4 address and has the following format: $y : y : y : y : y : y : x . x . x . x$. The IPv6 portion of the address (indicated with y) is always at the beginning, followed by the IPv4 portion (indicated with x):

- In the IPv6 portion of the address, y is called a segment and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons, not periods. The IPv6 portion of the address must have six segments but there is a short form notation for segments that are zero.
- In the IPv4 portion of the address, x is called an octet and must be a decimal value between 0 and 255. The octets are separated by periods. The IPv4 portion of the address must contain three periods and four octets.

Examples of valid IPv6 (Dual) addresses:

- 2001 : db8: 3333 : 4444 : 5555 : 6666 : 1 . 2 . 3 . 4
- :: 11 . 22 . 33 . 44 (implies all six IPv6 segments are zero)
- 2001 : db8: : 123 . 123 . 123 . 123 (implies that the last four IPv6 segments are zero)
- :: 1234 : 5678 : 91 . 123 . 4 . 56 (implies that the first four IPv6 segments are zero)
- :: 1234 : 5678 : 1 . 2 . 3 . 4 (implies that the first four IPv6 segments are zero)
- 2001 : db8: : 1234 : 5678 : 5 . 6 . 7 . 8 (implies that the middle two IPv6 segments are zero)

Subnet masks (IPv4) and prefix lengths (IPv6)

All IP addresses are divided into portions. One part identifies the network (the network number) and the other part identifies the specific machine or host within the network (the host number). Subnet masks (IPv4) and prefixes (IPv6) identify the range of IP addresses that make up a subnet, or a group of IP addresses on the same network. For example, a subnet can be used to identify all the machines in a building, department, geographic location, or on the same local area network (LAN).

Dividing an organization's network into subnets allows it to be connected to the Internet with a single shared network address. Subnet masks and prefixes are used when a host is attempting to communicate with another system. If the system is on the same network or subnet, it will attempt to find that address on the local link. If the system is on a different network, the packet is sent to a gateway which will then route the packet to the correct IP address. This is called Classless-InterDomain Routing (CIDR).

In IPv4, the subnet mask 255.255.255.0 is 24 bits and consists of four 8-bit octets. The address: 10.10.10.0 subnet mask 255.255.255.0 means that the subnet is a range of IP addresses from 10.10.10.0 - 10.10.10.255.

The prefix-length in IPv6 is the equivalent of the subnet mask in IPv4. However, rather than being expressed in four octets as it is in IPv4, it is expressed as an integer between 1-128. For example: 2001:db8:abcd:0012::0/64 specifies a subnet with a range of IP addresses from: **2001:db8:abcd:0012**:0000:0000:0000:0000 - **2001:db8:abcd:0012**:ffff:ffff:ffff:ffff. The portion in bold is called the network portion of the IP address, or the prefix. The non-bold portion is called the host portion of the IP address, because it identifies an individual host on the network.

IPv6 functionality

To support this functionality, changes have been made to the following components:

- ▶ Ethernet driver
The Ethernet driver has been modified to support either an IPv4 or IPv6 link layer configuration.
- ▶ Network Manager
The IP Stack configuration can be either IPv4 or IPv6. This includes IP addresses, subnet masks, and gateway addresses.
- ▶ Operator Panel
Allows the Ethernet connection to be configured as either IPv4 or IPv6.
- ▶ Call Home
Call Home determines the IP version used and presents the correct IP address and parameters to the IP Stack.
- ▶ Key Proxy
Determines the IP version used and presents the correct IP address and parameters to the IP Stack.
- ▶ Nonvolatile random access memory (RNVDRAM)
Stores the IPv4 and IPv6 IP and gateway addresses, as well as network masks for both. Functions have been provided to set and get the parameters.
- ▶ Vital product data (VPD) Cache
Contains the IPv4 and IPv6 IP and gateway addresses, as well as network masks for both. Functions have been provided to set and get the parameters.
- ▶ Web User Interface
Those pages that contain IP addresses now provide provisions for both IPv4 and IPv6 formats. For example, the page that contains the IP address for the External Key Manager provides both IPv4 and IPv6 formats.

Interoperability of applications

Most of the mechanisms of IPv6 transition have been developed to connect IPv4 networks with IPv6 networks and base their operations in entities located at an intermediate point of the network to perform some kind of processing, for example tunnels or translation of protocols.

IPv6 supported list of Tape Library products

IBM TotalStorage Tape Library products that can support IPv6 include:

- ▶ TS3500
- ▶ TS3400
- ▶ TS3310
- ▶ TS3200
- ▶ TS3100
- ▶ TS2900
- ▶ TS1120 Model C06

TS3100 network configuration

We show you an example of TS3100 network configuration for Dual Stacked IPv4 and IPv6.

The Web User Interface hosts a dedicated, protected Internet site that displays a graphical representation of your library. After establishing a connection to the library, open any HTML browser and enter the IP address of the library. To configure the Web User Interface, you must set the IP address. The library supports IPv4, IPv6, or Dual Stack IPv4 + IPv6 transportation.

For IPv6, enter your library static IP Address or Router Assigned IP Address using the following format: `http://[0:0:0:0:0:0:0:0]`. To determine your Router Assigned IP Address, navigate to **Monitor** → **Library** → **Network** on the Operator Control Panel. For the IPv6 Router Assigned Addresses to be displayed on the Operator Control Panel, the Network must be configured to IPv6 only and the Stateless Autoconfig must be set to ON.

Figure B-1 shows you the Network Configuration panel view from the Web User Interface.

IBM System Storage™ TS3100 Tape Library

Welcome admin Home | Help | Logo

Monitor Library

- Library Identity
- Drive Identity
- Library Status
- Drive Status
- Inventory

Manage Library

- Move Media
- Perform Inventory
- Release Magazine

Configure Library

- General
- Logical Libraries
- Path Failover
- Encryption

Drives

- Network
- User Access
- Date & Time
- Logs & Traces
- Event Notification
- Restore Defaults

Service Library

Network

Protocol Stack: Dual stack IPv4 + IPv6

IPv4

DHCP Address: ☐ On

Static address: 9.11.219.141

Network Mask: 255.255.255.0

Gateway address: 9.11.219.1

IPv6

DHCP Address: ☐

Stateless auto config address: ☒

Static assigned address: 2002:90B:E002:219:9:11:219:141

Prefix length: 64

Gateway address: 2002:90B:E002:219:1:1:1:1

SNMP (IPv4 or IPv6)

Enable: ☐

Target 1 - IP Address: 0.0.0.0 Version: SNMPv1

Target 2 - IP Address: 0.0.0.0 Version: SNMPv1

Target 3 - IP Address: 0.0.0.0 Version: SNMPv1

Community Name: public

Security User Name: initial

Enable SSL for Web: ☐

You will be required to login again if changes are made. If you change the IP address of the library, then you will need to use the new IP address when you attempt to access the library again.

Refresh Submit

System Status

[View Legend](#)

04/30/2008 09:57:01

Library Name: BOSTON141

Status: Media Attention

Drive 1 Status: Ready

Slots (Empty/Total): 22/23

I/O Station: Closed

Library Time: 09:57:01

Auto Clean Status: Chk Media/Rsvd Slot?

http://9.11.219.141/network_config.ssi

Figure B-1 Network Configuration panel

For more IPv6 information, refer to these additional resources from the Internet:

- ▶ Basic IPv6 Information:
<http://en.wikipedia.org/wiki/Ipv6>
- ▶ IBM IPv6 certification page:
<http://www-306.ibm.com/software/info/ipv6/index.jsp>
- ▶ Converting IPv4 programs to IPv6 (C/C++):
<http://www-128.ibm.com/developerworks/web/library/wa-ipv6.html>
- ▶ Java (JRE 1.4 and up must have IPv6 compliance):
http://java.sun.com/j2se/1.4.2/docs/guide/net/ipv6_guide/



IBM Tape product names

On 11 October 2005, IBM started an initiative to rename its newly announced tape products. All product names are preceded by the *IBM* brand and either *TotalStorage* (for earlier products) or *System Storage* for products being announced after that date.

Introducing the new TSxxxx “series family names”:

- ▶ The 1000 series is reserved for tape drives:
For example, the 3592 becomes the TS1120 and TS1130 Tape Drives.
- ▶ The 3000 series is reserved for automation, for example:
 - The 3572 becomes the TS2900 Tape Autoloader.
 - The 3576 becomes the TS3310 Tape Library.
 - The 3584 becomes the TS3500 Tape Library.

In the following tables, Table C-1 on page 518 through Table C-7 on page 520, you can find IBM tape products with the new naming and a model description.

TS1000 Tape Drives (LTO)

Table C-1 TS1000 Tape Drive naming

M/T	Model	Existing name	New name
3580/3588			
3580	L33	3580 Tape Drive Model L33	
	L3H	3580 Tape Drive Model L3H	
	L3H	3580 Tape Drive Express Model L3H	
3588	F3B		IBM System Storage TS1030 Tape Drive
3588	F4A		IBM System Storage TS1040 Tape Drive

TS1100 Tape Drive (Enterprise)

Table C-2 TS1100 Tape Drive naming

M/T	Model	Existing name	New name
3592			
3592	J1A	3592 Tape Drive Model J1A	
3592	E05	IBM System Storage TS1120 Tape Drive	
3592	E06/EU6	IBM System Storage TS1130 Tape Drive	
3592	C06		IBM System Storage TS1120 Tape Controller
3592	C20	3592 Tape Library Frame Model C20	IBM 3592 Tape Frame Model C20

TS2900 Tape Autoloader

Table C-3 TS2900 Tape Autoloader naming

M/T	Model	Existing name	New name
3572			IBM System Storage TS2900 Tape Autoloader
3572	S3H		IBM System Storage TS2900 Tape Autoloader
3572	S4H		IBM System Storage TS2900 Tape Autoloader

TS3100 Tape Library

Table C-4 TS3100 Tape Library naming

M/T	Model	Existing name	New name
3573	L2U		IBM System Storage TS3100 Express Tape Library
3573	L4S		IBM System Storage TS3100 Express Tape Library Model L4S
3573	S4S		IBM System Storage TS3100 Express Tape Library Model S4S
3573	F4S		IBM System Storage TS3100 Express Tape Library Model F4S
3573	L32/S32		IBM System Storage TS3100 Express Seller Tape Library Model L32/S32
3573	S42		IBM System Storage TS3100 Express Seller Tape Library Model S42

TS3200 Tape Library

Table C-5 TS3200 Tape Library naming

M/T	Model	Existing name	New name
3573	L4U		IBM System Storage TS3200 Express Tape Library
3573	F4H		IBM System Storage TS3200 Express Tape Library Model F4H
3573	L4H		IBM System Storage TS3200 Express Tape Library Model L4H
3573	S4H		IBM System Storage TS3200 Express Tape Library Model L4H
3573	S34/L34		IBM System Storage TS3200 Express Tape Library Model S34/L34
3573	S44		IBM System Storage TS3200 Express Tape Library Model S44

TS3310 Tape Library

Table C-6 TS3310 Tape Library naming

M/T	Model	Existing name	New name
3576		IBM System Storage TS3310 Tape Library	
3576	L5B		IBM System Storage TS3310 Model L5B
3576	E9U		IBM System Storage TS3310 Model E9U

TS3500 Tape Library

Table C-7 TS3500 Tape Library naming

M/T	Model	Existing name	New name
3584		3584 Tape Library	IBM System Storage TS3500 Tape Library
	L23		IBM System Storage TS3500 Model L23
	L53		IBM System Storage TS3500 Model L53
	D23		IBM System Storage TS3500 Model D23
	D53		IBM System Storage TS3500 Model D53
	S24		IBM System Storage TS3500 Model S24
	S54		IBM System Storage TS3500 Model S54
	HA1	3584 High Availability Frame Model HA1	IBM System Storage TS3500 Model HA1

IBM Express Portfolio is a set of IBM offerings for IBM Business Partners in Small and Medium Business. For details, refer to the following Web site:

http://www-1.ibm.com/partnerworld/pwhome.nsf/weblook/pub_strategies_smb_express.html



IBM Virtualization solutions

In order to reduce the Total Customer Ownership of the IT infrastructure, data centers have been adopting virtualization strategies in a number of areas, most notably in servers, with virtualization solutions, such as VMware, and in disk storage with solutions, such as IBM storage area network (SAN) Volume Controller (SVC). Now, starting from a base of over 3000 early adopters of the 3494 Virtual Tape Server (VTS) subsystem, IBM is extending that technology with the Virtualization Engine.

The storage industry refers to the IBM Virtualization Engine as a virtual tape library. A *virtual tape library* provides high performance backup and restore by using disk arrays and virtualization software. IBM has taken an IBM System x server running Linux and attached it to an IBM TotalStorage DS4000 disk subsystem running tape virtualization software to form a Virtualization Engine.

In the following section, we show you the three models of the TS7500 Virtualization Engine and their key characteristics. They are:

- ▶ IBM Virtualization Engine TS7510
- ▶ IBM Virtualization Engine TS7520
- ▶ IBM Virtualization Engine TS7530

TS7510 Virtualization Engine

The TS7510 is designed to provide centralized tape system services. It uses disk cache to reduce the time required to perform backup and restore. It improves sharing tape libraries across applications and servers. And, it facilitates data sharing and resource virtualization.

The TS7510 is a highly scalable, modular solution consisting of the TS7510 V1R1 software and an integrated set of components mounted in a 3952-F05 tape frame, including:

- ▶ Up to two 3954 CV5 Virtualization Engines
- ▶ Two 3955 SV5 cache controllers
- ▶ 14 optional 3955 SX5 disk cache modules

The TS7510 Virtualization Engine can support up to 46 TB of user disk cache. 3954 CV5 Virtualization Engine users can choose one or two 3954 CV5 engines with the capability for each to support:

- ▶ 64 virtual libraries
- ▶ 512 virtual tape drives
- ▶ 4096 virtual cartridges
- ▶ 4 Fibre Channel (FC) ports

With a second 3954 controller installed, these figures are doubled. And, the data center gains the capability to operate as an active-active cluster or in high-availability mode for the virtual tape environment with complete redundancy for nodes, disks, power, and I/O connections. A second 3952 tape frame is required for expansion to more than six disk cache modules.

TS7510 functional highlights

The TS7510 functions include:

- ▶ Network replication of a virtual tape cartridge over IP
- ▶ Network encryption of the data stream to help ensure end-to-end security and privacy
- ▶ Network compression to help maximize bandwidth utilization
- ▶ Investment protection for existing 3584 and 3494 libraries
- ▶ High availability with second engine
- ▶ Active-Active mode with second engine

In addition, TS7510 can attach 3494 and 3584 libraries, along with 3592 and Linear Tape-Open LTO2/LTO3 tape drives. The TS7510 supports a variety of servers, including System p and System x and operating systems, including Sun Solaris, Microsoft Windows 2000 Server and Windows Server 2003, Linux (Red Hat and SUSE), and Hewlett-Packard UNIX (HP-UX), plus Linux on the mainframe.

IBM Tape Virtualization Engine is intended to interoperate with a number of standard storage management applications, including Tivoli Storage Manager.

Note: Effective 26 April 2008, the IBM Virtualization Engine TS7510 Model CV5 and IBM Virtualization Engine TS7510 Model SX5 were withdrawn from marketing. After the effective dates of withdrawal, you can no longer order these products directly from IBM. You can obtain the products on an as-available basis through IBM Business Partners.

TS7520 Virtualization Engine

The TS7520 helps reduce restore time by utilizing the data stored in cache. With support for up to 4096 virtual tape drives and 512 virtual tape libraries, each backup server can be allocated its own virtual resources, allowing multiple and disparate backup applications to use the same physical resources. This design offers the potential for infrastructure simplification. Multiple tape libraries and tape drives can be aggregated to one or more TS7520s, helping to centralize the backup resources and further reduce the operational cost.

The TS7520 Virtualization Engine (3954 Model CV6) contains dual core processors to help improve performance. Every TS7520 configuration must contain at least one TS7520 Virtualization Engine. A second optional TS7520 Virtualization Engine enables the TS7520 to operate in a dual-node high-availability configuration. A TS7520 dual-node high-availability configuration can have more virtual cartridges, virtual volumes, and interface ports.

Each TS7520 Virtualization Engine supports up to twelve 4 Gb Fibre Channel connections. Four of the Fibre Channel ports are connected to the TS7520 Cache Controllers, and eight of the Fibre Channel ports are available for host server or tape attachment. In a dual node system, there are sixteen Fibre Channel ports available for host server or tape attachment.

A newly introduced disk drive feature provides 12 TB of unformatted storage capacity (RAID 5 formatted capacity of 9.75 TB) using sixteen 750 GB/7200 revolution per minute (rpm) Serial Advanced Technology Attachment (SATA) Enhanced Disk Drive Modules (E-DDMs) per enclosure.

New Fibre Channel switch features are also available on IBM 3952 Model F05 Tape Frames installed as TS7520 base units. A new 32-port switch with 16 ports active can be ordered on the Model F05 Tape Frame. One or two optional eight port enablement features can be added to activate additional Fibre Channel ports.

The TS7520 consists of three hardware machine types and a software program (5697-N65) Enterprise Edition or (5697-N66) Limited Edition. The 3952 Tape Frame Model F05 is an independent frame used to contain the other components of the TS7520. The frame 3952-F05 is designed to provide redundancy for critical hardware components and connections between components in a TS7520.

TS7520 functional highlights

Virtual support of IBM LTO 2, LTO 3, and LTO 4 Tape Drives, TS1120, and 3592 Tape Drives Model J1A and E05:

- ▶ Virtual support of IBM TS3500, TS3400, TS3310, TS3200, and TS3100 Tape Libraries
- ▶ Physical direct attach support for TS3500, TS3400, TS3200, TS3100, TS3310, and 3494 Tape Libraries
- ▶ Physical tape export offered in these modes:
 - Backup software-controlled
 - Operator-initiated
 - Policy-based physical tape migration
- ▶ Configuration of two TS7520 Virtualization Engines as an active-active failover cluster
- ▶ Support for real-time compression of data, reducing disk storage requirements

IBM Virtualization Engine TS7530

With support for up to 4096 virtual tape drives and 512 virtual tape libraries, each backup server can be allocated its own virtual resources, allowing multiple and disparate backup applications to use the same physical resources. This design offers the potential for infrastructure simplification. Various multiple tape libraries and tape drives can be aggregated to one or more TS7530s, helping to centralize the backup resources and further reduce the operational cost.

The TS7530 Server (3954 Model CV7) contains dual core processors to help improve performance. Every TS7530 configuration must contain at least one TS7530 Virtualization Engine. A second optional TS7530 Virtualization Engine enables the TS7530 to operate in a dual-node high-availability configuration. A TS7530 dual-node high-availability configuration can have more virtual cartridges, virtual volumes, and interface ports.

Each TS7530 Server supports up to sixteen 4 Gb Fibre Channel connections. Four of the Fibre Channel ports are connected to the TS7530 Cache Controllers, and twelve of the Fibre Channel ports are available for host server or tape attachment. In a dual node system, there are 24 Fibre Channel ports available for host server or tape attachment.

A newly introduced disk drive feature provides 16 TB of unformatted storage capacity (RAID 5 formatted capacity of 13 TB) using sixteen 1 TB GB/7200 rpm Serial Advanced Technology Attachment (SATA) Enhanced Disk Drive Modules (E-DDMs) per enclosure.

Fibre Channel switch features are also available on IBM 3952 Model F05 Tape Frames installed as TS7530 base units. A 32-port switch with 16 ports active can be ordered on the Model F05 Tape Frame. One or two optional 8-port enablement features can be added to activate additional Fibre Channel ports.

The TS7530 consists of three hardware machine types and a software program (5697-P19) Enterprise Edition. The 3952 Tape Frame Model F05 is an independent frame used to contain the other components of the TS7530. The frame 3952-F05 can provide redundancy for critical hardware components and connections between components in a TS7530.

TS7530 functional highlights

Functional highlights of the TS7530 include:

- ▶ Virtual support of IBM LTO 2, LTO 3, and LTO 4 Tape Drives, TS1120, and 3592 Tape Drive Model J1A.
- ▶ Virtual support of IBM TS3500, TS3400, TS3310, TS3200, and TS3100 tape libraries.
- ▶ Physical direct attach support for TS3500, TS3400, TS3200, TS3100, TS3310, and 3494 tape libraries.
- ▶ Physical tape export offered in these modes:
 - Backup software-controlled
 - Operator-initiated
 - Policy-based physical tape migration
- ▶ Configuration of two TS7530 Virtualization Engines as an active-active failover cluster.
- ▶ Support for optional hardware compression of data, reducing disk storage requirements.
- ▶ RAID 5 and 6.
- ▶ On demand allocation of disk storage to help maximize storage utilization using virtual cartridges. Static allocation is also supported for customized environments.

- ▶ Support of import/export to an IBM 3494 Tape Library using an Ethernet interface to manage the library.
- ▶ Interaction with the TS7520 Cache Controllers to perform transparent failover/failback from path (host bus adapter (HBA), port, switch, or channel) or storage controller failure to minimize disruption to backup or restore activities.

The 3952 F05 Tape Frame can contain:

- ▶ Two TS7530 Servers (3954 Model CV7) in a base unit frame
- ▶ Two TS7520 Cache Controllers (3955 Model SV6)
- ▶ Up to six TS7520 Cache Modules (3955 Model SX6) in a base unit frame
- ▶ Up to ten TS7520 Cache Modules (3955 Model SX6) in an expansion frame

The TS7530 can provide up to 1.7 PB of usable capacity for data backup and recovery requirements.

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this IBM Redbooks publication.

IBM Redbooks publications

For information about ordering these publications, refer to “How to get IBM Redbooks publications” on page 529. Note that some of the documents referenced here might be available in softcopy only:

- ▶ *Designing an IBM Storage Area Network*, SG24-5758
- ▶ *iSeries in Storage Area Networks: A Guide to Implementing FC Disk and Tape with iSeries*, SG24-6220
- ▶ *IBM Tape Solutions for Storage Area Networks and FICON*, SG24-5474
- ▶ *IBM System Storage TS3500 Tape Library with System z Attachment: A Practical Guide to TS1120 Tape Drives and TS3500 Tape Automation*, SG24-6789
- ▶ *Tivoli Storage Manager Version 5.1 Technical Guide*, SG24-6554
- ▶ *IBM TotalStorage Enterprise Tape 3592: Presentation Guide*, REDP-3749
- ▶ *Implementing IBM Tape in UNIX Systems*, SG24-6502
- ▶ *Implementing IBM Tape in Linux and Windows*, SG24-6268
- ▶ *Implementing IBM Tape in i5/OS*, SG24-7440
- ▶ *The LTO Ultrium Primer for IBM eServer iSeries Customers*, REDP-3580

Other publications

These publications are also relevant as further information sources:

- ▶ *IBM Tape Device Drivers Installation and User's Guide*, GC27-2130
- ▶ *IBM System Storage TS2230 Tape Drive Setup, Operator and Service Guide*, GC27-2099
- ▶ *IBM System Storage TS2240 Tape Drive Setup, Operator and Service Guide*, GC27-2151
- ▶ *IBM System Storage TS2900 Tape Autoloader Setup, Operator and Service Guide*, GC27-2212-00
- ▶ *IBM System Storage TS2340 Tape Drive Setup, Operator and Service Guide*, GC27-2103
- ▶ *IBM System Storage TS3400 Planning and Operator Guide*, GC27-2107
- ▶ *IBM Tape Device Drivers Programming Reference*, GA32-0566
- ▶ *IBM TotalStorage SMI-S Agent for Tape Installation Guide*, GC35-0512
- ▶ *IBM TotalStorage 3580 Tape Drive Setup, Operator, and Service Guide*, GC26-7708
- ▶ *IBM TotalStorage 3581 Tape Autoloader Setup, Operator, and Service Guide*, GA32-0470
- ▶ *IBM TotalStorage 3581 Tape Autoloader Setup, Operator and Service Guide*, GA32-0461
- ▶ *IBM TotalStorage 3582 Tape Library Setup, Operator, and Service Guide*, GA32-0458

- ▶ *IBM TotalStorage 3583 Tape Library 3583 Setup and Operator Guide for Multi-Path Libraries*, GA32-0411
- ▶ *IBM System Storage TS3500 Tape Library Introduction and Planning Guide IBM 3584 Tape Library*, GA32-0559
- ▶ *IBM System Storage TS3500 Tape Library with ALMS Introduction and Planning Guide*, GA32-0593
- ▶ *IBM System Storage Tape Library Operator Guide*, GA32-0560
- ▶ *IBM Tape Library with ALMS Operator Guide*, GA32-0450
- ▶ *IBM System Storage TS1120 and TS1130 Tape Drives and TS1120 ControllerOperator Guide (3592 Models J1A, E05, E06, EU6, J70 and C06)*, GA32-0556
- ▶ *IBM System Storage TS1120 and TS1130 Tape Drives and TS1120 ControllerOperator Guide (3592 Models J1A, E05, E06, EU6, J70 and C06)*, GA32-0555
- ▶ *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference*, GA32-0450-01
- ▶ *IBM System Storage TS3310 Tape Library Setup and Operator Guide*, GA32-0477
- ▶ *IBM System Storage TS3310 Tape Library Maintenance Information for IBM Service Personnel*, GA32-0478
- ▶ *IBM System Storage TS3310 Tape Library SCSI Reference*, GA32-0476
- ▶ *IBM TotalStorage UltraScalable Tape Library 3584 Advanced Library Management System Technology White Paper*, by Lee Jesionowski, which can be found at:
http://www.storage.ibm.com/tape/lto/white_papers/pdf/advanced_library_management_system.pdf

Online resources

These Web sites and URLs are also relevant as further information sources:

- ▶ This is the main Web site for information about IBM LTO products:
<http://www.ibm.com/storage/lto>
- ▶ The Linear Tape-Open Technology Organization Web site provides information about the technology, formats, and licensing:
<http://www.lto-technology.com/>
<http://www.ultrium.com>
- ▶ The SCSI Trade Association Web site provides information about SCSI standards and terms:
<http://www.scsita.org>
- ▶ This Web site describes the media available from IBM:
<http://www.ibm.com/storage/media>
- ▶ This Web site describes IBM Microelectronics products, including compression devices:
<http://www.chips.ibm.com>
- ▶ This Web site describes the Streaming Lossless Compression Algorithm:
<http://www.ecma-international.org/publications/standards/ECMA-321.HTM>
- ▶ IBM Tivoli Storage Manager SAN device support:
<http://www.ibm.com/software/tivoli/products/storage-mgr-san/platforms.html>

- ▶ Tape device driver downloads:
<ftp://ftp.software.ibm.com/storage/devdrv>
- ▶ Independent Software Vendor (ISV) Support Matrix for LTO:
http://www.storage.ibm.com/hardsoft/tape/conntrix/pdf/lto_isv_matrix.pdf
- ▶ Ultrium 3580 Drive firmware information:
<http://www.ibm.com/support/docview.wss?rs=543&org=ssg&doc=S4000055&loc=en-us>
- ▶ IBM 3582 Interoperability Matrix:
<http://www.storage.ibm.com/tape/lto/3582/3582opn.pdf>
- ▶ IBM 3583 Interoperability Matrix:
<http://www.storage.ibm.com/tape/lto/3583/3583opn.pdf>
- ▶ IBM 3584 Interoperability Matrix:
<http://www.storage.ibm.com/tape/lto/3584/3584opn.pdf>
- ▶ IBM 3584 drive and library firmware:
<ftp://ftp.software.ibm.com/storage/358x/3584>
- ▶ IBM Sales Manual:
<http://usmweb.boulder.ibm.com>
- ▶ IBM ServerProven compatibility for hardware, applications, and middleware:
<http://www.pc.ibm.com/us/compat>
- ▶ System x tape storage:
<http://www.pc.ibm.com/ww/eserver/xseries/tape.html>
- ▶ System i technical support:
<https://techsupport.services.ibm.com/server/support?view=iSeries>

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