

Lucent Technologies
Bell Labs Innovations



Metropolis[®] DMX Access Multiplexer (Release 3.0 and 3.1)

Applications and Planning Guide

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365-372-300
Issue 4.0
May 2002



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About this information product

Purpose This applications and planning guide (APG) provides the following information for the Metropolis[®] DMX Access Multiplexer:

- Features
- Applications
- Operation
- Engineering
- Support
- Specifications
- Ordering.

Reason for reissue A reissue of this document was needed to address all Release 3.0, and Release 3.1 features supported by the Metropolis[®] DMX Access Multiplexer (as well as features from past releases).

Safety labels This document may contain safety labels in the form of **DANGERS**, **WARNINGS**, and **CAUTIONS**.

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The alert symbol appears throughout this document to alert the user to these safety labels.

Intended audience This applications and planning guide is intended for network planners and engineers. However, it is also for anyone who needs specific information regarding the features, applications, operation, engineering, and ordering of the DMX Access Multiplexer.

How to use this information product The following is a brief description of the contents of each chapter in this document:

- **"About This Document"** describes the purpose, intended audience, reason for reissue, and organization of this document. This section references related documentation and explains how to order, make comments, or recommend changes to this document.
- Chapter 1, **"System Overview,"** describes the DMX Access Multiplexer. This introductory section also lists the features included in the releases covered by this document.
- Chapter 2, **"Features,"** briefly describes the features listed in Chapter 1. These features are described in more detail in Chapter 3, "Network Topologies," Chapter 4, "Product Description," and Chapter 6, "Operations, Administration, Maintenance, and Provisioning."
- Chapter 3, **"Applications and Configurations,"** describes how the DMX Access Multiplexer shelf serves diverse needs such as embedded network evolution, access transport for voice and private line services, interoffice transport, broadband business data access, DSLAM access, IP network infrastructure, enterprise LAN

interconnect and transport, ISP carrier access, and cable access to internet applications through configurations such as path switched ring, linear optical extensions, homing, and hubbing.

- Chapter 4, "**Product Description**," describes the DMX Access Multiplexer hardware, including the shelf, circuit packs, cables, and power.
- Chapter 5, "**System Planning and Engineering**," summarizes physical arrangement, cross-connection, and synchronization information to help you plan procurement and deployment of the DMX Access Multiplexer.
- Chapter 6, "**Operations, Administration, Maintenance, and Provisioning**," defines the "maintenance philosophy," outlining the various features available to monitor and maintain the DMX Access Multiplexer.
- Chapter 7, "**Ordering**," provides equipment ordering information for the DMX Access Multiplexer.
- Chapter 8, "**Product Support**," describes how Lucent Technologies supports the DMX Access Multiplexer. This chapter includes information about engineering and installation services, technical support, documentation support, and training available from Lucent Technologies.
- Chapter 9, "**Reliability and Quality**," provides the Lucent Technologies quality policy and describes the reliability program.
- Chapter 10, "**Technical Specifications**," lists the technical specifications for the DMX Access Multiplexer.
- Glossary provides definitions for telecommunication acronyms and terms.
- Index supplies users with specific subjects and corresponding page numbers to find necessary information.

Conventions used

Bold typeface signifies emphasis.

Italic typeface denotes a particular product line or information product.

Courier typeface signifies a command.

For the remainder of this information product, "DMX" is used in place of Metropolis[®] DMX Access Multiplexer in most cases.

Electronic documentation

Documentation for the DMX Access Multiplexer is now available in electronic form, on compact disk read only memory (CD-ROM). CD-ROM has many advantages over traditional paper documentation, including cost savings, search and retrieve capability, and the assurance of the most current documentation.

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1 System Overview

Overview

Purpose This chapter introduces the Metropolis[®] DMX Access Multiplexer system.

Contents The following topics are included in this chapter:

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Overview of the Metropolis[®] Portfolio

Purpose Metropolitan, "metro," networks are the communications networks that link homes and businesses to larger, long-distance core networks. These networks are complex because they are filled with both old and new networking equipment and must carry all types of service traffic, including voice, data and video.

Driven by the exponential growth of the Internet, requirements for metropolitan optical transport networks are changing quickly from pure circuit networks to hybrid networks. This evolution requires metro access networks to aggregate the local loop or last-mile bandwidth in order to integrate with the high-speed core/backbone networks. These requirements are driving metropolitan network evolution from traditional SONET multiplexers into more flexible, higher-speed, data-aware platforms - a necessity for optical edge solutions.

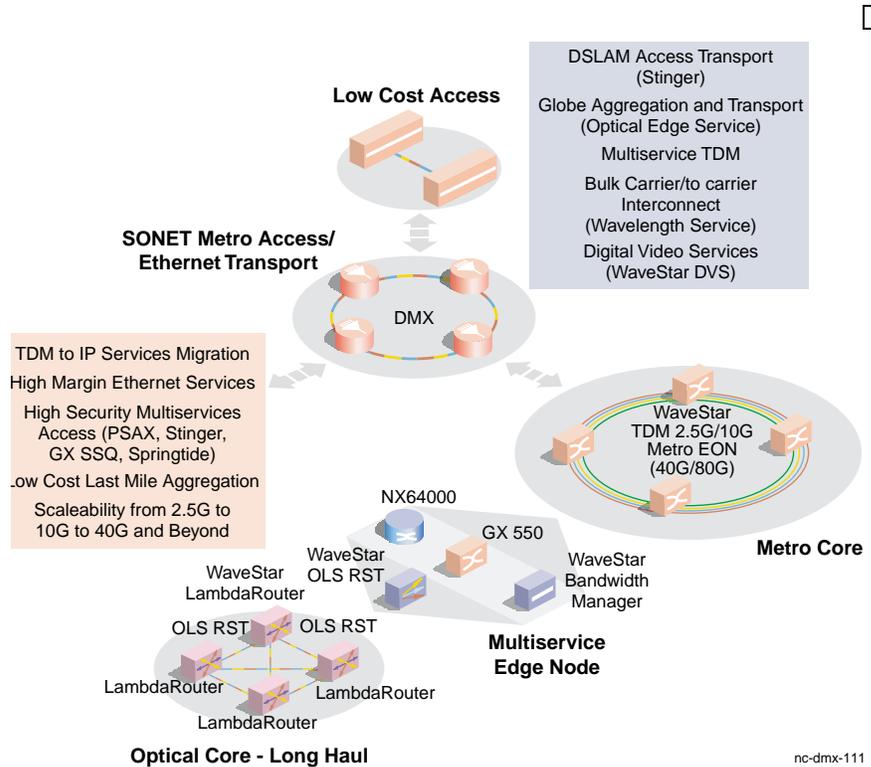
Solution Lucent Technologies is helping Service Providers to cost-effectively deploy solutions that can accommodate a multitude of services, such as voice, private line, Ethernet, IP, frame relay, and ATM. The Metropolis[®] portfolio offers a seamless evolution to next-generation metro solutions that can eliminate the bottleneck in the metropolitan network, allowing service providers to deliver new high-speed, revenue-generating services such as gigabit Ethernet, virtual private networks (VPN), storage area networks and digital subscriber lines (DSL).

Portfolio Lucent designed its Metropolis® portfolio so customers can choose the solution that best accommodates their existing networks, allowing them to bring new services to market quickly and cost effectively.

Metropolis® includes two categories of next-generation products based on the most common types of metro networks:

- Next-Generation SONET -- Metropolis DMX and DMXpress Access Multiplexers which leverages existing optical equipment while providing a solid foundation for future bandwidth, gigabit Ethernet and IP services growth.
- MetroWDM -- Metropolis EON Enhanced Optical Networking a metro core DWDM solution for regional traffic.

Each of the Metropolis® solutions can fuse with Lucent's new multiservice data switches and existing IP and ATM equipment to provide an end-to-end broadband network that links to long-distance or other metro networks.



nc-dmx-111

Metropolis[®] Products

Overview This section provides a brief description of each of the following products which comprise the Metropolis portfolio:

- Metropolis[®] DMXpress Access Multiplexer
- Metropolis[®] DMX Access Multiplexer

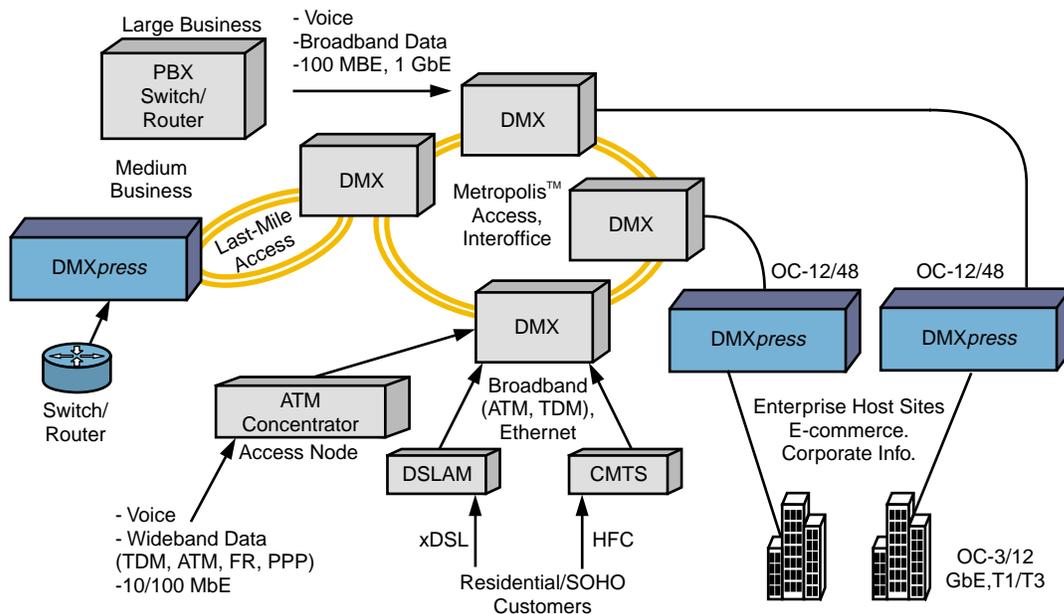


Metropolis[®] DMXpress

Introduction to DMXpress

The DMXpress system has been designed to provide a last-mile solution at the lowest-cost possible. In its ability to offer low-cost, high revenue, protected transport for both voice and data, DMXpress is an ideal solution for fiber-to-the-business applications. DMXpress eliminates the need for a LAN/WAN boundary and simplifies broadband data service delivery. Plus, the DMXpress has the transmission capability to send signals directly from a Multi-Tenant Unit (MTU) to a Central Office (CO).

DMXpress offers an OC-48 and OC-12 UPSR as a standard high-speed interface. DMXpress can be equipped with a standard TDM card offering either 16 DS1 ports and 1 DS3 port (which can be removed if not needed), or 12 DS3 ports. At the same time, the DMXpress can be equipped with an Ethernet option pack that provides for a provisionable Gigabit Ethernet (GbE) or Fast Ethernet (10/100 Mbps) packet ring capable of eliminating last-mile bottleneck and accommodating a growing demand for data service. Thus, DMXpress optimizes last-mile access for internet service growth while maintaining high-revenue voice and private-line capabilities.



The Metropolis[™] DMXpress allow network providers to choose from a variety of access network deployment strategies to meet their service delivery needs

DMXpress = Metropolis[™] DMXpress Access Multiplexer
 DMX = Metropolis[™] DMX Access Multiplexer

NO-XXXX-010

Introduction to the DMX Access Multiplexer

Overview The DMX Access Multiplexer is a single shelf network multiplexer designed primarily for access transport, business access, and regional interoffice applications transporting voice and data at the OC-48/OC-192 level via a unidirectional path switched ring.

Lucent's rich history of SONET multiplexers provides the foundation for the DMX. The DMX builds on that tradition by providing the tools necessary for the new generation of access networks: greater capacity, increased network flexibility, diverse functionality, and reliable service.

DMX supports a wide array of wideband and broadband transport, including traditional SONET transport of DS1, DS3, EC-1, OC-3, OC-12, OC-48, and OC-192 signals, as well as 10/100/1000 Mb/s LAN transport. The shelf can be equipped to serve many diverse network applications and supports a variety of operations interfaces for current and evolving network operations needs.

Functionality There are 13 circuit pack slots in each shelf, consisting of the following:

- 1 Control slot (CTL) for the SYSCTL
- 2 Main slots (M1, M2) for high speed optical line interface units (OC-12, OC-48, or OC-192)
- 8 multipurpose Function Unit slots (A through D) for DS1, DS3, EC-1, OC-3, OC-12, OC-48, 100BASE-TX, 1000BASE-SX, and 1000BASE-LX service
- 2 Growth slots (G1, G2) for OC-3, OC-12, OC-48, 1000BASE-SX, and 1000BASE-LX service

The Growth slots are regarded as Function Unit slots in Releases 3.0 and 3.1, but in the future may also be used for additional features.

Release 3.0 supports the following circuit packs:

- System Controller (LNW1)
- 28DS1 (LNW6)
- 28DS1PM (LNW7)
- 56DS1 (LNW8-- Release 3.1)
- DS3 TransMUX (LNW18)
- 12DS3/EC1 (LNW16)
- 48DS3/EC1 (LNW19-- Release 3.1)
- Quad OC-3 OLIU (LNW36)
- Dual OC-12 low-speed OLIU (LNW46)
- Dual OC-12 high-speed OLIU (LNW48-- Release 3.1)
- OC-48 OLIU (LNW26 and LNW26B)
- OC-48 OLIU (LNW27)
- OC-48 OLIU (LNW28)
- OC-48 OLIU (LNW29)
- OC-48 OLIU (LNW76)
- OC-48 OLIU (LNW77)
- OC-48 OLIU (LNW31)
- OC-48 DWDM OLIUs (32 wavelengths for both network and tributary interfaces)
- OC-192 OLIU (LNW56-- Release 2.1.1)
- OC-192 OLIU (LNW58-- Release 3.0)
- OC-192 DWDM OLIUs (Release 3.1-- 32 wavelengths for network interfaces)
- 10/100Mbps (100BASE-TX) (LNW66)
- 10/100Mbps (100BASE-TX) (LNW69-- Release 3.1)
- 10/100Mbps Private Line (100BASE-TX) (LNW71)
- 1G SX (1000BASE-SX) (LNW67)
- 1G LX (1000BASE-LX) (LNW68)
- 1G SX (1000BASE-SX/LX) (LNW70-- Release 3.1)

Important! Growth slots may be equipped with service and protection OC-3, OC-12, and OC-48 (LNW31) OLIUs, as well as service 1G SX and 1G LX circuit packs. DS1, DS3, EC-1, and 10/100T functionality is not supported in the Growth slots.

Capacity The DMX provides a VT1.5 and STS-1 cross-connect fabric for a variety of signals. The DMX's main switch fabric is contained in each of the high-speed (network-side interface) circuit packs, located in the MAIN slots of the DMX shelf. These MAIN slots have the capacity to house OC-12, OC-48, and OC-192 high-speed interfaces.

Listed below is the number of signals that DMX can transport if all Function Unit groups are equipped with a particular circuit pack (for example, 112 DS1s if all four Function Unit groups are equipped with the 28DS1 circuit pack):

- 112 DS1 (224 in Release 3.1)
- 48 DS3 (192 in Release 3.1)
- 48 EC-1 (192 in Release 3.1)
- 40 OC-3(c)
- 20 OC-12(c)
- 10 OC-48(c)
- 96 100BASE-TX
- 10 1000BASE-SX/LX

DMX also provides STS-1 virtual concatenation. This provides increased flexibility when managing Ethernet services. Each 100BASE-TX and 1000BASE-SX/LX Ethernet service can be provisioned to any number of STS-1s (up to 21 STS-1s).

Shelf size The standard DMX shelf has the following characteristics (dimensions including Fan Unit in parentheses):

- Width: 17.6 inches (17.6)
- Height: 16 inches (19.5)
- Depth (front to back): 13.75 inches
- Weight (Max.): 20 pounds.

The DMX High-Capacity shelf has an increased number of electrical connectors, provided to enable more electrical interfaces (DS1, DS3, EC-1). The High-Capacity shelf also has the following characteristics:

- Width: 17.6 inches
- Height: 19 inches (includes integral fan unit)
- Depth (front to back): 13.75 inches
- Weight (with circuit packs): 57 pounds
- Weight (without circuit packs): 38 pounds

Operations The DMX is representative of ten years of Lucent's innovation and experience in network operations, control, and maintenance. Utilizing Level 1 and Level 2 Target Identifier (TID) Address Resolution (TARP) protocol, a consistent and standard form of address resolution is in place, enabling the DMX network to be easily monitored and maintained.

DMX also supports standard interworking using the Open Systems Interconnection (OSI) seven-layer protocol stack over the DCC. The OSI seven-layer protocol stack refers to the OSI reference model, a logical framework for network operations standardized by the ISO. This provides for large networks up to 1000 NEs via level 1 area provisioning and level 2 routing.

The DMX is designed for easy installation and operation. Centralized operation is supported by a full set of single-ended operations (SEO), control, and maintenance features. Integrated test capabilities and default provisioning simplifies installation.

Basic maintenance tasks can be performed using faceplate LED displays and controls, while a craft interface terminal (CIT) or a remote OS gives access to sophisticated maintenance, provisioning, and reporting features.

Built-in maintenance capabilities support both installation and system operation. A DMX can be tested and installed without external test equipment.

Feature Release Plan

Overview This section outlines the major features of Releases 3.0 and 3.1 for the DMX. The feature release plan will be updated for each future release of the system.

Release 3.0 features Listed below are the major features for Release 3.0:

- **OC-192 high-speed optical interface (available in Release 2.1)**
The OC-192 OLIU is a intermediate reach 1550 nm optical line interface unit supporting OC-192 add/drop and UPSR and BLSR configurations, single- and dual-homing, non-revertive protection switching, and STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The OC-192 OLIU can cross-connect VTs in any 48 of 192 STS-1s in the OC-192 interface.
- **OC-192 HS unidirectional path switched ring (UPSR)**
- **OC-192 HS bidirectional line switched ring (BLSR)**
OC-192 High-speed BLSR at STS-1 level.
- **OC-48 to OC-192 HS BLSR and UPSR in-service upgrade (supported in Release 2.1)**
DMX supports in-service upgrades, from OC-48 to OC-192 UPSRs and from OC-48 to OC-192 BLSRs.
- **OC-48 LS bidirectional line switched ring (BLSR)**
OC-48 Low-speed BLSR with cross-connections at STS-1 level.
- **OC-48 HS linear optical extension**
A 1+1 protected linear extension from the circuit packs in the MAIN slots, offering fully-flexible VT1.5 granularity across any 48 STS-1s.
- **OC-48 LS DWDM optical interface (passive optics)**
DMX OC-48 Low-speed DWDM OLIUs are optical port units, available in 32 different wavelengths. By using the DWDM port units and the Passive Optic Shelves, you are able to increase fiber capacity by a factor of 8, 16, or 32. The OC-48 LS DWDM OLIUs may occupy both the Function and Growth slots.

- **24 port 100BASE-TX (10/100Mbps) Private Line Ethernet interface (LNW71)**

Enhanced 10/100 Mbps Ethernet interface designed to enable Fast Ethernet Private Line services. 96 10/100 Mbps drop capacity when four Function Unit groups are equipped with 10/100 Mbps circuit packs (24 ports per pack).
- **12-port DS1/DS3 TransMux circuit pack**

DMX supports a 12-port Trans/MUX card that can collect various DS1 signals from around a ring and combine them into a channelized DS3 signal.
- **Pipe Mode cross-connections**
- **1 Mbs Ethernet rate shaping**
- **BLSR auto ring discovery for BLSR interworking**
- **FTP/FTAM Gateway**

Also referred to as FTTD (File Transfer Translation Device), the FTTD allows DMX to function as a Gateway Network Element (GNE) that can facilitate the download of files located at FTP servers to remote NEs connected to the DMX.
- **Non-preemptible Unprotected Traffic (NUT)**

DMX allows the manual provisioning of NUT for multi-point Ethernet cross-connections through a BLSR. Though this traffic is unprotected, it's transmission priority will not be preempted by other service or protection traffic. NUT allows the DMX to host packet rings over BLSRs.
- **Network Time Protocol (NTP)**

NTP assures accurate time keeping with reference to radio and atomic clocks located on the Internet.
- **Utilization of Simple Network Management Protocol (SNMP)**

DMX allows SNMP to be used in provisioning/monitoring alarms and traps relative to the Ethernet circuit packs.
- **Optical Amplifiers**

External amplifiers, enabling transmission for OC-48/192 spans of up to 140 km.
- **Navis™ Optical INC and EMS support**

Navis™ Optical INC can be used to manage operations on DMX. Navis™ Optical EMS is still supported to manage operations.

Release 3.1 Features

Below is a list of features planned for in Release 3.1.

- **OC-192 HS DWDM optical interface (passive optics)**

DMX OC-192 High-speed DWDM OLIUs (LNW520-561) are passive optical port units, available in 32 different wavelengths. By using the DWDM port units and the Passive Optic Units (POUs), you are able to increase fiber capacity by a factor of 16 or 32. The OC-192 HS DWDM OLIUs may occupy Main slots 1 and 2.
- **OC-12 high-speed optical interface**

The OC-12 OLIU is a 1310 nm optical line interface unit supporting OC-12 add/drop and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), and STS-12(c) signal transport. The OC-12 OLIU can cross-connect VTs in any 12 of 12 STS-1s in the OC-12 interface.
- **24 port 100BASE-TX (10/100T) Ethernet interface-- for Ethernet enhancements (LNW69)**

LNW69 is an enhanced 10/100 Mbps Ethernet interface designed to enable such features as Committed and Peak Information Rate (CIR and PIR) billing options. 96 10/100 Mbps drop capacity when four Function Unit groups are equipped with 10/100 Mbps circuit packs (24 ports per pack).
- **4 port Gigabit Ethernet (GbE) interface-- for Ethernet enhancements (LNW70)**

LNW70 is an enhanced 10/100 Mbps Ethernet interface designed to enable such features as Committed and Peak Information Rate (CIR and PIR) billing options. 20 1000BASE-SX/LX drop capacity when all Function Unit groups (including Growth slots) are equipped with 1G SX and/or 1G LX circuit packs (4 ports per pack).
- **56 port DS1 interface (LNW8)**

224 DS1 drop capacity when four Function Unit groups are equipped with LNW8 circuit packs (56 ports per pack, 1x1 hardware protected).
- **48 port DS3/EC1 interface (LNW19)**

192 DS3/EC1 drop capacity when four Function Unit groups are equipped with LNW19 circuit packs (48 ports per pack, 1x1 hardware protected).

- **In-service upgrade from low-density to high-density electrical interface circuit packs.**
DMX allows an in-service upgrade from either the LNW16 to the LNW19 or the LNW6 and LNW7 to LNW8.
- **UPSR and BLSR bridge and roll cross-connections**
Help to enable DRI.
- **Dual Ring Interworking (DRI)**
ANSI/Bellcore compliant DRI (through drop and continue method) with interconnected rings (OC-48 or OC-192 UPSR interfaces)
- **Performance monitoring (PM) on VLANs**
DMX can provide PM on VLAN pass-through cross-connections.
- **Ethernet Enhancements**
DMX Ethernet interfaces are capable of providing CIR and PIR rate shaping, dynamic bandwidth allocation (LCAS), and jumbo frame support in R3.1 (jumbo frame support begins on 10/100 Mbps interface in R3.0).
- **Ring Circuit Audits**
- **Auto-generated Squelch Map**

Highlighted Features From Past Releases

Below is a list of important features included in past releases of the DMX.

- **High-capacity DMX Shelf**
New shelf design with additional DS1/DS3 interfaces on the back of the shelf, enabling a maximum of 224 DS1s and 192 DS3s.
- **OC-48 HS Unidirectional or Bidirectional line switched ring (UPSR and BLSR)**
OC-48 UPSR at VT1.5, STS-1, STS-3c, STS-12c, and STS48c level (DMX BLSRs do not support VT1.5 in the Releases covered in this document).
- **OC-48 High-speed optical interface**
- **OC-48 low-speed optical interface**
Capacity of 10 low-speed OC-48 ports when all Function Unit groups (including Growth slots) are equipped with OC-48 OLIU circuit packs (1 bidirectional port per pack). Capacity of 5 OC-48 rings when ports are protected.

- **OC-48 HS DWDM optical interface (passive optics)**

DMX OC-48 High-speed DWDM OLIUs are passive optical port units, available in 32 different wavelengths. By using the DWDM port units and the Passive Optic Units (POUs), you are able to increase fiber capacity by a factor of 16 or 32. The OC-48 HS DWDM OLIUs may occupy Main slots 1 and 2.
- **Quad OC-3 low-speed optical interface**

Forty OC-3 port capacity when all Function Unit groups (including Growth slots) are equipped with OC-3 OLIU circuit packs (4 ports per pack). Twenty OC-3 port capacity when signals are protected.
- **Dual OC-12 low-speed optical interface**

Twenty OC-12 capacity when all Function Unit groups (including Growth slots) are equipped with OC-12 OLIU circuit packs (2 ports per pack). 10 OC-12 capacity when signals are protected.
- **100BASE-TX (10/100T) Ethernet interface**

Ninety-six 100BASE-TX drop capacity when four Function Unit groups are equipped with 10/100T circuit packs (24 ports per pack).
- **1000BASE-SX/LX (1G SX/LX) optical Ethernet interfaces**

Ten 1000BASE-SX/LX drop capacity when all Function Unit groups (including Growth slots) are equipped with 1G SX and/or 1G LX circuit packs (2 ports per pack).
- **Port-provisionable 12DS3/EC1 circuit pack**

In early releases the 12DS3/EC1 circuit pack was switch selectable for DS3 or EC-1 service on a per-pack basis. In release 2.0 DS3 or EC-1 service can be provisioned on a per-port basis.
- **EC-1 electrical interface**

Forty-eight EC-1 capacity when four Function Unit groups are equipped with 12DS3/EC1 circuit packs (12 ports per pack).
- **DS1s 1x1 protected**

112 DS1 drop capacity when four Function Unit groups are equipped with 28DS1 circuit packs (28 ports per pack).
- **DS3s 1x1 protected**

Forty Eight DS3 drop capacity when four Function Unit groups are equipped with 12DS3/EC1 circuit packs (12 ports per pack).

- **Low-speed OC-48 UPSR**
- **1+1 protected linear optical extensions (OC-3, OC-12)**
- **Single- and dual-homed 0x1 ring tributaries: OC-3, OC-12, OC-48**
- **Transmission Control Protocol/Internet Protocol (TCP/IP)**
Provides access to SNMS or PC-CIT over TCP/IP LAN to a DMX and subtending DMX, DDM-2000, and other NEs that support DMX operations interworking.
- **VT1.5 granularity**
Fully-flexible VT1.5 granularity across 48 STS-1s.
- **VT and Ethernet Hairpinning**
- **VLAN Transparency**
- **Support of 4096 Virtual Local Area Networks (VLANs) and stacked VLANs**
- **GbE Private Line**
Allows the DMX to provide dedicated bandwidth for individual customers.
- **DMX PC-CIT**
The PC-CIT manages the DMX system through the LAN/Serial ports, providing TL1 messaging, software download, and full operations, maintenance, and provisioning functions through a Graphic User Interface (GUI).
- **Product family 2000 and WaveStar product family Operations interworking (OI)**
OI compatibility with Product Family 2000 (DDM-2000 and FT-2000), and WaveStar Product Family.
- **WaveStar BandWidth Manager interworking over OC-48 BLSRs**
- **Multivendor Operations interworking (OI)**
DMX supports interoperability with many other vendors. Ask your account representative for more information.





2 Features

| Overview

Purpose This chapter briefly highlights the features of the DMX Access Multiplexer. These features are more thoroughly described in Chapter 3, “Network Topologies,” Chapter 4, “Product Description,” Chapter 5, “System Planning and Engineering”, and Chapter 6, “Operations, Administration, Maintenance, and Provisioning,” as applicable.

Contents The following topics are included in this chapter:

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Hardware Features

Overview This section briefly describes the major hardware related features supported through Release 3.1 of the Metropolis[®] DMX Access Multiplexer. All features associated with Release 3.0 and 3.1 display release number next to the feature title. If no release number is specified, the feature was part of a previous release of the DMX.

Below is a list of the sections included in Hardware Features:

- DMX High Capacity Shelf
- Network interface circuit packs (those housed in the MAIN slots of the DMX shelf)
- Optical, tributary interface circuit packs
- Electrical, tributary interface circuit packs
- Ethernet circuit packs
- Other hardware features

Important! For more detailed information on the capabilities of these circuit packs, refer to the sections entitled “Circuit Packs” in Chapter 4. For technical specifications refer to Chapter 10.

DMX High Capacity Shelf In Release 2.1 a new version of the DMX shelf became available. Though the high capacity shelf became available with Release 2.1, it is not software dependant. This new design incorporates additional DS1/DS3 interfaces that enable the DMX to support 224 DS1s or 192 DS3s. In order to support this amount of traffic, the DMX high capacity shelf must be equipped with new, higher density DS1 and DS3 circuit packs that will become available in Release 3.1.

Network Interface Circuit Packs

This section briefly details the network interface circuit packs available through Release 3.1 of the DMX. “Network Interface” is used to refer to the high-speed circuit packs, housed in the MAIN slots of the DMX shelf, and used to provide the connection to the core-side of the network.

OC-192 Network Interface Circuit Packs

The DMX supports the following OC-192 network interface cards:

- LNW56-- R2.1 (1550nm, intermediate-reach, full VT mapping)
- LNW58-- R3.0 (1310nm, short-reach, full VT mapping)
- LNW521-559B-- R3.1 (passive, 1550nm, intermediate-reach, full VT mapping)

OC-48 Network Interface Circuit Packs

The DMX supports the following OC-48 network interface cards:

- LNW26 (1310nm, long-reach, VT mapping across 6 STS-1s)
- LNW26B (1310nm, long-reach, VT mapping across 12 STS-1s)
- LNW27 (1310nm, long-reach, VT mapping across 48 STS-1s)
- LNW28 (1310nm, long-reach, VT mapping across 12 STS-1s, OSP hardened)
- LNW29 (1550nm, long-reach, VT mapping across 48 STS-1s)
- LNW76 (1310nm, short-reach, VT mapping across 48 STS-1s)
- LNW77 (1310nm, intermediate-reach, VT mapping across 12 STS-1s)
- LNW121B-159B (passive, 1550nm, long-reach, VT mapping across 12 STS-1s)
- LNW221-259 (passive, 1550nm, long-reach, VT mapping across 48 STS-1s)

Optical, Tributary Interface Circuit Packs

DMX supports the following optical, tributary interface circuit packs:

- OC-3-- LNW36 (1310nm, long-reach, 4 ports)
- OC-12-- LNW46 (1310nm, long-reach, 2 ports)
- OC-48-- LNW31 (1310nm, intermediate-reach, 1 port, VT mapping across 12 STS-1s)
- OC-48 (R3.0)-- LNW421-459 (passive, 1310nm, long-reach, 1 port, VT mapping across 12 STS-1s)

**Electrical, Tributary
Interface Circuit Packs**

DMX supports the following electrical, tributary interface circuit packs:

- 28DS1-- LNW6 (28 ports)
- 28DS1PM-- LNW7 (28 ports, enables PM functionality on DS1 interfaces)
- 56DS1PM (R3.1)-- LNW8 (56 ports, enables PM functionality on DS1 interfaces)
- 12DS3/EC1-- LNW16 (12 ports, DS3 or EC-1 service is provisionable on a per-port basis)
- 48DS3/EC1(R3.1)-- LNW19 (48 ports, DS3 or EC-1 service is provisionable on a per-port basis)
- DS1/DS3 Trans/MUX (R3.0)-- LNW18 (12-port, capable of collecting various DS1 signals from around a ring and combining them into channelized DS3 signals)

**Ethernet Interface Circuit
Packs**

DMX supports the following Ethernet interface circuit packs:

- Fast Ethernet-- LNW66 (24 ports, 10/100 Mbps)
- Fast Ethernet (R3.0)-- LNW71 (24 ports, 10/100 Mbps, enhancements to enable Ethernet private line services)
- Fast Ethernet (R3.1)-- LNW69 (24 ports, 10/100 Mbps, further enhancements to enable Ethernet CIR and PIR)
- Gigabit Ethernet (GbE)-- LNW67 (2 ports-- 1 gigabit each, short reach)
- GbE-- LNW68 (2 ports-- 1 gigabit each, long reach)
- GbE (R3.1)-- LNW70 (4 ports-- 1 gigabit each, short/long reach, enhancements to enable Ethernet CIR and PIR)

Other Hardware Features

DMX also supports the following hardware:

External Optical Amplifiers (R3.0)

For OC-48/192 spans of up to 140km, Lucent Technologies offers external optical amplifiers. The external optical amplifier is a stand-alone shelf and can be used with both OC-48 and OC-192 optics. In-line amplifiers can be installed at intermediate locations to achieve distances of up to 500 km.

External optical amplifiers consist of one booster and one pre-amplifier part. The booster part is connected via a Dispersion Compensation Module (DCM) to the transmit interface of the respective OC-192 or OC-48 port unit. For ordering information on this pack, see Chapter 7, "Ordering." The pre-amplifier part is connected by means of a DCM to the receive interface of the associated port unit.

Passive Optics Units (POUs)

The Lucent Passive Optics Units (POUs) is a lower-cost solution to using DWDM for transmitting large amounts of traffic on one fiber. This module fits into a bay frame, but reduces the number of DMX shelves in a bay to three. The box does not require any electrical powering.

POUs are available to support the following applications:

- 1, 2, or 4 wavelengths: Optical add-drop and point-to-point only
- 16 unidirectional/bidirectional wavelengths (2 versions):
MUX/DMUX
- 32 wavelengths; 16 unidirectional/bidirectional wavelengths with a wavelength interleaver used to add another 16 wavelengths:
MUX/DMUX

□

In-service Upgrades

Overview

This section briefly describes the in-services upgrades supported through Release 3.1 of the Metropolis[®] DMX Access Multiplexer. All features associated with Release 3.0 and 3.1 display release number next to the feature title. If no release number is specified, the feature was part of a previous release of the DMX.

OC-48 UPSR to OC-192 UPSR in-service upgrade (R2.1)

DMX supports an in-service upgrade, enabling you to increase UPSR network capacity from OC-48 to OC-192 without affecting service.

OC-48 BLSR to OC-192 BLSR in-service upgrade (R2.1)

DMX supports an in-service upgrade, enabling you to increase BLSR network capacity from OC-48 to OC-192 without affecting service.

In-service electrical upgrade from low to high-density DS1/DS3 circuit packs (R3.1)

DMX supports an in-service electrical upgrade, enabling you to increase DS1/DS3 capacity without affecting service. Total DS1 capacity can be increased from 112 to 224 DS1 interfaces per shelf. Total DS3/EC1 capacity can be increased from 48 to 192. Electrical in-service upgrades can be performed on shelves hosting a mix of DS1 and DS3/EC1 circuit packs without affecting service. The DMX High-Capacity shelf is required when using high-density DS1/DS3 circuit packs.



Topologies

Overview

This section briefly describes the major topologies supported through Release 3.1 of the Metropolis® DMX Access Multiplexer. All features associated with Release 3.0 and 3.1 display release number next to the feature title. If no release number is specified, the feature was part of a previous release of the DMX.

High-speed (Network interface) OC-192 UPSR for STS-1/VT1.5 (R2.1)

DMX supports UPSR at the STS-1 and VT1.5 level. When both Main slots are equipped with OC-192 circuit pack (LNW56 & LNW58 in R2.1 or LNW521-559 in Release 3.1) circuit packs, an STS-1 switching fabric (STS-1, STS-3c, STS-12c, and STS-48c) supports the low-speed interfaces. Each circuit pack establishes both an east-to-west and a west-to-east rotation on the ring. A UPSR ring provides a very valuable and reliable foundation for services protecting against fiber cuts and node failures.

High-speed (Network interface) OC-192 BLSR for STS-1 (R3.0)

The DMX system supports an OC-192 Bidirectional Line Switched Ring (BLSR). When both Main slots are equipped with OC-192 OLIU (LNW56) circuit packs, an STS-1 switch fabric supports the low-speed interfaces (STS-1, STS-3c, STS-12c, and STS-48c). A 2-fiber bidirectional line-switched ring (BLSR) is a self-healing ring configuration in which traffic is bidirectional between each pair of adjacent nodes and is protected by redundant bandwidth on the bidirectional lines that interconnect the nodes in the ring. Because traffic flow is bidirectional between nodes, traffic can be added at one node and dropped at the next without traveling around the entire ring. This leaves the spans between other nodes available for additional traffic. Therefore, with distributed traffic patterns, a BLSR can carry more traffic than the same facilities could carry if configured for a unidirectional path-switched ring. In BLSR configurations, the VT switch fabric located in the MAIN packs is used only for Function Unit or Growth Slot hairpins.

High-speed (Network interface) OC-48 UPSR

DMX supports UPSR on the STS-3c, STS-12c, and STS-48c levels, in addition to STS-1 and VT1.5. When both Main slots are equipped with OC-48 OLIU (LNW26, LNW26B, LNW27, LNW28, LNW29, LNW76, LNW77, and LNW121B-159B or 221-259) circuit packs, an STS-1 switching fabric (STS-1, STS-3c, STS-12c, and STS-48c) supports the low-speed interfaces. Each circuit pack establishes both an east-to-west and a west-to-east rotation on the ring. A UPSR ring provides a very valuable and reliable foundation for services protecting against fiber cuts and node failures.

OC-48 BLSR The DMX system supports an OC-48 Bidirectional Line Switched Ring (BLSR). When both Main slots are equipped with OC-48 OLIUs, an STS-1 switch fabric supports the low-speed interfaces (STS-1, STS-3c, STS-12c, and STS-48c). A 2-fiber bidirectional line-switched ring (BLSR) is a self-healing ring configuration in which traffic is bidirectional between each pair of adjacent nodes and is protected by redundant bandwidth on the bidirectional lines that interconnect the nodes in the ring. Because traffic flow is bidirectional between nodes, traffic can be added at one node and dropped at the next without traveling around the entire ring. This leaves the spans between other nodes available for additional traffic. Therefore, with distributed traffic patterns, a BLSR can carry more traffic than the same facilities could carry if configured for a unidirectional path-switched ring. In BLSR configurations, the VT switch fabric located in the MAIN packs is used only for Function Unit or Growth Slot hairpins.

OC-48 Low-speed BLSR (R3.0) In addition to the capability of hosting high-speed BLSRs on OC-48 packs in the MAIN slots, the DMX can host a single low-speed BLSR on the OC-48 packs in the Function and Growth Slots in Release 3.0. A total of 1 low-speed BLSRs can be supported if a function group (or Growth Slots) in the DMX is populated with low-speed OC-48 OLIU (LNW31).

High-speed (Network interface) Linear optical extensions (R3.0) DMX supports 1+1 protected linear optical extensions for data transport originating at a data device. The high-speed linear optical extension may connect the DMX shelf, by way of OC-48 network interfaces in the MAIN slots, to an OC-48 node. This feature performs true linear switching based on line layer defects.

Low-speed UPSRs (for STS-1 termination and VT Ring Closure) The DMX can host multiple rings on the low-speed interfaces of the DMX shelf. This is accomplished by intra-function group, pass-through cross-connections. The DMX can close a low-speed ring by supporting a cross-connection between a receive port on one circuit pack and a transmit port on another circuit pack in the same function or growth group. All protection switching advantages/capabilities of low-speed UPSR configurations still apply in VT Ring Closure applications. The DMX can support the following number of low-speed BLSRs per line rate when all function units (including Growth Slots are populated with that respective OLIU): OC-3= 20, OC-12= 10, OC-48= 5.

Low-speed (Tributary interface) Linear optical extensions

DMX supports 1+1 protected linear optical extensions for data transport originating at a data device. The low-speed linear optical extension may connect the DMX shelf, by way of OC-3/12/48 tributary interfaces in the Function and/or Growth slots, to an OC-3, OC-12, as well as an OC-48 node. This feature performs path switching on all paths within a line if that particular line fails.

Single- and dual-homed ring extensions

The DMX supports low-speed OC-3/12/48 0x1 protected broadband tributaries, including single- and dual- homed ring extensions. A DDM-2000 OC-3, OC-12, FiberReach, or DMXpress Multiplexer may be the add/drop multiplexer on the lower-speed ring.

Hairpinning

See the section entitled, Hairpinning cross- connections (2-16) in this chapter.

Dual Ring Interworking

DMX supports UPSR DRI only in Release 3.1. DMX dual node ring interworking (DRI) cross-connection complies with Telcordia GR-1400 (which refers to GR-253-CORE) standards. A service selector exists for each STS-N tributary provisioned for DRI. The service selector selects the better of two received path-level signals in accordance with a given hierarchy of conditions. These conditions include STS Path Signal Fail and PDI-P (Payload Defect Indicator - Path Level). This release supports DRI with the Drop and Continue method to a UPSR.

GbE Packet Rings (R1.1)

DMX supports Gigabit Ethernet (GbE) packet rings that enable cost-effective internet access and business-to-business LAN services. GbE packet rings allow interworking among 10/100 Mbps and 1000 Mbps (GbE) Ethernet lines while VLAN tagging ensures individual customer privacy. These GbE capabilities allow the DMX to support various Quality of Service (QoS) features, including fast packet-layer restoration.

4093 VLANs

DMX allows the provisioning of up to 4093 separate IEEE 802.1q VLANs. VLANs are a way in which LAN users at the enterprise level, located on physically separated LAN networks, are assigned priority access privileges across a WAN backbone. Although they are in different locations, they appear to be on the same physical segment of an enterprise-level LAN. Thus, VLANs are logical groupings of various users, regardless of their physical location on the network.

Stacked VLANs (VLAN Transparency)

DMX allows customer traffic to be identified and segregated using “stacked” IEEE 802.1q VLAN tags. VLAN tags enable the formation of Virtual Private Networks (VPNs) by segregating various units of traffic and isolating different end-customers. This allows data from different customers to efficiently share common bandwidth while simultaneously ensuring a basic level of security for each customer (hence VPN).

The notion of VLAN “transparency” comes from the fact that individual customer packets are tagged using a second tag, called a customer ID (CID is provided by customer equipment). There is no need to coordinate VLAN tags between the customer and service provider. Therefore, customer packets are transmitted through a service provider’s network “transparently”.

GbE Private Line

DMX GbE private lines (1000 Mbps) enable premium data transport services offering GbE transport with optional bandwidth provisioning up to full line-rate. GbE private lines provide the user the ability to transport frames completely transparently between two DMX NEs. No VLAN knowledge or packet-layer provisioning is required by the user in this application. Simple, SONET cross-connect provisioning is all that is required when using “private line” or “no tag” mode. These GbE capabilities allow the DMX to provide dedicated bandwidth for individual customers and fast SONET-layer restoration.

**Fast Ethernet Private Line
(R3.0)**

DMX Fast Ethernet (10/100 Mbps) private lines enable premium data transport services offering 10/100 Mbps transport with optional bandwidth provisioning up to 100Mbps (variable bandwidth provisioning of 1, 2, or 3 STS1s). Fast Ethernet private lines provide the user the ability to transport frames completely transparently between two DMX NEs. No VLAN knowledge or packet-layer provisioning is required by the user in this application. Simple, SONET cross-connect provisioning is all that is required. These Fast Ethernet capabilities allow the DMX to provide dedicated bandwidth for individual customers and fast SONET-layer restoration. LNW71 must be used to enable Fast Ethernet private lines.

**Passive Dense Wave
Division Multiplexing
(PWDM)**

DMX supports PWDM on OC-48 high-speed and low-speed (low-speed PWDM available in release 3.0) and OC-192 high-speed interfaces (R3.1). PWDM enables you to combine multiple OC-48/192 wavelengths on the same fiber. With PWDM, fiber capacity can be increased by a factor as great as 32.

**Non-preemptable
Unprotected Traffic (R3.0)**

DMX allows the manual provisioning of non-preemptable unprotected traffic (NUT) for multi-point and 0x1 Ethernet cross-connections that originate on low-speed (tributary) interfaces and share bandwidth on the high-speed (Network side) BLSR ring.

NUT provisioning is used when hosting packet rings on BLSRs. NUT ensures that data transmission over SONET BLSR topologies runs smoothly. When using multi-point cross-connections through a BLSR, packets do not receive standard BLSR protection due to the necessary functioning of NUT. Yet, protection on all data packets is provided for with rapid spanning tree protocol (IEEE 802.1w). Thus, NUT enables protected packet rings without utilizing SONET layer protection.

□

Networking Capabilities

Overview This section briefly describes the major networking capabilities supported through Release 3.1 of the Metropolis® DMX Access Multiplexer. All features associated with Release 3.0 and 3.1 display release number next to the feature title. If no release number is specified, the feature was part of a previous release of the DMX.

1 Mbps Rate Limiting (R3.0) DMX supports rate shaping at the level of 1 Mbps for Ethernet interfaces. This means that DMX can automatically establish Ethernet transmission channels to fit the need of the user upon connection. For each connection, the DMX will create a virtual channel of the appropriate size (in 1 Mbps intervals) to facilitate the desired Service Level Agreement (SLA). Rate limiting at the 1Mbps level provides a transmission ceiling for highly efficient allocation of shared bandwidth for data communications.

VT1.5 granularity VT1.5 granularity is provided across any 6 STS-1 signals within the OC-48 OLIU (LNW26 and LNW121-159) providing a fully-flexible assignment of VT1.5 timeslots across any 6 STS-1s. Release 2.0 provides VT1.5 granularity across any 12 STS-1 signals within the OC-48 OLIU (LNW26B, LNW77, LNW28, and LNW121B-159B) providing a fully-flexible assignment of VT1.5 timeslots across any 12 STS-1s. Release 2.1 provides VT1.5 granularity across 48 STS-1 signals within the OC-48 OLIUs (LNW27, LNW29, LNW76, and LNW221-259). Release 2.1 also provides VT1.5 granularity across 48 STS-1 signals within the OC-192 OLIUs (LNW58, LNW56, and LNW521-559-- Release 3.1).

Automatic Ring Discovery for BLSR Interworking (R3.0) DMX supports automatic ring discovery to better facilitate BLSR interworking with Lucent's FT-2000, WaveStar BandWidth Manager, Lambda Unite, and WaveStar 2.5G/10G.

Non-preemptable Unprotected Traffic (R3.0) DMX allows the manual provisioning of non-preemptable unprotected traffic (NUT) for multi-point ethernet and 0x1 cross-connections on service tributaries. Though this traffic is unprotected, its transmission priority will not be preempted by other service or protection traffic.

DMX/Lambda UNITE bay configuration

The compact size of the DMX allows you to place two DMX shelves and one Lambda UNITE in the same bay. As the needs of an access site grow to the point where equipment is required to hub more than 6 OC-48 rings, it becomes advantageous to upgrade a DMX shelf to a Lambda UNITE. The Short Reach (SR) OC-48 and OC-192 optics supported by the DMX are designed for such an application. Once the Lambda UNITE is installed as the hub-node, the Unite node can hub 64 OC-48 rings or 16 OC-192 rings while simultaneously using the original DMX as a drop node or mini-DCS.

Committed Information Rate (CIR) and Peak Information Rate (PIR) service/billing capabilities (R3.1)

DMX supports Ethernet CIR and PIR service/billing capabilities in R3.1. The Ethernet circuit packs introduced in R3.1 (LNW70 & LNW69) support enhanced Ethernet features such as CIR, PIR, and dynamic bandwidth allocation (LCAS).

CIR refers to the committed information transfer rate guaranteed by the service provider under normal conditions. The Ethernet circuit packs offered in R3.1, therefore, enable the provisioning of particular information rates (translates to bandwidth guarantees) for individual customers.

PIR refers to the peak information transfer rate guaranteed by the service provider during certain time periods that are specified by the customer. The Ethernet circuit packs offered in R3.1, therefore, enable the provisioning of a peak information rate (translates to bandwidth) that an individual customer is guaranteed during a specified time period (for instance, between 8am and 1pm on business days).

Link Capacity Adjustment Scheme (LCAS)

DMX supports dynamic bandwidth allocation (also known as Link Capacity Adjustment Scheme-- LCAS) capabilities in R3.1. The Ethernet circuit packs introduced in R3.1 (LNW70 & LNW69) support enhanced Ethernet features such as CIR, PIR, and dynamic bandwidth allocation (LCAS).

This feature enables the DMX to provide each interface with only as much bandwidth as it might need at a particular time by allowing the aggregation of one or more links to form a link aggregation group, such that a MAC Client can treat the group as though it were a single link. This works because the DMX assigns channels on its high-speed (network side) interface only to circuits that are transmitting at that time.

LCAS increases bandwidth, distributes MAC traffic across multiple links, and can adjust to a new configuration if changes in the physical connectivity occur.

**Jumbo Frame Support
(R3.0)**

DMX supports jumbo-sized Ethernet frames with a maximum capacity of 9,000 bytes. Jumbo frame support can increase the total throughput of an Ethernet switch by reducing the number of frames that must be processed when switching a high volume of data.

In R3.0 jumbo frames are supported with the Fast Ethernet (10/100 Mbps) Private Line circuit pack (LNW71). In R3.1 the Fast Ethernet (LNW69) and GbE/4 (LNW70) will also support jumbo frames.

Multicast Ethernet Packets

DMX supports multicast Ethernet packets in all releases. A multicast packet is identified by the first bit in the MAC destination address. Such a MAC address will never appear as a source address, and so multicast destination addresses (TIDs) are not learned. Since unknown source addresses are treated as broadcast, multicast packets/frames are sent to ALL ports in the VLAN (IEEE 802.1Q) or Transparent LAN (customer/port tag) for that packet.

**Fast Spanning Tree/
IEEE802.1w Rapid
Reconfiguration**

Ethernet requires a network with a tree structure in order to work effectively. Ethernet bridges and switches build tables that define the paths to specific devices. A MAC bridge, for example, will have a filtering database that defines where to send any packets addressed to a specific MAC within the network. The tables are built based on input from devices within the network. DMX supports an improved/faster spanning tree algorithm, documented in IEEE 802.1w Rapid Reconfiguration.

If there is a loop in the network, that is, if there is more than one way to get to a destination device, two problems can result:

Frames may be duplicated in the network.

- That is, the same frame may be sent to a node via two different paths.

The address information will be changed as packets from that device are received across different paths. In a meshed network, the reconfiguration of the filtering database can begin to use up all the network resources, so that little bandwidth is left for data traffic.

The spanning tree accomplishes two important functions:

- It removes loops from the bridged network
- It allows Ethernet layer reconfiguration if a link fails.

Important! DMX has been designed with multi-vendor interoperability in mind. As many vendor's equipment (including legacy equipment) may not be able to use IEEE802.1w, DMX can automatically fall back on IEEE802.1d in the event that other NEs in the network are running standard spanning tree protocol. However DMX employs IEEE 802.1w as a default spanning tree protocol.



Cross-connection Types

All allowable cross-connections

This section details the new types of cross-connections supported by the DMX. Thus, this represents only a fraction of the total allowable cross-connections. For an in depth look at cross-connections supported by the DMX, refer to the section entitled “Cross-connections” in Chapter 5 of this document.

Hairpinning cross-connections

In a “hairpinning” topology, low-speed tributary traffic is routed into the system and back out of the system without ever being placed on the high-speed (OC-48 or OC-192) UPSR interfaces. The cross-connection capability of connecting any input on a circuit pack in a function or growth slot to any output on a circuit pack in a different function or growth slot in the same shelf, allows you to use a combination of add/drop and hairpinning of compatible payloads through a variety of interfaces. You can bring traffic in from one remote site and cross-connect it at the VT1.5, STS-1, STS-3c, STS-12c, STS-48c, or Ethernet (both 100 BASE-TX and 1000 BASE-SX/LX) level back out to other remote sites without consuming any capacity on the high-speed UPSRs.

Bridge and Roll cross-connections (R3.1)

Bridge and roll cross-connections are coordinated activity between two NEs designed to move traffic from one facility to another without affecting service.

By combining the bridge and roll functionalities detailed in the “Cross-connections” section of Chapter 5, the user can change the source of the input tributary of a cross-connection without affecting service.

Bridged Cross-connections

Bridging of an existing cross-connection consists of adding a one-way cross-connection with the same input tributary as that of an existing cross-connection, resulting in a 1x2 multicast from an input tributary to two output tributaries. DMX supports bridging for each of the supported SONET cross-connection rates. You can bridge any existing cross-connection to a second output port without impairing the existing signal. Conversely, either half of a bridged signal can be taken down without impairing the remaining cross-connected signal.

Rolling cross-connections

The DMX provides the capability to change the location or source of the input tributary of a given cross-connection, without affecting service (maximum interrupt in service of 2.5 milliseconds). The DMX supports facility rolling for all supported signal rates as follows:

- Disconnection of the circuit cross-connecting input tributary to output tributary
- Cross-connection of either a new input tributary to the corresponding input tributary

Pipe-mode (adaptive-rate) cross-connections (R3.0)

Path level fault, PM and protection switching automatically adjust to changes in the constituent signal structure of an existing cross-connection. For example, a given STS-3(c) cross-connection may be carrying 3 STS-1s or a single STS-3(c). Fault, PM and protection switching would automatically adjust to changes between the two possible constituent signal structures.



Operations Features

Overview This section briefly describes the major Operations related features supported through Release 3.1 of the Metropolis[®] DMX Access Multiplexer. All features associated with Release 3.0 and 3.1 display release number next to the feature title. If no release number is specified, the feature was part of a previous release of the DMX.

DMX PC-CIT with GUI The PC-CIT manages the DMX system through the TL1/CIT port, providing TL1 messaging, software download, and full operations and provisioning capability via a Graphic User Interface (GUI) or TL1 command builder. The PC-CIT can run a full-featured GUI or TL1 scripts. Using the GUI, a crafts person can access all DMX software functions and context-sensitive help. The TL1 command builder, also known as the TL1 Translation Device (T-TD), is a flexible TL1 command instructor that supports full TL1 management through TCP/IP or RS-232 interfaces.

The PC-CIT is not used to download release software to the system (the PC is used, but not the CIT software). Release software can be copied to other NEs remotely, provided the initial download of DMX release software has occurred on each system.

Performance monitoring Performance monitoring (PM) data will be reported on the VT1.5, STS-1, STS-3c, STS-12c, DS1, DS3, OC-48 and OC-192 levels.

Support of Simple Network Management Protocol (R3.0) DMX makes use of Simple Network Management Protocol (SNMP). SNMP is the most common protocol used by data network management applications to query a management agent using a supported Management Information Base (MIB). SNMP operates at the OSI Application layer. The IP-based SNMP is the basis of most network management software, to the extent that today the phrase “managed device” implies SNMP compliance. The DMX provides limited SNMP support of certain reports and traps. For more information, see the section entitled “SNMP Parameters and Traps” in Chapter 6 of this document.

TL1 management TL1 messaging is supported via the Serial, IAO LAN, and X.25 interfaces. The DMX PC-CIT, when used in conjunction with the TL1 command builder, provides full TL1 management through TCP/IP to OSI interfaces.

**TL1 management via
TCP/IP**

TL1 message exchange is supported over TCP/IP via IAO LAN, OSI LAN, and PC-CIT interfaces. IAO LAN supports TCP/IP protocol and OSI protocol. These provide a communication link from a DMX to a local node that may serve as a gateway to the network.

**Integrated TCP/IP
Management Interface**

The DMX supports two types of IP Access. In one case, the DMX can serve as a TL1 Translation Device (T-TD) by being a gateway network element that allows a Navis EMS and/or PC-CIT to communicate to other network elements (NEs) on an OSI network through an IP access network. In the second instance, the DMX can functionally encapsulate IP packets within OSI packets to be transmitted through the OSI network to the proper NE. This capability is called IP tunneling.

TL1 Translation

The DMX can copy the application information within an IP packet into an OSI packet. Thus, all IP protocol information is lost. This translation is performed at the application layer. Separate gateways can be provided by a single DMX.

IP Tunneling

IP tunneling allows for file transfer through an IP access network. IP tunneling is used to perform end-to-end FTP through the OSI portion of the IP access network. In this instance the DMX serves as a gateway network element (GNE) that encapsulates an IP packet within an OSI packet. When the final destination of the file is reached, the IP packet is removed from within the OSI packet and processed by the TCP/IP stack. Thus, IP tunneling allows a Navis EMS and/or CIT to reach NEs in an OSI based DCN network with FTP over IP. In this case, the end points of the IP tunnel are the actual terminating points for the IP traffic.

**FTP/FTAM Gateway for
remote software download
(R3.0)**

Also referred to as FTTD (File Transfer Translation Device), the FTTD allows DMX to function as a Gateway Network Element (GNE) that can facilitate the download of files located at FTP servers to remote NEs connected to the DMX.

**Software download over
DCC**

This feature enables software (upgrade) to be downloaded to remote NEs from a central office site via the data communications channel (DCC).

OSI seven-layer protocol stack	This feature provides interworking using the Open Systems Interconnection (OSI) seven-layer protocol stack over the data communications channel (DCC). The OSI seven-layer protocol stack refers to the OSI reference model, a logical structure for network operations standardized by the International Standards Organization (ISO).
Remote NE Status	This feature partitions a subnetwork into maintenance domains (alarm groups). An Alarm Group is a set of NEs that share status information. Alarm groups can be nodes in a ring or any other logical grouping such as a maintenance or geographical group. Each Level 1 area can be identified as a separate Alarm Group, as long as it does not exceed 50 nodes. You must provision one NE in an Alarm Group as an alarm gateway NE (AGNE) to support office alarms and a summary alarm information of remote NEs in the local alarm report. More than one AGNE can be provisioned per alarm group, but this is not recommended.
Security	Security features include 1-999 day password aging, customized login proprietary messages, and 150 users.
TARP	DMX is compatible with any other-vendor NEs that support Target ID Address Resolution Protocol (TARP), OSI, IAO LAN, and TL1/X.25 as specified in Telcordia Technologies GR-253.
SONET	Many of the traditional SONET maintenance, provisioning, operations, control, and synchronization features are included in the DMX. The flexible SONET standard provides a formidable foundation for the DMX to build upon.
TIRKS/NMA/Transport compatibility	DMX is supported by Telcordia OSs <i>TIRKS</i> , <i>NMA</i> , and <i>Transport</i> .
Multivendor Operations Interworking	DMX supports interoperability with many vendors' equipment.

**Product Family
2000/WaveStar Product
Family Interworking**

DMX supports TARP interoperability with Product Family 2000 nodes such as the FT-2000 OC-48 Lightwave System, the DDM-2000 OC-3/OC-12 Multiplexer, and the DDM-2000 FiberReach Multiplexer.

DMX also provides interoperability with all *WaveStar* Product Family nodes supporting TARP over both UPSR (Release 1.1) and BLSR (Release 2.1) applications.

DMX provides interoperability with *WaveStar* BandWidth Manager nodes supporting TARP over both OC-48 and OC-192 (R3.0) BLSRs.

**Navis™ Operations
Support**

DMX supports operations via Lucent's Navis™ Optical EMS and Navis™ Optical INC.



Synchronization

Embedded Stratum 3 timing generator

The OC-12/48/192 high-speed circuit packs contain an embedded Stratum 3 timing generator. This timing generator is used when the DMX is configured in a free running mode.

Line timing and external timing are also supported by DMX. Line timing is derived from an incoming MAIN OC-12/48/192 line, while external timing is derived from an external timing source.

DS1 timing output

The embedded Stratum 3 timing generator can generate a DS1 timing output to time other externally-timed systems.

S1 byte synchronization messaging

DMX uses the S1 byte of the SONET overhead to pass timing status information to different nodes in an access transport network.

Network Time Protocol (R3.0)

Network Time Protocol (NTP) assures accurate synchronization of the DMX with reference to radio and/or atomic clocks located on the Internet.





3 Applications and Configurations

Overview

Purpose The DMX Access Multiplexer supports a wide range of service applications and a variety of network configurations economically and efficiently.

Because DMX is very flexible, most of the applications described in this section can be served over many of the available network topologies. The product configuration deployed depends on many factors such as fiber layout location, mix of services offered, and interconnections to other networks.

The first section of this chapter describes service applications. The second section explains the network topologies supported.

Contents The following sections are included in this chapter:

Service Applications	3 - 3
Network Configurations	3 - 25



Service Applications

Overview

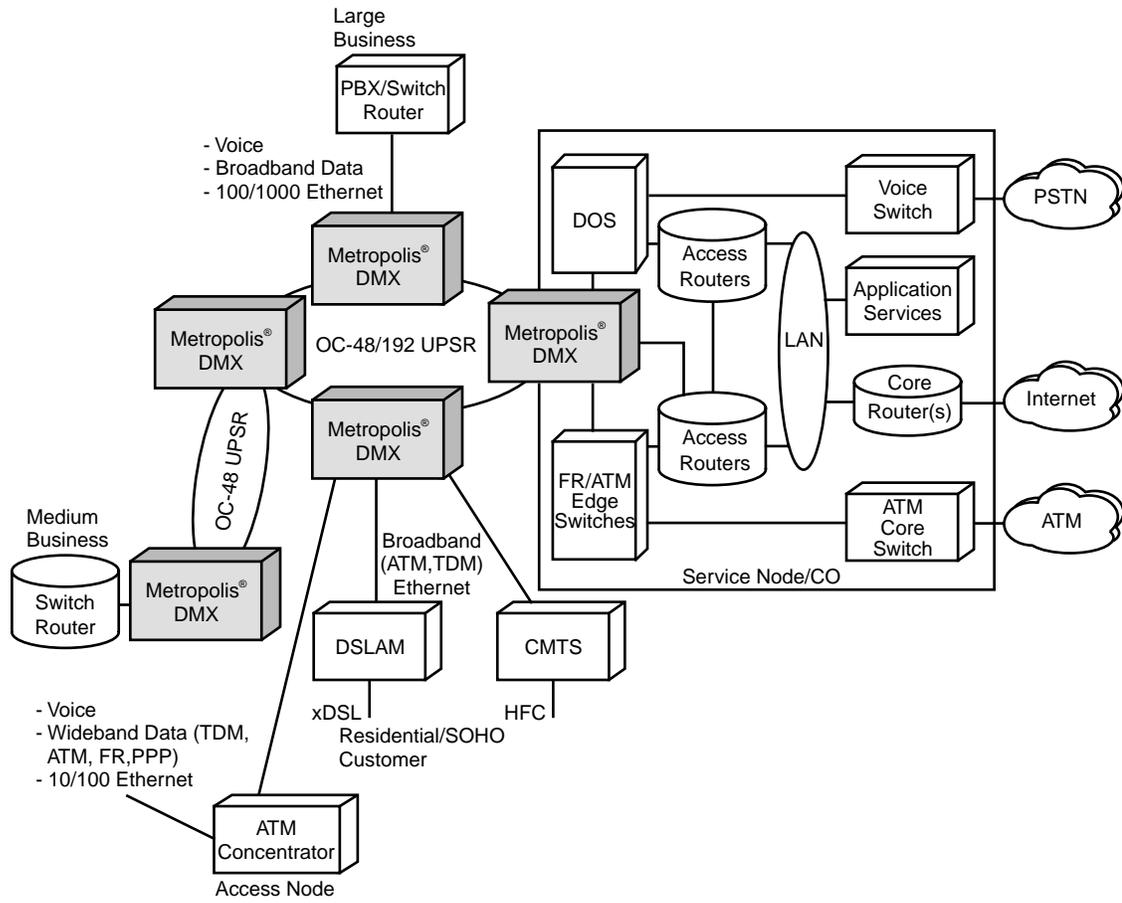
Purpose The DMX Access Multiplexer provides a wide range of service applications transporting voice and data from the access edge of the network to the core of the network. These applications range from traditional SONET applications to advanced data transport applications.

Features DMX provides the following features for the service applications described in this section:

- DS1 transport and switching
- DS3 transport and switching
- EC-1 transport and switching
- OC-3(c) transport and switching
- OC-12(c) transport and switching
- OC-48(c) transport and switching
- 100BASE-TX transport and switching
- 1000BASE-SX/LX transport and switching
- Synchronization distribution (DS1 timing inputs and outputs)
- Single-ended or independent operations
- Long reach single-mode fiber spans for OC-3, OC-12, OC-48, and OC-192 optics
- Passive wavelength division multiplexing (DWDM)-compatible optics.

The figure below shows how the DMX fits into Lucent's metropolitan optical networking solution.

Figure 3-1 Multiservice Optical Access Network



nc-dmx2-029

Contents Service applications described in this section include:

Established Network Evolution	3 - 6
Access Transport for Voice and TDM Private Line Services	3 - 8
Interoffice Transport	3 - 9
Ethernet Private Line	3 - 10
Multi-point Ethernet Private Line	3 - 12
Ethernet Rate Shaping Services	3 - 14
Virtual LAN Services	3 - 16
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Best Effort Ethernet Service	3 - 19
Ethernet/TDM Access to Frame Relay and/or ATM Service	3 - 20
Ethernet/TDM Access to IP Network	3 - 21
DSLAM Access	3 - 23
TransMUX	3 - 24



Established Network Evolution

Overview The DMX offers a capacity upgrade from an OC-3 or OC-12 network to an OC-48/OC-192 network. Implementing a DMX ring at the edge of the network, in combination with pre-existing OC-3 and OC-12 rings, provides increased network capacity and flexibility with the opportunity to interwork with or replace current-generation access multiplexers.

Description The DMX can interwork with existing Lucent and other-vendor SONET network elements to support all of the applications and topologies described in this section. The figures below show the network evolving from an OC-3/OC-12 network to an OC-48/192 network. Figure 3-2 (3-6) shows the original network, while Figure 3-3 (3-7) shows the network evolution when once DMX is deployed.

Figure 3-2 Established Network

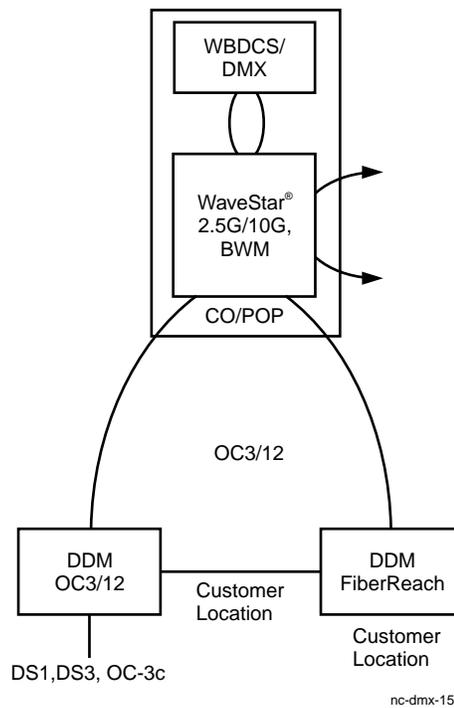
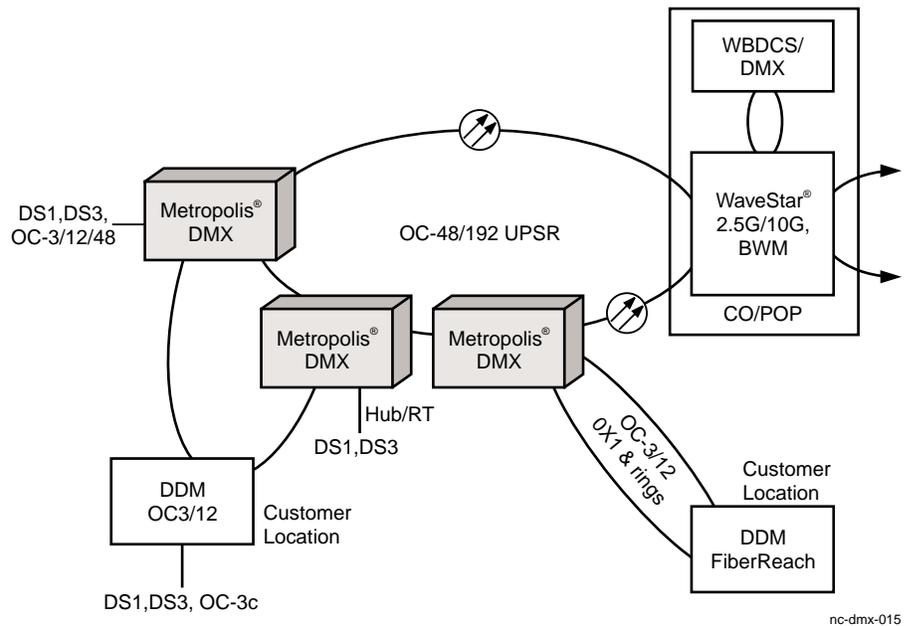


Figure 3-3 Established Network Evolution



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Application advantage

As greater capacity is needed, the DMX provides customers a graceful upgrade path from smaller capacity OC-3/12 networks to OC-48/192 DMX networks capable of enhanced applications, topologies, and capacities. The features of the DMX enable it to cost-effectively serve your needs now while protecting your networking future.

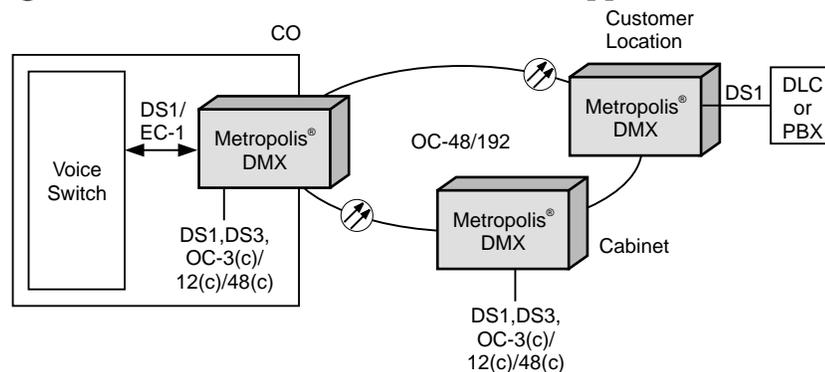
Access Transport for Voice and TDM Private Line Services

Overview The DMX supports a full set of interfaces, topologies, and operations to provide the flexibility, upgradability, and ease of operation required to meet the dynamic requirements of the access transport environment. A DMX OC-48/OC-192 path switched ring for TDM transport of voice and private line services is a reliable infrastructure for residential or small business voice services.

Description DMX is particularly suited to the evolving needs of voice and private line access transport applications due to its compact size, environmental hardening, and capacity growth potential. The DMX's flexibility allows the infrastructure to be optimized for a particular fiber topology, service mix, and growth forecast. DMX can simultaneously support wideband and broadband private line services for DS1, DS3, OC-3(c), OC-12(c), and OC-48(c) client interfaces.

The figure below shows a path switched ring transporting low-speed DS1 signals that are carrying voice services from a PBX or a digital loop carrier (DLC) system over an OC-48 or OC-192 ring. In this application, DMX hands off these voice circuits to the voice switch in the central office using a very cost-effective DS1/EC-1 interface.

Figure 3-4 Voice and Private Line Access Application



Application advantage The access transport application provides low-cost transport of revenue-generating voice and private line wideband and broadband services in a single multiplexer.

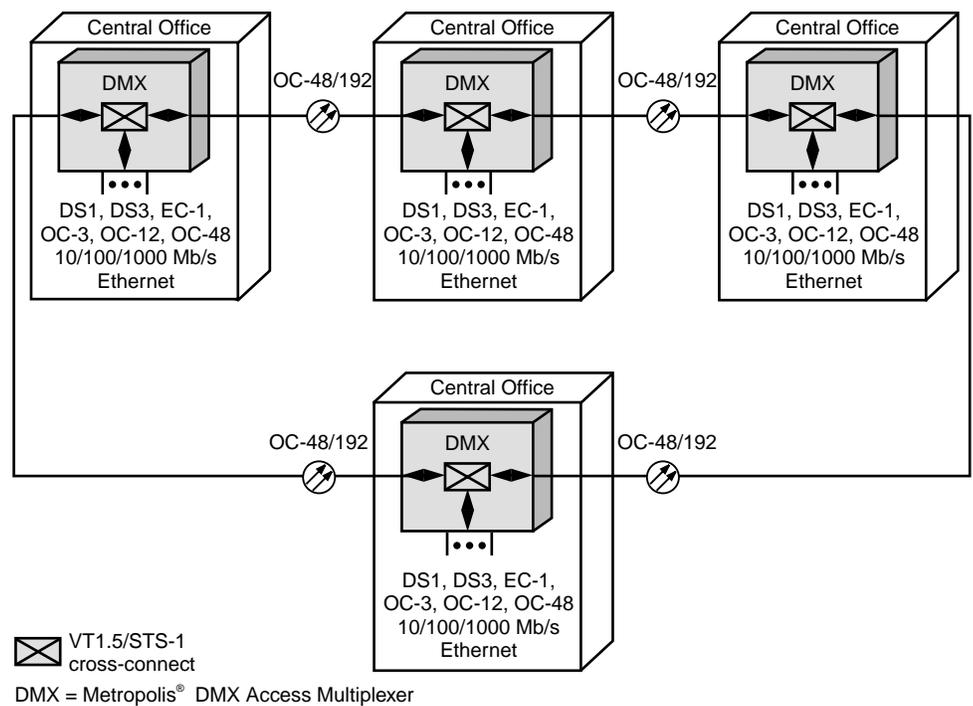
Interoffice Transport

Overview The DMX provides the features necessary for interoffice transport in a greater metropolitan area, including long-span optics, easy capacity upgrades, and add/drop interfaces to other CO equipment. A VT1.5/STS-1 OC-48 path switched ring is a very effective self-healing network configuration for large cross-section interoffice networks.

Description The DMX is ideal for metropolitan interoffice transport applications due to its large capacity and mixture of voice, data, and Ethernet services. An OC-48/192 UPSR/BLSR ring provides fast and reliable transport of DS1, DS3, EC-1, OC-3(c), OC-12(c), OC-48(c), and 10/100/1000 Mbps Ethernet services. Note: while the DMX can transport DS1 signals in a BLSR configuration, it can not groom them (this applies only in BLSR applications).

The figure below, shows a sample interoffice transport configuration.

Figure 3-5 Interoffice Transport



Application advantage DMX's interoffice transport applications provide low-cost, self-healing voice, Ethernet, asynchronous transfer mode (ATM), and frame relay (FR) transport on a single multiplexer.

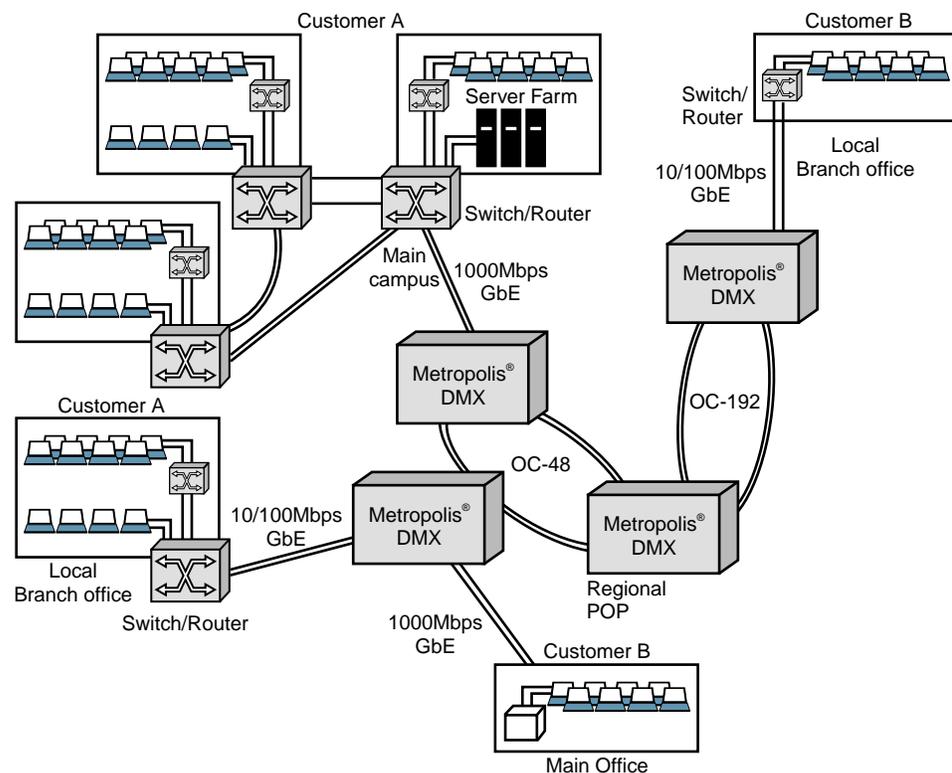
Ethernet Private Line

Overview Ethernet private lines provide the user the ability to transport frames completely transparently between two DMX NEs. No VLAN knowledge or packet-layer provisioning is required by the user in this application. Simple, SONET STS-1 cross-connect provisioning is all that is required. These private line capabilities allow the DMX to provide dedicated bandwidth for individual customers and fast SONET-layer restoration in the event of a facility-based failure.

Ethernet Private Line (point-to-point Ethernet) for Enterprise LAN transport

DMX utilizes standard STS-1 virtual concatenation (ITU G.707) to transport 10/100 Mbps or 1000 Mbps Ethernet services over a SONET OC-48/OC-192 UPSR/BLSR ring. In this configuration, Ethernet traffic from an end customer may be fed to a core router in the central office (CO), while voice traffic is fed from the same ring to a voice switch in the CO. In private line LAN transport configurations, standard SONET UPSRs/BLSRs provide restoration of service within 50 milliseconds.

Figure 3-6 Ethernet Private Line Transport Application



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Application advantage

Ethernet Private Lines simplify networks by eliminating intermediate WAN protocols, such as frame relay or ATM while providing service providers an ideal migration path from traditional private line, circuit-based services.

Ethernet Private Lines also provide dedicated bandwidth and absolute QoS for business critical data transport applications. Private lines are protected by SONET layer protection switching with a guaranteed restoration time of less than 50 milliseconds.

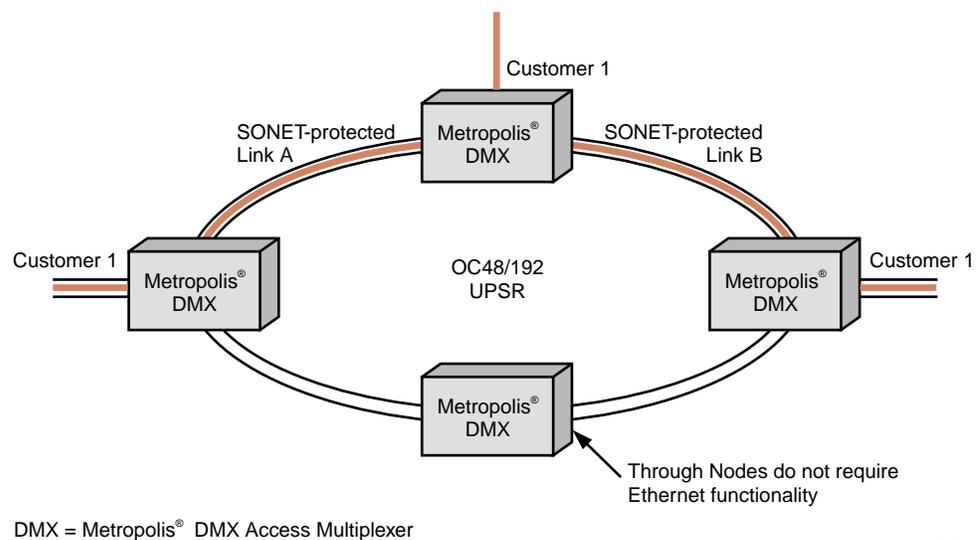
Multi-point Ethernet Private Line

Overview This section is meant to supplement the previous section (Ethernet Private Line) and aims at better describing the Multipoint Ethernet cross connection functionality of private lines.

Multi-point Ethernet Private Line for Enterprise LAN transport

Similar to the figure discussed in the previous section, the figure below shows a customer (Customer A) with a private line connecting multiple sites. In such applications, multi-point connectivity enables simultaneous connectivity to all sites serviced by the private line at all times. Ethernet private line links are sized independently and are configured for 802.1q or Transparent VLAN mode. Finally, in multi-point ethernet applications, the intermediate nodes (the DMX at the bottom of the ring in the figure below) provide a simple bridging function, passing-through all Ethernet traffic on the private line. As such, the intermediate nodes do not require Ethernet functionality.

Figure 3-7 Multi-point Ethernet Private Line Application



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Multicast Ethernet Packets Multicast Ethernet packets/transmission can be used to facilitate certain private line applications. Yet, Ethernet private line can be implemented using a variety of Ethernet cross-connection types. For more information about Ethernet cross-connection types, refer to the section entitled "Cross-connections" in Chapter 5 of this document.

Multicast Ethernet can also be used to facilitate video distribution, webcasting, and any other application in which multipoint Ethernet cross-connections are used. For more information on the functionality

of multicast Ethernet in the DMX, refer to the section entitled “Networking Capabilities” in Chapter 2 of this document.

Application advantage

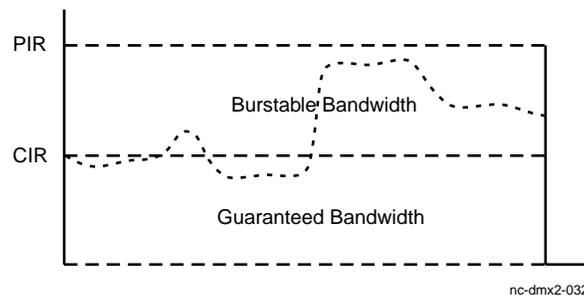
Multi-point Ethernet Private Lines eliminate the need for an adjunct data switch and further simplify networks by eliminating intermediate WAN protocols, such as frame relay or ATM while giving service providers an ideal migration path from traditional private line, circuit-based services.

Multi-point Ethernet Private Lines also provide absolute QoS and security for data transport applications with dedicated bandwidth and SONET layer protection switching (less than 50 millisecond restoration time).

Ethernet Rate Shaping Services

Overview Rate-shaped services offer a statistical multiplexing model that makes efficient use of shared bandwidth. DMX supports two primary forms of rate shaping: rate limiting, and guaranteed rate services (plus various combinations of both).

Rate limiting is achieved using Peak Information Rate (PIR) provisioning. Guaranteed rate service is achieved using Committed Information Rate (CIR) provisioning. PIR institutes a limit, or “ceiling”, of maximum bandwidth to be allocated to a particular customer at any time. CIR, on the other hand, provides a guaranteed minimum, or “floor” throughput even during periods of high congestion. Banded and/or burstable services can also be deployed based on CIR and PIR combinations.

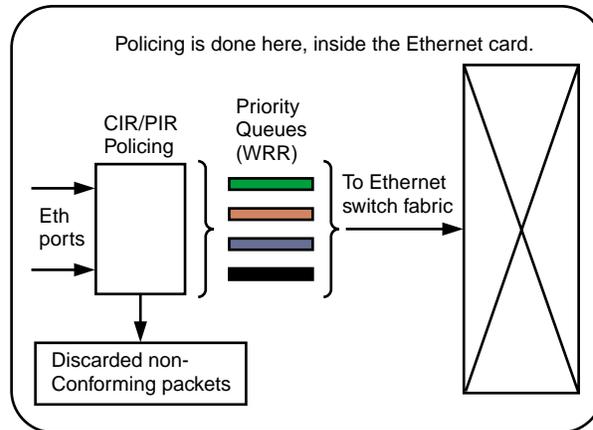


How it Works The figure above demonstrates the relationship between CIR and PIR services for a single customer’s bursty data stream. Again, PIR represents the maximum bandwidth a particular customer will be allocated at any time, while CIR is guaranteed minimum bandwidth that insures a constant level of service even during periods of high congestion. CIR can be provisioned on a per-port or per-VLAN basis.

As the figure above suggests, if the maximum bandwidth for a customer (PIR) is exceeded, surplus packets may be dropped. On the other hand, if a customer’s traffic exceeds their CIR, but remain below their PIR, the packets that exceed the CIR will be marked as discardable. This means that they will not be dropped unless other traffic requires that bandwidth. If the network is not congested when packets exceed the CIR level, the packets will reach their destination. As long as a customer does not exceed their CIR, none of their traffic will ever be dropped.

Policing takes place first in order to ensure that a customer meets the CIR/PIR stipulations of their contract. The priority queuing relative to other customer's traffic then occurs; providing another QoS capability.

Figure 3-8 Bandwidth Allocation within Ethernet circuit packs



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Application advantage

Rate shaping provides the capability to offer both a guaranteed minimum “floor” throughput during periods of high congestion (CIR), and a maximum “ceiling” throughput in place at all times. Thus, the DMX enables a versatility in QoS for Ethernet applications. With the possibility of burstable services, the DMX not only provides the possibility of a guaranteed QoS, but also the ability to provide a customer with throughput above and beyond their CIR (when network conditions permit). Finally, all private line services are protected by tried and tested dependability of SONET layer protection.

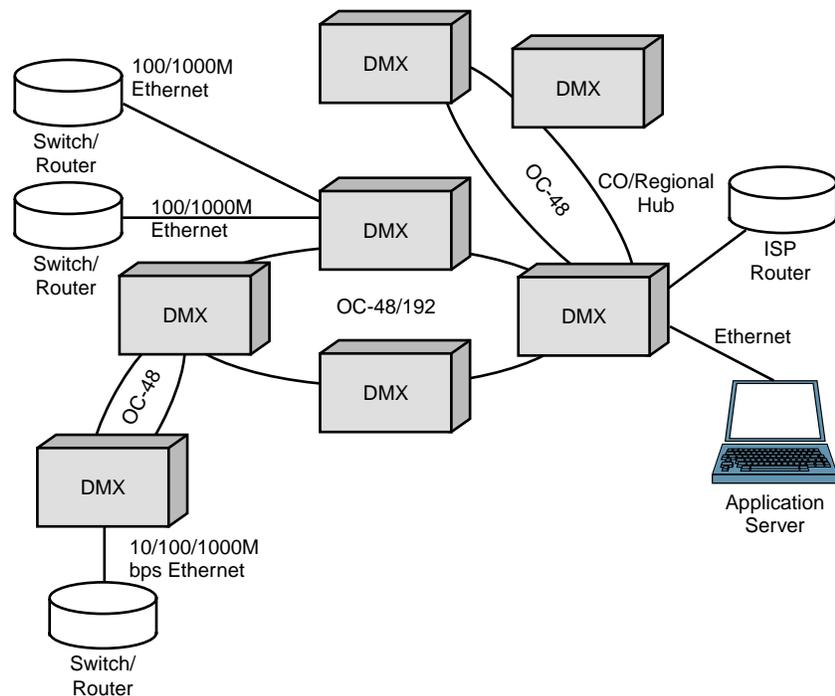
Virtual LAN Services

Overview The Virtual LAN (VLAN) Service application provides a packet-based Ethernet connection via a shared packet over SONET connection.

Description VLAN Service applications can be utilized by multiple customers over a shared ring for improved bandwidth efficiency. DMX uses VLANs and allows bandwidth to be shared among customers. Up to 4093 VLANs can be assigned to guarantee privacy among various customers. Multiple customers can use the VLAN interconnect (multipoint LAN) capability of DMX at multiple sites.

The figure below, shows DMX's varied VLAN capabilities.

Figure 3-9 VLAN Service Application



DMX = Metropolis® DMX Access Multiplexer

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Application advantage DMX Ethernet services extend packet switching from the LAN to the WAN. In doing so, enterprise interconnect locations in metropolitan areas can transport traffic much more efficiently over shared and/or provisionable access bandwidth. ISP carrier access applications can use spanning tree protection and flexible bandwidth allocation (using STS-1 virtual concatenation) in the WAN.

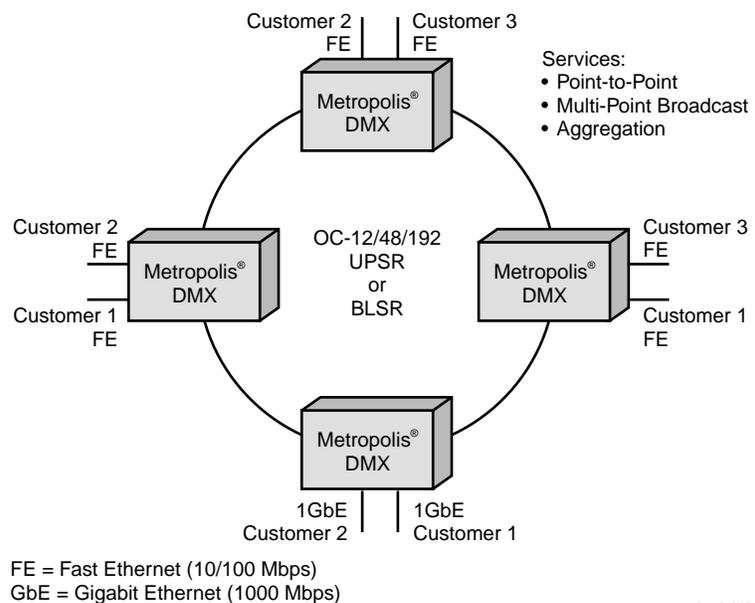
Transparent LAN Services

Overview The enterprise LAN (local area network) interconnect and transport applications provide business-to-business networking of routers and data switches. Transparent LAN service is similar to VLAN service, except that Transparent LANs can be deployed using rate shaping OR on a best effort basis.

Enterprise LAN interconnect (multipoint Ethernet) description

The multipoint LAN interconnect capability of DMX allows data to be transported across a DMX network from any point to any other point. Protection is provided via the standard spanning tree algorithm. The DMX software determines which DMX NE is the “root” of the data network. The data spans out from that DMX NE, enabling the customer to extend its enterprise network into the WAN as a virtual private LAN. The figure below depicts two high-speed DMX path switched rings transporting data in either a point-to-point or multipoint configuration between DMX clients through multiple nodes and switching points.

Figure 3-10 Transparent LAN Services



Multicast Ethernet Packets

Multicast Ethernet packets/transmission can be used to facilitate certain Transparent LAN applications. Yet, Transparent LANs can be implemented using a variety of Ethernet cross-connection types. For more information about Ethernet cross-connection types, refer to the section entitled “Cross-connections” in Chapter 5 of this document.

Multicast Ethernet can also be used to facilitate video distribution, webcasting, and any other application in which multipoint Ethernet cross-connections are used. For more information on the functionality of multicast Ethernet in the DMX, refer to the section entitled “Networking Capabilities” in Chapter 2 of this document.

Application advantage

The Transparent LAN application supports fast, packet-layer protection throughout the WAN, as well as the ability to offer both dedicated and shared bandwidth transport services with improved efficiency and flexible quality of service (QoS).

Best Effort Ethernet Service

Overview Best effort Ethernet Services is an over-subscription service model that functions without Rate Shaping. Ideal for broadband Internet access within a metro area, Best Effort Ethernet Service enables service providers/carriers to offer an economy-class of service that maximizes revenue potential of a fixed amount of bandwidth.

Description In the Best Effort service model customers share common bandwidth and are given no quality of service (QoS) or throughput rate guarantees. Thus best effort applications function without rate shaping services and provide customers with throughput relative to available bandwidth only.

If customers require that their traffic be separated from common network traffic (for security purposes), this can be achieved by VLAN tagging (IEEE 802.1q) or Transparent VLANs (see the sections above). Traffic in best effort applications may also be prioritized via IEEE 802.1p tags.

Protection in this application is provided by standard both SONET layer switching within the WAN and Rapid Spanning Tree protocol (IEEE 802.1w) in the Ethernet environment.

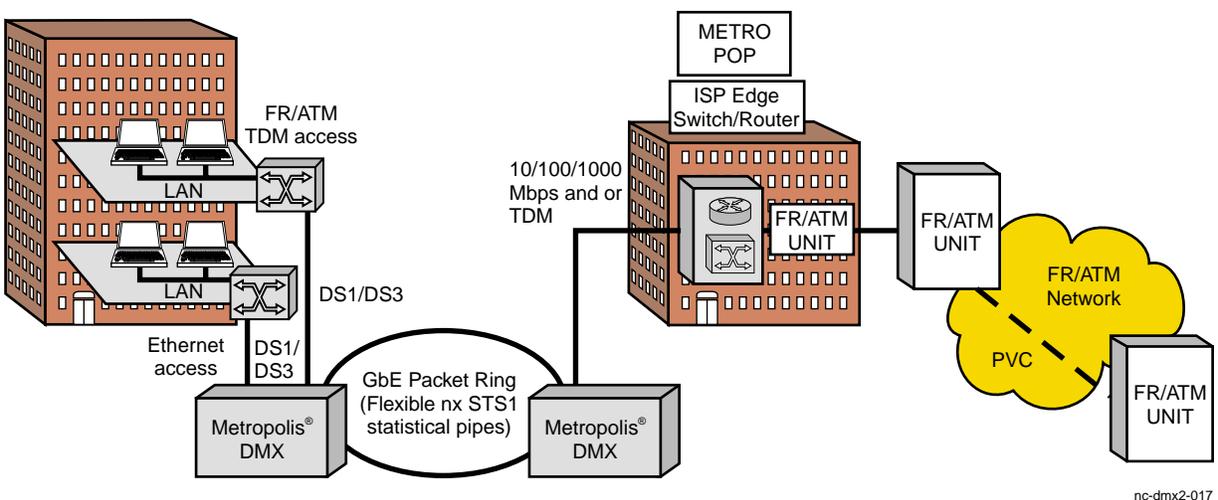
Application Advantages Best effort services are ideal for providing internet access. This application enables service providers to offer economy-class service facilitated by over-subscribing bandwidth shared by numerous customers. Thus best effort services enable service providers/carriers to maximize the revenue potential of a fixed amount of bandwidth.

Ethernet/TDM Access to Frame Relay and/or ATM Service

Overview The DMX supports business data access applications for a variety of broadband service interfaces. These services can cost-effectively reach remote data aggregation switches at collocated sites and business premises.

Description In this application, DMX transports DS1, DS3, OC-3(c), OC-12(c), and OC-48 (c) signals from an edge aggregator (Figure 3-11 (3-20)) to the core switch. It also provides DS1 and DS3 (TDM) low-cost backhaul of frame relay and ATM to the hub multiservice switch. This application also provides 10/100/1000 Mbps Ethernet transport and switching.

Figure 3-11 DMX Providing Access to Frame Relay and/or ATM Network



Application advantage DMX satisfies evolving data service delivery requirements for business customers through its flexible, scalable access network infrastructure, offering a next-generation infrastructure that is stable against the churn of data technology.

DMX simplifies data service delivery by enabling access to existing ATM and Frame Relay networks through Ethernet and/or TDM interfaces. Thus, traffic originating at Frame Relay or ATM equipment can enter the DMX through a 10/100/1000 Mbps Ethernet or DS1/DS3 TDM interface to be transmitted across SONET networks to its final destination (be it a Frame Relay/ATM based network or an Ethernet LAN).

Ethernet/TDM Access to IP Network

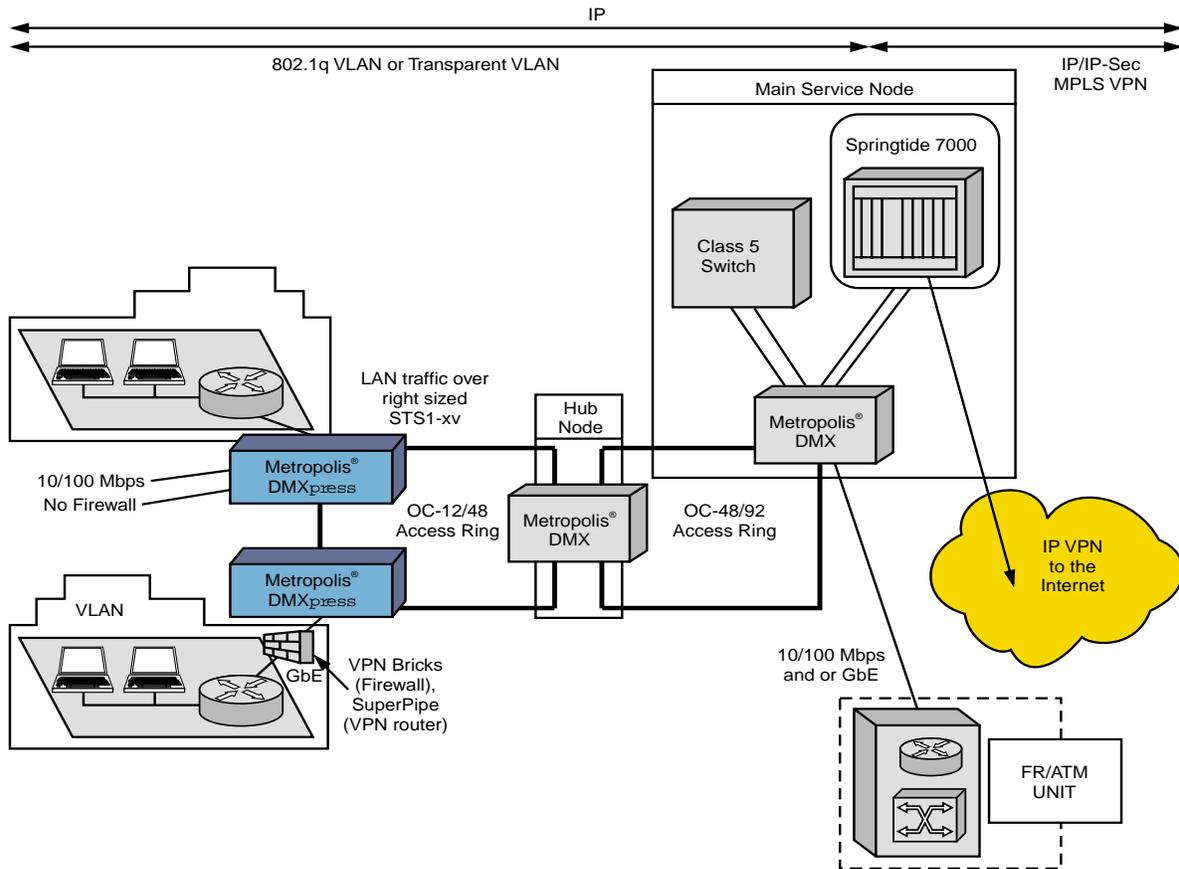
Overview DMX provides access to the IP service delivering platforms, which enable such capabilities as virtual routing services, Layer 3 VPNs, firewalling, and IPsec Tunnels. These enhanced IP services allow service providers to offer customers state-of-the-art networking capabilities such as network based VPNs, built-in QoS, bullet-proof security, multi-tenant internet access, voice/data convergence, and other next generation applications.

Description While DMX single-handedly enables such things as voice/data convergence, it is important to state that the majority of the services listed above are supported by various IP Services platforms (Lucent's SpringTide[®] Switches, Access Point[®] Routers, and Brick Firewall Family for example). The DMX, however provides an efficient and crucial link between metro area networks and these IP Services platforms located in the network core.

In the figure below the DMX is hosting an OC-48/192 metro ring connected to an OC-12/48 access ring on one end, and the metro core on the other. On the access ring side, DMX provides a link to CPE sized mutlplexers (which are in-turn connected to routers or firewalling platforms) or directly to IP routers (over 10/100/1000 Mbps Ethernet interfaces).

On the other side of the metro ring, the DMX is connected to an IP Services switch (both TDM and Ethernet interfaces supported by some IP switches). IP services switches can then provide a range of enhanced IP services.

Figure 3-12 DMX providing Ethernet/TDM access to the Internet



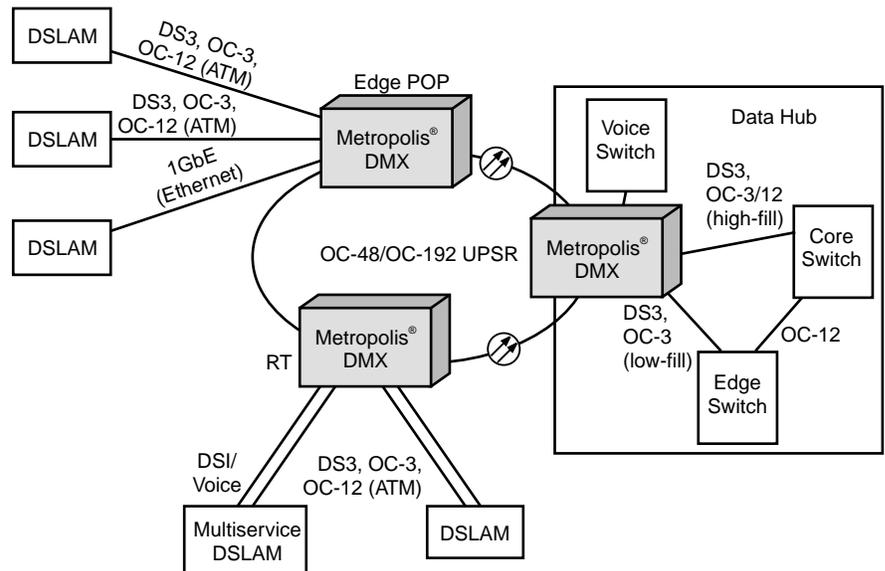
Application Advantages DMX allows service provider's access networks to support today's enterprise customer needs with TDM to IP services migration, access to high-security multiservice platforms (i.e. SpringTide[®]), and efficient aggregation of last-mile voice and data services.

DSLAM Access

Overview The DMX provides a cost-effective aggregation and transport vehicle for digital subscriber line (DSL) or remote digital subscriber line access multiplexer (DSLAM) gateways.

Description In the figure below, DMX is located at a central office where it collects DS3 and/or OC-3/OC-12/GbE signals from multiple DSLAMs, multiplexes them to the OC-48/192 line rate, and sends them out on the OC-48/192 ring for back-haul to centrally located ATM switches that can be used more cost-effectively than distributed ATM switches.

Figure 3-13 DSLAM Application



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Application advantage A DMX offers a cost-effective, scalable access network infrastructure for DSL access transport.

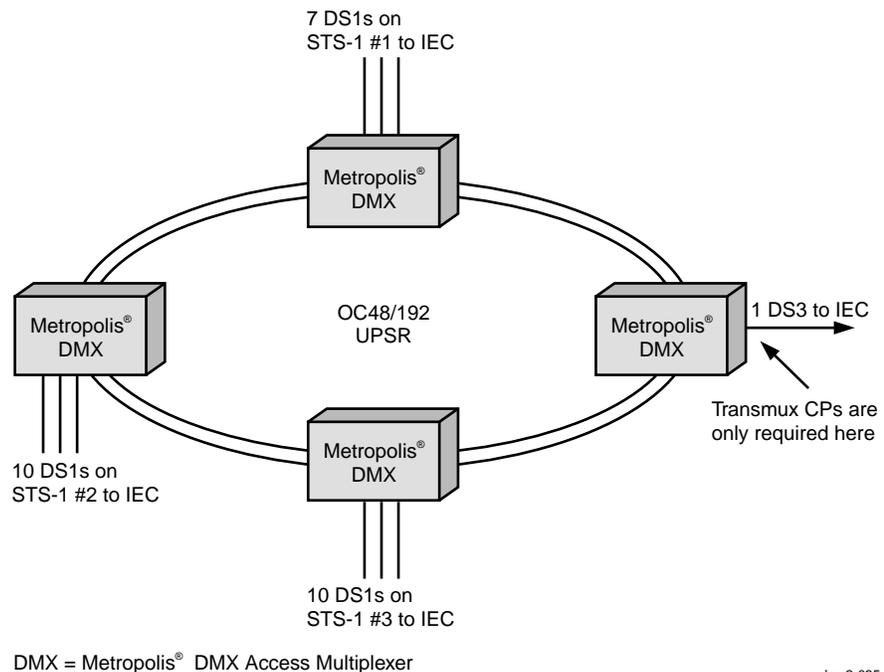
TransMUX

Overview The DMX provides a cost-effective/ bandwidth preserving aggregation and transport vehicle for DS1 signals.

Description In the figure below, DMX is pictured collecting multiple DS1s around the UPSR and, in the node at the far right of the figure, transmitting them within a channelized DS3 signal back to the core network. This TransMUX capability is provided by the TransMUX circuit packs located in the DMX at the far right of the picture.

Here, the TransMux circuit pack combines the various DS1s collected from about the ring and packs them into a single channelised DS3 signal for transmission back to the network core.

Figure 3-14 TransMUX Application



Application advantage TransMUX functionality enables the DMX to:

- DS1 grooming for channelized DS3s
- Eliminate the need for separate M-13 MUXs at the DS1 aggregation site
- Pack DS3s with multiple DS1s to use bandwidth back to the network core most efficiently



Network Configurations

Overview

Purpose DMX provides the flexibility required for operation in today's changing telecommunications networks. With topology and capacity upgrades, a DMX network can be installed with minimum first cost and then easily grown to add new sites and services.

Network flexibility The following sections describe some of the network topologies in which DMX can be used. Many other combinations of these network configurations can be used to meet specific network and fiber topologies.

Contents Network topologies discussed in this section include:

Path Switched Rings	3 - 27
2-Fiber BLSRs	3 - 30
Packet Rings	3 - 34
DWDM Optics	3 - 36
Increased Span Length: External DWDM Optical Amplifiers (OAs) (Release 3.0)	3 - 38
Dual Node Ring Interworking (Release 3.1)	3 - 40
Single and Dual-Homing	3 - 43
Hairpinning	3 - 45
Linear Optical Extensions	3 - 47
Hubbing	3 - 49



Path Switched Rings

Overview	This section describes the unidirectional path switched ring configuration available with the DMX.
Purpose of path switched rings	<p>The need to prevent service outage caused by network failure has created path switched ring applications. The path switched rings configuration provided by DMX is a self-healing network that automatically protects against service outages caused by cable cuts and equipment failures, which in turn protects customer traffic and increases revenue opportunity.</p> <p>DMX path switched rings operate in an easily-managed, integrated, single-ended fashion. Restoration is fast and reliable. Complex network-level coordination is not necessary to restore traffic. Furthermore, bandwidth administration and network reconfigurations (for example, adding or deleting nodes) are easier because path switching does not require special time slot assignment rules.</p>
Typical path switched ring application	A network that requires the majority of its traffic to be dropped at a single node is an ideal application for path switched rings. A typical access network, where most traffic is between the customer locations and a point-of-presence (POP) or end office, fits this mold. Such an application calls for reliable delivery between customers and POPs. In cases where a mixture of wideband and broadband services is required, a DMX path switched ring is ideal.
OC-12/OC-48/OC-192 path switched rings	The OC-12/OC-48/OC-192 path switched ring allows several remote sites to share the two-fiber ring facility back to the CO. DMX interfaces to the ring through the Main slots at the OC-12/OC-48/OC-192 rate and uses its programmable VT1.5/STS-1/STS-3(c)/STS-12(c)/STS-48(c) cross-connect capability (STS-48(c) not supported on OC-12 interfaces). Path switching can be done on VT1.5, STS-1, STS-3(c), STS-12(c), or STS-48(c) paths, or a mixture of these, and all can be added/dropped from the DMX path switched ring at any node. Using the ring's path protection scheme, time slots are reserved all the way around the ring. Cross-connections offer full flexibility in assigning signals between low-speed ports and the high-speed interface at each node. DMX can easily adapt to unpredicted growth at a ring node.
Ring topology	The ring topology routes traffic between a CO site and a set of remote sites, or between multiple COs, while providing complete protection. In

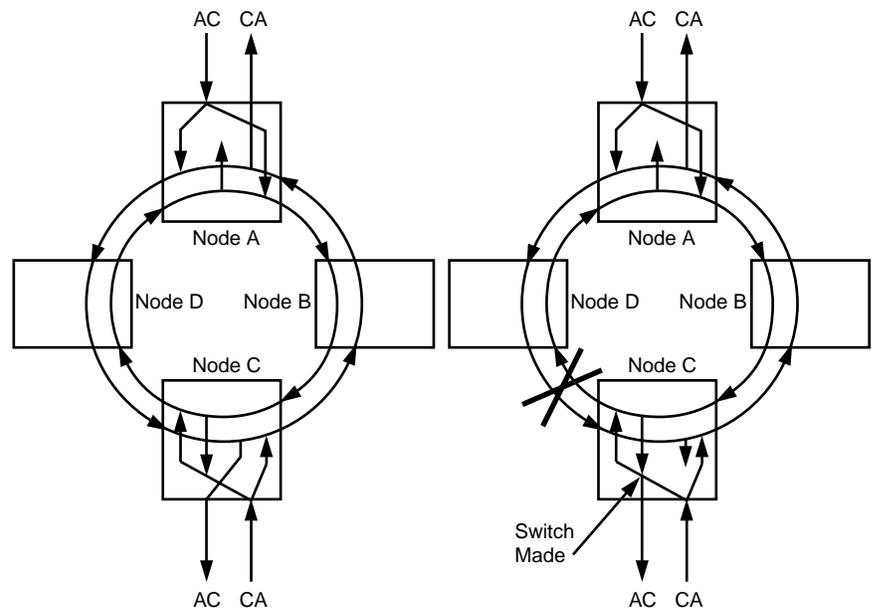
addition, only two OLIUs are needed per DMX, which provides a cost savings. Traffic can also be routed between remote nodes. The ring can start with as few as two nodes and grow to support many nodes through in-service node additions.

For protection against a CO failure, it may be desirable to include a second CO node in the ring. DMX's support for dual homing architectures allows all services to be routed to the alternate CO while the first CO is out of service.

Operation The DMX OC-48/OC-192 path switched ring operates as shown in Figure 3-15 (3-29). Traffic entering a path switched ring node is sent onto both rotations of the ring. At the receiving node, the signal having the highest integrity (based on SONET path information) is selected and dropped as outgoing traffic. At intermediate nodes, the traffic is "passed-through" without changing the SONET path information. The DMX VT1.5/STS-1/STS-3(c)/STS-12(c)/STS-48(c) cross-connect capabilities make the provisioning of add/drop and pass-through traffic quick and easy.

The self-healing nature of the path switched ring is shown in Figure 3-15 (3-29) (b). In this case, the fiber failure between nodes C and D causes node C to switch from the counterclockwise ring to the clockwise ring, thus maintaining service between node all nodes on the ring.

Figure 3-15 Path Switched Rings



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Configuration advantage

Path switched rings are the industry standard for self-healing networks, providing reliable transport for access networks while accommodating almost any type of application.

2-Fiber BLSRs

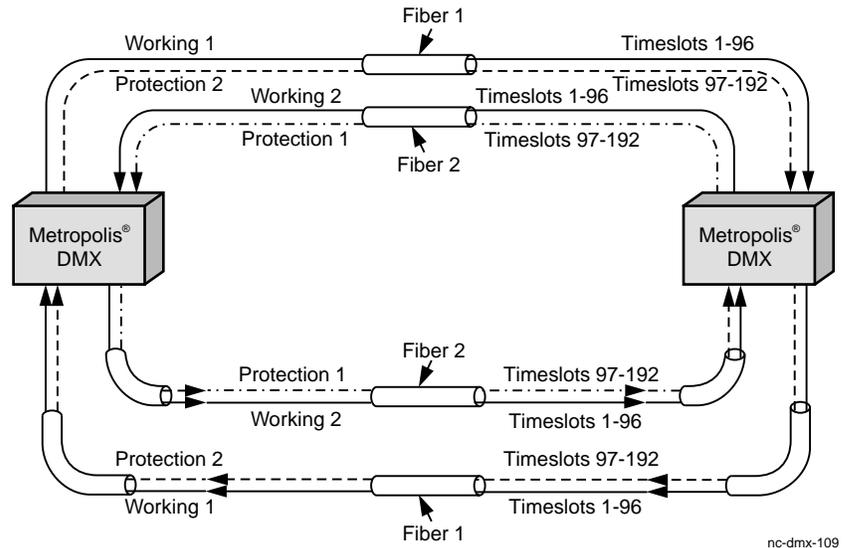
Overview A 2-fiber bidirectional line-switched ring (BLSR) is a self-healing ring configuration in which traffic is bidirectional between each pair of adjacent nodes and is protected by redundant bandwidth on the bidirectional lines that interconnect the nodes in the ring. Because traffic flow is bidirectional between nodes, traffic can be added at one node and dropped at the next without traveling around the entire ring. This leaves the spans between other nodes available for additional traffic. Therefore, with distributed traffic patterns, a BLSR can carry more traffic than the same facilities could carry if configured for a unidirectional path-switched ring.

The DMX supports one high-speed OC-48 2-fiber BLSR (Release 2.1) or one high-speed OC-192 2-fiber BLSR (Release 3.0) and one low-speed OC-48 BLSR (Release 3.0). In the latter application, the low-speed OC-48 BLSR is hosted by OC-48 circuit packs housed in the Function slots and can add and drop traffic with the high-speed OC-192 circuit packs housed in the Main slots.

Traffic capacity

The following figure shows working (also called service) and protection traffic capacities in an OC-192 2-fiber BLSR. The OC-48 2-fiber BLSR operates in the same way, but has 48 STS-1 timeslots in each direction, 24 for working traffic and 24 for protection.

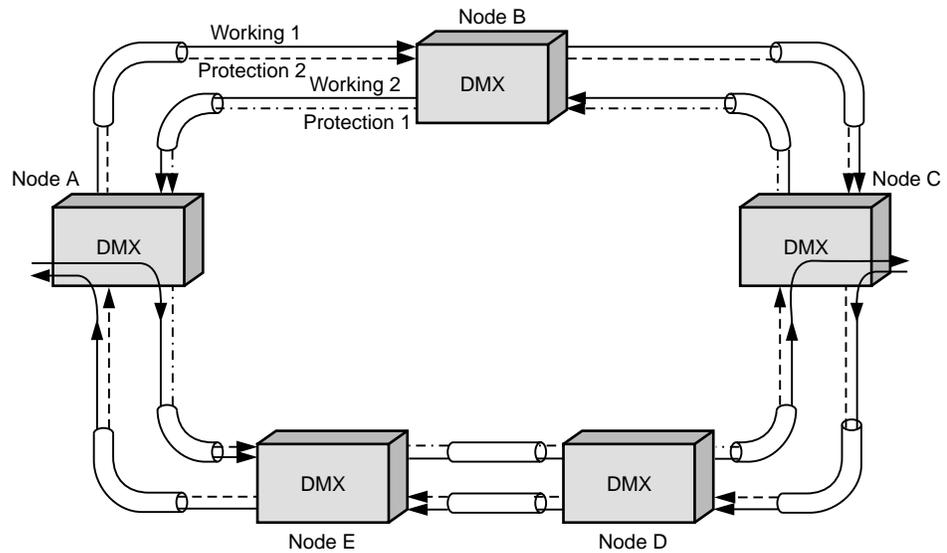
Figure 3-16 Traffic Capacity in an OC-192 2-Fiber BLSR

**Self-healing rings**

DMX 2-fiber BLSRs are self-healing in that transport is automatically restored after node or fiber failures. Each OC-192 line carries 96 STS-1 equivalent timeslots of working capacity plus 96 STS-1 equivalent timeslots of protection capacity. Each OC-48 line carries 24 STS-1 equivalent timeslots of working capacity plus 24 STS-1 equivalent timeslots of protection capacity. In the event of a fiber or node failure, service is restored by switching traffic from the working capacity of the failed line to the protection capacity in the opposite direction around the ring (see the figure below and the figure on the following page.). In the event of a node failure, traffic added and dropped from the failed node is not protected by path switching.

2-fiber BLSR traffic flow The figure below shows normal (non-protection-switched) traffic flow on a 2-fiber BLSR.

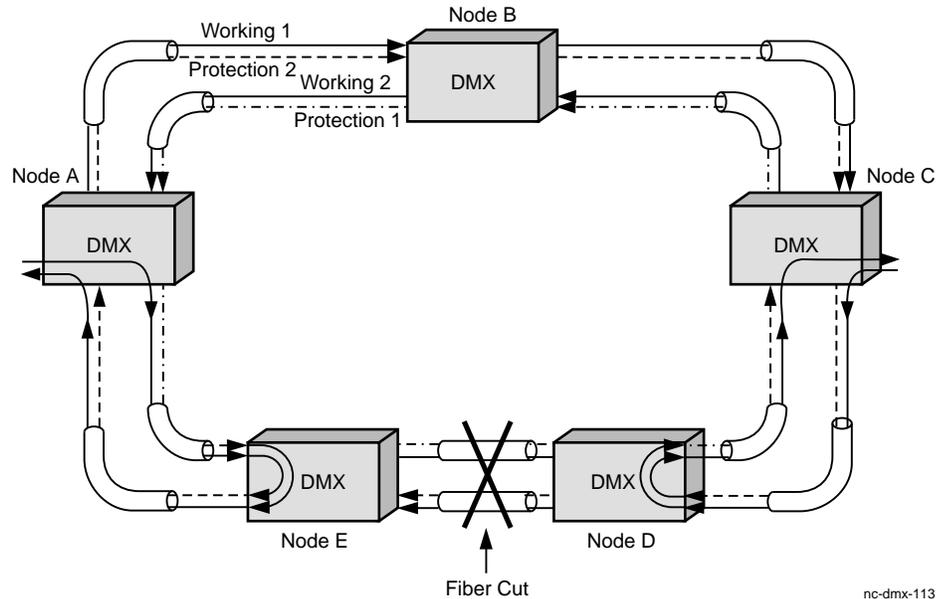
Figure 3-17 Normal Traffic Flow in a 2-Fiber BLSR



Protection switching When a line failure triggers a protection switch, the nodes adjacent to the failure switch traffic on to protection capacity. Traffic heading toward the failure is looped back on to the protection capacity traveling away from the failure to reach its destination by traveling the opposite way around the ring (see the figure below). Service is reestablished on the protection capacity in ≤ 50 milliseconds after detection of the failure (for catastrophic failures in rings without existing protection switches or extra traffic).

Fiber cut example The figure below illustrates a 2-fiber BLSR protection switch that results from a fiber cut.

Figure 3-18 Loopback Protection Switch in a 2-Fiber BLSR



Protection traffic flow In the figure above, traffic going from Node A to Node C that normally passes through Node E and Node D on “working 2” capacity is switched at Node E on to the “protection 2” capacity of the line leaving Node E in the direction of Node A. The traffic loops back through Nodes A, B, and C to Node D where it is looped back to Node C. Similarly, traffic going from Node C to Node A that normally passes through Node D and Node E on “working 1” capacity is switched at Node D on to the “protection 1” capacity of the line leaving Node D in the direction of Node C. The traffic loops back through Nodes C, B, and A to Node E where it is looped back to Node A. Note that only the nodes adjacent to the failure perform loopback protection switches. The same approach is used for a node failure. For example, if Node D fails, Nodes C and E perform loopback protection switches to provide an alternate route for ring traffic.

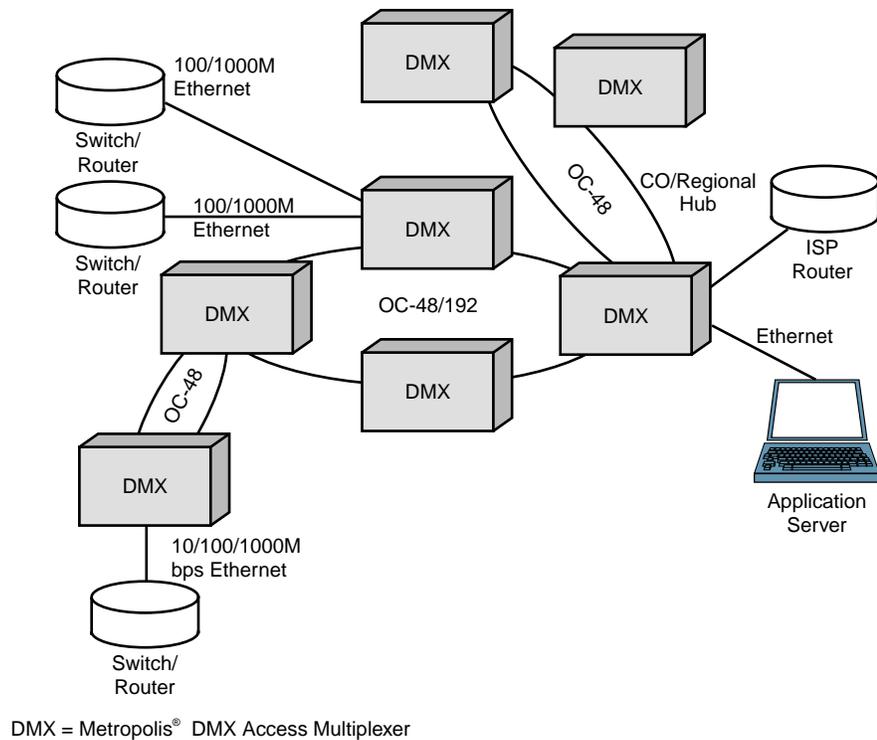
Packet Rings

Overview Packet Ring configurations provide business-to-business networking of routers and data switches using Ethernet transport over a reliable, low-cost multiservice network. The DMX provides the unique capability for a packet ring to span multiple ring topologies. As shown on the figure below, packet rings hosted by the DMX can span multiple OC-192, OC-48, or OC-12 ring configurations (UPSRs or BLSRs). Additionally, packet rings hosted by the DMX can reach into areas serviced by dual and single-homed ring extensions (see the figure below).

Ethernet over SONET A Packet Ring is a set of packet switches connected in a ring topology that use the inherent redundancy of the ring configuration to provide durability and fast restoration in the event of failures.

Packet rings can be used with or without SONET layer protection. At the packet layer, the rapid spanning tree protocol (as defined in IEEE 802.1) is used to provide protection.

Figure 3-19 Packet Rings



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DMX uses standard Generic Framing Procedure (GFP) encapsulation (ITU G.7041) for Ethernet over SONET mapping. Packet rings provide efficient aggregation and transport for Ethernet traffic. DMX's virtual concatenation capability (ITU G.707) provides flexible bandwidth granularity in the wide area network (WAN), which can grow with your service demand.

Packet Rings over a BLSR

DMX allows the manual provisioning of non-preemptable unprotected traffic (NUT) for multi-point Ethernet cross-connections that originate on low-speed (tributary) interfaces and share bandwidth on the high-speed (Network side) BLSR ring.

When using multi-point cross-connections through a BLSR, packets do not receive standard BLSR protection due to the necessary functioning of NUT. Yet, protection on all data packets is provided for with rapid spanning tree protocol (IEEE 803.1w).

Packet Ring Capacity

Beginning in Release 3.0, DMX supports the following number of packet rings per Ethernet interface circuit pack:

- 1 packet ring on each 10/100 Mbps Fast Ethernet circuit pack (LNW66, LNW69, and LNW78)
- 2 packet rings on each 1000 Mbps GbE circuit pack (LNW67, LNW68, and LNW70)

Specific Applications Supported

DMX supports the following enterprise LAN (local area network) interconnect and transport applications:

- Ethernet Private Line
- Ethernet Rate Shaping Services
- Virtual LAN Services
- Transparent LAN Services
- Best Effort Service
- Ethernet/TDM Access to Frame Relay or ATM Network
- Ethernet/TDM Access to IP Network
- DSLAM Access

Each of these packet ring applications are detailed in the "Service Applications" section of this chapter.

DWDM Optics

Overview Metropolis® DMX Access Multiplexer supports low-cost passive optics. These optics include 16 different OLIUs (2 wavelengths per OLIU) for OC-48 transmission, and a choice of 5 different Passive Optics Units (POUs) where the various wavelengths are combined for transmission over one fiber. The DWDM wavelengths or channels are chosen at 100 GHz increments per the ITU grid.

Port units DMX OC-48 DWDM OLIUs are available in 32 different wavelengths. Each port unit is capable of transmitting 2 different wavelengths (1 wavelength at a time). These units are compatible with the SONET standards.

The DWDM OLIUs are designed to be used with the Lucent POUs. By using the DWDM OLIUs and the POUs, you are able to increase fiber from 1 to 32.

Passive optics shelves Each MUX/DMUX POU is capable of multiplexing and demultiplexing many wavelengths together for transmission over a single fiber. The Add/drop units are capable of adding or dropping wavelengths to a DWDM line.

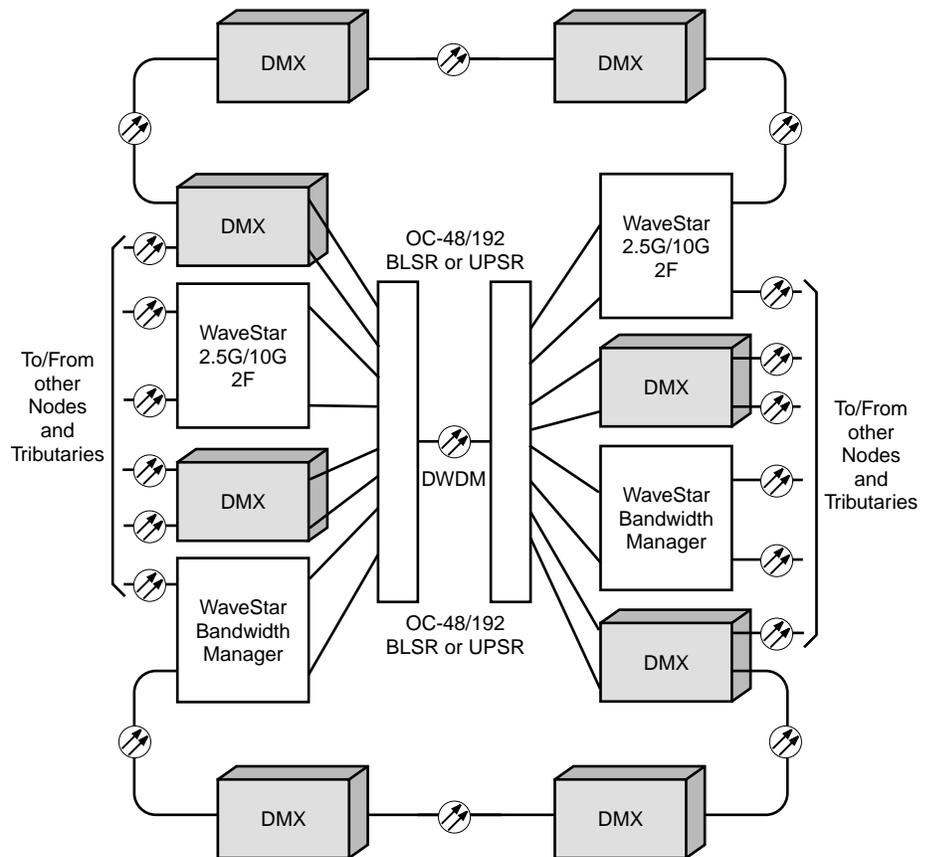
Lucent offers the following options for the Passive Optics Units (POUs):

- 1, 2, or 4 dual add/drop optical multiplexer (OADM) POUs. These three types of OADMs are capable of adding or dropping 1, 2, or 4 wavelengths to/from a DWDM line.
- 16 Channel MUX: This POU supports unidirectional and bidirectional transmission systems.
- 16 Channel DMUX: This POU supports unidirectional and bidirectional transmission systems. The filters are cascaded in reverse order of the 16 Channel MUX module.
- 16 Channel MUX and Interleaver: This POU supports unidirectional and bidirectional transmission systems, and includes an interleaver to support 16 additional channels.
- 16 Channel DMUX and Interleaver: This POU supports unidirectional and bidirectional transmission systems. The filters are cascaded in reverse order of the 16 Channel MUX and Interleaver POU. The POU also includes an interleaver to support 16 additional channels.

Protection The passive optic port units support the same protection modes as the standard port units. For example, both sets of passive port units support BLSR, UPSR, and 0x1 protection. The DWDM passive OLIUs also support 1+1 protection.

MUX/DMUX Example The figure below shows 16 lines to and from DMX systems. The OC-48 traffic from the 8 incoming (receive) and 8 outgoing (transmit) lines is transmitted over one fiber using DWDM on the Lucent passive optics shelf to a remote Lucent passive optics shelf. The traffic is similarly transmitted and received by that system. Alternatively, the equipment can be set up to handle 16 or 32 transmit lines on one end of the passive optics unit and 16 or 32 receive lines on the other end.

Figure 3-20 Lucent Passive Optics Unit with DMX



DMX = Metropolis® DMX Access Multiplexer

nc-dmx-114

Increased Span Length: External DWDM Optical Amplifiers (OAs) (Release 3.0)

Overview For OC-192 spans of up to 140km, Lucent Technologies offers DWDM optical amplifiers. The DWDM optical amplifier is a stand-alone shelf and can be used with both regular and PWDM OC-48 and OC-192 optics. In-line amplifiers can be installed at intermediate locations to achieve distances of up to 500 km.

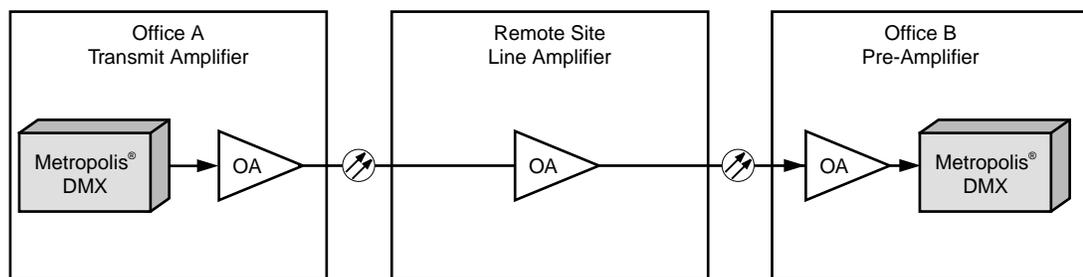
Concept Optical amplifiers consist of one booster and one pre-amplifier part. The booster part is connected via a Dispersion Compensation Module (DCM) to the transmit interface of the respective OC-192 or OC-48 port unit. The pre-amplifier is connected by means of a DCM to the receive interface of the associated port unit.

Applications The DWDM optical amplifier has two main applications:

- Single span application
- Multiple span application

A simple example for a single span application is shown in the following figure.

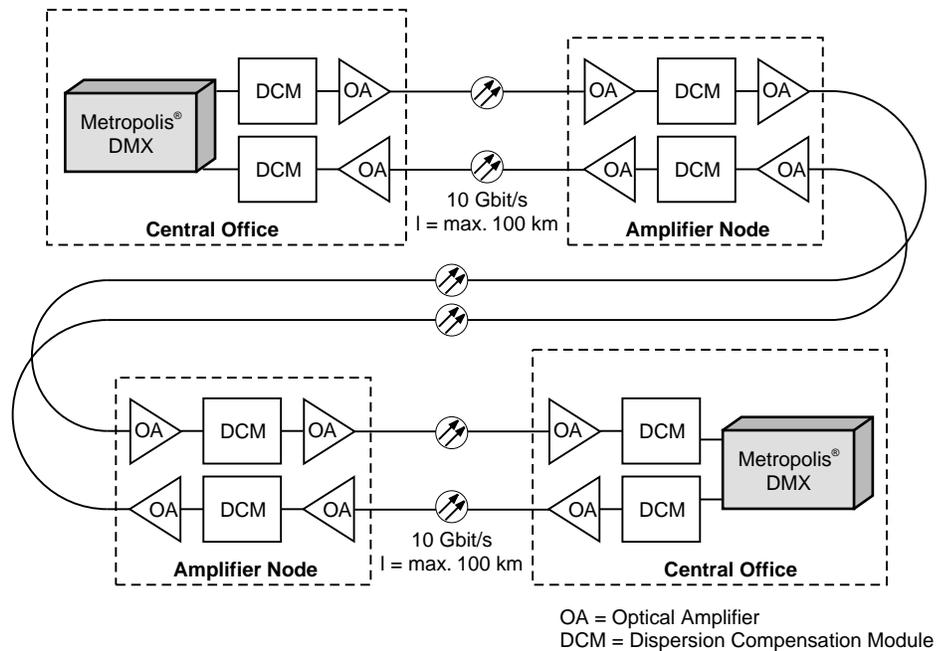
Figure 3-21 External Optical Amplifier Single Span Application



nc-dmx-165

A simple example for a multispan application is shown in the following figure.

Figure 3-22 External Optical Amplifier Multispan Application



nc-dmx-163

For long distances beyond 140 km, amplifiers can be used. In the amplifier nodes, one inline amplifier is needed for each direction. Up to five spans can thus be combined to a multispan connection of up to 5 x 100.

Further Information

For a description of the optical amplifier's physical specifications, see the section entitled "External Optical Amplifier" in Chapter 4 of this document.

For a description of the optical amplifier's optical specifications, see the section entitled "External Optical Amplifier" in Chapter 10 of this document.

Dual Node Ring Interworking (Release 3.1)

Overview Dual node ring interworking (DRI) is a configuration that provides path-level protection for selected STS-N circuits that are being carried through two UPSRs. Protection for the route between the two rings is provided by interconnecting the rings at two places (see Figure 3-23 (3-41)).

Each circuit that is provisioned with DRI protection is dual-homed, meaning it is duplicated and subsequently terminated at two different nodes on a ring. The two interconnecting nodes in each ring do not need to be adjacent.

DRI protection The self-healing mechanisms of the two UPSRs remain independent and together protect against simultaneous single failures on both rings (not affecting the interconnections). The DRI configuration additionally protects against failures in either of the interconnections between the rings, whether the failure is in a facility or an interconnection node.

Ring interworking All DMX tributary (linear) interfaces (DS3, EC-1, OC-3, OC-12, and OC-48) support DRI. The DMX high-speed ring can be an OC-48 or OC-192 2-Fiber UPSR. A DMX ring supports DRI with 2-fiber UPSRs, including rings using the following products:

- DMX
- WaveStar TDM 2.5G/10G (2-Fiber)
- WaveStar BandWidth Manager
- DDM-2000 OC-3
- DDM-2000 OC-12
- FT-2000 ADR

Additionally, there can be intermediate network elements in the interconnection routes between the two rings.

UPSR-to-UPSR interworking In the UPSR to UPSR interworking both UPSR DRI nodes select the better of two paths travelling in the drop direction and pass traffic to one rotation of the ring in the add direction.

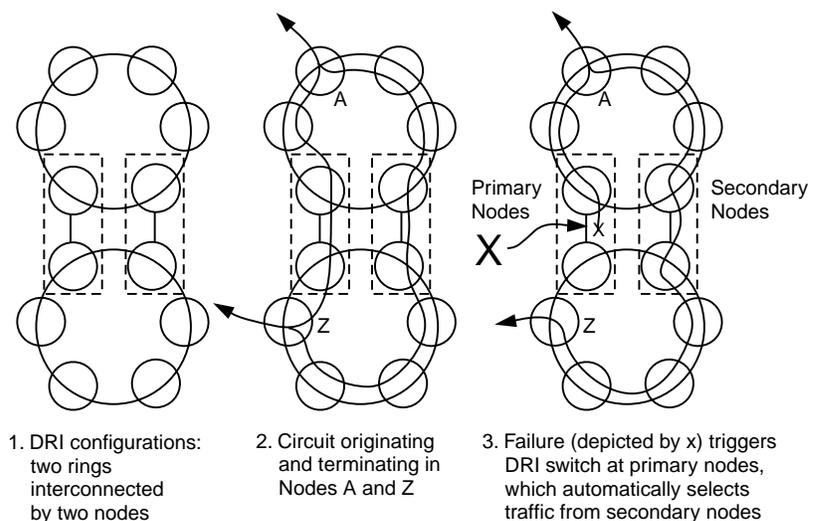
UPSR drop and continue DMX supports the drop and continue method of DRI, in which both UPSR DRI nodes select the better of two paths travelling in the drop direction and pass traffic to one rotation of the ring in the add direction. Each node drops the circuit in the direction of the other ring and no bridge to the circuit to the other DRI node is needed. The best of the 2 resulting signals is dropped at the terminating node of the new ring.

**UPSR to UPSR
protection switching
example**

The figure below illustrates a failure of the interconnection to a DRI node at the point labeled “X” in the figure. A failure in the route from Node A to Node Z results in a DRI switch at the DRI node in the lower ring. A failure in the route from Node Z to Node A results in a DRI switch at the corresponding DRI node in the top ring. As you can see, while all nodes and lines remain fully functional DRI functions as described in the section above. Both DRI nodes in the top ring select the best of the 2 signals received from that ring, and transmit them to the DRI nodes in the lower ring. The best of the signals received at the terminating node is dropped.

A DRI protection switch in a DMX occurs in ≤ 50 milliseconds (not counting the detection time) plus a provisionable hold-off time nominally of 100 milliseconds.

Figure 3-23 Dual Ring Interworking Protection



NC-DMX-149

Types of connections The two types of connections shown in the figure above are the following:

- A direct intraoffice connection between the primary nodes, Node 1 and Node 3, at the first central office (CO 1).
- An optically extended, direct secondary connection between the secondary nodes (Node 3 at the second central office (CO 2) and Node 4 of the DDM-2000 OC-3 ring). This type of connection is achieved through the OC-3 low-speed interfaces at the interconnected nodes and can go through other equipment.

Both types of connections can be used in either primary or secondary nodes.

DRI protection switching Protection switching results from specific failure conditions.

EC-1, OC-3, OC-12, OC-48, or OC-192 SONET interface

DMX DRI protection switching results from the following failure conditions (grouped by priority, from highest to lowest):

- LOP-P, AIS-P, or UNEQ-P
- Excessive STS path BER
- STS PDI-P
- STS signal degrade

DS1 or DS3 electrical interface

For DS3 interfaces, protection switching results from the following failure conditions (grouped by priority, from highest to lowest):

- LOS or OOF
- AIS



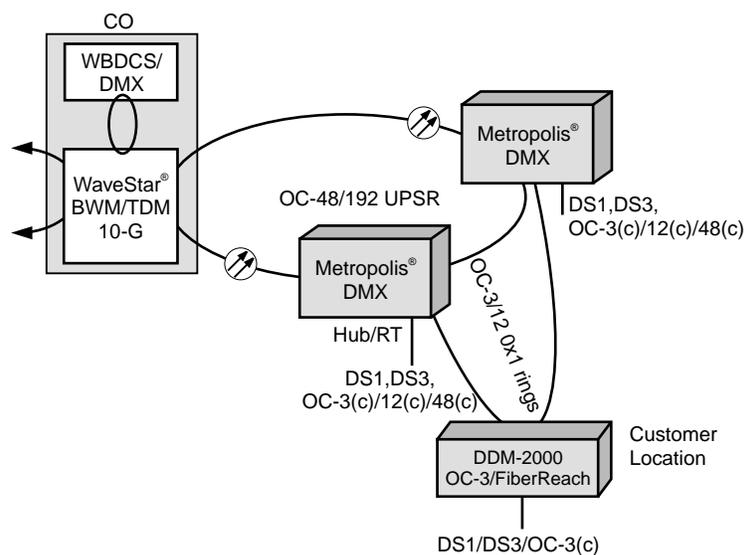
Single and Dual-Homing

Overview End users are demanding service with high availability. Service providers are responding with tariffs that rely on self-healing networks to offer high availability service. Some of these tariffs even call for penalties for the service provider when service is interrupted or has a high error rate. The Lucent SONET product family offers many options for meeting these service needs. One of these, OC-3/OC-12 ring transport on DMX ring networks, can be implemented in single- and dual-homing configurations.

For lower-density TDM applications, DMX can provide an OC-3 or OC-12 optical ring termination for a DDM-2000 OC-3 Multiplexer, DDM-2000 OC-12 Multiplexer, DDM-2000 FiberReach, or any other compliant network element. This feeder ring is useful for evolving lower-density access transport applications into high-rate access networks.

Description The figure below shows a dual-homed OC-3 extension from two remote nodes on a DMX access ring. OC-3 extensions from DMX rings are available when the DMX Function Unit groups are equipped with OC-3 OLIU (LNW36) circuit packs. OC-12 extensions from DMX rings are available when the DMX Function Unit groups are equipped with OC-12 OLIU (LNW46) circuit packs. The host nodes must be DMX NEs. For an example of single homing, see the following page.

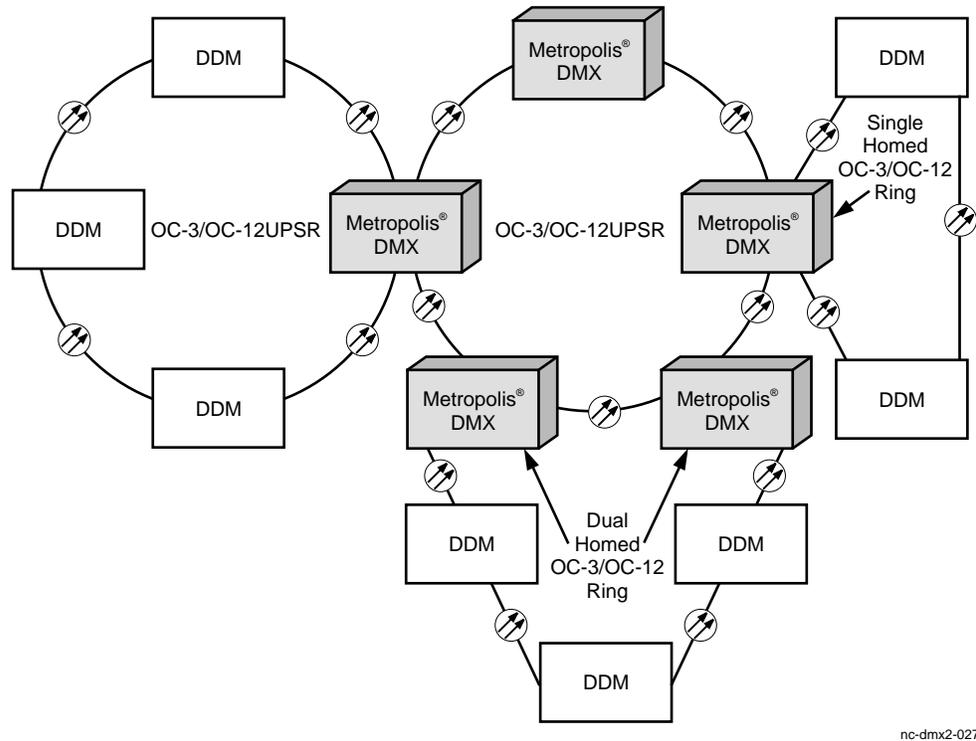
Figure 3-24 Dual Homing Example



nc-dmx-011

Description (continued) The figure below provides an example of both single and dual-homing. Path protection switching is employed for dual-homed and single-homed applications in the same manner. That is, 50 millisecond path switching is supplied by the remote DDM-2000 OC-3/OC-12/FiberReach nodes and the DMX systems. The DMX host node dual homing configuration differs from that used for single-homing because each host node terminates only one leg of the OC-3/OC-12/OC-48 extension. At each host node, a connection is made from the single OC-3/OC-12/OC-48 extension to just one rotation of the DMX host ring. Dual- and single-homed extensions can also be mixed at a host node, allowing the access network to be tailored efficiently to different groups of customers.

Figure 3-25 Multinode OC-3/OC-12 Ring with OC-48 Ring Transport



nc-dmx2-027

Configuration advantage The DMX provides a seamless transmission and operations integration with lower-capacity ring networks, as well as increased scalability for those established networks. So, single and dual-homing provide additional topological flexibility in UPSR configurations supporting voice and data services.

Hairpinning

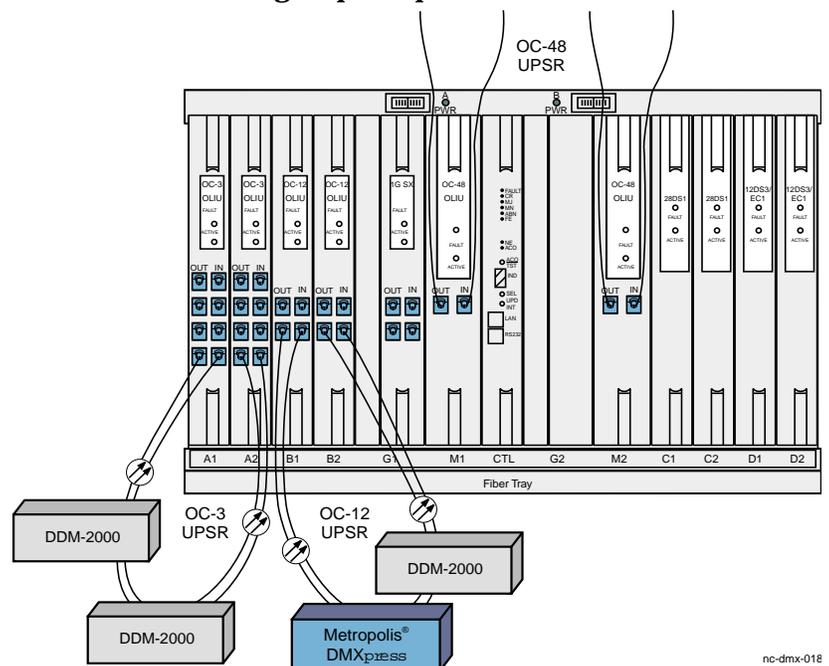
Overview The DMX supports both inter-function group and pass-through (VT ring closure) hairpinning cross-connections. These capabilities allow you to route traffic in and out of the DMX system without consuming bandwidth on the high-speed (OC-48 or OC-192) UPSR interfaces, and to host multiple rings on the low-speed interfaces of the DMX shelf (OC-48, OC-12, OC-3).

Inter-function group hairpin

In a “hairpinning” topology, low-speed tributary traffic is routed into the system and back out of the system without ever being placed on the high-speed (OC-48 or OC-192) UPSR interfaces. The cross-connection capability of connecting any input on a circuit pack in a function or growth slot to any output on a circuit pack in a different function or growth slot of the same shelf allows you to use a combination of add/drop and hairpinning of compatible payloads through a variety of interfaces. You can bring traffic in from one remote site and cross-connect it at the STS-1, STS-3c, STS-12c (Release 1.1), VT, or STS-48c (both in Release 2.0) level back out to other remote sites without consuming any capacity on the high-speed UPSRs.

The figure below demonstrates a topology in which traffic is hairpinned among OC-12 and OC-3 low-speed interfaces. For instance, a signal dropped from the OC-3 UPSR in the bottom left of the figure can travel out of the DMX on the OC-12 UPSR on a completely different tributary.

Figure 3-26 Inter-function group hairpin

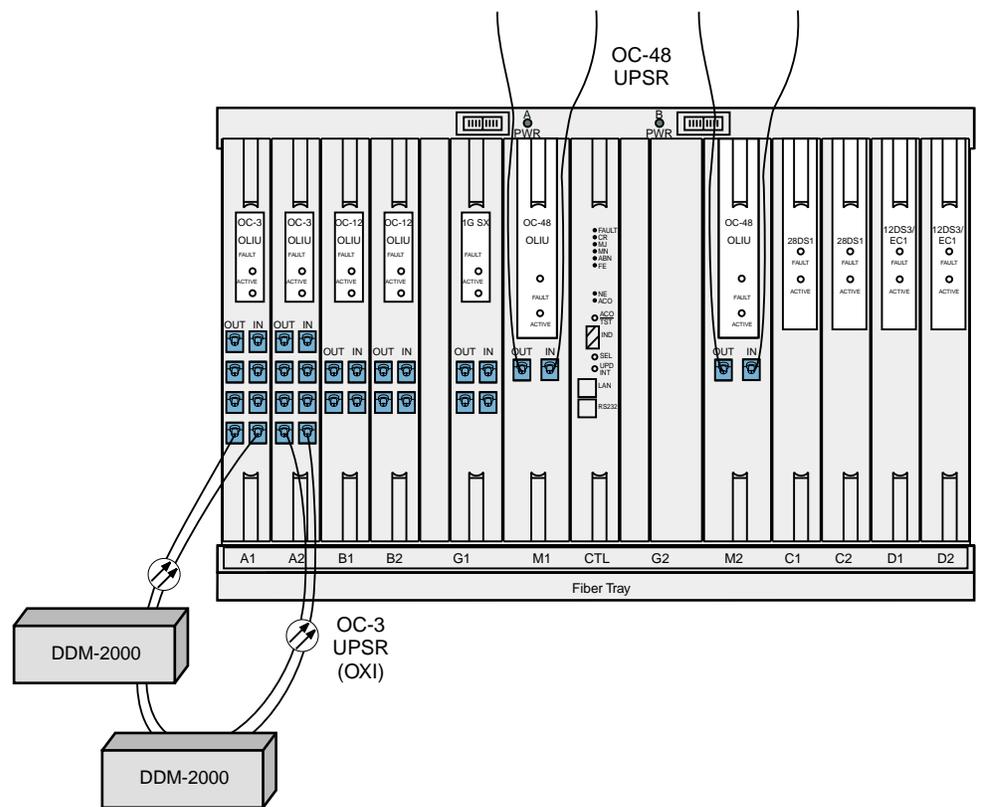


Low-speed Ring closure

The DMX can host multiple rings on the low-speed interfaces of the DMX shelf. This is accomplished by intra-function group, hairpin cross-connections that allow a signal to be “passed-through” a ring node on the same timeslot. The DMX can close a low-speed ring by supporting a cross-connection between a receive port on one circuit pack and a corresponding transmit port on another companion circuit pack in the same function or growth group. All protection switching advantages/capabilities of UPSR configurations still apply in low-speed ring closure applications.

The figure below demonstrates a pass-through topology in which both an OC-3 or OC-12 ring is being hosted on the low-speed interfaces alone. Notice that this consumes no bandwidth on the OC-48, high-speed UPSR in the top of the figure.

Figure 3-27 low-speed ring closure



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Linear Optical Extensions

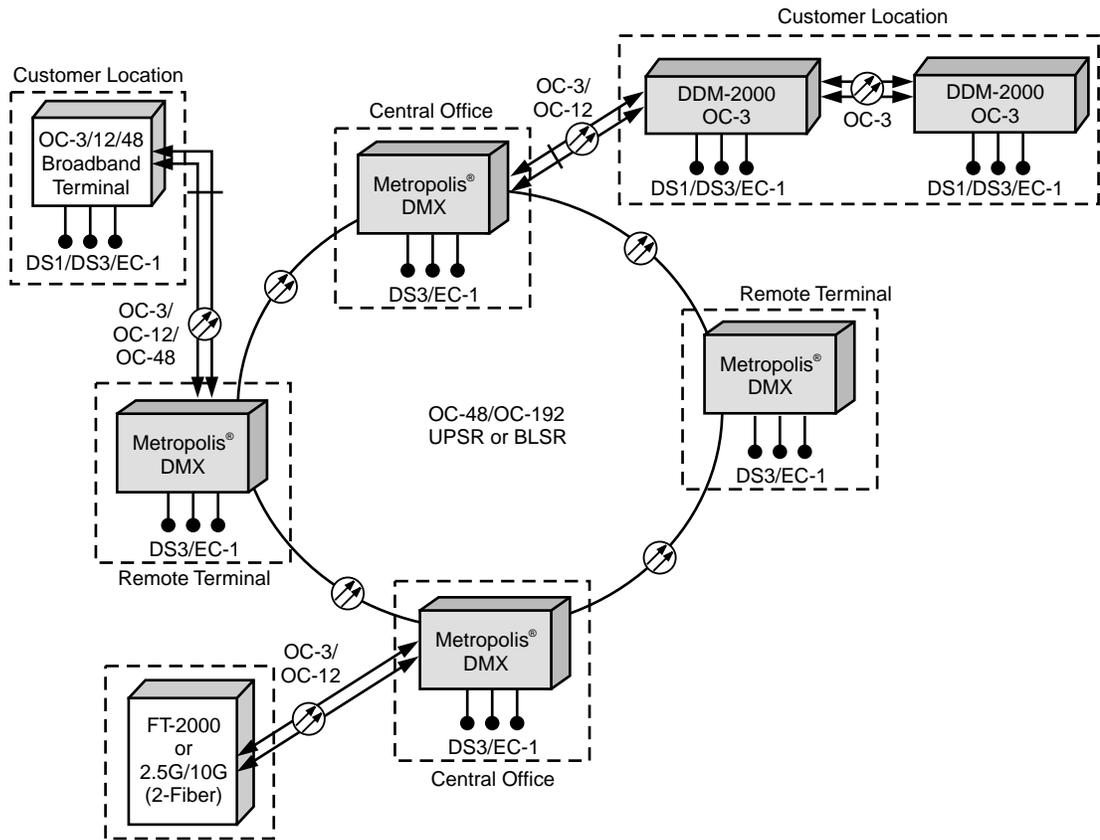
Overview An additional topological flexibility offered by the DMX is 1+1 protected linear OC-3, OC-12, and OC-48 optical extensions from the DMX ring. Using this capability, DMX can support many of the new network configurations desired in evolving access networks.

Description An access provider can use linear optical extensions from an OC-48/OC-192 ring to provide OC-3(c), OC-12(c), and OC-48(c) signals directly to end users. This gives the end users the bandwidth they need for large bandwidth applications, such as video, data, and ATM.

Linear optical extensions can also be used to interconnect SONET subnetworks. Examples include interconnection of two access networks and interconnection between access and interoffice rings. Optical extensions can be used to interconnect DMX ring networks to an OC-3, OC-12, or OC-48 terminal, an OC-3, OC-12, OC-48, or OC-192 add/drop network, or another OC-3, OC-12, OC-48, or OC-192 ring. In a linear optical extension, the node performing the path switching closes the ring.

The figure below, shows a DMX OC-48/OC-192 path switched ring with OC-3/OC-12/OC-48 services using linear optical extensions.

Figure 3-28 Linear Optical Extensions



nc-dmx-010

Configuration advantage Optical extensions from a DMX ring provide fast, reliable transport of voice, video, data, and ATM directly to end users when fiber topologies warrant protected linear (rather than ring) connections.



4 Product Description

Overview

Purpose This chapter provides a detailed view of the DMX Access Multiplexer architecture. After introducing the DMX shelf, this chapter describes the system circuit packs, control, power, and cabling.

Contents The following hardware is described in this chapter:

Shelf Description	4 - 2
Circuit Packs	4 - 7
Circuit Pack Descriptions	4 - 10
Passive Optics Units (POUs)	4 - 21
External Optical Amplifier	4 - 26
Control	4 - 28
Power Specifications	4 - 30
Cabling	4 - 32



Shelf Description

Overview The DMX is a single-shelf multiplexer that may house DS1, DS3/EC1, TransMUX, OC-3, OC-12, OC-48, OC-192, 10/100T, 1G SX, and 1G LX circuit packs.

Size and capacity Each Function Unit slot in the DMX shelf has a 2.5 Gb/s IO capacity. The Growth slots have 5 Gb/s capacity, and the Main slots have 10 Gb/s. Up to four systems can fit in a bay (including Fan Unit), and all shelves are individually mounted.

The dimensions of the Standard DMX shelf are below (dimensions including fan unit in parenthesis):

- Width: 17.6 inches (17.6)
- Height: 16 inches (19.5)
- Depth (front to back): 13.75 inches
- Weight (Max.): 20 pounds.

The dimensions for the High-capacity shelf (which includes a fan unit) are below:

- Width: 17.6 inches
- Height: 19 inches (includes integral fan unit)
- Depth (front to back): 13.75 inches
- Weight (with circuit packs): 57 pounds
- Weight (without circuit packs): 38 pounds

High Capacity Shelf In Release 2.1 a new version of the DMX shelf becomes available. Though the availability of this new high capacity shelf coincides with Release 2.1, the functionality of the shelf is not software dependant. Thus, the high capacity shelf can operate using any release of DMX software.

This new design incorporates additional DS1/DS3 D-SUB cable connectors on the rear of the shelf that enable the DMX to support 224 DS1s or 192 DS3s. In order to support this amount of traffic, the DMX high capacity shelf must be equipped with new, higher density DS1 and DS3 circuit packs that become available in Release 3.1.

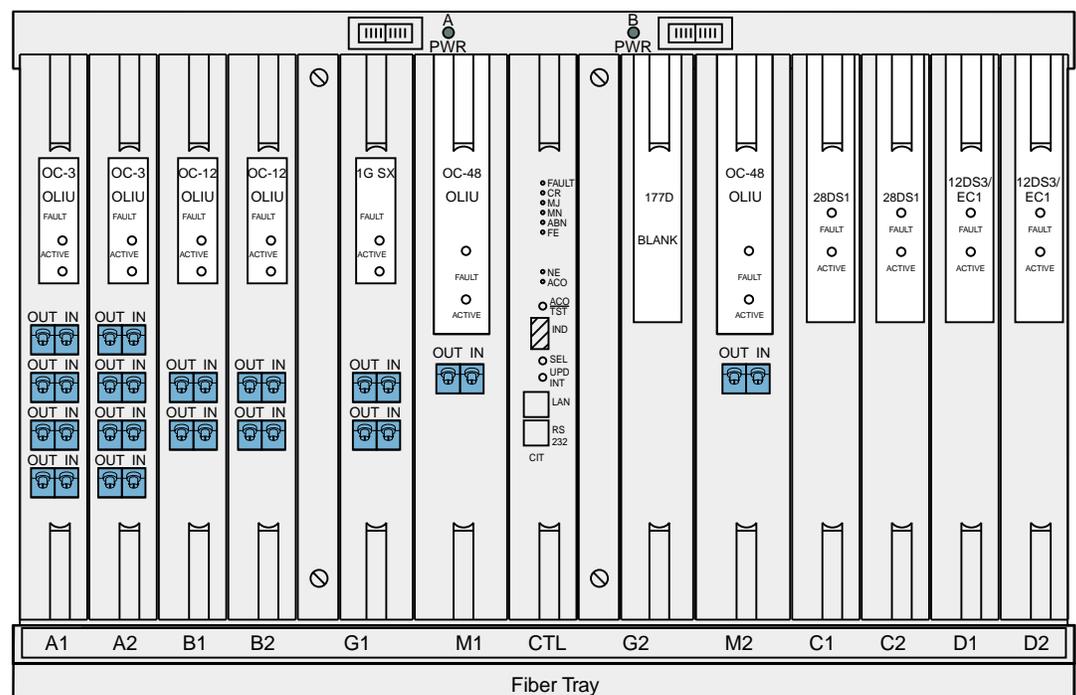
All other existing and future electrical, optical, and Ethernet circuit packs can also be used in the high capacity shelf.

Front view The figure below shows the front of the DMX shelf equipped with the following:

- quad OC-3 circuit packs in Function Unit group A
- dual OC-12 circuit packs in Function Unit group B
- 28DS1 circuit packs in Function Unit group C
- 12DS3/EC1 circuit packs in Function Unit group D
- a dual 1G SX circuit pack in Growth slot G1
- an apparatus blank in Growth slot G2
- OC-48 circuit packs in Main slots 1 and 2
- SYSCTL circuit pack in the CTL slot.

Note that high-speed OC-192 and OC-12 network interface OLIUs are not pictured, but could populate Main slots 1 and 2; 10/100T circuit packs are not pictured, but could populate slot 1 of Function Unit groups A, B, C, and D; 1G LX (2 or 4 port) circuit packs are not pictured, but could also populate slot 1 of Function Unit groups A, B, C, and D, as well as Growth slot G1. TransMUX, 56DS1, and 48DS3 circuit packs not pictured, but could populate slots 1 and 2 of Function Groups A-D (56DS1 and 48DS3 only in high capacity shelf).

Figure 4-1 Shelf Front View



Front view description

As shown in Figure 4-1, Shelf Front View (4-3), the DMX shelf contains 10 Function Unit slots (including Growth slots), 2 Main slots, and one CTL slot.

Function units

The Function Units are divided into five groups designated A, B, C, D, and G (Growth slots). Function Unit groups A through D can be equipped, depending on the application, with DS1 (28 or 56), DS3/EC1 (12 or 48), TransMUX, OC-3, OC-12, OC-48, 10/100T, 1G SX, or 1G LX circuit packs. Function Units A-D in the high capacity shelf can be populated with all of the above listed packs, as well as with the 56DS1 and 48DS3 circuit packs. 10/100T, 1G SX, and 1G LX circuit packs cannot be protected and must be inserted into slot 1 of a Function Unit group. Slot 2 must contain an apparatus blank if an ethernet circuit pack is housed in slot 1.

Growth slots

Function Unit G (Growth slots) may house OC-3, OC-12, and OC-48 OLIUs, as well as the 1G SX and 1G LX gigabit ethernet interfaces. 1G SX and 1G LX circuit packs cannot be protected and must be housed in slot G1. Slot G2 must contain an apparatus blank if an ethernet circuit pack is housed in slot G1. Protection is available for OC-3, OC-12, OC-48 circuit packs.

Main slots

The Main slots are reserved for service and protection main OC-12, OC-48, or OC-192 OLIU circuit packs. The stratum 3 timing generator and main TDM switch fabrics are embedded in both circuit packs.

Control slot

The CTL slot is reserved for the non-redundant System Controller (SYSCTL) circuit pack.

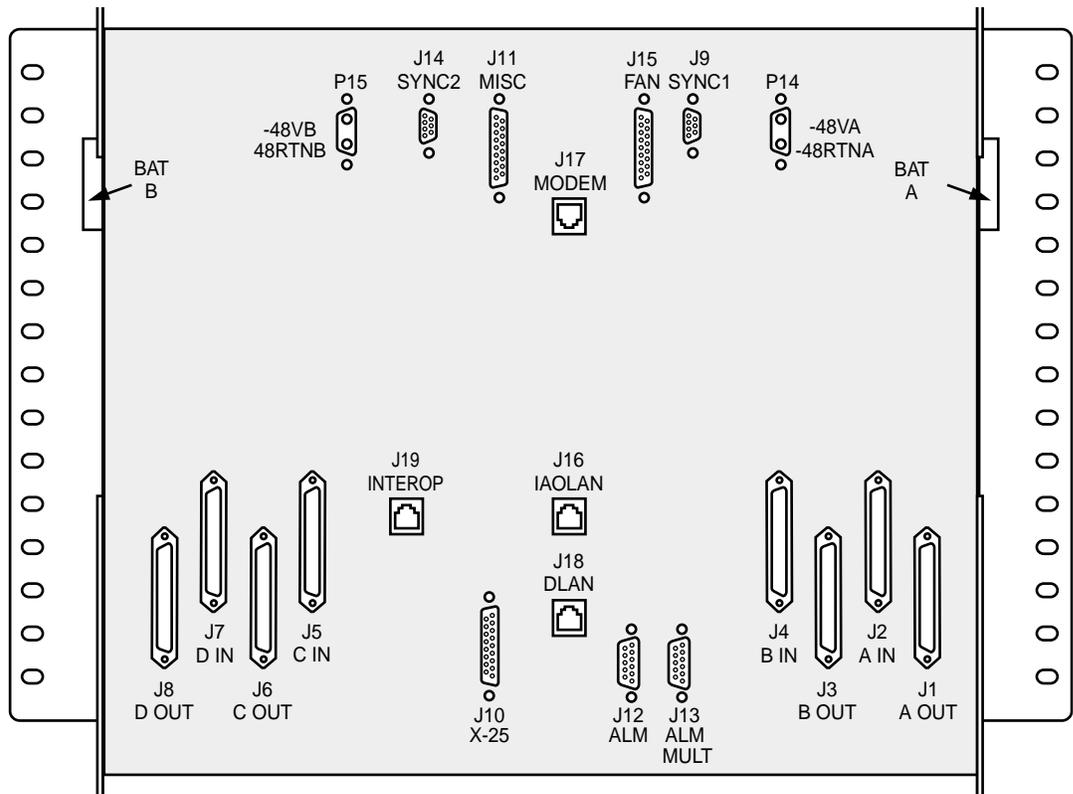
Fan Unit

Not pictured in this view of the shelf is the fan unit. In the standard shelf, the fan unit is a separate entity. It is the same width and depth as the DMX standard shelf, and is mounted above the shelf.

In the DMX High-capacity shelf, the fan unit is included. The height of the High-capacity shelf is less than that of the standard shelf and fan unit combined.

Rear view (standard shelf)

The figure below shows the various jacks and cable inputs on the backplane of the standard shelf.

Figure 4-2 Standard Shelf Backplane**Backplane description**

As shown in Figure 4-2, Shelf Backplane (4-5), the DMX contains jacks for communication with a MODEM and IAOLAN.

The backplane also contains the following cabling inputs:

- two synchronization (SYNC1 and SYNC2)
- one fan (FAN)
- two power (P14, P15)
- one miscellaneous discrete (MISC)
- one X.25
- one office alarm (ALM)
- one office alarm mult (ALM MULT)
- four DS1/DS3 inputs (J1, J3, J6, J8)
- four DS1/DS3 outputs (J2, J4, J5, J7).

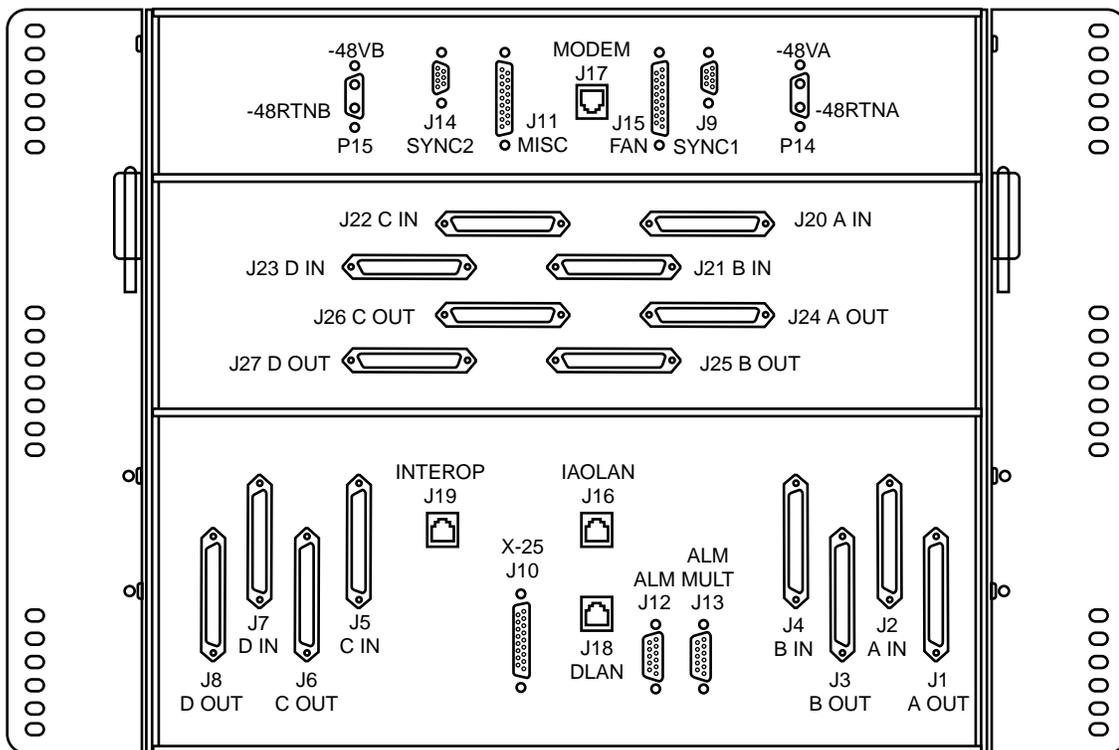
The power interfaces (BAT A and BAT B) are located on the side of the shelf.

Rear view (high-capacity shelf)

The figure below shows the various jacks and cable inputs on the DMX high-capacity shelf backplane. Notice the 8 additional D-SUB connectors in the middle of the shelf.

The high-capacity shelf supports all of the circuit packs used by the standard DMX shelf. The only difference between the two shelves is the 8 additional D-SUB connectors on the rear of the high-capacity shelf (shown below). Thus, while the high density DS1 and DS3 circuit packs needed to support the increased capacity of 224 DS1s or 192 DS3s will not be available until Release 3.1, it is still advisable to order the high-capacity shelf and additional cables now if it is determined that the increased DS1/DS3 capacity will be needed in the future.

Figure 4-3 High-capacity Shelf Backplane



NC-DMX-156

Circuit Packs

Available circuit packs The table below contains a list of each circuit pack supported by the DMX, indicates which slots they are able to be housed in, and in what release each circuit pack is available.

Table 4-1 Circuit Packs in DMX Shelf

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
System Controller (SYSCTL)	LNW1	CTL	1.0	extended temp. certification for outside cabinet deployment (OSP Hardened)
OC-192 OLIU	LNW56	M1, M2	2.1	High-speed, intermediate reach, 1550nm, 48 STS-1 VT fabric
OC-192 OLIU	LNW58	M1, M2	2.1	High-speed, short reach, 1310nm, 48 STS-1 VT fabric
OC-192 DWDM OLIU	LNW521-LNW559	M1, M2	3.1	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range, 48 STS-1 VT fabric.
OC-48 OLIU	LNW29	M1, M2	2.1	High-speed, long reach, 1550nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW26	M1, M2	1.0	High-speed, long reach, 1310nm, 6 STS-1 VT fabric
OC-48 OLIU	LNW26B	M1, M2	2.0	High-speed, long reach, 1310nm, 12 STS-1 VT fabric
OC-48 OLIU	LNW28	M1, M2	1.0	High-speed, long reach, 1310nm, 12 STS-1 VT fabric, OSP Hardened
OC-48 OLIU	LNW27	M1, M2	2.1	High-speed, long reach, 1310nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW31	A-D, G1, G2	2.0	Low-speed, intermediate reach, 1310nm, 12 STS-1 VT fabric
OC-48 OLIU	LNW76	M1, M2	2.1	High-speed, short reach, 1310nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW77	M1, M2	2.0	High-speed, intermediate reach, 1310nm, 12 STS-1 VT fabric

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
OC-48 OLIU	LNW121B- LNW159B and LNW221- LNW259	M1, M2	2.0 and 2.1	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range. The 121B series supports 12 STS-1 VT fabric while the 221 series supports 48 STS-1 VT mapping.
OC-48 OLIU	LNW421- LNW459	A-D, G1, G2	3.0	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range. 6 STS-1 VT fabric.
OC-12 OLIU (2 ports)	LNW46	A-D, G1, G2	1.1	Low-speed, long reach. 1310 nm, OSP Hardened
OC-12 OLIU (2 ports)	LNW48	M1, M2	3.1	High-speed, Intermediate reach. 1310 nm, OSP Hardened
OC-3 OLIU (4 ports)	LNW36	A-D, G1, G2	1.1	Low-speed, long reach. 1310 nm, OSP Hardened
12DS3/EC1	LNW16	A-D	1.0	12 ports, OSP Hardened
48DS3/EC1	LNW19	A-D	3.1	48 ports, for use in DMX High Capacity Shelf, OSP Hardened
DS1/DS3 TransMUX	LNW18	A-D	3.0	12 ports, receives/transmits both DS1 and DS3 signals
28DS1	LNW6	A-D	1.0	28 ports, OSP Hardened
28DS1PM	LNW7	A-D	1.0	28 ports, OSP Hardened
56DS1PM	LNW8	A-D	3.1	56 ports, for use in DMX High Capacity Shelf, OSP Hardened
10/100T (24 ports)	LNW66	A1, B1, C1, D1	1.1	100 BASE-TX ethernet interface, may only occupy slot 1 of a function group
10/100T (24 ports) Private Line	LNW71	A1, B1, C1, D1	3.0	Same specifications as LNW66, but supports Ethernet Private Lines
10/100T (24 ports) for Ethernet Enhancements	LNW69	A1, B1, C1, D1	3.1	Same specifications as LNW66, but supports Enhanced Ethernet features (CIR, PIR, Spanning Tree per VLAN)
1GbE SX (2 ports)	LNW67	A1, B1, C1, D1, G1	1.1	1000 BASE-SX ethernet interface, may only occupy slot 1 of a function group or a growth slot

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
1GbE LX (2 ports)	LNW68	A1, B1, C1, D1, G1	1.1	1000 BASE-LX ethernet interface, may only occupy slot 1 of a function group or a growth slot
1GbE (4 ports) for Ethernet Enhancements	LNW70	A1, B1, C1, D1, G1	3.1	Supports Enhanced Ethernet features (CIR, PIR, Spanning Tree per VLAN) and small form factor pluggable optics
Apparatus Blank	177D	A-D, G1, G2	1.0	Filler plates to be used in unpopulated slots of the DMX shelf
Apparatus Blank	177E	M1, M2	1.0	Filler plates to be used in unpopulated slots of the DMX shelf



Circuit Pack Descriptions

Overview This section briefly describes DMX circuit packs.

System Controller (LNW1) The SYSCTL provides communication with other circuit packs on the DMX shelf. The SYSCTL supports all DMX operations interfaces, including IAO LAN (OSI or TCP/IP), TL1/X.25, PC-CIT, office alarms, and miscellaneous discretes. The SYSCTL also supports DCC terminations for each optical line interface, a cross-connect fabric that supports path switching, and timing functions.

The SYSCTL faceplate has push-button switches, alarm/status LEDs, and a 7-segment numeric display to facilitate local operations. The SYSCTL provides redundancy by duplicating all cross-connect information on the OLIU circuit packs. Transmission is not affected if the SYSCTL fails.

The SYSCTL circuit pack provides a microprocessor, nonvolatile memory to store the generic program software and provisioning database, and additional memory for system operation. The SYSCTL circuit pack also has interfaces across the backplane to monitor and control every circuit pack in the shelf.

The SYSCTL supports PC-CIT front access to the DMX via the IAO LAN (Release 1.1) and a serial RS-232 port located on the back of the DMX shelf.

**28DS1 (LNW6) and
28DS1PM (LNW7)**

These circuit packs contain 28 DS1 ports that can be cross-connected to VT1.5 timeslots when the system is operating with a UPSR or 1+1 Main interface. Both packs are 1x1 protected, and non-revertive protection switching is supported. Line build-outs and DS1 signal encoding are software provisionable. Both circuit packs terminate up to 28 bidirectional DS1 electrical signals and support the transport of DS1 signals coded in either alternate mark inversion (AMI) or bipolar 8-zero substitution (B8ZS) modes. The signals received from the DSX-1 are mapped into SONET VT1.5 signals and then routed to the high-speed OLIU circuit pack.

Both circuit packs can occupy Function Unit groups A, B, C, and D. All electric interface circuit packs are 1x1 hardware protected. So, although both slots in each function group can house a LNW6 or LNW7 circuit pack, one slot in each function group populated by LNW6 or LNW7 circuit packs is always used for hardware protection. Thus the DMX shelf supports up to 112 working ports when four Function Unit groups are equipped with the LNW6 or LNW7 circuit pack.

In addition to maintenance and provisioning functions, the 28DS1PM circuit pack provides performance monitoring capabilities.

56DS1PM (LNW8)

These circuit packs can be used only in the high capacity shelf and contain 56 DS1 ports that can be cross-connected to VT1.5 timeslots. 56DS1 packs are 1x1 protected, and non-revertive protection switching is supported. Line build-outs and DS1 signal encoding are software provisionable. These packs terminate up to 56 bidirectional DS1 electrical signals and support the transport of DS1 signals coded in either alternate mark inversion (AMI) or bipolar 8-zero substitution (B8ZS) modes. The signals received from the DSX-1 are mapped into SONET VT1.5 signals and then routed to the high-speed OLIU circuit pack.

56DS1PM circuit packs can occupy Function Unit groups A, B, C, and D. All electric interface circuit packs are 1x1 hardware protected. So, although both slots in each function group can house a LNW8 circuit packs, one slot in each function group populated by LNW8 circuit packs is always used for hardware protection. Thus the DMX shelf supports up to 224 working ports when four Function Unit groups are equipped with the LNW8 circuit pack.

In addition to maintenance and provisioning functions, the 56DS1PM circuit pack provides performance monitoring capabilities.

12DS3/EC1 (LNW16) The 12DS3/EC1 (LNW16) circuit pack contains 12 ports, is 1x1 protected, and supports non-revertive protection switching. The 12DS3/EC1 circuit pack provides bidirectional transport of 12 DS3 signals and maps the DS3 signals into STS-1 signals, and supports transport of DS3 signals coded in bipolar 3-zero substitution (B3ZS). In Release 2.0, DS3 or EC-1 service will be provisionable on a per-port basis within each pack.

The LNW16 may occupy Function Unit groups A, B, C, and D, on the DMX shelf. All electric interface circuit packs are 1x1 hardware protected. So, although both slots in each function group can house a LNW16 circuit pack, one slot in each function group populated by LNW16 circuit pack is always used for hardware protection. Thus the DMX shelf supports up to 48 working ports when four Function Unit groups are equipped with the LNW16 circuit packs.

48DS3/EC1 (LNW19) The 48DS3/EC1 (LNW19) circuit pack can be used only in the high capacity shelf, contains 48 ports, is 1x1 protected, and supports non-revertive protection switching. The 48DS3/EC1 circuit pack provides bidirectional transport of 48 DS3 signals and maps the DS3 signals into corresponding STS-1 signals, and supports transport of DS3 signals coded in bipolar 3-zero substitution (B3ZS). DS3 or EC-1 service is provisionable on a per-port basis within each pack.

The LNW19 may occupy Function Unit groups A, B, C, and D, on the DMX shelf. All electric interface circuit packs are 1x1 hardware protected. So, although both slots in each function group can house a LNW19 circuit pack, one slot in each function group populated by LNW19 circuit pack is always used for hardware protection. Thus the DMX shelf supports up to 192 working ports when four Function Unit groups are equipped with the LNW19 circuit packs.

**Trans/MUX circuit pack
(LNW18)**

DMX supports a 12-port Trans/MUX card that can collect various DS1 signals from around a ring and combine them into a channelized DS3 signal.

The LNW18 may occupy Function Unit groups A, B, C, and D, on the DMX shelf. All electric interface circuit packs are 1x1 hardware protected. So, although both slots in each function group can house a LNW18 circuit pack, one slot in each function group populated by LNW18 circuit pack is always used for hardware protection. Thus the DMX shelf supports up to 48 working ports when four Function Unit groups are equipped with the LNW18 circuit packs.

The Trans/MUX circuit pack functions in the following manner:

Transmit Functions

- Receives a B3ZS-encoded DS3 signal from a DSX-3
- Recovers DS3 clock and NRZ data
- Calculates parity errors on the DS3 input
- Demultiplexes the M13 or C-bit formatted DS3 signal into 28 DS1s
- Maps the 28 DS1s into VT1.5s and then into an STS-1
- Inserts STS-1 path overhead
- Provides the STS-1 signal to the OLIU circuit packs

Receive Functions

- Interprets the STS-1 pointer values
- Terminates the STS-1 path
- Disinterleaves the STS-1 signal into 28 VT1.5s and interprets VT pointer values
- Converts the VT1.5 signals to 28 DS1 signals
- Multiplexes the 28 DS1 signals to an M13 or C-bit formatted DS3 signal
- B3ZS encodes the outgoing DS3 signal
- Pre-equalizes the DS3 signal (with LBO) and transmits it to a DSX-3

OC-3 OLIU (LNW36) The quad OC-3 OLIU (LNW36) low speed circuit pack is a four-port, long-reach, 1310 nm optical line interface unit supporting VT1.5, STS-1 and STS-3(c) path switching. The OC-3 OLIU can interface with other OC-3 rings in the network and can also be used as an interface for OC-3 linear optical extensions, as well as single- and dual- homed ring extensions. Fiber access is provided via four pairs of LC-type connectors on the LNW36 faceplate.

The LNW36 can occupy any Function Unit group on the DMX shelf (including Growth slots), and up to 40 ports are addressable when all Function Unit groups are equipped with the LNW36 circuit pack.

OC-12 OLIU (LNW46) The dual OC-12 OLIU (LNW46) low speed circuit pack is a two-port, long-reach, 1310 nm optical line interface unit supporting VT1.5, STS-1, STS-3(c), and STS-12(c) path switching. The LNW46 provides an OC-12 interface to other OC-12 rings, linear optical extensions, and single- and dual-homed ring extensions. Fiber access is provided via two pairs of LC-type connectors on the LNW46 faceplate.

The LNW46 can occupy any Function Unit group on the DMX shelf (including Growth slots), and up to 20 ports are addressable when all Function Unit groups are equipped with the LNW46 circuit pack.

OC-12 OLIU (LNW48) The OC-12 OLIU (LNW48) high speed circuit pack is an intermediate reach 1310 nm circuit pack. The LNW48 supports OC-12 add/drop, UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), and STS-12(c) signal transport. The LNW48 OLIU can cross-connect VTs in 12 of 12 STS-1s. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-12 OLIU.

The LNW48 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW48 faceplate.

OC-48 OLIU (LNW26) The OC-48 OLIU (LNW26) high speed circuit pack is a long reach 1310 nm optical line interface unit. The LNW26 supports OC-48 add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW26 OLIU can cross-connect VTs in any 6 of 48 selected STS-1s. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW26 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW26 faceplate.

OC-48 OLIU (LNW26B) The OC-48 OLIU (LNW26B) high speed circuit pack is a long reach OC-48, 1310 nm optical line interface unit. The LNW26 supports OC-48 add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW26B pack can cross-connect VTs in 12 of 48 STS-1s of the OC-48 signal. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW26B may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW26B faceplate.

OC-48 OLIU (LNW27) The LNW27 high speed circuit pack is a long reach OC-48, 1310 nm optical line interface unit. The LNW27 supports OC-48 add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW27 circuit pack can cross-connect VTs in all 48 STS-1s of the OC-48 signal.

The LNW27 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW27 faceplate.

OC-48 OLIU (LNW28) The LNW28 has the same capabilities as the LNW26B circuit pack. It is, however, designed specifically for outside cabinet deployment and has been certified to withstand extreme temperatures.

The OC-48 OLIU (LNW28) high speed circuit pack is a long reach 1310 nm optical line interface unit. The LNW28 supports OC-48 add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW28 can cross-connect 12 of 48 selected STS-1s in Release 2.1. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW28 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW28 faceplate.

OC-48 OLIU (LNW29) The LNW29 high speed circuit pack is a long reach OC-48, 1550 nm optical line interface unit. The LNW29 supports OC-48 add/drop, BLSR, UPSR, and 1+1 configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW29, like the LNW27 circuit pack, can cross-connect VTs in all 48 STS-1s of the OC-48 signal.

The LNW29 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW29 faceplate.

OC-48 Tributary OLIU (LNW31) The OC-48 OLIU (LNW31) circuit pack is a single port (bidirectional), low speed, intermediate reach, OC-48 1310 nm optical line interface unit. The LNW31 supports OC-48 add/drop, BLSR, UPSR, and 1+1 configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW31 circuit pack can route VTs in 12 STS-1s of the OC-48 signal to the MAIN circuit packs for VT grooming. The central TDM switch/grooming fabrics are embedded in the OC-48 MAIN OLIU.

The LNW31 may occupy any Function Unit group on the DMX shelf (including Growth slots), and up to 10 ports are addressable when all Function Unit groups are equipped with the LNW31 circuit pack. Fiber access is provided via a pair of LC-type connectors on the LNW31 faceplate.

OC-48 OLIU (LNW76) The LNW76 (Release 2.1) high speed circuit pack is a short reach, 1310 nm optical line interface unit. It is designed for intra-office transmission. The LNW76 supports OC-48 add/drop, BLSR, UPSR, and 1+1 configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.

The LNW76 circuit pack can cross-connect VTs in all 48 STS-1s of the OC-48 signal.

The LNW76 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW76 faceplate.

OC-48 OLIU (LNW77)	<p>The LNW77 circuit pack is a intermediate reach (20km), high-speed 1310 nm optical line interface unit. The LNW77 supports OC-48 add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.</p> <p>The LNW77 pack can cross-connect VTs in 12 of 48 STS-1s of the OC-48 signal.</p> <p>The LNW77 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW77 faceplate.</p>
OC-48 High-speed (network interface) DWDM OLIUs	<p>The DMX OC-48 DWDM OLIUs are optical port units designed for use with passive MUX/DMUX and optical add/drop shelves. These are available in 32 different wavelengths. Each port unit supports two wavelengths via a special hardware configuration. These units are compatible with the SONET and SDH standards.</p> <p>The optical port units are designed to be used with the Lucent Passive Optics Units (POUs). By using the DWDM port units and the POUs, you are able to increase fiber capacity by a factor of 16 or 32.</p> <p>OC-48 DWDM OLIUs support add/drop, BLSR and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-48 OLIU.</p> <p>One set of OC-48 DWDM OLIUs can cross-connect VTs in any 12 of 48 selected STS-1s (LNW121B-159B). Another set of OC-48 DWDM OLIUs can cross-connect VTs in all 48 STS-1s of the OC-48 signal (LNW221-259). The LNW121B-159B packs are available in Release 2.0. The LNW221-259 packs are available in Release 2.1.</p> <p>The OC-48 DWDM OLIUs may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the OC-48 DWDM OLIU faceplate.</p>
OC-48 Low-speed (tributary interface) DWDM OLIUs	<p>The low-speed OC-48 DWDM OLIUs (LNW421-459) are similar to those mentioned above, except that they are tributary interface circuit packs that any Function Unit group on the DMX shelf (including Growth slots), and up to 10 ports are addressable when all Function Unit groups are equipped with the low-speed DWDM circuit packs. These packs can cross-connect VTs in any 12 of 48 selected STS-1s.</p>

OC-192 OLIU (LNW56) The OC-192 OLIU (LNW56) circuit pack is an intermediate reach 1550 nm optical line interface unit. The LNW56 supports OC-192 add/drop, UPSR, and BLSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW56 circuit pack can cross-connect VTs in any 48 of 192 STS-1s in the OC-192 signal. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-192 OLIU.

The LNW56 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW56 faceplate.

OC-192 OLIU (LNW58) The OC-192 OLIU (LNW58) circuit pack is a short reach 1550 nm optical line interface unit. The LNW58 supports OC-192 add/drop, UPSR, and BLSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The LNW58 circuit pack can cross-connect VTs in any 48 of 192 STS-1s in the OC-192 signal. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-192 OLIU.

The LNW58 may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the LNW58 faceplate.

OC-192 DWDM OLIUs (LNW521-LNW559) OC-192 DWDM OLIUs are available in Release 3.1. The DMX OC-192 DWDM OLIUs are optical port units designed for use with passive MUX/DMUX and optical add/drop shelves. DMX's OC-192 DWDM interface supports 32 different wavelengths. Each port unit supports two wavelengths via a special hardware configuration. These units are compatible with the SONET standards.

The optical port units are designed to be used with the Lucent POUs. By using the DWDM port units and the POUs, you are able to increase fiber capacity by a factor of 1 to 32.

OC-192 DWDM OLIUs support add/drop and UPSR configurations, single- and dual-homing, non-revertive protection switching, and VT1.5, STS-1, STS-3(c), STS-12(c), and STS-48(c) signal transport. The stratum 3 timing generator and central TDM switch fabrics are embedded in the OC-192 OLIU.

The OC-192 DWDM OLIUs can cross-connect VTs in any 48 STS-1s of an OC-192 signal.

The OC-192 DWDM OLIUs may occupy Main slots 1 and 2. Fiber access is provided via a pair of LC-type connectors on the OC-192 DWDM OLIU faceplate.

10/100T (LNW66) 100BASE-TX ethernet interface

The 10/100T circuit pack has 24 ports and provides data transport at the rate of 10/100 Mbps using standard ethernet switching IEEE 802.1, standard encapsulation according to *ANSI T1X1.5/2000-024R4* (ITU G.gfp), and standard STS-1 virtual concatenation according to ITU G.707. The LNW66 can transmit signals across spans as long as 100 meters. Each LNW66 circuit pack can support 1 packet ring. The LNW66 is an unprotected pack.

The 10/100T may occupy slot 1 of Function Unit groups A, B, C, and D, and 96 LNW66 ports are addressable when four Function Unit groups are equipped with LNW66 circuit packs. When the LNW66 circuit packs occupy slot 1 of a Function Unit group, slot 2 must be populated with an apparatus blank.

10/100T (LNW71) Private Line Ethernet interface

The LNW71 circuit pack conforms to the same specifications as the LNW66 described above. Yet, rather than supporting packet ring transport (like the LNW66), the LNW71 circuit pack is designed specifically to support Fast Ethernet Private Line applications. Each LNW71 circuit pack can support 24 private lines in R3.0.

10/100T (LNW69) for Ethernet Enhancements

The LNW69 circuit pack conforms to the same specifications as the LNW66 described above. The only difference is that the LNW69 circuit pack contains enhancements that enable it to support enhanced Ethernet rate shaping with CIR and PIR. Each LNW69 circuit pack can support 2 packet rings.

1G SX (LNW67) 1000BASE-SX optical ethernet interface

This 2-port Ethernet interface provides short-reach high-speed optical data transport at the rate of 1 Gb/s using standard ethernet switching IEEE 802.1, standard encapsulation according to ANSI T1X1.5/2000-024R4 (ITU G.gfp), and standard STS-1 virtual concatenation according to ITU G.707. The LNW67 is an unprotected pack. Fiber access is provided by two LC-type connector pairs on the LNW67 faceplate. The LNW67 transmits signals at a wavelength of 850nm. Each LNW67 circuit pack can support 2 packet rings or 2 GbE private lines (protected or unprotected).

The LNW67 may occupy slot 1 of any Function Unit group on the shelf (including Growth slots), and up to 10 1G SX ports are addressable when all Function Unit groups are equipped with LNW67 circuit packs. When the LNW67 circuit packs occupy slot 1 of a Function Unit group, slot 2 must be populated with an apparatus blank.

1G LX (LNW68) 1000BASE-LX optical ethernet interface

While providing the same functionality as the 1G SX interface, the LNW68 supports long-reach optics. LNW68 transmits signals at a wavelength of 1310nm. Each LNW68 circuit pack can support 2 packet rings. For more information on LNW68, please refer to the section entitled *1G LX (1000BASE-LX) Ethernet (LNW68)*, in Chapter 10.

GbE (LNW70) for Enhanced GbE Packet Ring

While providing the same functionality as the 1G SX or LX interface, the LNW70 contains enhancements that enable it to support enhanced Ethernet services such as CIR and PIR rate shaping. The LNW70 is described as both SX and LX because it supports pluggable optics that allow the user to chose which interface they need (short- or long-reach) and “plug” the appropriate optics module into the circuit pack.

The LNW70 provides space for 4 bidirectional ports instead of 2 (1 gigabit each). Each LNW70 circuit pack can support 2 packet rings, 2 SONET protected private lines, or 4 unprotected GbE private lines. For more information on LNW70, please refer to the section entitled *1G LX (1000BASE-LX) Ethernet (LNW70)*, in Chapter 10.

Important! All Ethernet circuit packs are unprotected interfaces and must occupy slot 1 of a Function Unit group (including Growth slots). When the LNW66, LNW67, LNW68, LNW69, LNW70, and LNW71 circuit packs occupy slot 1 of a Function Unit group, slot 2 must be populated with an apparatus blank.

□

Passive Optics Units (POUs)

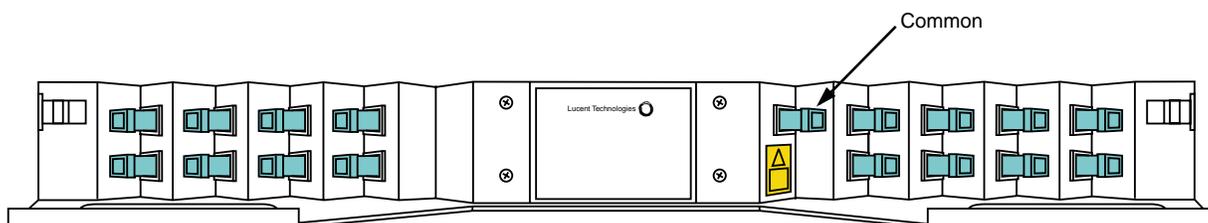
Passive Optics Units The Passive Optics Units (POUs) are a lower-cost solution to using DWDM for transmitting large amounts of traffic on one fiber. The shelf fits in a bay frame with DMX. If the POU is used in the same bay frame with DMX, then the number of DMX shelves in that bay frame is limited to three. The POUs do not need any power supply or management system.

POU shelves are available to support the following applications:

- Optical add-drop module (OADM): 1, 2, or 4 wavelengths
- 16 unidirectional/bidirectional wavelengths (2 versions): MUX/DMUX
- 32 wavelengths; 16 unidirectional/bidirectional wavelengths with a wavelength interleaver used to add another 16 wavelengths: MUXINT/DMUXINT

The following figure shows the POU shelves.

Figure 4-4 Passive Optics Unit (POU) Shelves (DWDM Filter Units): MUX/DMUX



nc-dmx-103

The dimensions of the MUX/DMUX module are:

Height (mm/inches)	Width (mm/inches)	Depth (mm/inches)
74/2.913	498/19.606	378.64/14.907

POU Versions

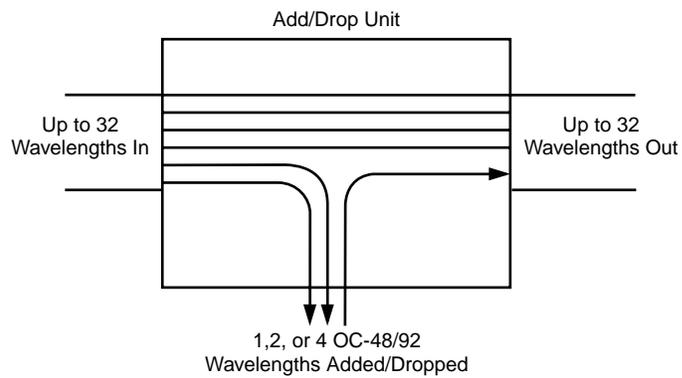
As the variety of applications listed above suggests, there are various versions of the POU, each designed to maximize functionality in a variety of deployment scenarios. The bulleted list below details the various forms of POUs:

- 16 Channel MUX: This POU supports unidirectional and bidirectional transmission systems.
- 16 Channel DMUX: This POU supports unidirectional and bidirectional transmission systems. The filters are cascaded in reverse order of the 16 Channel MUX module.
- 16 Channel MUX and Interleaver: This POU supports unidirectional and bidirectional transmission systems, and includes an interleaver to support 16 additional channels.
- 16 Channel DMUX and Interleave: This POU supports unidirectional and bidirectional transmission systems. The filters are cascaded in reverse order of the 16 Channel MUX and Interleaver POU. The POU also includes an interleaver to support 16 additional channels.
- 1 Channel Dual Optical Add Drop: This POU supports unidirectional transmission systems and can add/drop one channel from a DWDM line carrying up to 32 different channels.
- 2 Channel Dual Optical Add Drop: This POU supports unidirectional transmission systems and can add/drop one channel from a DWDM line carrying up to 32 different channels.
- 4 Channel Dual Optical Add Drop: This POU supports unidirectional transmission systems and can add/drop one channel from a DWDM line carrying up to 32 different channels.

Important! The last four bulleted items in the list above describe the various OADMs as “Dual” Optical Add Drop. Here, “Dual” is in reference to the fact the each OADM contains 2 add/drop interfaces (of the number specified-- 1, 2, or 4), enabling it to support 2 fibers carrying DWDM signals in different directions. Thus, the 1 channel OADM contains 2 add/drop interfaces, enabling it to support 1 add/drop in each direction. The 2 channel OADM, therefore, contains 4 add/drop interfaces, and the 4 channel OADM: 8.

The following figure shows a diagram of transmission with up to 32 wavelengths (channels) being received and passed-through one of the Add/Drop units. Also, the diagram shows how 1, 2, or 4 wavelengths can be added and/or dropped from a passive DWDM OC-48/192 line using the Add/Drop Units.

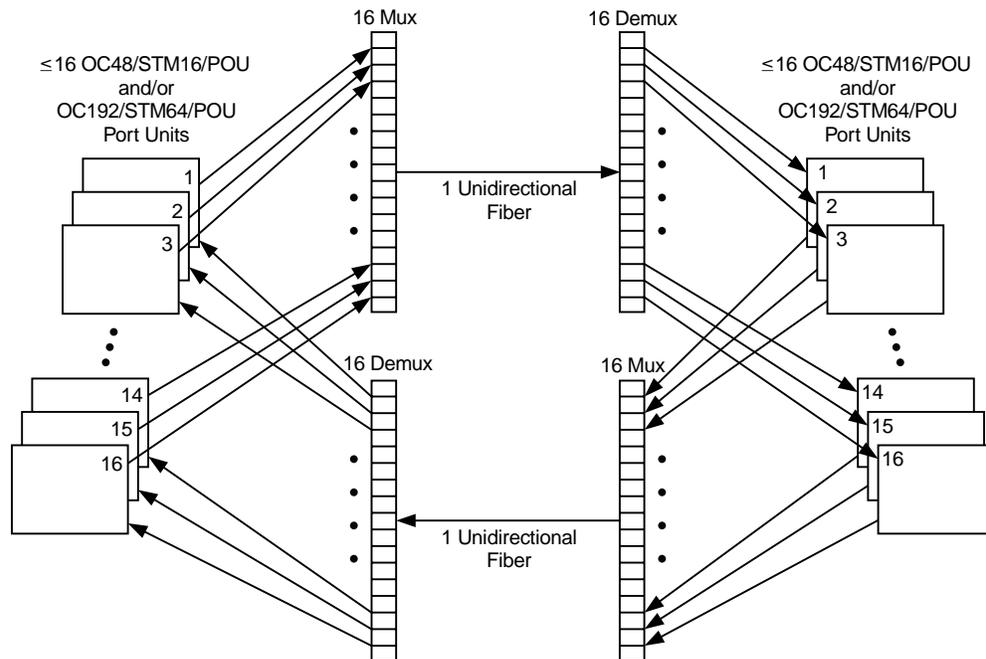
Figure 4-5 Add/Drop Unit



nc-dmx-166

The following figure shows a diagram of transmission with 16 lines transmitting at one end of the fiber and 16 lines receiving at the other end. The 16 port units on each side of transmission may be a combination of OC-192 DWDM OLIUs and/or OC-48 DWDM OLIUs (Release 2.0). Each OLIU is equipped with a bidirectional port (both transmit and receive). The fiber between the two POUs (DWDM Filter Units) on the upper portion of the figure is unidirectional in the east direction. The fiber between the two Passive Optics Shelves on the lower portion of the figure is unidirectional in the west direction. Another Passive Optics Shelf, with a wavelength interleaver, can be added to transport 32 wavelengths at the OC-192 or OC-48 rate on one fiber.

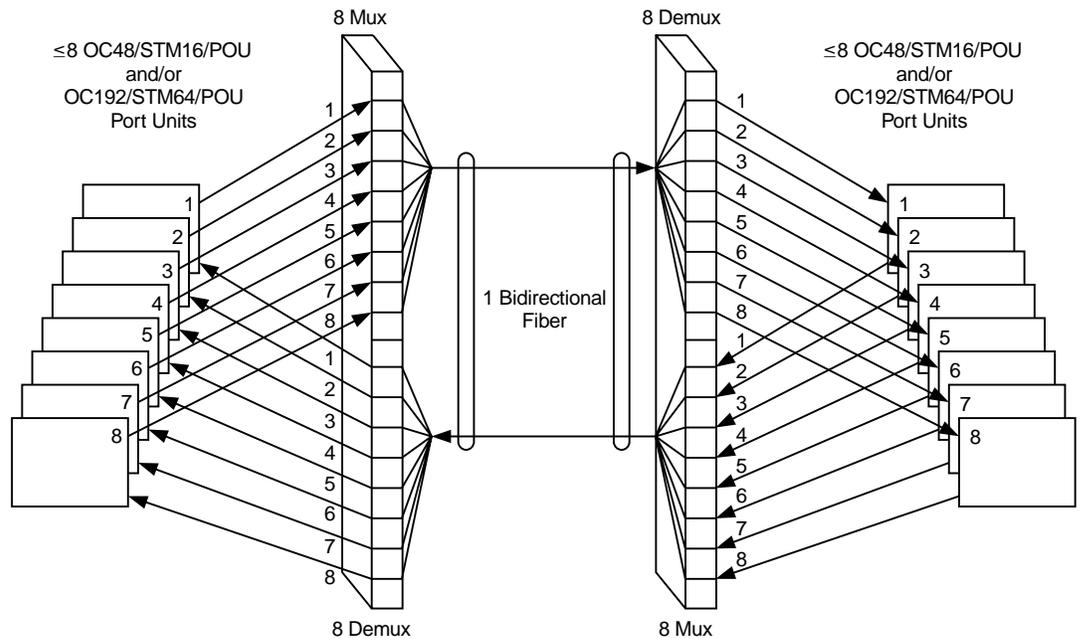
Figure 4-6 MUX/DMUX Passive Optics Shelf (16 Transmit at One End, 16 Receive at the Other End)



wbwm02021

The following figure shows a diagram of bidirectional transmission with eight lines transmitting at one end of the fiber and eight lines receiving at the other end. This is the same POU pictured above, except that it is being used in a bidirectional application. The eight port units on each side of transmission may be a combination of OC-192 DWDM OLIUs and/or OC-48 DWDM OLIUs. Each OLIU is equipped with a bidirectional port (both transmit and receive). The fiber between the two POU shelves (DWDM filter unit box) is bidirectional (transmit and receive).

Figure 4-7 MUX/DMUX Passive Optics Shelf (8 Transmit and 8 Receive at Each End)



wbwm02020

Important! This figure assumes a full set of 8 bidirectional point-to-point cross-connections.



External Optical Amplifier

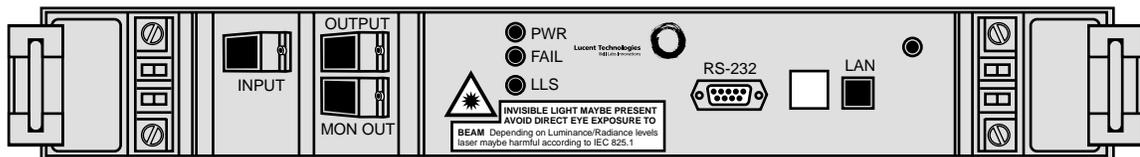
Overview The Lucent external optical amplifier provides service providers, system integrators, and network equipment manufacturers with one of the key technologies needed to build next generation DWDM and OADM networks. With the optical amplifier, operators enhance system performance while minimizing capital expenditures.

Service Delivery The optical amplifier can be configured to provide variable gain between 13 dB and 22 dB. This enables users to optimize optical transmission performance as needs grow. After gain setting is provisioned, the amplifier dynamically controls and maintains signal levels even as the number of amplified wavelengths change.

The amplifier features dynamic transient suppression and gain flattening across C-band to reduce the likelihood of data errors, channel outage, and signal degradation. In dynamic metro access networks or long-haul optical networks, these features allow service providers to provision and deliver reliable wavelength services to their end customers on demand.

Below is a rendering of the front of the amplifier unit.

Figure 4-8 External Optical Amplifier



nc-dmx2-015

Physical Attributes The table below provides the physical specifications for the optical amplifier.

Table 4-2 Physical Attributes

Specification	Measurement
Dimensions (HxWxD)	1.75x17.19x11.1
Weight	10.0 lbs
Optical Connector	SC-UPC

Operation and Maintenance

The optical amplifier provides a 10/100 Mbps and an RS-232 port for operations and maintenance communications (similar to DMX). These ports are located on the front of the unit (see figure above). The amplifier is virtually maintenance free because it has the ability to continuously monitor its own electrical and optical performance. If operating parameters exceed user-set thresholds, autonomous alarms are reported. This makes long term network operation and management extremely easy.

The amplifier may be managed by any of the following means:

- **SNMP** (Version 1 and 2c)
An embedded SNMP agent and published management information base (MIB) enable the optical amplifier to be controlled from third party SNMP management systems. See Chapter 5 for the SNMP parameters and traps supported by DMX.
- **TL1 Messages** (GR-833 CORE)
The TL1 management protocol allows management and control TCP/IP port (similar to the DMX)
- **FTP** (RFC 956)
FTP provides for remote software downloads and upgrades.
- **Alarm Relays**
Alarm Relays provide external notification of alarm conditions using contact closures.

Power Supply Requirements

The table below details the power supply requirements for the optical amplifier.

Table 4-3 Optical Amplifier Power Specifications

Item	Description
Voltage range, all components	-40.0V to -60V
Power Feeders	two -48V power feeders [BREAKER (A) and BREAKER (B)]
Current	0.52 Amps. (max.) at -48V
Power Consumption	25 Watts (max.); 6 Watts (typical) at 50° C

NOTE

The optical specifications for the optical amplifier can be found in Chapter 10, in the section entitled “External Optical Amplifier”



Control

Overview DMX provides extensive control features, accessible through a number of technician and operations system (OS) interfaces. In addition to accessing local DMX NEs through direct interfaces, technicians and OSs can use the operations features supported via the DCC in the optical signals to access remote NEs. Control functions are supported by the SYSCTL circuit pack.

Three-tiered operations interface DMX maintenance procedures are built on three levels of system information and control. The first tier is provided by the LEDs, displays, and push-button switches located on the faceplate of the SYSCTL circuit pack. The second tier uses a *DMX* PC-CIT to provision and retrieve detailed reports of performance monitoring, alarm and status, and system configuration for both local and remote NEs. The third tier uses the OS interfaces such as TL1/X.25 and TL1 over IAO LAN (TCP/IP or OSI) or PC-CIT to monitor performance, gather alarm information, and configure the system (R2.0). Also, the IAO LAN interfaces provisioned for TCP/IP support software download and provisionable database backup/restore via FTP.

SYSCTL faceplate

The faceplate of the SYSCTL circuit pack contains indicators that provide system-level information and control functions. The condition of the individual transmission circuit packs can be determined using faceplate LEDs.

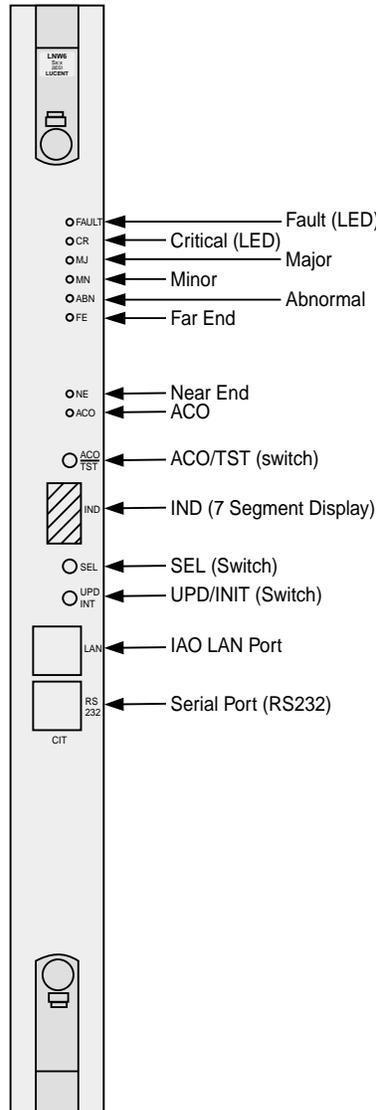
The figure on the following page, shows the SYSCTL faceplate. There is a 7-segment numeric LED display and three push-button switches for Update/Initialize (UPD/INIT), ACO/test (ACO/TEST), and Select (SEL) for local operations.

In addition to the FAULT LED which is lit if the SYSCTL detects its own failure, there are also seven alarm/status LEDs on the SYSCTL faceplate, listed below:

- Critical (CR)
- Major (MJ)
- Minor (MN)
- Abnormal (ABN)
- Far End Activity (FE)

- Near End Activity (NE)
- Alarm Cut-Off (ACO)

Figure 4-9 SYSCTL Circuit Pack



nc-dmx-001

Embedded operations channel

Access and control extends beyond the local DMX to remote DMXs via the SONET section DCC. Craft interface dialogs and operations messages are exchanged in the DCC overhead bytes on each OC-3, OC-12, OC-48, and OC-192 interface.



Power Specifications

Power supply The table below lists DMX power requirements.

Table 4-4 DMX Power Supply Requirements

Item	Description
Voltage range, all components	-40.0V to -60V
Power Feeders	two -48V power feeders [BREAKER (A) and BREAKER (B)]
Circuit Breakers (two per shelf)	20.0A

The following table lists DMX High Capacity shelf power requirements.

Table 4-5 DMX High Capacity Shelf Power Supply Requirements

Item	Description
Voltage range, all components	-40.0V to -60.0V
Power Feeders	two -48V power feeders [BREAKER (A) and BREAKER (B)]
Circuit Breakers (two per shelf)	30.0 A

Circuit breakers DMX uses on-board power conversion eliminating the need for slots for bulk power converters. Two independent -48V office power feeders (A and B) enter the shelf through connectors and are filtered and distributed to the circuit packs through circuit breakers. Power conversion is performed through modular power converters located on the circuit packs. In each circuit pack, the feeders are diode ORed, fused, filtered, and regulated by the board-mounted power modules. This provides the required redundancy in case of the loss of one feeder or circuit breaker. The green Power LEDs located next to each circuit breaker (A and B) indicate power is being fed to the breaker.

Current drains The following table provides the maximum and average current drain requirements for a shelf.

Table 4-6 Shelf Current Drains

Shelf	Current Drains per Feeder in Amperes			
	Average @ -48V	Maximum @ -48V	Average @ -40V	Maximum @ -40V
DMX Shelf	6.3	14.5	7.5	17.5
DMX High Capacity Shelf	6.3	23.0	7.5	27.5

The following table provides the maximum and average current drain requirements for a bay equipped with four shelves.

Table 4-7 Bay Current Drains

Bay	Current Drains per Feeder in Amperes			
	Average @ -48V	Maximum @ -48V	Average @ -40V	Maximum @ -40V
Bay equipped with four DMX Shelves	25.2	58.0	30.0	70.0
Bay equipped with four DMX High Capacity Shelves	25.2	92.0	30.0	110.0

The following table provides the maximum and average heat dissipation figures for both the standard DMX shelf and the High Capacity Shelf.

Table 4-8 Shelf Heat Dissipation

Shelf	Heat Dissipation in Watts			
	Average @ -48V	Maximum @ -48V	Average @ -40V	Maximum @ -40V
DMX Standard Shelf	260	700	260	700
DMX High Capacity	260	700	260	700

Cabling

Overview This section briefly describes cabling information, including the number of particular cables required. For information regarding available cable lengths and ordering comcodes, refer to Table 7-2, Orderable Cables (7-5).

Cable types The table below lists available cables along with the required number (if any).

Table 4-9 Cables

Cable Assembly Description	Quantity per Shelf	See Note
Power	1 per shelf	1
DS1	1 per Function Unit housing a 28DS1 circuit pack (as required)	2
DS3/EC1	1 per Function Unit housing a 12DS3/EC1 circuit pack (as required)	3
X.25 - X.25	variable	4
X.25 - Switch	variable	4
Office Alarm	1 (bottom shelf in bay frame only)	5
Office Alarm Mult	1 for any adjacent shelves (as required)	6
Miscellaneous Discrete	1 per shelf (as required)	
LAN 10/100 BaseT (Crossover)	1 per shelf (as required)	7
LAN 10/100 BaseT (Straight Through)	1 per shelf (as required)	7
LAN 100 BASE-TX	1 per shelf (as required)	
Sync Timing	1 per shelf (as required)	
PC-CIT Interface	1 per shelf (as required)	
Modem Cable Assembly	1 per shelf (as required)	

Table notes

1. One cable assembly supports both the -48VA and -48VB main power feeders on the DMX shelf. Cable assemblies are available in 2,4, and 6 AWG cable kits including the required Storey connectors for connection a the shelf. The connectors are also available seperately for customers who choose to supply their own cable.
2. One DS1 Cable Assembly is required for each Function Unit group housing a 28DS1 circuit pack. Only One DS1 Cable Assembly is required even when both slots of a Function Unit group are populated with 28DS1 circuit packs. The DS1 Cable Assembly consists of two separate cables, each containing 28 pairs of 24 gauge shielded cable. On each of the 28 pairs of cable, cable 1 is for input and cable 2 is for output.
3. One DS3/EC1 Cable Assembly is required for each Function Unit group housing a 12DS3/EC1 circuit pack. Only one DS3/EC1 Cable Assembly is required even when both slots of a Function Unit group are populated with DS3/EC1 circuit packs. The DS3 Cable Assembly consists of two separate cables, each containing 735A cables. Cable 1 consists of 12 inputs and cable 2 consists of 12 outputs. DS3/EC1 cable assemblies in a combination of 734 and 735-type cable and available in lengths greater than 450 feet are available for connecting DMX to other NEs.
4. Either an X.25 - X.25 Cable Assembly (for use when connecting to a synchronous modem or Packet Assembler/Dissambler [PAD]) or an X.25 - Switch Cable Assembly (for X.25 switching applications) may be ordered as needed. Both cable assemblies are equipped with RS-232 connectors on each end of the cable.
5. One Office Alarm Cable Assembly is required for the bottom DMX shelf in a bay frame. Other DMX shelves in the bay frame do not require this assembly.
6. One Office Alarm Mult Cable Assembly is required for any adjacent DMX shelves in a bay frame. For example, if four DMX shelves are located in a single 7-foot bay frame, three cable assemblies are required. These cables cannot reach any further than an adjacent shelf.
7. The *Crossover* cable is used when connecting to a PC. The *Straight Through* cable is used when connecting with a hub.



5 System Planning and Engineering

Overview

Purpose This section summarizes basic system planning and engineering information to plan procurement and deployment of the DMX Access Multiplexer. There are a number of considerations that should be kept in mind when planning the DMX's role in the network. Projected customer requirements will determine initial capacity needed, as well as evolution to higher capacities. The advanced networking capabilities of the DMX offer many economic and planning benefits, and certain guidelines should be followed to maximize these benefits. Physical installation considerations will be guided by the installation location (central office, uncontrolled, or customer locations). Initial network configuration will determine synchronization requirements. Synchronization should be planned on a network basis considering items like topology, reliability, internetwork connectivity, and service evolution.

Contents The following sections are included in this chapter:

Physical Arrangements	5 - 2
Cross-connections	5 - 14
Synchronization	5 - 33



Physical Arrangements

Overview

Purpose This section describes the possible physical arrangements of the DMX Access Multiplexer.

Contents The following physical arrangement considerations are covered in this section:

Shelf Configurations	5 - 3
Network Bay Frames	5 - 9
Cabinet Arrangements	5 - 11
Cabling	5 - 12
Environmental Considerations	5 - 13



Shelf Configurations

Overview DMX is designed to provide a vast array of wideband and broadband voice and data services. Therefore, there is great flexibility in the configuration of the shelf. Various combinations of circuit packs may be used for whatever service is desired. The following paragraphs outline the specific packs that may be used in the Function Unit groups for certain applications. For possible circuit pack combinations in every topology covered in this document, see Table 5-2-- Shelf Configurations.

Requirements The OC-48 OLIUs or the OC-192 OLIUs must always be located in the M1 and M2 slots on the shelf. The SYSCTL (LNW1) must always be located in the CTL slot.

Important! The service and protection slots of a Function Unit group (for example, A1 and A2) must always contain the same circuit pack (DS1/DS3 packs are the exception to this rule. Ethernet circuit packs (10/100T, 1G SX, 1G LX), however, can only be housed in slot 1 of a Function Unit group (including Growth slots), while the other slot must contain an apparatus blank. The 10/100T (LNW66) circuit pack does not function in the Growth slots, it can only be housed in slot 1 of a Function Unit group.

Growth slots (G1 and G2) may house OC-3 (LNW36), OC-12 (LNW46), OC-48 (LNW31- R2.0), 1G SX (LNW67), and 1G LX (LNW68) circuit packs. Apparatus Blanks must be used if function slots are not populated.

Circuit packs The table below contains a list of each circuit pack supported by the DMX, indicates which slots they are able to be housed in, and in what release each circuit pack is available.

Table 5-1 Circuit Packs in DMX Shelf

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
System Controller (SYSCTL)	LNW1	CTL	1.0	extended temp. certification for outside cabinet deployment (OSP Hardened)
OC-192 OLIU	LNW56	M1, M2	2.1	High-speed, intermediate reach, 1550nm, 48 STS-1 VT fabric
OC-192 OLIU	LNW58	M1, M2	2.1	High-speed, short reach, 1310nm, 48 STS-1 VT fabric
OC-192 DWDM OLIU	LNW521-LNW559	M1, M2	3.1	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range, 48 STS-1 VT fabric.
OC-48 OLIU	LNW29	M1, M2	2.1	High-speed, long reach, 1550nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW26	M1, M2	1.0	High-speed, long reach, 1310nm, 6 STS-1 VT fabric
OC-48 OLIU	LNW26B	M1, M2	2.0	High-speed, long reach, 1310nm, 12 STS-1 VT fabric
OC-48 OLIU	LNW28	M1, M2	1.0	High-speed, long reach, 1310nm, 12 STS-1 VT fabric, OSP Hardened
OC-48 OLIU	LNW27	M1, M2	2.1	High-speed, long reach, 1310nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW31	A-D, G1, G2	2.0	Low-speed, intermediate reach, 1310nm, 12 STS-1 VT fabric
OC-48 OLIU	LNW76	M1, M2	2.1	High-speed, short reach, 1310nm, 48 STS-1 VT fabric
OC-48 OLIU	LNW77	M1, M2	2.0	High-speed, intermediate reach, 1310nm, 12 STS-1 VT fabric
OC-48 OLIU	LNW121B-LNW159B and LNW221-LNW259	M1, M2	2.0 and 2.1	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range. The 121B series supports 12 STS-1 VT fabric while the 221 series supports 48 STS-1 VT mapping.

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
OC-48 OLIU	LNW421- LNW459	A-D, G1, G2	3.0	16 DWDM circuit packs. 32 different wavelengths in the 1550 nm range. 6 STS-1 VT fabric.
OC-12 OLIU (2 ports)	LNW46	A-D, G1, G2	1.1	Low-speed, long reach. 1310 nm, OSP Hardened
OC-12 OLIU (2 ports)	LNW48	M1, M2	3.1	High-speed, Intermediate reach. 1310 nm, OSP Hardened
OC-3 OLIU (4 ports)	LNW36	A-D, G1, G2	1.1	Low-speed, long reach. 1310 nm, OSP Hardened
12DS3/EC1	LNW16	A-D	1.0	12 ports, OSP Hardened
48DS3/EC1	LNW19	A-D	3.1	48 ports, for use in DMX High Capacity Shelf, OSP Hardened
TransMUX	LNW18	A-D	3.0	12 ports, DS3 TransMUX
28DS1	LNW6	A-D	1.0	28 ports, OSP Hardened
28DS1PM	LNW7	A-D	1.0	28 ports, OSP Hardened
56DS1PM	LNW8	A-D	3.1	56 ports, for use in DMX High Capacity Shelf, OSP Hardened
10/100T (24 ports)	LNW66	A1, B1, C1, D1	1.1	100 BASE-TX ethernet interface, may only occupy slot 1 of a function group
10/100T (24 ports) Private Line	LNW71	A1, B1, C1, D1	3.0	Same specifications as LNW66, but supports Ethernet Private Lines
10/100T (24 ports) for Ethernet Enhancements	LNW69	A1, B1, C1, D1	3.1	Same specifications as LNW66, but supports Enhanced Ethernet features (CIR & PIR)
1GbE SX (2 ports)	LNW67	A1, B1, C1, D1, G1	1.1	1000 BASE-SX ethernet interface, may only occupy slot 1 of a function group or a growth slot
1GbE LX (2 ports)	LNW68	A1, B1, C1, D1, G1	1.1	1000 BASE-LX ethernet interface, may only occupy slot 1 of a function group or a growth slot
1GbE (4 ports) for Ethernet Enhancements	LNW70	A1, B1, C1, D1, G1	3.1	Supports Enhanced Ethernet features (CIR, PIR, Spanning Tree per VLAN) and small form factor pluggable optics

Circuit Pack	Apparatus Code	Slot(s)	Release	Comments
Apparatus Blank	177D	A-D, G1, G2	1.0	Filler plates to be used in unpopulated slots of the DMX shelf
Apparatus Blank	177E	M1, M2	1.0	Filler plates to be used in unpopulated slots of the DMX shelf

OC-48/192 UPSR An OC-48/192 UPSR ring configuration for VT1.5/STS-1/STS-3(c)/STS-12(c) path switching can house the following circuit packs in any combination:

- 28DS1 (LNW6)
- 28DS1PM (LNW7)
- 56DS1 (LNW8)
- 12DS3/EC1 (LNW16)
- 48DS3/EC1 (LNW19)
- TransMUX (LNW18)
- Quad OC-3 OLIU (LNW36)
- Dual OC-12 OLIU (LNW46)
- Single OC-48 low-speed OLIU (LNW31)
- Single OC-48 low-speed DWDM OLIUs (LNW421-459)

Note that STS-3(c) path switching requires the LNW36, LNW46, or LNW31. STS-12(c) path switching requires the LNW46 or LNW31. STS48(c) path switching requires the LNW31.

OC-48/192 UPSR with Ethernet (data) transport

DMX can be configured as a data transport shelf for use with many of the available network topologies, such as UPSR. Ethernet transport requires at least one of the following circuit packs:

- 10/100T (LNW66)
- 10/100T (LNW69)
- 10/100T (LNW70)
- 1G SX (LNW67)
- 1G LX (LNW68)
- 1G LX (LNW71)

If data transport is desired, it is required that slot 1 of at least one Function Unit group contains either the LNW66, LNW67, LNW68, LNW69, LNW70, and LNW71 depending on the desired application. The other Function Unit groups may house any other DMX circuit packs depending on the desired service.

Single- and dual-homing shelf

A single-homing or dual-homing shelf configuration requires at least one of the following circuit packs:

- Quad OC-3 OLIU (LNW36)
- Dual OC-12 OLIU (LNW46)
- Single OC-48 OLIU (LNW31)
- Single OC-48 low-speed DWDM OLIUs (LNW421-459)

If the DMX shelf is homing an OC-3 ring, the LNW36 circuit pack must occupy at least one Function Unit group. If the DMX shelf is homing an OC-12 ring, the LNW46 must occupy at least one Function Unit group. If the DMX shelf is homing an OC-48 ring, the LNW31 must occupy at least one Function Unit group. It is possible to single- or dual-home to OC-3, OC-12, or OC-48 rings on the same shelf. Any other DMX circuit pack may occupy other Function Unit groups depending on the desired service.

The table below shows the required or optional status of DMX interfaces for various network configurations.

Table 5-2 Shelf Configurations

Network Configuration	28DS1, 12DS3/EC1, 56DS1, 48DS3/EC1	10/100T/1G SX/1G LX (Note 1)	OC-3/OC-12	OC-48/192 (Note 2)
OC-48/192 UPSR	Optional	Optional	Optional	Required
OC-3/12 Rings with OC-48/192 Ring Transport	Optional	Optional	Required	Required
Single- or Dual-Homing	Optional	Optional	Required	Required
Linear Optical Extensions	Optional	Optional	Required	Required
Hubbing	Optional	Optional	Required	Required

Table Notes

1. Ethernet services can be utilized in any network configuration provided that at least one Function Unit contains an ethernet circuit pack. If desired, DMX can be configured as a data transport shelf and house only ethernet circuit packs in the Function Units.
2. An OC-12/OC-48/OC-192 OLIU is always required in the Main slots.



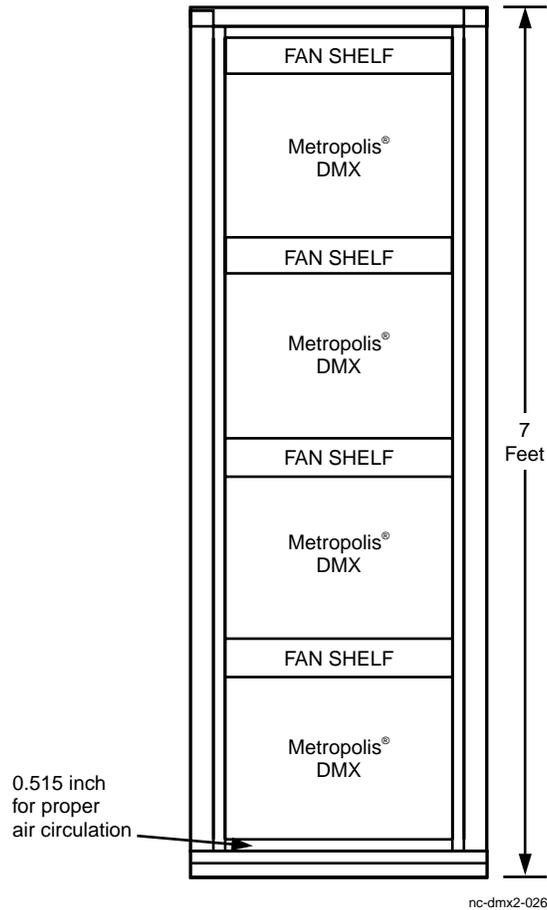
Network Bay Frames

Overview The DMX can be mounted in frames of both 23-inch and 19-inch widths. 23-inch wide frames available through Lucent include the ED8C800 (for rear mounting) and the ED8C801 (for front mounting). Both of these 7-foot frames may accommodate up to four DMX shelves per bay. Yet, when a fuse panel is mounted at the top of one of these 7-foot bays, 3 standard DMX shelves or 4 high-capacity shelves will fit. 19-inch wide EIA310-D bay frames are available through a number of third-party suppliers.

Bay arrangements A standard 7-foot bay arrangement may contain up to four DMX Access Multiplexers. When a bay frame is fully-equipped with four DMX shelves and four Fan Units, a 0.515-inch space must remain open at the bottom of the rack to allow for proper air circulation. DMX shelves should be installed from bottom to top. This arrangement is configured for rear access cabling.

The figure below shows a typical bay arrangement using the standard DMX shelf, including the Fan Unit. Note that the Fan Unit is always mounted on top of the standard DMX shelf.

Figure 5-1 Typical Bay Frame Arrangement



Important! When using the high-capacity DMX shelf, 4 shelves can fit in a bay with a fuse panel. Note that the Fan Unit is not separate from the high-capacity shelf (it is built in), and is mounted at the bottom of the high-capacity shelf.

□

Cabinet Arrangements

Overview Outside plant (OSP) cabinet configurations will be available with the introduction of the LNW28 OC-48 OLIU. More specific information will be included in this section as it becomes available.



Cabling

Overview Lucent offers a full complement of transmission cables and optical jumpers. All interfaces to the DMX are connectorized. For synchronization interfaces, wire-wrap connections are available. Also, a special 9-pin D-SUB connector (408267722) can be used for synchronization purposes. Rear access cabling is available.

For more information For more information regarding cable ordering, refer to Chapter 7, "Ordering." For more information on required cables and cable arrangements, refer to Chapter 4, "Product Description."



Environmental Considerations

Overview DMX meets NEBS Level 3 standards for use in central office environments as specified in GR-63-CORE and GR-1089-CORE. DMX also meets standards for uncontrolled environments as specified in GR-63-CORE and GR-499-CORE. For detailed specifications, refer to Chapter 10, “Technical Specifications.”



Cross-connections

Overview

Purpose This section provides cross-connection information for the DMX Access Multiplexer. For cross-connect provisioning information, refer to Chapter 6, “Operations, Administration, Maintenance, and Provisioning.”

Contents The following cross-connect information is included in this section:

Cross-Connect Types	5 - 15
Allowable Cross-Connects	5 - 17



Cross-Connect Types

Overview The DMX has cross-connect capabilities offering users flexibility in directing traffic flow through systems to support a wide variety of customer applications using two-way and mltp (multi-point [data specific]) cross-connections.

Making cross-connections Cross-connections are made by specifying the SONET rate (VT1.5 or STS-n), the end point addresses (AIDs), and the cross-connection type (for example, two-way). Each single cross-connection command establishes a one-way or two-way cross-connection.

Bidirectional (two-way) cross-connections The two-way cross-connection connects a low-speed port or channel to a channel in the high-speed ring interface. This is used in path switched ring applications where VT1.5, STS-1, STS-3(c), STS-12(c), STS-48(c) low-speed signals on high-speed channels are cross-connected to low-speed DS1, DS3, EC-1, OC-3, OC-12, 100BASE-TX, or 1000BASE-SX/LX ports. With high-speed OC-192 optics, high-speed OC-48 signals may also be cross-connected. In the transmit direction, all added signals are bridged onto both rotations of the ring. In the receive direction, the better of the two received signals is selected and dropped. Bidirectional cross-connections can be used in Hairpinning and pass-through applications as well.

Unidirectional (one-way) cross-connections The one-way cross-connection connects a low-speed port or channel to a channel in the high-speed ring interface or connects a channel on the high-speed ring (1-way add) to a low-speed (tributary) port or channel (1-way drop), but not both at the same time as with bidirectional cross-connections. This is used in path switched ring applications where VT1.5, STS-1, STS-3(c), STS-12(c), or STS-48(c) low-speed signals on high-speed channels are cross-connected to low-speed DS1, DS3, EC-1, OC-3, OC-12, 100BASE-TX, or 1000BASE-SX/LX ports. With high-speed OC-192 optics, high-speed OC-48 signals may also be cross-connected. In the transmit direction, all added signals are bridged onto both rotations of the ring. In the receive direction, the better of the two received signals is selected and dropped. Bidirectional cross-connections can be used in Hairpinning and pass-through applications as well.

**Multi-point (data specific)
cross-connections**

The data specific multi-point (mltpt) cross-connection is a bidirectional cross-connection between two STS-1 Virtual Concatenation Groups (VCGs) on 100BASE-TX or 1000BASE-SX/LX ports to two different ring interfaces. All mltpt cross-connections are done at the STS-1 level (multi-point cross-connections can be made at the STS-3c level beginning in Release 3.0). Multi-point cross-connections are used to create packet rings.

Bridged cross-connections

Bridging of an existing cross-connection consists of adding a one-way cross-connection with the same input tributary as that of an existing cross-connection, resulting in a 1x2 multicast from an input tributary to two output tributaries. DMX supports bridging for each of the supported SONET cross-connection rates. You can bridge any existing cross-connection to a second output port without impairing the existing signal. Conversely, either half of a bridged signal can be taken down without impairing the remaining cross-connected signal.

**Manual cross-connect
rates**

The following lists the signals that can be cross-connected:

- VT1.5
- STS-1
- STS-3c
- STS-12c
- STS-48c



Allowable Cross-Connects

Overview In addition to the data specific mltp (multi-point) cross-connect, the DMX utilizes several types of two-way SONET and Ethernet cross-connections, including:

- add/drop
 - Unidirectional Path Switched Ring (UPSR)
 - Bidirectional Line Switched Ring (BLSR)
 - dual 0x1
 - single 0x1
- pass-through
- pass-through hairpin (VT ring closure)
- SONET hairpinning: inter-function group hairpin (hairpin from one low-speed function group to another)
- multi-point (ethernet only)
- ethernet hairpinning

Add/Drop A two-way add/drop cross-connection is a bidirectional cross-connection between a channel on a path protection-switched ring and a port or channel on a ring or non-ring interface. Thus it is most accurately seen as a MAIN to FN (Function Group) cross-connection, as the tributary interface could be supporting a variety of topologies, including low-speed rings. A one-way add/drop cross-connection is a unidirectional cross-connection between a channel on a path protection-switched ring and a port or channel on a ring or non-ring interface.

Unidirectional Path Switched Ring

A Unidirectional Path Switched Ring (UPSR) is self-healing ring configuration in which traffic is sent onto both rotations (both fibers) of the ring in opposite directions. “Path-switched” means that if the working signal fails, the path switches to the protection signal. UPSRs operate in an integrated, single ended fashion-- negating the need for complex network-level coordination in the effort to restore traffic.

Bidirectional Line Switched Ring

A 2-fiber bidirectional line-switched ring (BLSR) is a self-healing ring configuration in which traffic is bidirectional between each pair of adjacent nodes and is protected by redundant bandwidth on the bidirectional lines that interconnect the nodes in the ring. Because traffic flow is bidirectional between nodes, traffic can be added at one node and dropped at the next without traveling around the entire ring. This leaves the spans between other nodes available for additional traffic. Therefore, with distributed traffic patterns, a BLSR can carry more traffic than the same facilities could carry if configured for a unidirectional path-switched ring.

Dual 0x1

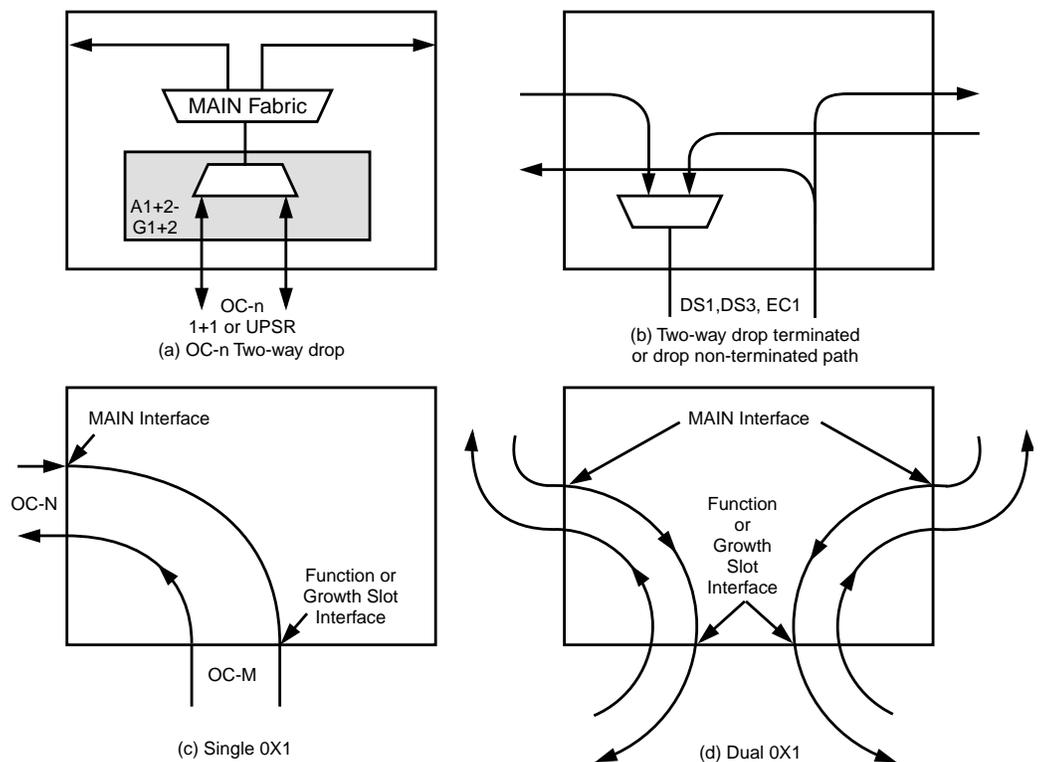
A two-way dual 0x1 cross-connection is a bidirectional cross-connection between channels on both sides of ring interfaces. Dual 0x1 cross-connections do not support path switching or equipment switching.

Single 0x1

A two-way single 0x1 cross-connection is a bidirectional cross-connection between channels on one side of DMX interfaces (same slot in the FNs on both sides of connection: Slot 1 to Slot 1 or Slot 2 to Slot 2). Single 0x1 cross-connections are primarily used in dual homing applications and do not support path switching or equipment switching.

The figure below shows high-level schematics of two-way add/drop, single 0x1, and dual 0x1 cross-connections.

Figure 5-2 Two-way add/drop, single 0x1, and dual 0x1



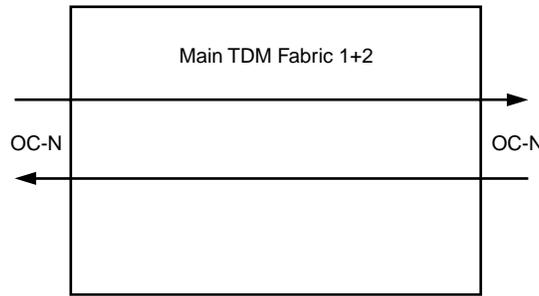
NC-DMX-154

Pass-through

A pass-through cross-connection is made between two ring interfaces in the same MAIN or Function Unit group, allowing the signal to be “passed-through” a ring node on the same timeslot.

The figure below shows a pass-through cross-connection on the high-speed interface (OC-48 or OC-192).

Figure 5-3 Pass-through cross-connection on High-speed interface



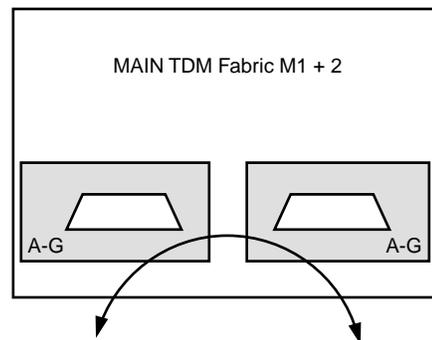
Two-way pass through path

nc-dmx-160

Pass-through hairpin (VT ring closure)

The DMX can host multiple rings on the low-speed interfaces of the DMX shelf. This is accomplished by intra-function group, pass-through cross-connections. The DMX can close a low-speed ring by supporting a cross-connection between a receive port on one circuit pack and a transmit port on another circuit pack in the same function or growth group. All protection switching advantages/capabilities of UPSR configurations still apply in VT Ring Closure applications.

Figure 5-4 Pass-through hairpin



Ring Pass - Through
(VT - Ring Closure)

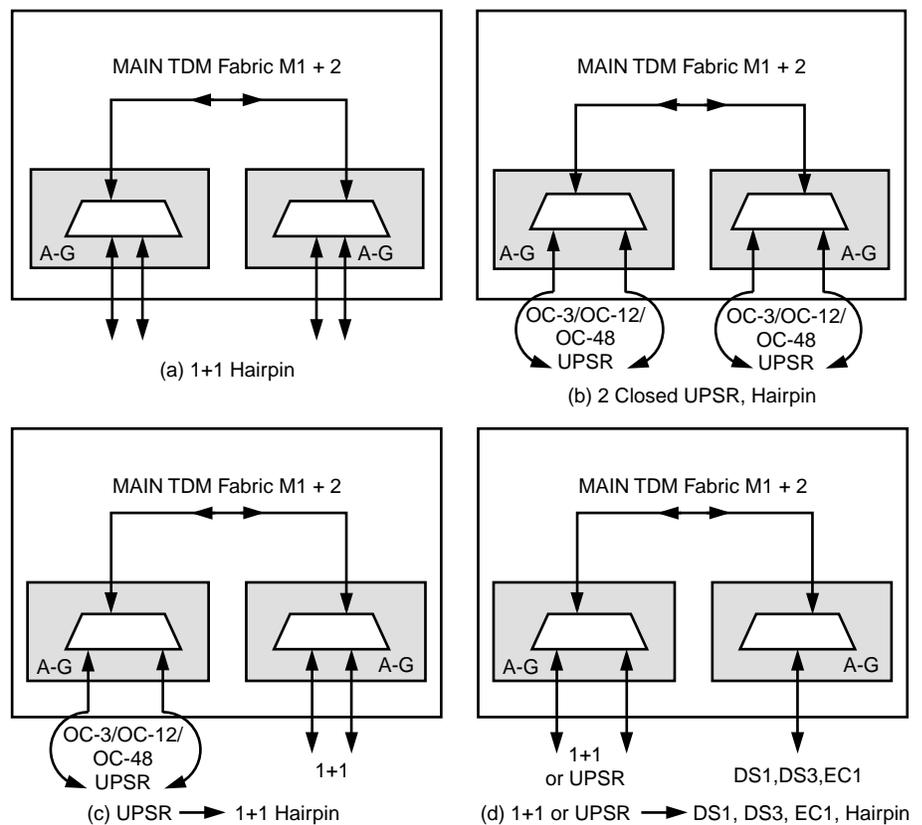
nc-dmx-159

SONET Hairpinning Cross-connections

In a “hairpinning” topology, tributary traffic is routed from one tributary into the system and back out on another tributary without ever being placed on the high-speed (OC-48 or OC-192) UPSR interfaces. The cross-connection capability of connecting any input on a circuit pack in a function or growth slot to any output on a circuit pack in a different function or growth slot on the same shelf, allows you to use a combination of add/drop and hairpinning of compatible payloads through a variety of interfaces. You can bring traffic in from one remote site and cross-connect it at the STS-1, STS-3c, STS-12c (Release 1.1), or VT 1.5 level back out to other remote sites without consuming any capacity on the high-speed UPSRs.

The figure below shows various SONET hairpinning schematics.

Figure 5-5 SONET Hairpinning

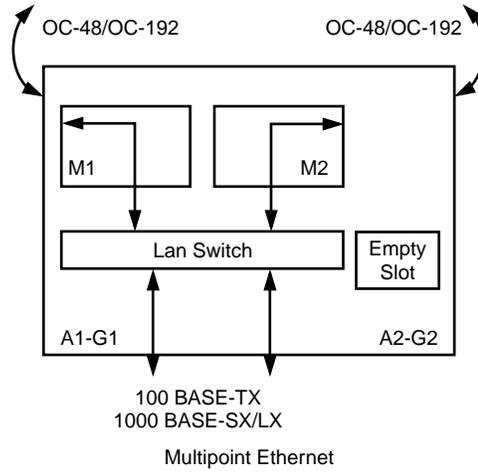


NC-DMX-151

Multi-point (Ethernet only) The data specific multi-point cross-connect is a bidirectional cross-connection between two STS-1 Virtual Concatenation Groups (VCGs) on 100BASE-TX or 1000BASE-SX/LX ports to two different ring interfaces.

The figure below shows Ethernet Multipoint cross-connection schematic.

Figure 5-6 Ethernet Multi-point cross-connection

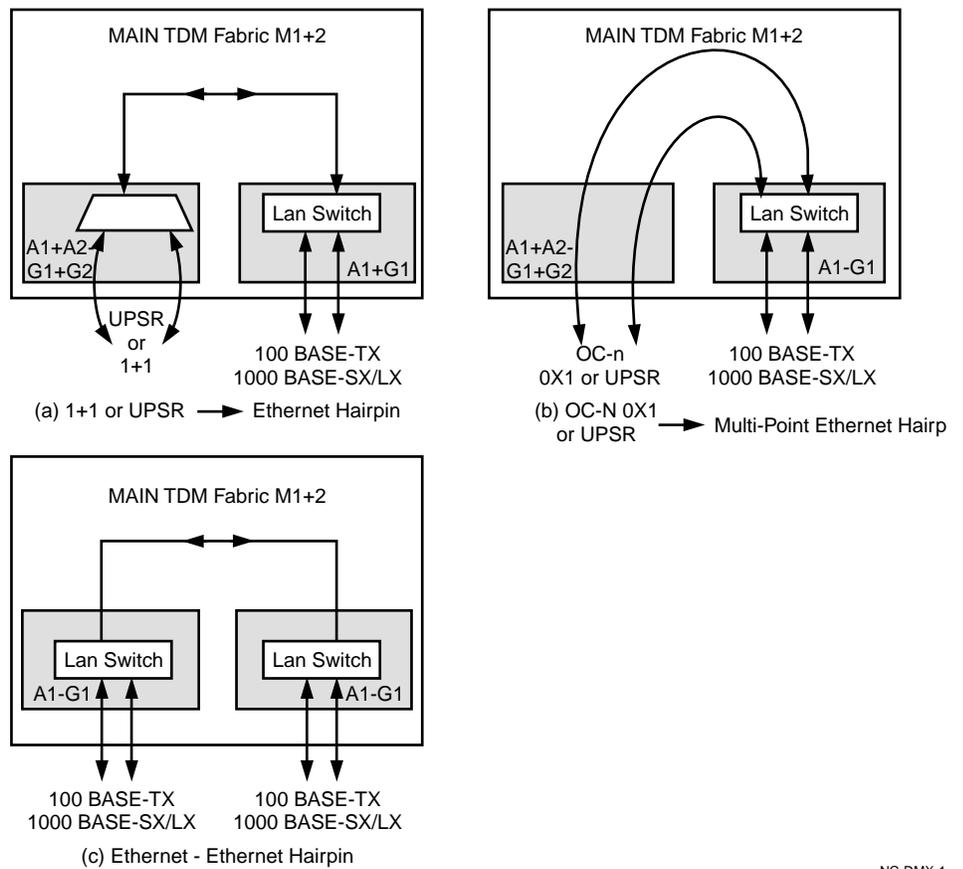


Ethernet Hairpinning Cross-connections

With Ethernet-to-Ethernet hairpinning, traffic may travel from one Ethernet port on a circuit pack in one set of slots, to another port on a circuit pack in a different set of slots (from A1 to C1, for example). From there, the traffic may be multiplexed with other packet traffic before being switched onto another Ethernet or SONET interface.

The figure below shows high-level schematics of Ethernet hairpinning cross connections.

Figure 5-7 Ethernet Hairpinning



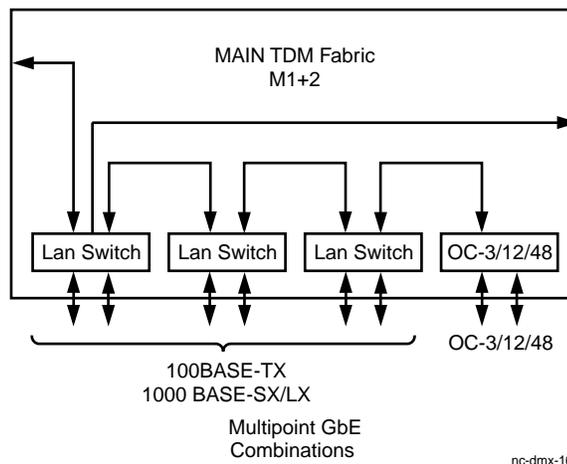
NC-DMX-1

Multi-point Ethernet Combinations

In much the fashion as shown in the figure below, the DMX supports Multi-point Ethernet cross-connections from one Ethernet interface (A1-G1) to the following combinations of interfaces:

- both OC-48/192 MAIN OLIUs & one 100-TX or 1000-SX/LX(A1-G1)
- two other Ethernet circuit packs: 100-TX and/or 1000-SX/LX packs (A1-G1)
- one OC-3/12/48 OLIU (A1-G2) & two 100-TX or 1000-SX/LX interface (A1-G1)
- one OC-3/12/48 OLIU (A1-G2) & one 100-TX or 1000-SX/LX(A1-G1)

Figure 5-8 Multi-point Combinations



Ethernet Circuit Pack Capacities and Ring Configurations

The table below details the allowable Ethernet-related ring configurations (Ethernet applications within UPSR and BLSR topologies) and the number of these configurations that may be supported by each Ethernet circuit pack in the DMX.

Important! Capacities for each configuration are available in the later of the release numbers shown at the left of the row and the top of the column. For example, consider the second row (“packet Rings on a BLSR”): one packet ring on a BLSR is supported on the LNW67/68 in R2.1 (which is the later of R2.1 and R1.1), and 2 packet rings on a BLSR are supported on the LNW69 in R3.1 (the later of R2.1 and R3.1)

For more information on Packet Rings, Ethernet Private Lines, and Ethernet Rate Shaping, refer to the corresponding section in Chapter 3 of this document.

Table 5-3 Ethernet Circuit Pack Capacities for Ring Configurations

Configurations	Release	Port Units				
		LNW66	LNW67/68	LNW69	LNW70	LNW71
		10/100Mbps (FE-BPR)	1000 Mbps (GbE-BPR)	10/100 Mbps (FE-EPR)	1000Mbps (GbE-EPR)	10/100 Mbps (FE-EPL)
		R1.1	R1.1	R3.1	R3.1	R3.0
Packet Rings on UPSRs	1.1	1	2	2	2	0
Packet Rings on BLSRs ¹	2.1	0	1	2	2	0
Packet Rings on BLSRs w/ NUT	3.0	1	2	2	2	0
EPL on UPSR w/ UPSR protection	1.1	1	2	4	2-4 ³	16-24 ²
EPL on UPSR w/out UPSR protection	1.1	2	2	4	4	16-24 ²
EPL on BLSR w/ BLSR protection	2.1	1	2	4	2-4 ³	16-24 ²
EPL on BLSR w/ NUT	3.0	2	2	4	4	16-24 ²
BPR= Basic Packet Ring						
EPR= Enhanced Packet Ring (w/ rate shaping)						

Configurations	Release	Port Units				
		LNW66	LNW67/68	LNW69	LNW70	LNW71
		10/100Mbps (FE-BPR)	1000 Mbps (GbE-BPR)	10/100 Mbps (FE-EPR)	1000Mbps (GbE-EPR)	10/100 Mbps (FE-EPL)
		R1.1	R1.1	R3.1	R3.1	R3.0
EPL= Ethernet Private Line (point-to-point)						
FE= Fast Ethernet (10/100 Mbps)						
GbE= Gigabit Ethernet (100 Mbps)						

NOTES

1. Each span of the packet ring has BLSR protection. It is not necessary to “close” the packet ring on a BLSR: BLSR protection is provided on each span, so spanning tree protection is unnecessary. Capacity on one span of the BLSR can be used for other purposes.
2. For LNW71: 16 ports for STS-3c mode, 24 ports otherwise.
3. For LNW70: 2 at full line rate; 4 at subrates totaling 48 STS1s.

All Allowable UPSR Add-drop Cross -connections

The table below contains a list of UPSR add-drop cross-connections supported by DMX in Release 3.0. The cross-connections in the table below are all add-drop cross-connections.

Table 5-4 All Allowable UPSR Add-drop Cross-connections

From	To
OC-192 OLIU (UPSR)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (0x1, 1+1 and UPSR), 1000-SX/LX (UPSR only), 100-TX
STS-1 Multipoint ----->	1000-SX/LX (UPSR only), 100-TX
STS-3c ----->	OC-3/12/48 (0x1, 1+1, and UPSR)
STS-12c ----->	OC-12/48 (0x1, 1+1, and UPSR)
STS-48c ----->	OC-48 (0x1, 1+1, and UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12/48 (0x1, 1+1 and UPSR), 1000-SX/LX (UPSR only)
OC-48 High-Speed OLIU (1+1/UPSR)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (0x1, 1+1 and UPSR), 1000-SX/LX (UPSR only), 100-TX
STS-1 Multipoint ----->	1000-SX/LX (UPSR only), 100-TX
STS-3c ----->	OC-3/12/48 (0x1, 1+1, and UPSR)
STS-12c ----->	OC-12/48 (0x1, 1+1, and UPSR)
STS-48c ----->	OC-48 (0x1, 1+1, and UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12/48 (0x1, 1+1 and UPSR), 1000-SX/LX (UPSR only)

All Allowable BLSR Add-drop Cross-connections

The table below contains a list of BLSR add-drop cross-connections supported by DMX in Release 3.0. The cross-connections in the table below are all BLSR add-drop cross-connections.

Table 5-5 All Allowable BLSR Add-drop Cross-connections

From	To
OC-192 High-Speed OLIU	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (1+1 and UPSR), 1000-SX/LX, 100-TX
STS-3c ----->	OC-3/12/48 (1+1 and UPSR)
STS-12c ----->	OC-12/48 (1+1 and UPSR)
STS-48c ----->	OC-48 (1+1 and UPSR)
OC-48 High-Speed OLIU	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (1+1 and UPSR), 1000-SX/LX, 100-TX
STS-3c ----->	OC-3/12/48 (1+1 and UPSR)
STS-12c ----->	OC-3/12/48 (1+1 and UPSR)

All allowable UPSR and BLSR Pass-through Cross-connections (high-speed interface)

DMX supports direct pass-through cross-connections from a particular timeslot on one side of a UPSR to/from the same timeslot on the other side of the ring. BLSR pass-through cross-connections function in the same manner.

Important! The DMX does not support VT cross-connections on BLSR transmissions.

All Allowable Hairpin Cross-connections

The table below contains a list of hairpin cross-connections supported by DMX in Release 2.0. The cross-connections in the table below are all Hairpin cross-connections.

Table 5-6 All Allowable Hairpin Cross-connections

From	To
OC-3 (1+1)	
STS-1 ----->	DS1, DS3, EC1, OC-3 ^{a,b} /12/48 (1+1 and UPSR)
STS-3c ----->	OC-3 ^{a,b} /12/48 (1+1 and UPSR)
VT1.5 ----->	DS1, EC1, OC-3 ^b /12/48 (1+1 and UPSR)
OC-3 (0x1)	
STS-1 ----->	OC-3 ^{a,b,d} /12/48 (0x1 ^c)
STS-3c ----->	OC-3 ^{a,b,d} /12/48 (0x1 ^c)
VT1.5 ----->	OC-3 ^{a,b,d} /12/48 (0x1 ^c)
STS-1 Multipoint ----->	1000-SX/LX
OC-3 (UPSR)	
STS-1 ----->	DS1, DS3, EC1, OC-3 ^{a,b,d} /12/48 (1+1 and UPSR), 1000-SX/LX
STS-1 Multipoint ----->	1000-SX/LX
STS-3c ----->	OC-3 ^{a,b,d} /12/48 (1+1 and UPSR)
VT1.5 ----->	DS1, EC1, OC-3 ^{b,d} /12/48 (1+1 and UPSR)
12 OLIU (1+1)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12 ^{a,b} /48 (1+1 and UPSR)
STS-3c ----->	OC-3/12 ^{a,b} /48 (1+1 and UPSR)
STS-12c ----->	OC-12 ^{a,b} /48 (1+1 and UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12 ^b /48 (1+1 and UPSR)

From	To
OC-12 OLIU (0x1)	
STS-1 ----->	OC-3/12 ^{a,b,d} /48 (0x1 ^c)
STS-1 Multipoint ----->	1000-SX/LX
STS-3c ----->	OC-3/12 ^{a,b,d} /48 (0x1 ^c)
STS-12c ----->	OC-12 ^{a,b,d} /48 (0x1 ^c)
VT1.5 ----->	OC-3/12 ^{a,b,d} /48 (0x1 ^c)
OC-12 (UPSR)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12 ^{a,b,d} /48 (1+1 and UPSR)
STS-1 Multipoint ----->	1000-SX/LX
STS-3c ----->	OC-3/12 ^{a,b,d} /48 (1+1 and UPSR)
STS-12c ----->	OC-12 ^{a,b,d} /48 (1+1 and UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12 ^{b,d} /48 (1+1 and UPSR)
OC-48 Low-Speed OLIU (1+1)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (1+1 and UPSR), 1000-SX/LX
STS-3c ----->	OC-3/12/48 (1+1 and UPSR)
STS-12c ----->	OC-12/48 (1+1 and UPSR)
STS-48c ----->	OC-48 (1+1 and UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12/48 (1+1 and UPSR)
OC-48 Low-Speed OLIU (UPSR)	
STS-1 ----->	DS1, DS3, EC1, OC-3/12/48 (1+1), OC-3/12/48 ^{b,d} (UPSR)
STS-1 Multipoint ----->	100-TX, 1000-SX/LX
STS-3c ----->	OC-12/48 (1+1), OC-12/48 ^{b,d} (UPSR)
STS-12c ----->	OC-12/48 (1+1), OC-12/48 ^{b,d} (UPSR)
STS-48c ----->	OC-48 (1+1), OC-48 ^{b,d} (UPSR)
VT1.5 ----->	DS1, EC1, OC-3/12/48 ^b (1+1) OC-3/12/48 ^{b,d} (UPSR)

From	To
OC-48 Low-Speed OLIU (0x1)	
STS-1 ----->	OC-3/12/48 ^{b,d} (0x1 ^c)
STS-1 Multipoint ----->	1000-SX/LX
STS-3c ----->	OC-3/12/48 ^{b,d} (0x1 ^c)
STS-12c ----->	OC-12/48 ^{b,d} (0x1 ^c)
STS-48c ----->	OC-48 ^{b,d} (0x1 ^c)
VT1.5 ----->	OC-3/12/48 ^{b,d} (0x1 ^c)
1000-SX/LX	
STS-1 ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR), OC-48 (1+1)
100-TX- non private line	
STS-1 ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR)
STS-1 Multipoint ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR)
100-TX- private line	
STS-1 ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR)
STS-1 Multipoint ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR or 0x1)
STS-3c ----->	100-TX, 1000-SX/LX, OC-3/12/48 (UPSR)
TransMUX	
STS-1 ----->	OC-3/12/48 (1+1 and UPSR)
VT1.5 ----->	OC-3/12/48 (1+1 and UPSR)
DS1	
STS-1 ----->	OC-3/12/48 (1+1 and UPSR)
VT1.5 ----->	OC-3/12/48 (1+1 and UPSR)
DS3	
STS-1 ----->	OC-3/12/48 (1+1 and UPSR)

From	To
EC-1	
STS-1 ----->	OC-3/12/48 (1+1 and UPSR)
STS-1 Multipoint ----->	EC-1 ^b , OC-3/12/48 (1+1 and UPSR)

NOTES

- (a) intra-Function Group: the 2 ends of the connection are on different ports on the same Function Group
- (b) inter-Function Group: the 2 ends of the connection are on ports on different Function Group
- (c) requires identical 0x1 configuration (0x1 in Slot 1 or 0x1 in Slot 2, or Dual 0x1) at both ends of the cross-connection
- (d) direct pass-through: particular timeslot on one side of ring to/from the same timeslot on the other side of the same ring

□

Synchronization

Overview

Purpose This section describes synchronization features and functions for the DMX Access Multiplexer.

Contents The following synchronization topics are discussed in this section:

Network Synchronization Environment	5 - 34
Synchronization Features	5 - 36
Network Configurations	5 - 39
Timing Distribution	5 - 46
Synchronization Messaging	5 - 50
Frequently Asked Network Timing Distribution Questions	5 - 54



Network Synchronization Environment

Overview Careful consideration should be given to proper design of the SONET network's synchronization environment. Proper synchronization engineering minimizes timing instabilities, maintains quality transmission network performance, and limits network degradation due to unwanted propagation of synchronization network faults. The synchronization features of the DMX are designed to complement the existing and future synchronization network and allow it not only to make use of network timing but also to take on an active role in facilitating network synchronization.

Published sources A number of published sources give generic recommendations on setting up a synchronization network. The DMX is designed to operate in a network that complies with recommendations stated in GR-253-CORE and GR-436-CORE.

Recommendations

The following are some key recommendations from the documents listed above. For further detailed explanation, the sources should be consulted directly.

1. A node can only receive the synchronization reference signal from another node that contains a clock of equivalent or superior quality (Stratum level).
2. The facilities with the greatest availability (absence of outages) should be selected for synchronization facilities.
3. Where possible, all primary and secondary synchronization facilities should be diverse, and synchronization facilities with the same cable should be minimized.
4. The total number of nodes in series from the Stratum 1 source should be minimized. For example, the primary synchronization network would ideally look like a star configuration with the Stratum 1 source at the center. The nodes connected to the star would branch out in decreasing Stratum level from the center.
5. No timing loops may be formed in any combination of primary and secondary facilities.

Stratum 3 Timing Generator

DMX supports an embedded Stratum 3 Timing Generator. The timing generator operates with an internal oscillator of +/- 4.6 ppm long-term accuracy in the free running mode, while in holdover the accuracy is +/- .37 ppm over the full -40 to +65° C temperature range. The timing generator should be used according to the recommendations in the documents referenced previously.



Synchronization Features

Overview Synchronization is an important part of all SONET products. DMX is designed for high performance and reliable synchronization and can be used in a number of synchronization environments. Each DMX can be provisioned to free run from an internal oscillator, line time from an incoming high-speed interface, or get external timing from the digital synchronization network via DS1 references. DMX also supports distribution of timing references using DS1 timing outputs.

- Synchronization features** DMX supports three synchronization reference configurations:
- **External Timing** from a Stratum 3 or better office clock (typical CO installations should be synchronized with DS1 timing references from a Stratum 3).
 - **Line Timing** from incoming OC-12/OC-48/OC-192 signal (for small COs or remote sites).
 - **Free Running** from the multiplexer's internal Stratum 3 Timing Generator (no synchronization inputs).
 - **Network Time Protocol (NTP)** deriving timing reference to radio and/or atomic clocks located on the Internet.

These timing modes are supported by the embedded Stratum 3 Timing Generator in the OC-12, OC-48 or OC-192 circuit pack. The three basic timing modes can be combined into various network configurations.

Internal timing functions such as reference interfaces, the on-board clock elements, and timing distribution, are provided by the Stratum 3 Timing Generator. The timing generator distributes clock and frame signals, derived from the selected reference source, to the transmission packs.

External timing mode In external timing mode, the timing generator accepts two DS1 references from an external Stratum 3 or better clock. This Stratum 3 (or better) clock would typically be traceable to a primary reference source (PRS). The DS1 references from the clock synchronize the local DMX with other network equipment operating under the same primary clock source. A high-stability digital phase-locked loop (DPLL) removes any transient impairments on the DS1 references for improved jitter performance.

The PRS is equipment that provides a timing signal whose long-term accuracy is maintained at 10^{-11} or better with verification to universal coordinated time, and whose timing signal is used as the basis of reference for the control of other clocks in the network. Universal coordinated time is a time and frequency standard maintained by the US National Institute of Standards and Technology.

The DS1 reference inputs are monitored for error-free operation. If the selected reference becomes corrupted or unavailable, the timing generator will switch to the protection reference without causing service degradations. A switch to the protection reference is nonrevertive. If both DS1 inputs are corrupted, the DPLL circuit holds the on-board oscillator frequency at the last good reference sample (holdover). The timing generator will switch back to the external timing mode when a reference is no longer corrupted, but it can be provisioned to require a manual switch. Switching between the two DS1 reference inputs can also be done using a manual command.

Line timing mode In line timing mode, the timing generator derives local shelf timing from the incoming service OC-12/OC-48/OC-192 high-speed signal in the Main slot. The DPLL serves to remove any timing transients for improved network jitter performance. If one of the OC-n references is corrupted or unavailable, the timing generator will make a nonrevertive protection switch to the other reference without causing timing degradations. If all OC-n timing signals are lost (for example, due to a cable cut), the timing generator will switch to holdover mode. The timing generator will normally switch back to the line timing mode when a reference is no longer corrupted, but it can be provisioned to require a manual switch.

Free running mode In free running mode, no mode switching is performed. The timing generator derives timing from a high stability temperature-compensated, voltage-controlled crystal oscillator that has an end of life performance of +/- 4.6 ppm. This oscillator is capable of Stratum 3 accuracy. Only one DMX in a subnetwork can be provisioned in the

free running mode. All other DMX NEs in the subnetwork must be line timed to this free running system to avoid performance degradation.

DS1 timing output

DMX also supports a DS1 timing output feature that facilitates network timing distribution. The DS1 timing output is derived from the OC-n line rate, so it is not subjected to multiplexing or pointer processing effects. The result is a DS1 traceable to the far-end source with extremely low jitter and wander. The timing output can follow the protection switching of the OC-n line, be locked to a specific OC-n, or be automatically controlled using synchronization messaging.

The line coding and frame format on the DS1 input is provisionable. Provisioning options include specifying alternate mark inversion (AMI) or bipolar 8-zero substitution (B8ZS) line coding and superframe format (SF) or extended SF (ESF). The output DS1 is a framed all-ones signal under normal conditions or an AIS signal under failure conditions.

Holdover mode

In case of unprotected synchronization reference failure, the Stratum 3 timing generator will switch to “holdover mode” and continue to provide system timing, using the internal oscillator to maintain the last known good reference frequency. If the DS1 (R1.1) timing output is enabled for network synchronization, DS1 AIS will be inserted on detection of unprotected optical reference failure.



Network Configurations

Overview The following pages detail the three different network configuration types: free running/line timing, external timing/line timing, and external timing.

Free running/line timing configuration

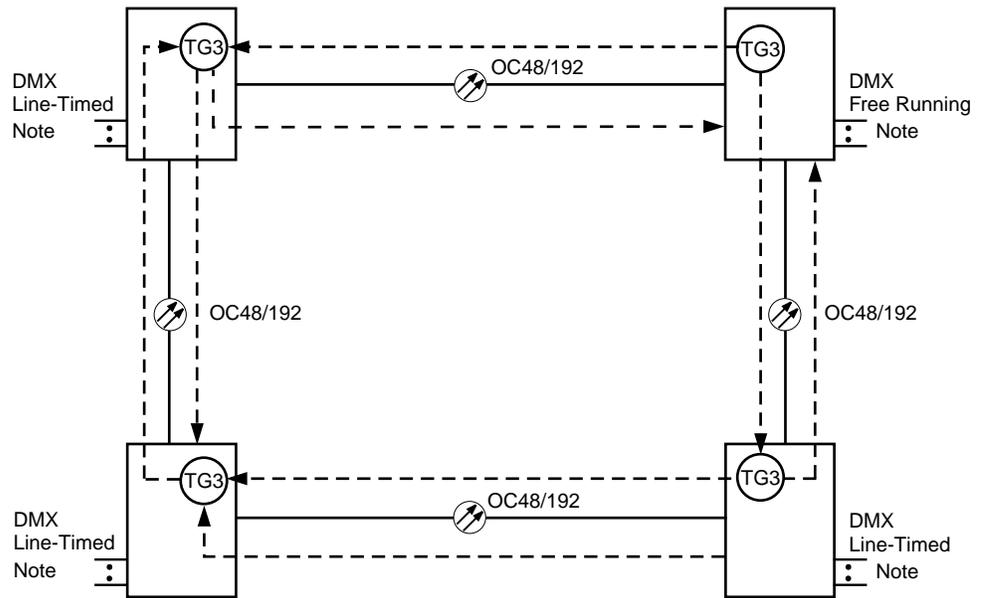
For initial SONET deployment with DS1 and/or DS3 low-speed interfaces, minimum first cost may be a primary concern. The free running/line timing network can operate without an external clock source, so the expense of connecting to one is eliminated. This configuration may be useful for initial access transport and customer location applications, and also meets the needs of an end-office trunk facility. This configuration should not be used to provide OC-n timing distribution or where SONET interconnections to other SONET networks are needed.

The local DMX times its transmitted signals at the low- and high-speed interfaces from the internal ± 4.6 ppm of the Stratum 3 timing generator. The remote DMX recovers timing from the incoming OC-n signal and uses this timing for its transmitted signals.

Because the free running/line timed DMX network is asynchronous to the DS1/DS3 services carried over it, additional jitter will be experienced on the demultiplexed DS1s/DS3s. Certain interconnected equipment may be sensitive to such jitter and this configuration should not be used in cases where it would cause a problem for that equipment. In particular, downstream equipment containing Stratum 3 or better clocks could be sensitive to this jitter.

The figure below shows free running/line timed configuration in a ring network.

Figure 5-9 Free Running/Line Timed Configuration - Ring Network



Note: DS1/DS3/EC-1/OC-3/OC-12/OC-48

nc-dmx2-025

External timing/line timing configuration

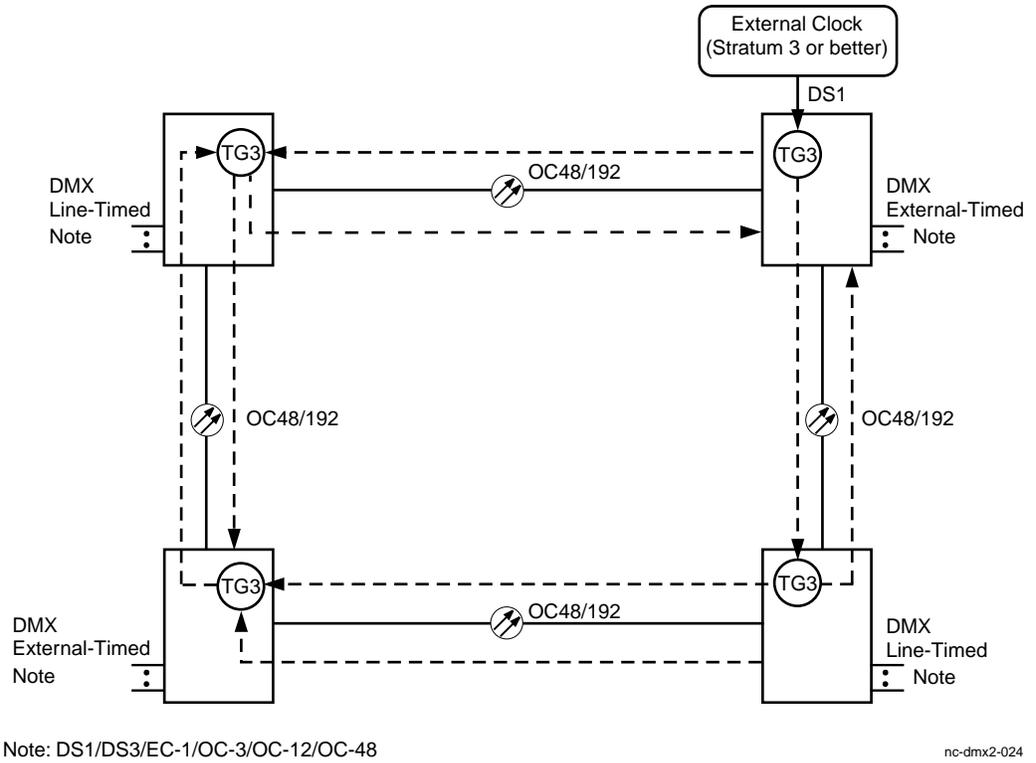
The external timing/line timing configuration integrates access transport and customer location networks into the digital synchronization network as required by the SONET standard. This application is ideal for networks where only one location has a building integrated timing supply (BITS) clock, for example, access transport. The network is synchronized to a local central office clock via DS1 references. The local office clock should be Stratum 3 or better, with timing traceable to a primary reference source. The local DMX times its transmitted signals at the low- and high- speed interfaces from the internal oscillator that is locked on the external reference. The remote DMX recovers timing from the incoming OC-n (OC-48 or OC-192) signal and uses this timing for its transmitted signals.

External timing is required when EC-1 low-speed interfaces are used to interconnect the local DMX with other SONET equipment. Thus, the external timing/line timing configuration should be the long-term goal for all access transport and customer location applications.

In a ring topology, synchronization messaging allows automatic synchronization reconfiguration in the event of a fiber or equipment failure.

The figure below, shows external timing/line timing in a ring configuration.

Figure 5-10 External Timing/Line Timing - Ring Network

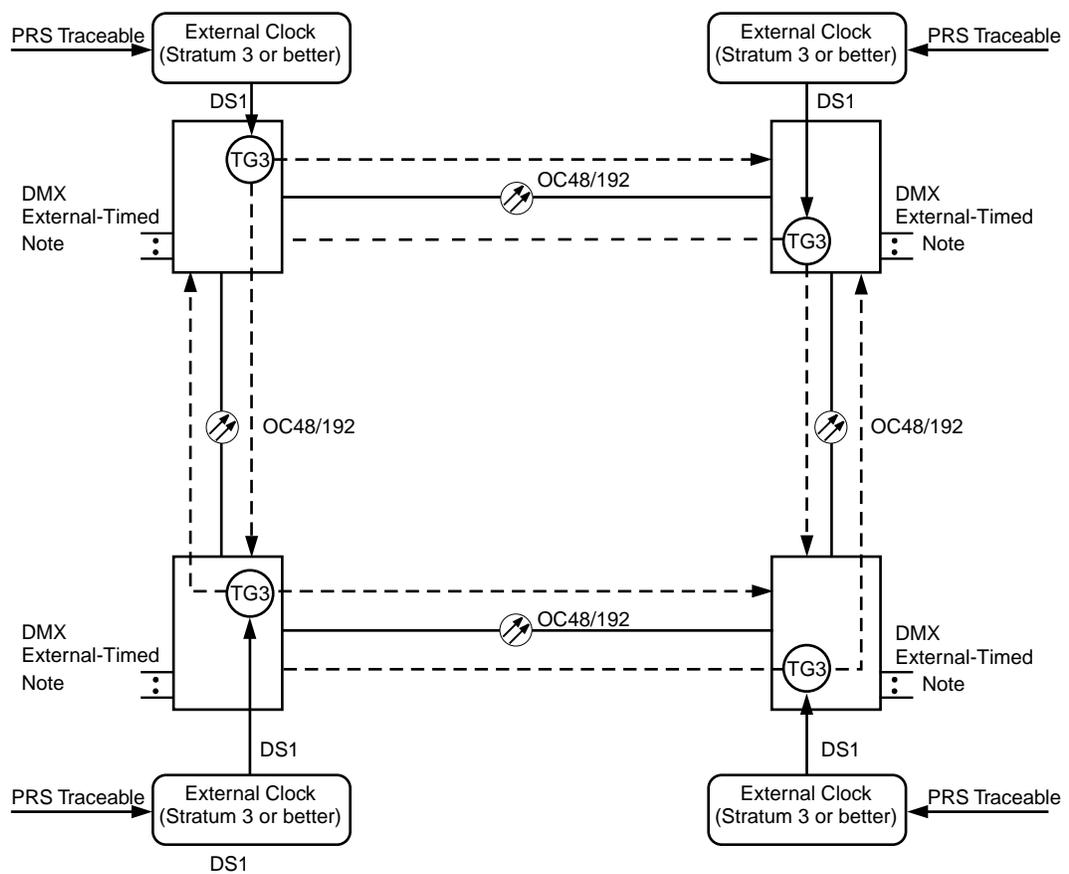


External timing configuration

The external timing configuration uses external DS1 timing to each DMX in the network. Since it requires local office clocks at each site, it is most suited to interoffice applications. A DMX network may have all DS1 references traceable to a common primary reference source (for example, outstate trunking) referred to as synchronous, or to multiple primary reference sources (for example, a carrier-to-carrier interface). The multiple primary reference source is referred to as plesiochronous operation. The figure on the following page shows an external timing configuration.

A tributary signal (for example, DS1) that traverses several plesiochronous regions may encounter increased STS-1 and VT pointer adjustments compared to that encountered in a synchronous environment. These pointer adjustments may increase jitter on the tributary when dropped from the SONET network. While standard jitter generation limits are perfectly acceptable for most service needs, some data services or other equipment may be particularly sensitive to jitter-induced degradations. Therefore, it is generally desirable to minimize the number of plesiochronous regions within a network, through Stratum 1 clock traceability and line timing of remote SONET elements.

Figure 5-11 External Timing Configuration - Ring Network



Note: DS1/DS3/EC-1/OC-3/OC-12/OC-48

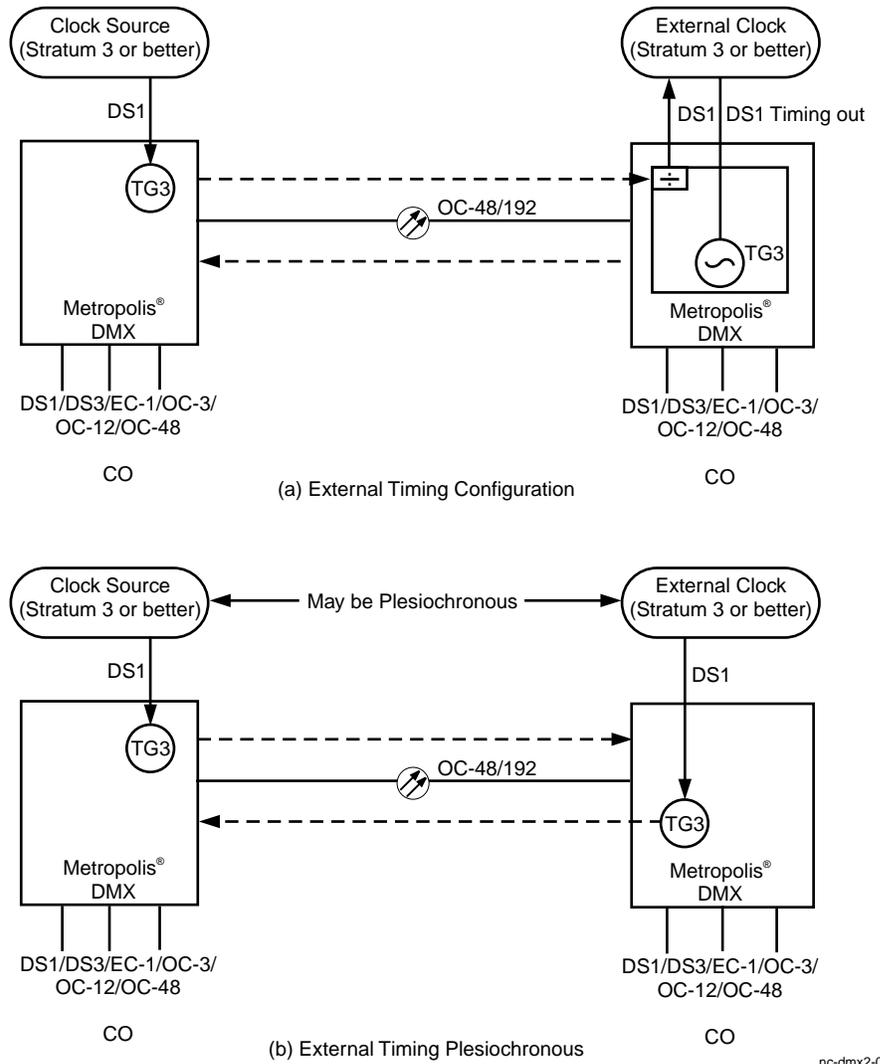
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External timing with DS1 timing output

External timing may be combined with the DS1 timing output feature as shown in the figure below. Note that the DS1 timing output feature

and plesiochronous operation are mutually exclusive. Each of the network topologies (hubbing, ring) can use external timing.

Figure 5-12 DS1 Timing Output and Plesiochronous Timing Configurations



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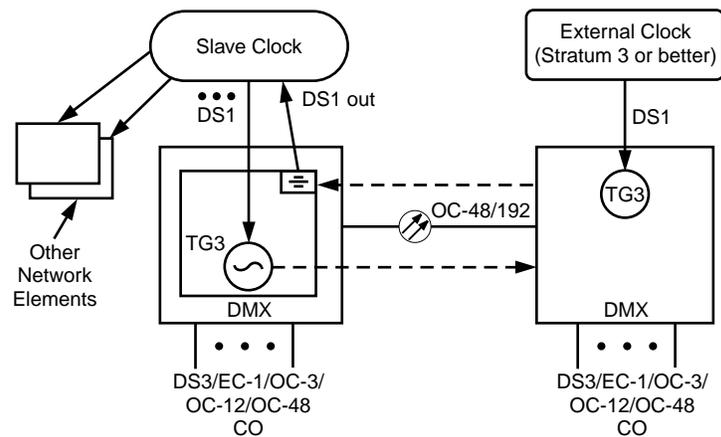
Timing Distribution

Network timing distribution DS1 signals have long been used to pass timing information through the network synchronization hierarchy. These DS1 timing references should be transmitted between master and slave clock sources over the most reliable facilities available. In some cases, these DS1 signals also carry traffic. The facility of choice has evolved from T-carrier through asynchronous lightwave systems to SONET lightwave systems. As these systems are upgraded to SONET systems, timing distribution plans should be revisited to ensure the quality of the timing signals are not degraded. With proper planning, SONET can be used to improve the overall quality of the network timing.

Interoffice timing distribution One way SONET can be used to improve the quality of interoffice network timing is through the use of OC-n (OC-48 or OC-192) timing distribution. DMX supports the evolution to interoffice OC-n timing distribution by providing a DS1 timing output derived from the incoming OC-n signal. The DS1 timing output is traceable to the clock source that times the DMX subnetwork and has extremely low jitter and wander. This is true regardless of the number of DMX systems connected in the network. This DS1 can be fed to the local BITS clock which subsequently times the local DMX and the other equipment in the office. If a BITS clock is not available in the office, the DS1 timing output can be used to time other equipment (including another DMX) directly. DMX can provide DS1 timing outputs in all supported topologies (for example, add/drop and ring).

With OC-n timing distribution, the OC-n line signal, rather than a DS1 multiplexed into the SONET payload, will provide a timing transport mechanism better suited to a complex, heavily interconnected SONET network. In this configuration, a DS1 reference from the CO BITS clock still times the OC-n transmitted to the remote site. At the remote site, a DS1 output reference is created directly from the received OC-n signal, as shown in the figure below.

Figure 5-13 OC-n (OC-48 or OC-192) Derived DS1 Timing Reference



DMX = Metropolis® DMX Access Multiplexer

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Potential advantages

OC-n (OC-48 or OC-192) timing distribution has several potential advantages. It preserves transport bandwidth for customer services and guarantees a high-quality timing signal. Also, as the CO architecture evolves to replace DSX interconnects with SONET EC-1 interconnects and direct OC-n interfaces, OC-n distribution becomes more efficient than multiplexing DS1 references into an access facility in the CO.

A previous drawback to using OC-n timing distribution was that the network timing failures could not be communicated to downstream clocks via DS1 AIS, since the DS1 signal does not pass over the OC-n interface. A standard SONET synchronization messaging scheme to convey synchronization failures is now in place. The DMX multiplexer supports this synchronization messaging scheme. With this option, clock Stratum levels can be passed from NE to NE, allowing downstream clocks to switch timing references without creating timing loops, if a network synchronization failure occurs. If a quality timing reference is no longer available, the DMX sends AIS over the DS1

interface. If the local OC-n lines fail, DMX outputs AIS on the DS1 output or an upstream DMX enters holdover.

Access network timing distribution

OC-n (OC-48 or OC-192) timing distribution can also be used in access networks or to small COs. In this configuration, a DS1 reference from the CO BITS clock still times the OC-n transmitted to the remote site. The line timing capability of DMX provides the ability to recover OC-n timing. The DS1 timing output feature can be used to also extend timing to customer networks or remote sites. In this case, the DS1 timing output may be used to time switch remotes, DMX shelves, or other local equipment directly. Ideally, the equipment can provide an external timing reference. Otherwise, the signal must be input to a traffic DS1 port on the external equipment which will tie up some of this equipment's bandwidth. In this configuration, it is important that the DS1 reference to the DMX in the CO be traceable to the same clock used to source the DS1s being carried to the customer site or small CO. If it is not, slips may occur.

Alternate timing sources

Although an ideal source of timing, OC-n timing distribution, via a DS1 timing output, cannot be used to provide timing in all applications. In cases where the local equipment is not provided with an external timing reference input, or in some private networks where the timing is to be distributed from another private network location, timing may be distributed via traffic-carrying DS1s. In these applications, a stable DS1 timing source can be achieved by ensuring that all elements in the SONET network are directly traceable to a single master clock via line timing. In this environment, the high-performance desynchronizer design of the DMX allows a DS1 timing reference to be carried as a multiplexed DS1 payload.

It is recommended that, where possible, the DS1 sources (switch, PBX, or other equipment) be traceable to the same timing source used to time the DMX SONET network. Multiplexed DS1 reference transport is also consistent with current planning and administration methods.

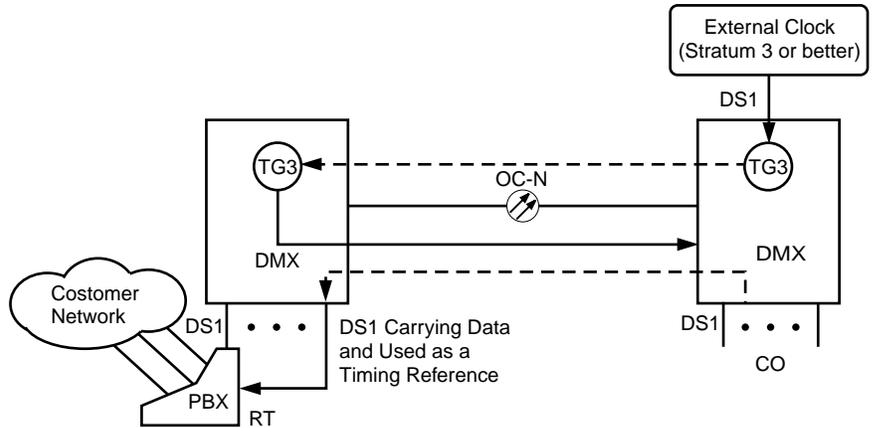
Applications include passing synchronization from the public switched network to a PBX-based private network (see figure on following page) and synchronizing an end-office remote switch to a larger office's host switch.

Note:

Synchronous operation via line timing eliminates the generation of VT pointer adjustments, thus maintaining the phase stability needed for a high-quality DS1 timing reference. Cross-connecting at the STS-1 level

also eliminates the VT pointer adjustments. While the design of the DMX maintains jitter/wander within standard DS1 interface requirements, even in the presence of VT pointer adjustments, and while the DS1 is likely to be stable enough for most equipment to use as a timing reference, some equipment may have more stringent stability requirements for its timing references.

Figure 5-14 Timing from Multiplexed DS1



Signal may not go directly from DMX to the POX, but may pass through another piece of equipment such as a DDM-2000 OC-3 multiplexer

DMX = Metropolis® DMX Access Multiplexer

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Synchronization Messaging

Overview DMX provides a synchronization messaging feature to ensure the integrity of network synchronization during both normal and abnormal conditions. Through the use of synchronization messaging, the current quality of the timing source can be conveyed from one DMX Multiplexer to the next. This capability allows the DMX to automatically change their timing reference in order to always maintain the highest quality timing available. The capability also allows the DMX to inform a local BITS clock when the DS1 timing output has been degraded and should no longer be used as a reference. This synchronization messaging feature is compliant with the scheme developed in the *ANSI T1X1* standards committee.

Applications The applications that are currently supported with the synchronization messaging feature can be divided into three categories:

- DS1 timing output integrity
- Automatic synchronization reconfiguration
- Synchronization provisioning integrity.

DS1 timing output integrity

The derived DS1 timing outputs are typically used as a synchronization reference to a BITS clock which provides the timing reference to an externally-timed DMX Multiplexer. The synchronization reference is derived from the SONET transmission facility which is synchronized from an upstream timing reference. In this way, the timing from the BITS clock in one office (master) is distributed to the next office (slave) using the SONET transmission facilities between them as the synchronization vehicle.

The BITS are typically capable of synchronizing to a Stratum 3 or better accuracy. The DMX equipped with the embedded Stratum 3 timing generator is capable of synchronizing to a +/- 4.6 ppm clock or better. The Stratum timing hierarchy requires that clocks of equal or better Stratum level be used to synchronize other clocks. In this way, the Stratum timing hierarchy is preserved under all failure conditions. Under non-failure conditions, the DMX does not introduce its own internal timing source onto the SONET facility, but merely transfers the quality of its timing reference. A failure of all derived DS1 timing references to the BITS at the master office will cause the BITS to enter holdover mode, whose minimum accuracy is dependent on its internal clock. If the BITS internal clock is of equal or better Stratum level than the DMX, the externally-timed DMX will use this reference to synchronize all outgoing SONET transmission facilities. This preserves the required hierarchical structure of the timing network and should be maintained at all times.

If the externally-timed DMX at the master office enters holdover due to a disconnected reference cable or a local BITS failure, the quality of the derived DS1 timing output at the slave office will now be traceable directly to the DMX. The Stratum timing hierarchy will be violated if the slave office BITS requires timing accuracy of better Stratum level than that provided by the master DMX's internal clock. Because the DMX contains the embedded Stratum 3 Timing Generator, Stratum 3 accuracy will be maintained indefinitely. This provides acceptable timing for Stratum 3 NEs at slave offices.

Another scenario that will cause the Stratum timing rules to be violated is when at least one line-timed DMX exists at a site between the master and slave offices. In this scenario, a fiber cut between the master office and the line-timed site will cause the line-timed DMX to enter holdover (with accuracy dependent upon its internal clock). If the BITS at the slave office requires a higher accuracy clock than that generated by the DMX in holdover, the Stratum timing hierarchy will be violated.

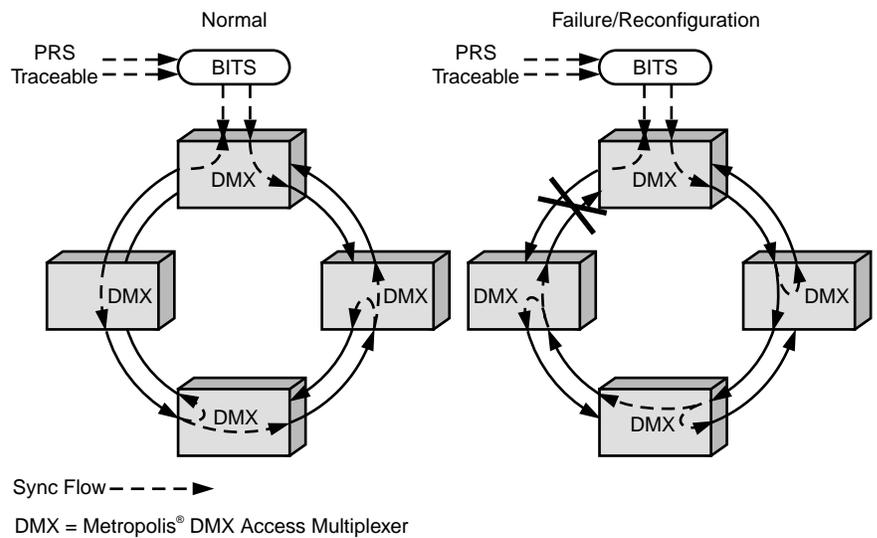
**Automatic synchronization
reconfiguration**

SONET was designed to operate optimally in a synchronous environment. Although plesiochronous and asynchronous operation can be supported through the use of pointer adjustments, transmission quality is affected by the generation of additional jitter and wander due to pointer adjustments. Because of this, it is desirable to maintain synchronous operation whenever possible. Through the use of synchronization messages, the quality of the different timing references can be made available at each DMX NE. The DMX shelf can be optioned to determine the best timing reference available and switch to that reference. Through this mechanism, the synchronous operation of the subnetwork can be maintained. The switching of timing references is hitless, and the synchronization messages also allow it to be done without creating timing loops in the process.

Access ring network

Under normal operation in the access ring network pictured in the figure below, the ring has one DMX externally timed and the others line timed in the counterclockwise direction. If a fiber failure occurs between the first two DMX Multiplexers, the synchronization autoreconfiguration feature will cause the DMX Multiplexers to change their line timing directions to clockwise. The result is that the ring is again operating synchronously. The ring already provides self-healing of the traffic, so it is especially important to maintain synchronous operation during this type of failure to prevent service degradation due to increased jitter and wander.

Figure 5-15 Synchronization Reconfiguration - Access Ring



Synchronization provisioning integrity

A welcome side feature of synchronization messaging is that it helps prevent provisioning errors. Provisioned timing loops on DMX Multiplexers will be quickly detected through the synchronization messaging algorithm and prevented by forcing a shelf into holdover. The system can then be reprovvisioned correctly.

□

Frequently Asked Network Timing Distribution Questions

Overview The following are some frequently asked questions about network timing distribution.

1 *How do I time DMX shelves in a central office environment?*

Each DMX should be externally referenced to the BITS clock in the office. If a BITS clock is not available in the office, a traffic-carrying DS1 from the local switch may be bridged (for example, using a bridging repeater) as the reference to the DMX. Line timing the DMX may also be used, but at least one DMX in the network must be externally timed.

2 *Where do I use the DS1 timing output feature?*

The primary application is for supplying a timing reference to the office BITS clock. This allows the BITS clock to be slaved to a BITS clock in another office that is, in turn, traceable to the primary reference source (PRS). Typically, the DMX supplying the DS1 timing output will, in turn, be externally timed by the BITS clock. If there is no BITS clock, the DS1 timing output can be used to time a switch or switch remote (if the switch remote is equipped for that option) directly or even another DMX Multiplexer.

3 *How do I prevent my BITS clock from using a DS1 timing output when a failure in the network results in this DS1 being timed from a SONET NE in holdover?*

SONET sync messaging informs the local DMX of this condition, and AIS is inserted on the DS1 timing output.

4 *What is the advantage of using the DS1 timing output instead of a multiplexed DS1 as the timing reference?*

The DS1 timing output is derived from the optical line rate and is superior because:

- The DS1 is virtually jitter-free
- Sync messages guarantee the traceability of the timing
- Administration of traffic DS1s for timing is eliminated.

5 *Can I ever use the DMX in the free running timing mode?*

If a PRS traceable external reference is available, it is the recommended timing mode for any/all CO applications. The free running timing mode can be used but a slight increase in jitter will result. If one DMX is provisioned for free running, all other DMX NEs in the network must be line timed and SONET interfaces to other equipment are not allowed. The DS1 timing output is not allowed with a free running network.

6 *How do I provide timing to a central office host switch that does not have the option for an external reference?*

A DS1 carried over SONET may contain significant jitter/wander and be unacceptable to the switch as a timing reference. If the central office has a BITS clock, the recommendation is to use the output from the BITS clock into an unused DS1 traffic port on the switch. If the central office does not have a BITS clock, the recommendation is to use the DS1 timing output from the DMX as the line timing reference into an unused DS1 traffic port on the switch.

7 *Can a DS1 carried over SONET ever be used as a timing reference?*

YES! In many applications there is no other choice. Most switch remotes, for instance, obtain their timing from a specific DS1 signal generated by their host switch, so these remotes must line time from the DS1 signal. In addition, DLC equipment, channel banks, and PBXs will not likely have external references and may be allowed to line time from a DS1 carried over SONET.

8 *Are there any specific concerns when using a DS1 carried over SONET to time equipment such as a switch remote or DLC?*

Yes. The major concern is to make sure all the equipment is synchronous. The DMX NEs should be synchronous to each other to prevent pointer adjustments. This can be accomplished by having one source DMX that is externally timed. The other DMX NEs in the network should be line timed, or they should be externally timed to a clock to which they provide a DS1 timing output. The DMX NEs should also be synchronous to the switch to prevent excessive mapping jitter. This can be done by synchronizing the host switch to the BITS clock used to reference the DMX.

- 9** *Will I have any problems providing timing to a customer that has a high quality PBX or switch?*

If the network is completely synchronous, as described in the previous answer, there should be no problems. If the PBX is sensitive to the jitter produced, even under the synchronous conditions, the DS1 timing output of DMX may be required to be used as a timing reference to this equipment.

- 10** *Why does Bellcore say that DS1s carried over SONET should not be used for timing?*

Bellcore has provided this recommendation because there are several limitations. Bellcore says that DS1s carried over SONET must be used in applications such as switch remotes and will be acceptable, provided pointer adjustments are not created.

- 11** *Can pointer adjustments be prevented?*

Neither random nor periodic pointer adjustments will occur if the DMX shelf is provisioned for line timing.

- 12** *How do I time DMX at a remote site?*

Line time.

- 13** *How many DMX NEs can I chain together in an add/drop configuration before the timing becomes degraded?*

The Stratum level traceability of the nth node in an add/drop chain is the same as that in the first node. Also, while timing jitter will theoretically increase as the number of nodes is increased, the high quality timing recovery and filtering on the DMX allows add/drop chains to be extended to any practical network limit without detectable increases in jitter levels. In practice, the only effects on timing at the nth node will occur whenever high-speed protection switches occur in any of the previous n-1 nodes. These effects should be rare.

- 14** *How do I time a DMX ring network?*

An interoffice ring should have each node externally timed if BITS clocks are available. All other rings should have one node externally timed (two in some dual homing architectures) and the rest of the nodes line timed. Synchronization reconfiguration is automatic.

- 15** *Why are there more issues related to timing with SONET equipment than there are with asynchronous equipment?*

SONET equipment was designed to work ideally in a synchronous network. When the network is not synchronous, mechanisms such as pointer processing and bit-stuffing must be used and jitter/wander increases.

- 16** *Can DS3 signals be used to carry DS1 timing signals without the worry of having the network synchronous?*

Yes, although this option is more expensive.

- 17** *What are the limitations on automatic synchronization reconfiguration?*

Automatic synchronization reconfiguration is only available when the DMX is provisioned for line timing mode. This allows the timing direction of an OC-n (OC-48 or OC-192) ring network to change automatically in response to a failure. When the DMX is provisioned for external timing, automatic synchronization reconfiguration is not available. When an OC-n fault is detected in the timing direction, AIS is inserted on the derived DS1s which forces the BITS into holdover preventing timing loops.

- 18** *How do I synchronize a BITS clock and maintain automatic synchronization reconfiguration on a DMX ring?*

Provision all but the host node (node with co-located PRS) for line timing. Provide each non-host BITS clock with a pair of derived DS1s. The DMX will detect faults and provide the BITS clocks with good inputs if available. Timing loops will be prevented. The host node should be set for external timing and get its timing from an externally timed BITS clock. To prevent a timing loop, the host BITS clock should get its timing from a PRS traceable source. The non-host nodes should not be timed from the co-located BITS clock since this would disable the automatic synchronization reconfiguration feature.

□



6 Operations, Administration, Maintenance, and Provisioning

Overview

Purpose This chapter describes the operations, administration, maintenance, and provisioning (OAM&P) functions for the DMX Access Multiplexer.

Contents The following sections are included in this chapter:

Maintenance	6 - 2
Protection Switching	6 - 21
Performance Monitoring	6 - 30
SNMP Parameters and Traps	6 - 39
Provisioning	6 - 45
Reports	6 - 53
Administration	6 - 60



Maintenance

Overview

Purpose This section describes the maintenance philosophy of the DMX Access Multiplexer.

Contents The following maintenance topics are discussed in this section:

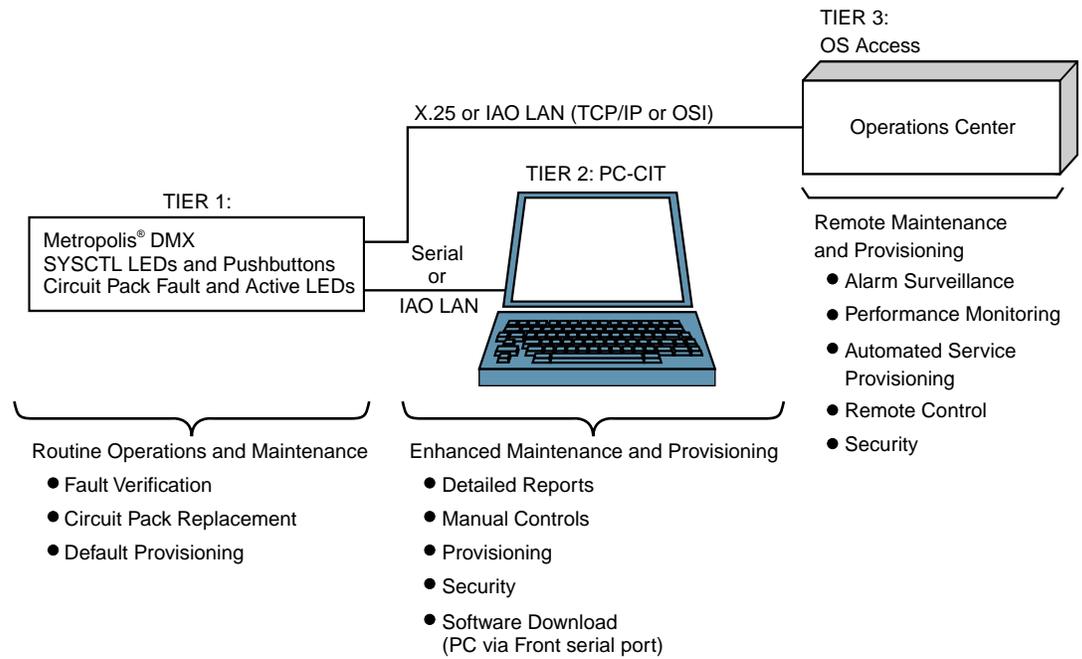
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Loopbacks and Tests	6 - 20



Three-tiered Operations

Overview The figure below, shows the three-tiered operations procedures for DMX. The DMX operations procedures are built on three levels of system information and control, spanning operations needs from summary-level status to detailed reporting.

Figure 6-1 Three-Tiered Operations



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**SYSCTL faceplate
(Operations Tier 1)**

Office alarms are provided by a set of discrete relays that control office audible and visual alarms. Separate relays handle critical (CR), major (MJ), and minor (MN) alarms, although the CR and MJ alarms can be wire ORed and reported as office major, if desired.

The light-emitting diodes (LEDs) and push buttons on the SYSCTL faceplate allow routine tasks to be performed without a PC-CIT or any test equipment. The SYSCTL faceplate LEDs provide system-level alarm and status information for the local NEs and a summary for all remote NEs in the alarm group. The circuit pack faceplate FAULT LEDs allow fast and easy fault isolation to a particular circuit pack.

The SYSCTL faceplate LEDs default to show local system information. The highest active alarm level is shown by the red LEDs for CR and MJ alarms. Yellow LEDs are shown for MN alarms. A green ACO button is used to activate the alarm cutoff function. When activated, the LED is on. The green ACO button also initiates an LED test when the button is depressed and held. A green PWR ON LED shows that the power is on and the terminal is receiving a -48V source. Three yellow status LEDs show abnormal (ABN) conditions, near-end activity (NE), and far-end activity (FE). The yellow ABN LED is lighted when a temporary condition, potentially affecting transmission, exists. For example, this condition could be a manual protection switch or lockout, loopback, or system test in progress.

The Update/Initialize (UPD/INIT) button addresses the local system. The recessed UPD/INIT button serves several functions during installation and circuit pack replacement. During the first 10 seconds after powering up the SYSCTL circuit pack, depressing this button initializes the nonvolatile memory with provisioning and state information. Secondly, after removing a circuit pack or low-speed input, depressing this button updates the system equipment list to show the slot or signal is now unequipped.

The SYSCTL faceplate's remote display functions serve the single-ended maintenance needs of access transport applications. When any alarm or status condition exists at a remote DMX shelf in the same alarm group, the FE LED on the faceplate is lighted.

Table 6-1, SYSCTL Faceplate Indicators and Functions (6-5), details the various LEDs and push-button switches and describes their functions.

Table 6-1 SYSCTL Faceplate Indicators and Functions

LED/Push-button	Indicator name	Function
FAULT	Fault	Indicates isolated circuit pack failure.
CR	Critical	Indicates critical alarm for local system.
MJ	Major	Indicates major alarm for local system.
MN	Minor	Indicates minor alarm for local system.
ABN	Abnormal	Indicates temporary transmission-affecting condition.
FE	Far-End Activity	Indicates remote alarm or status condition.
NE	Near-End Activity	Indicates local alarm or status condition.
ACO	Alarm Cut-Off	Activates alarm cut-off (will also display software version information when depressed for 3 seconds).
ACO/TEST	Alarm Cut-Off/Test	Performs LED tests.
SEL	Select	When the SEL and the UPD/INIT buttons are simultaneously depressed for a period of 5 seconds, you will receive a P. on the display. This lets you know that you can now force a software download.
UPD/INIT	Update/Initialize	Updates the local system.

Circuit pack LEDs

To supplement the SYSCTL faceplate's system-level view, each circuit pack provides a red FAULT LED on its faceplate. A lighted FAULT LED shows that the DMX has isolated a failure to that circuit pack. On transmission circuit packs, a flashing FAULT LED shows that an incoming signal to that circuit pack has failed.

**Local craft interfaces
(Operations Tier 2)**

The local craft interfaces include the PC-CIT, which may be utilized in a variety of ways.

Craft Interface Terminal (PC-CIT) (software download-- front serial port only)

DMX supports a front serial port over an RJ45 interface. This port is configured as data communications equipment (DCE) for direct terminal access, and it provides data rates of up to 115,000 baud. Local and remote software download operations can only be performed through the front serial port (a PC must be connected directly to the front serial interface).

DMX also supports TL1 over PC-CIT through the serial port, allowing TL1 messages to be exchanged over PC-CIT asynchronous ports.

PC-CIT (TL1 over TCP/IP)

The PC-CIT is a small CIT interface that provides a flexible TL1 command instructor. The PC-CIT connects to a DMX using either the front or rear serial ports, the front IAO LAN port (R1.1), or the rear IAO LAN port (R1.0). The PC-CIT supports TCP/IP (or OSI) connections in R1.1 through both the front and rear IAO LAN interfaces.

The PC-CIT is used for report generation, as well as command and system response. Access to the system is provided via serial or IAO LAN interfaces.

**Operations System (OS)
TL1/LAN interfaces
(Operations Tier 3)**

The third operations tier consists of OS access. DMX OS interfaces include X.25 and IAO LAN TCP/IP or OSI).

TL1/X.25

The TL1 message-based OS interface provides remote OS access, as well as detailed reporting and control capabilities. The interface uses standard X.25 protocol and needs no mediation device (i.e., the interface can be connected directly to an X.25 network). The virtual channels in the X.25 link can be used to provide remote access between users and DMX via a packet data network. The remote user could be an OS or a user at a terminal. Lucent Technologies is involved in an active OSMINE process to ensure compatibility of DMX NEs with Telcordia OSs.

The DMX supports TL1 alarm surveillance and performance monitoring with OSs such as Telcordia's Network Monitoring and Analysis (NMA). The DMX supports service provisioning with memory administration OSs such as Lucent's SNMS or Telcordia's TEMS. The DMX also supports remote recovery and control functions, installation provisioning, and security over the TL1/X.25 link. The TL1 message set used has been updated to offer full remote reporting capabilities.

The OS can use more than one NE as a GNE to provide redundancy and/or to distribute TL1 message volume across multiple X.25 links. The TL1/X.25 GNE serves as a single interface to the OS for the NEs in the same subnetwork. The TL1/X.25 GNE receives operations information from all the NEs through the DCC and reports this information, as well as its own information, to the OS. The operations information is in the form of TL1 messages. Through the GNE, the OS can send TL1 commands to any NE in the subnetwork. Lucent's SNMS, as well as other-vendor NEs that adhere to GR-253-CORE, can serve as the TL1/X.25 GNE for the DMX.

Front IAO LAN

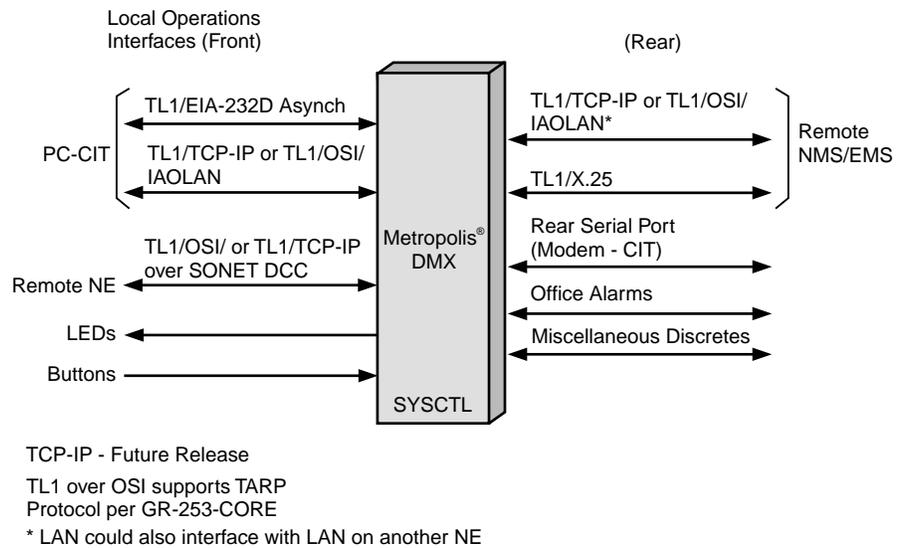
The front IAO LAN interface (R1.0) is intended to provide a connection to the PC-CIT and supports OSI or TCP/IP communications. OAM&P activities such as loopbacks and testing, protection switching, provisioning, PM, retrieving reports, and security on any and all DMX NEs in a subnetwork are provided by the front IAO LAN interface. The front IAO LAN is located on the faceplate of the SYSCTL circuit pack.

Rear IAO LAN

The primary purpose of the rear IAO LAN port is to provide remote OS access (such as OS TL1 access over TCP/IP Gateway). It also supports a faster software download from Lucent SNMS using file transfer protocol (FTP) to Lucent DMX systems (R2.0) when software is being upgraded (both the rear and front IAO LAN ports support this functionality). This rear IAO LAN port can also be used for PC-CIT OSI-based interfaces and TCP/IP support in Release 1.1.

The figure below, shows how with the various DMX operations interfaces.

Figure 6-2 Operations Interfaces



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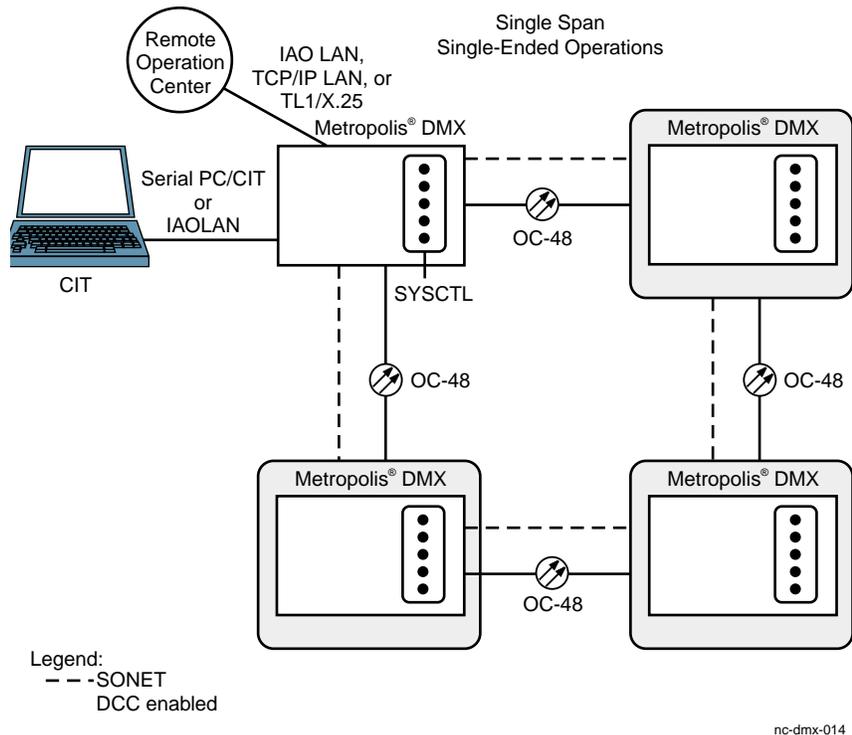
Operations Philosophy

Overview The DMX has incorporated an operations philosophy that is optimized for operations in the access transport environment. This allows operation and maintenance of remote NEs from a single location. Similarly, a technician working at a remote site can gain access to other NEs. In addition, OSs are available to allow operation of the DMX NEs from a centralized operations center.

The DMX uses the SONET data communications channel (DCC) to provide remote PC-CIT access, remote CO alarms, remote alarm reports, and remote OS access. The terms remote operations, single-ended operations (SEO), and Operations Interworking (OI) are synonymous.

SEO capability The figure below, shows the SEO capability that provides remote access to all DMX systems in a subnetwork from a single DMX location. This minimizes the need for technician travel because most maintenance, provisioning, and administration can be performed on all NEs with DCC connectivity by accessing any one NE. The SEO capability can be disabled between NEs to create maintenance boundaries (for example, interoffice applications) or for security reasons.

Figure 6-3 Remote Operations Philosophy



Lucent Operations Interworking

Overview Operations interworking (OI) provides the capability to access, operate, administer, maintain, and provision remote Lucent NEs from any Lucent NE with DCC connectivity in a network or from a centralized OS.

OI support Lucent OI is available among NEs that are connected through the SONET DCC or IAO LAN. With this feature, users can perform OAM&P activities on a centralized basis, saving travel time and money.

OI features including the following:

- Remote OS access via TL1 over TCP/IP (or OSI) or TL1/X.25
- Remote PC-CIT access
- Remote NE status
- Remote software download and copy
- Remote time and date synchronization

For more information on OI, refer to *Lucent Technologies WaveStar Product Family Operations Interworking Guide*, 365-372-303.

The table below provides a list of the products the DMX supports OI with. The table also indicates which release of the DMX each product is supported by.

Table 6-2 DMX OI Support

Product	DMX Release			
	Release 1.1	Release 2.0	Release 2.1	Release 3.0
DMXpress Release 1.0	X	X	X	X
DDM-2000 OC-3 Release 15.0	X	X	X	X
DDM-2000 OC-12 Release 7.0	X	X	X	X
FiberReach Release 4.0	X	X	X	X

Product	DMX Release			
	Release 1.1	Release 2.0	Release 2.1	Release 3.0
FT-2000 Release 9.1	X	X	X	X
WaveStar 2.5G/10G (2-Fiber) Release 4.0 Release 5.0 Release 6.0	X X	X X	X X	X X
WaveStar BandWidth Manager Release 4.0 Release 4.1	X	X	X	X X
NCC Release 3.2	X	X	X	X
Lambda Unite Release 2.0		X	X	X
PC-CIT Release 5.2 - GUI Release ? Release ?	X	X	X	X
EMS (formerly "SNMS") Release 5.1 Release 7.0 Release 8.0 Release 9.0	X	X	X	X
NMS Release 6.0			X	X
Lucent (Ascend) GX550 ^(b)	*	*	*	*
Lucent (Ascend) CBX500	*	*	*	*

Product	DMX Release			
	Release 1.1	Release 2.0	Release 2.1	Release 3.0
ETEK		X	X	X
Avanex		X	X	X
TIRKS Release 19.4 Release 19.5 Release 19.6 Release 19.7	X	X	X	X
NMA Release 10.1 Release 11.0 Release 11.1 Release 12.0	X X	X	X	X
Transport (TEMS) Release 2.0 Release 2.2 Release 2.4 Release 2.5	X	X	X	X

NOTES

(*) Transmission interworking only

Alarm groups

An alarm group is a set of NEs that share status information between themselves, such as alarms, LEDs, and ACO status. The set of remote NEs that an NE can exchange status information which is determined by the value of the local alarm group parameter. This parameter is provisioned at each local NE and specifies whether that local NE does or does not exchange remote NE status with other Lucent NEs in the same SONET subnetwork. In DMX, all NEs are defaulted into the same alarm group (number 255).

Alarm groups can be nodes in a ring, nodes of a linear extension, or any other logical grouping such as a maintenance group or geographical group. For example, 24 NEs could be provisioned into three alarm groups with eight NEs that share a community of interest such as the same OC-3 low-speed optical interface.

All members of the same alarm group share NE status information but do not share information with other alarm groups.

Alarm group functions

Depending on provisioning, a member of an alarm group can:

- Know the alarm/status of all members of the same alarm group and, if the NE is at the CO, activate audible office alarms for the alarm group.
- List a report of the summary alarm or status condition of other NEs in the group.
- Display composites of the highest alarm level among other member NEs in the same alarm group.

Alarm Gateway Network Element (AGNE)

Members of an alarm group exchange information through one or more alarm gateway NEs (AGNEs) that are defined in the same alarm group. All DMX NEs use the DCC to receive and report alarm and status information to the AGNE(s). The AGNE rebroadcasts all alarm and status information from one NE to all the other NEs in the same alarm group.

This information is used to activate remote far-end summary alarm reports and remote office alarms for each NE in the alarm group. At least one NE in each alarm group must be provisioned as the AGNE. An additional AGNE can be provisioned for redundancy, but it is recommended that only one AGNE be provisioned for each alarm group. Considerations for choosing an NE as an AGNE include being central to the group to make communications links easily accessible for maintenance purposes.

The AGNE and TL1/X.25 GNE should be separate NEs. Furthermore, the AGNE is a “collection point” and does not have to be a NE in a CO.

Multi-Vendor Operations Interworking

TARP To support multi-vendor OI, the DMX supports Target ID Address Resolution Protocol (TARP).

TARP provides NSAP-TID translations and is the established multi-vendor standard for SONET NEs that support TL1 OS interfaces. DMX supports the TARP Data Cache (TDC) function to reduce the frequency of TARP propagation throughout the subnetwork and to improve performance.

Compatibility DMX is developed to be compatible with any other-vendor NEs that support TARP, OSI, IAO LAN, and TL1/X.25 as specified in Telcordia Technologies GR-253. In addition, DMX's TARP Manual Adjacency feature enables it to operate in networks that include CMISE-based NEs which may not support TARP propagation. DMX supports user provisioning of several OSI parameters to allow users to adjust their operations network, if necessary. For example, to support Level 2 Routing in large networks, DMX supports user provisioning of NSAP area addresses and Level 2 Intermediate System (IS) functionality.

DMX's compatibility with other-vendor NEs could be tested by customers or independent third parties such as Telcordia Technologies.



Software Download and Copy

Overview DMX can upgrade the system software while in-service. Yet, initial software installation must be done locally using a PC connected to the DMX via the front serial port. It uses flash erasable programmable read-only memory (flash EPROM) chips to store the system software. System software can be downloaded using a PC (see specifications in Section 10) through the RS-232 interface on the SYSCTL faceplate into the local system, or to another system connected to the local system via the SONET DCC. In addition, system software can be copied between DMX systems connected by the SONET DCC. The remote software download and copy capabilities enable the network service providers to avoid costly craft dispatches for software upgrade.

Downloads DMX systems accept downloads without disrupting transmission and with minimal impact on operation functions. This enables the software downloads to be transparent to the transmission services and to the network operations. While the current software version is still running, DMX accepts the downloading of compressed, dormant software copies without affecting the operation of the system. An “apply” command can be scheduled to be applied at any time the user specifies. An OS(s) will lose communications while the network is being upgraded for a half an hour or less.

The DMX can also accept software downloads from Lucent’s SNMS and PC-CIT when upgrading to subsequent releases (R2.0 and higher).

Maintenance Signaling

Alarm indication signals Alarm indication signals (AIS) are maintenance signals that notify equipment downstream from a failure that the failure has been detected and alarmed by some upstream equipment and notify upstream equipment to initiate trunk conditioning because of a downstream detected failure (remote defect indicator [RDI]).

Compliance Maintenance signaling is compliant with SONET (Telcordia Technologies GR-253) and asynchronous (Telcordia Technologies TR-TSY-000191) network requirements. Alarm indication signals include SONET line AIS, STS-1 path AIS, virtual tributary (VT) path AIS, DS3 AIS, and DS1 AIS. Remote defect indication signals include STS-1 path RDI and VT path RDI. Other maintenance signals include STS-1 path unequipped, and VT path unequipped.

Fault Detection, Isolation, and Reporting

Overview DMX continuously monitors incoming signals and internal system conditions. Incoming SONET signals are monitored for loss of signal (LOS), loss of frame (LOF), loss of pointer (LOP), line AIS, path AIS, bit error ratio (BER) thresholds and unequipped signals. The BER threshold crossings are detected for DS1, DS3, EC-1, OC-3, OC-12, OC-48, OC-192, STS-1, STS-3c, STS-12c, and STS-48c signals.

Fault detection When an internal fault is detected, automatic diagnostics isolate the faulty circuit pack. Faults are reported to local technician and OSs so that technician dispatch and repair decisions can be made. If desired, OS personnel and local technicians can use the PC-CIT to gain more detailed information on the fault condition.

Fault isolation All fault conditions detected by the system are stored and made available to be reported, on demand, through the PC-CIT. In addition, a history of past alarm and status conditions and PC-CIT events is maintained and available for on-demand reporting. Each event is real time and date stamped.

Fault reporting The system can also report all detected alarm and status conditions through the appropriate office alarm relays, SYSCTL faceplate LEDs, transmission circuit pack LEDs, and TL1 interfaces.

Loopbacks and Tests

Overview The DMX allows technicians to perform loopback tests on all low- and high-speed interfaces. Low-speed DS1, DS3, and EC-1 electronic loopbacks, directed toward the high-speed line (terminal loopback), are individually controllable from the CIT or the OS interface. Active electronic loopbacks are shown by the ABN LED on the SYSCTL faceplate and in the alarm and status report. EC-1, DS1, and DS3 facility loopbacks toward the DSX are also available.

Manual optical loopbacks Front access to the optical connectors on the optical line interface unit (OLIU) circuit pack allows easy manual optical loopback. This loopback is performed by connecting a fiber jumper from the OLIU circuit pack output to its input. In some cases a lightguide buildout assembly is required to prevent receiver overload when performing loopbacks.

Internal testing capabilities Technicians can use the internal testing capabilities for installation and manual troubleshooting. The DS1 and DS3 test signal generators and detectors are integrated into the system, eliminating the need for external test equipment to perform transmission tests.

Specific testing

DMX also allows technicians to test specific system components. In addition to the automatic diagnostics, DMX provides tests for LEDs, office alarms, and the SYSCTL circuit pack.

Protection Switching

Overview

Purpose This section describes the types and functions of protection switching in the DMX Access Multiplexer.

Contents The following protection switching topics are discussed in this section:

Line Protection Switching	6 - 22
Path Protection Switching (Path Switched Rings)	6 - 23
Line Protection Switching (Line Switched Rings)	6 - 25
Spanning Tree	6 - 27
Equipment Protection	6 - 29



Line Protection Switching

Overview Line protection switching (1+1) occurs automatically in response to detected faults, as well as in response to external commands from technicians at a local or remote CIT or OS. DMX provides SONET standard line protection switching on low-speed optical interfaces as a user-provisionable option.

Protection switching priorities DMX uses standard protection switching priorities as follows:

- Inhibit automatic protection switch
- Lockout of protection
- Forced switch
- Automatic switch: signal fail
- Automatic switch: signal degrade
- Manual switch.

DMX uses unidirectional 1+1 nonrevertive line switching. Automatic protection switch procedures as specified by the SONET standard are used.

To support 1+1 compatibility on the OC-n interface, the interface must be provisioned for the “identical” application mode.

Automatic line switching Automatic line switches are initiated by signal fail and signal degrade conditions on the received OC-n signal. This signal’s BER is calculated from violations in the SONET line overhead B2 parity byte. Signal fail is declared for incoming loss of signal, loss of frame, line AIS, or a BER exceeding 10^{-3} , while a BER exceeding a provisionable 10^{-5} to 10^{-9} threshold causes the signal degrade condition. A line protection switch is completed within 50 milliseconds of the onset of a hard failure such as a fiber cut.

In multispans applications (for example, hubbing), each OC-n span switches independently. For example, in hubbing applications, a switch on the central office-to-hub span will not cause switches on any of the hub-to-remote spans. Similarly, a line switch on a hub-to-remote span will not propagate to other hub-to-remote or central office-to-hub spans.

Path Protection Switching (Path Switched Rings)

Overview DMX supports path switched ring applications using the path protection switching schemes described in Telcordia Technologies GR-1400. This scheme offers 60-millisecond restoration times and simple network administration for access applications. The ring facility consists of two fibers, with service and protection rotating in opposite directions. Each input is bridged and transmitted in both directions around the ring. The receiving end terminal monitors the quality of both signals and selects the best signal to drop.

Application modes There are three types of protection application modes, listed below:

- distinct (UPSR)
- identical (1+1-- linear)
- 0x1

The identical application mode is functionally equivalent to a 1+1 protected configuration, providing path switching on all paths within a high-speed line if that particular line fails.

The distinct application mode (UPSR) provides ring path protection switching on low-speed OC-3 and OC-12 interfaces.

The 0x1 application mode is an unprotected mode used on low-speed OC-3, OC-12, or OC-48 low-speed interfaces (R2.0).

UPSR configurations DMX supports the following OC-12/OC-48/OC-192 path switched ring configurations:

- VT1.5/STS-1
- VT1.5/STS-1/STS-3c/STS-12c
- VT1.5/STS-1/STS-3c/STS-12c/STS-48c

Path protection switching is non-revertive. A manual path protection switching command allows switching to the other path for ease of ring maintenance. STS-n path switching is triggered by incoming line LOS, LOF, LOP, AIS, and unequipped or STS-1 path BER exceeding a signal fail (10^{-3}) or signal degrade threshold. The system also supports VT path protection switching based on VT AIS, LOP, unequipped, and signal degrade.

DMX also supports STS-1/STS-3(c) non-revertive path protection switching on low-speed (OC-3/OC-12) optical interfaces, as well as

STS-12(c) path switching on OC-12 low-speed interfaces. Path protection is user-provisionable on a per-port basis.

- Unprotected paths (0x1)** DMX provides an unprotected or locked cross-connect mode, referred to as 0x1, on OC-3 and OC-12 low-speed ports. This option is user-provisionable on a per-port basis and supports single- and dual-homed ring on ring topologies.
- Mixed protection modes** DMX supports mixed protection modes (identical, distinct, and 0x1) on different ports on the same OLIU. In Release 3.0, DMX supports mixed protection modes (identical, distinct, and 0x1) on different channels on the same line or port.
- Ethernet interface protection** On the WAN (SONET) side of the network, DMX utilizes standard IEEE 802.1D spanning tree protection for multipoint applications and/or STS-1 UPSR protection (for point-to-point applications). See the section beginning on the following page for more detailed information on Spanning Tree Protection.

Line Protection Switching (Line Switched Rings)

Overview A 2-fiber bidirectional line-switched ring (BLSR) is a self-healing ring configuration in which traffic is bidirectional between each pair of adjacent nodes and is protected by redundant bandwidth on the bidirectional lines that interconnect the nodes in the ring. Because traffic flow is bidirectional between nodes, traffic can be added at one node and dropped at the next without traveling around the entire ring. This leaves the spans between other nodes available for additional traffic. Therefore, with distributed traffic patterns, a BLSR can carry more traffic than the same facilities could carry if configured for a unidirectional path-switched ring.

The DMX supports one high-speed OC-48 2-fiber BLSR (Release 2.1) or one high-speed OC-192 2-fiber BLSR (Release 3.0) and one low-speed OC-48 BLSR (Release 3.0). In the latter application, the low-speed OC-48 BLSR is hosted by OC-48 circuit packs housed in the Function slots and can add and drop traffic with the high-speed OC-192 circuit packs housed in the Main slots.

Self-healing rings DMX 2-fiber BLSRs are self-healing in that transport is automatically restored after node or fiber failures. Each OC-192 line carries 96 STS-1 equivalent timeslots of working capacity plus 96 STS-1 equivalent timeslots of protection capacity. Each OC-48 line carries 24 STS-1 equivalent timeslots of working capacity plus 24 STS-1 equivalent timeslots of protection capacity. In the event of a fiber or node failure, service is restored by switching traffic from the working capacity of the failed line to the protection capacity in the opposite direction around the ring. In the event of a node failure, traffic added and dropped from the failed node is not protected by path switching.

Protection switching When a line failure triggers a protection switch, the nodes adjacent to the failure switch traffic on to protection capacity. Traffic heading toward the failure is looped back on to the protection capacity traveling away from the failure to reach its destination by traveling the opposite way around the ring (see the figure below). Service is reestablished on the protection capacity in ≤ 50 milliseconds after detection of the failure (for catastrophic failures in rings without existing protection switches or extra traffic).



Spanning Tree

Overview This section provides information on the spanning tree protocol and spanning tree groups. The DMX now supports a faster spanning tree algorithm documented in IEEE 802.1w.

Important! DMX has been designed with multi-vendor interoperability in mind. As many vendor's equipment (including legacy equipment) may not be able to use IEEE802.1w, DMX can automatically fall back on IEEE802.1d in the event that other NEs in the network are running standard spanning tree protocol. However DMX employs IEEE 802.1w as a default spanning tree protocol.

Function of spanning tree Ethernet requires a network with a tree structure in order to work effectively. Ethernet bridges and switches build tables that define the paths to specific devices. A MAC bridge, for example, will have a filtering database that defines where to send any packets addressed to a specific MAC within the network. The tables are built based on input from devices within the network.

If there is a loop in the network, that is, if there is more than one way to get to a destination device, two problems can result:

- Frames may be duplicated in the network. That is, the same frame may be sent to a node via two different paths.
- The address information will be changed as packets from that device are received across different paths. In a meshed network, the reconfiguration of the filtering database can begin to use up all the network resources, so that little bandwidth is left for data traffic.

The spanning tree accomplishes two important functions:

- It removes loops from the bridged network
- It allows reconfiguration if a link fails.

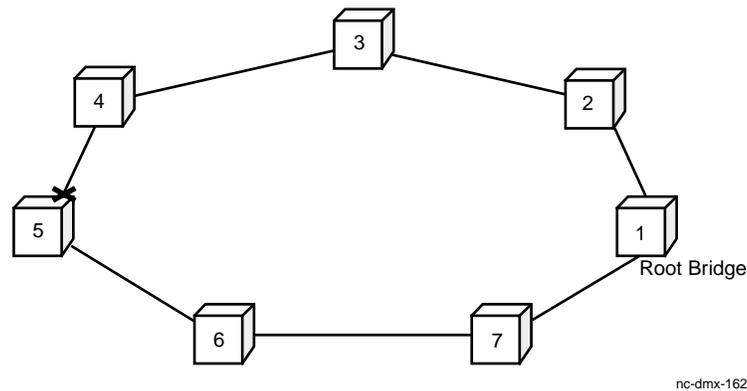
How it works The spanning tree works as follows:

1. Initially, every node in the group thinks it is the root node.
2. As information about the network becomes clear, one node is designated the root node.

It is from this node that the distance to any point in the network may be measured.

3. Configuration BPDUs are sent from each node to determine the most economical route from each node to the root node.
4. Some ports are blocked so that there are no loops in the network and so that the network provides the most efficient paths from the root to the nodes.
This effectively creates a tree structure for the network.
5. If an active link fails, the network is reconfigured so that previously blocked links can be used for traffic.

The following figure illustrates the spanning tree:



Legend:

Active Links 1- 2; 2- 3; 3 -4 ; 5-6; 6-7; 7-1

Inactive Links 4-5

X Indicates a blocked port (no packets sent or received on this port).

Note that the configuration provides the shortest (most efficient) path from each node to the root. The configuration also provides only one path from the root node to any other node.

Reconfiguration

If one of the active links were broken, the network would reconfigure to allow traffic to get to the nodes. For example, if the link between 3 and 4 were broken, the link between 5 and 4 would be enabled. When the failure/break is repaired, the network will revert to the original configuration.

□

Equipment Protection

Overview All transmission circuit packs are optionally 1x1 protected (not including ethernet interfaces) and use non-revertive switching. The ACTIVE LEDs on the 1x1 protected circuit pack faceplates show which circuit packs are carrying service. This aids technicians in circuit pack replacement procedures.

Protection switching priorities The following protection switching priorities on equipment are user-controllable through TL1 commands:

- inhibit switch
- forced switch
- manual switch.

Protection switching is available for all traditional SONET interfaces when provisioned for path and/or line protection switching.

If protection is not desired, SONET interfaces can be provisioned for no protection by not equipping the adjacent Function Unit slot. For example, if Function Unit slot A1 is equipped with an OC-3 circuit pack, then slot A2 would remain unpopulated.

Performance Monitoring

Overview

Purpose This section lists and describes performance monitoring parameters, SNMP traps and parameters, data storage, thresholds, and TCA transmission.

Contents The following performance monitoring information is included in this section:

Performance Monitoring Parameters	6 - 31
SNMP Parameters and Traps	6 - 39
Performance Monitoring Data Storage	6 - 42
Performance Parameter Thresholds	6 - 43
TCA Transmission to OS	6 - 44



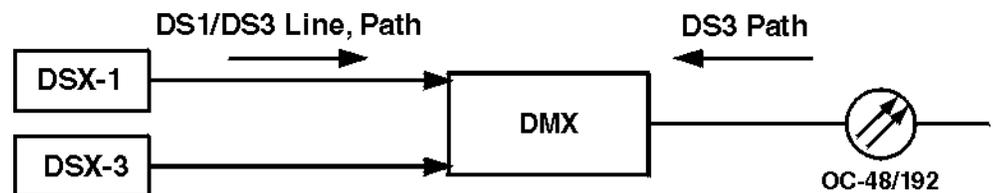
Performance Monitoring Parameters

Overview DMX uses performance monitoring (PM) to support proactive maintenance of the network and tariffed service performance verification. Proactive maintenance refers to the process of detecting degrading conditions not severe enough to initiate protection switching or alarming but indicative of an impending hard or soft failure. Hard and soft failures result in reactive maintenance. PM conditions are reported on both SONET and ethernet interfaces.

Proactive maintenance Proactive maintenance consists of monitoring performance parameters associated with the SONET sections, lines and paths within the SONET network, as well as incoming and outgoing bytes and frames on ethernet ports. Table 6-2, SONET PM Parameters (6-34), lists the SONET performance parameters monitored by DMX. These parameters are thresholded to indicate degraded performance. When a performance-monitoring threshold is crossed, it is reported to the message-based operations system where all threshold crossings associated with a particular path can be correlated, and the likely source of the degradation can be identified. Ethernet performance monitoring parameters are listed later in this section.

Figure 6-4, DS1/DS3 Line/Path Performance Monitoring (6-31), shows DS1/DS3 line and path and DS3 path performance monitoring. DMX monitors DS3 line and path parameters from the DSX-3 and DS3 path parameters from the optical path.

Figure 6-4 DS1/DS3 Line/Path Performance Monitoring



Line parameter A line is a physical transport vehicle that provides the means of moving digital information between two points in a network. The line is characterized by a metallic transmission medium and its specific coding type. A line is bounded by its two end points, known as line terminations. A line termination is the point where the electrical,

bipolar line signal is generated and transmitted, or received and decoded.

Path parameter

A path is a framed digital stream between two points in a network and represents digital signal transport at a specified rate, independent of the equipment and media providing the physical means of transporting the signal. A path is defined by its two end points, called path terminations, where its frame structure is generated and decoded. A path may be carried wholly within one transport segment (line), or it may span a sequential arrangement of two or more transport segments.

DS1 performance monitoring

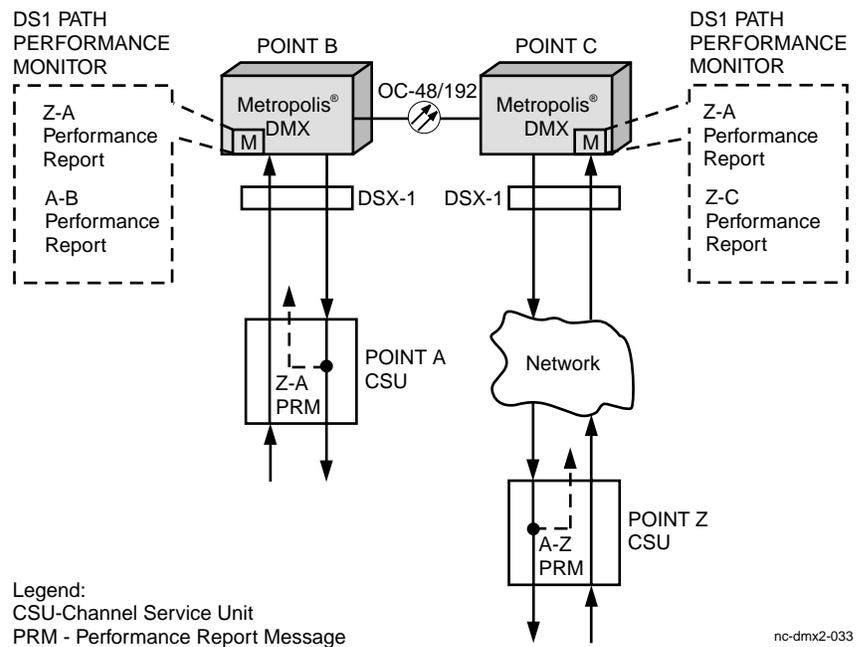
Tariffed service verification consists of monitoring performance parameters that can be associated with the customer's end-to-end service. The DMX system provides this capability for DS1 services with the DS1 performance monitoring feature. Based on *ANSI T1.403* extended superframe format (ESF), this capability retrieves performance messages written into the ESF data link by the customer's terminal equipment. From these messages, the DMX can determine and report the end-to-end error performance of the entire DS1 link *as seen by the customer*. These parameters, listed in Table 6-2, SONET PM Parameters (6-34), are thresholded and reported to indicate degraded performance, and the counts are retrieved by the message-based operations system to determine if the service is operating within tariffed limits.

Application of the DS1 performance monitoring feature for tariffed service verification is shown in Figure 6-5, DS1 Path Performance Monitoring (6-33). This shows an *ANSI T1.403* ESF format DS1 service carried between points A and Z, using an OC-48/OC-192 system and terminated at the customer's premises with channel service units (CSUs). At the "A" end, the received error performance, (Z - A) is detected and written by the customer CSU onto the outgoing (A - Z) ESF data link as a performance report message (PRM). The DS1 PM circuit pack interfacing the A end reads the incoming DS1 signal's PRM (received from the customer's premises) and reports the Z - A performance. Likewise, the OC-48/OC-192 system interfacing the Z end reports the A - Z performance by reading the PRM from the customer's "Z" CSU. By reviewing data from each OC-48/OC-192 system, the service provider can determine the complete end-to-end performance (A - Z and Z - A) of the customer's service.

DS1PM circuit pack

Additionally, each 28DS1PM circuit pack measures the near-end performance of the incoming DS1, allowing the service provider to determine if a good DS1 signal was received from the customer before transporting it through the network. This information can then aid in sectionalizing any reported performance problems. The 28DS1PM circuit pack can also provide this same near-end information for super frame (SF) formatted (sometimes known as “D4 framing”) DS1 services, but complete end-to-end performance verification is limited due to the lack of the PRM in the SF format.

Figure 6-5 DS1 Path Performance Monitoring



SONET PM parameters Table 6-2, SONET PM Parameters (6-34), lists the performance monitoring parameters for the SONET interfaces.

Table 6-3 SONET PM Parameters

Facility	Measured parameter
OC-3 Section	Severely Errored Frame Seconds (SEFS)
OC-12 Section	Severely Errored Frame Seconds (SEFS)
OC-48 Section	Severely Errored Frame Seconds (SEFS)
DS1 Line	Errored Seconds, Line (ESL) Enhanced Line Signal Threshold (BERL)
DS3 Line	Line Coding Violations (CVL) Errored Seconds (ES) Severely Errored Seconds (SES)
EC-1 Line	B2 Coding Violations (CV) B2 Errored Seconds (ES) B2 Errored Seconds Type A (ESA) B2 Errored Seconds Type B (ESB) B2 Severely Errored Seconds (SES) B2 Unavailable Seconds (UAS) STS Pointer Justifications Counts (PJC)
OC-3 Line	B2 Coding Violations (CV) B2 Errored Seconds (ES) B2 Errored Seconds Type A (ESA) B2 Errored Seconds Type B (ESB) B2 Severely Errored Seconds (SES) B2 Unavailable Seconds (UAS) Line Protection Switch Counts (PSC-L) STS Pointer Justification Counts (PJC)

Facility	Measured parameter
OC-12 Line	B2 Coding Violations (CV) B2 Errored Seconds (ES) B2 Errored Seconds Type A (ESA) B2 Errored Seconds Type B (ESB) B2 Severely Errored Seconds (SES) B2 Unavailable Seconds (UAS) Line Protection Switch Counts (PSC-L) STS Pointer Justification Counts (PJC)
OC-48 Line	B2 Coding Violations (CV) B2 Errored Seconds (ES) B2 Errored Seconds Type A (ESA) B2 Errored Seconds Type B (ESB) B2 Severely Errored Seconds (SES) B2 Unavailable Seconds (UAS) Line Protection Switch Counts (PSC-L) STS Pointer Justification Counts (PJC)
OC-192 Line (R2.0)	B2 Coding Violations (CV) B2 Errored Seconds (ES) B2 Errored Seconds Type A (ESA) B2 Errored Seconds Type B (ESB) B2 Severely Errored Seconds (SES) B2 Unavailable Seconds (UAS) Line Protection Switch Counts (PSC-L) STS Pointer Justification Counts (PJC)
STS-1, STS-3c, STS-12c, STS-48c Path	B3 Coding Violations (CV) B3 Errored Seconds (ES) B3 Errored Seconds Type A (ESA) B3 Errored Seconds Type B (ESB) B3 Severely Errored Seconds (SES) B3 Unavailable Seconds (UAS)
VT1.5 Path	V5 Errored Seconds (ES) V5 Severely Errored Seconds (SES) V5 Unavailable Seconds (UAS)

Facility	Measured parameter
DS1 Path	Coding Violations, Path (CVP) Coding Violations, Path Far-End (CVPFE) Errored Seconds, Path (ESP) Errored Seconds, Path Far-End (ESPFE) Severely Errored Seconds, Path (SESP) Severely Errored Seconds, Path Far-End (SESPFE) Unavailable Seconds, Path (UASP) Unavailable Seconds, Path Far-End (UASPFE)
DS3 Path	P-bit Coding Violations Severely Errored Frame Seconds (SEFS)
DS3 Path for both P-bit and F&M bits (from fiber only)	CP-V Coding Violations Severely Errored Frame Seconds (SEFS) ES-P Errored Seconds SES-P Errored Seconds UAS-P Unavailable Seconds
DS3 Path for P-bit, F&M bits, and C-bit (from fiber and DSX)	CV-P Coding Violations Severely Errored Frame Seconds (SEFS) ES-P Errored Seconds SES-P Errored Seconds UAS-P Errored Seconds

DS3 performance monitoring

DMX provides DS3 performance monitoring with three DS3 path PM options: P-bit (parity bit), adjusted F&M bit (frame and multiframe bit), and C-bit. The options are selected using a command that also sets the PM mode to “on” (default) or “off,” which enables or disables the monitoring and reporting of DS3 path PM data.

P-Bit

When provisioned for P-bit, the system calculates and provides counts of DS3 P-bit coding violations (CV), errored seconds (ES), and unavailable seconds (UAS) incoming from the fiber. Quarter-hour and day registers are provided with provisionable threshold crossing alerts (TCAs) on a per shelf basis. Severely errored frame seconds (SEFS) are also monitored.

Because P-bits can be corrected at nodes provisioned for VMR along a DS3 path, the DS3 P-bit PM data may not provide a complete report of the end-to-end DS3 path errors.

Adjusted F&M Bit

Adjusted F&M bit performance monitoring provides an alternative method for determining and accumulating DS3 path performance data based on an error estimation technique using errors on the F&M framing bits to approximate the actual error counts in the DS3 path payload. F&M bits are not corrected at nodes provisioned for VMR along a DS3 path. When provisioned for adjusted F&M bit, the system calculates and provides estimated counts of DS3 adjusted F&M bit coding violations (CV), errored seconds (ES), severely errored seconds (SES), and unavailable seconds (UAS) incoming from the fiber.

Quarter-hour and current day registers are provided with provisionable threshold crossing alerts (TCAs) on a per shelf basis. Severely errored frame seconds (SEFS) are also monitored.

C-Bit

DMX also provides DS3 path PM using the C-bit option. When the C-bit option is selected, both near-end and far-end (far-end block errors) PM data are monitored and displayed.

The system provides counts of DS3 C-bit parity coding violations (CV-P), errored seconds (ES-P), severely errored seconds (SES-P), and unavailable seconds (UAS-P) incoming from the DSX-3 and the fiber. The type of performance monitoring is provisioned per DS3 service by a CIT command.

For C-bit PM, the DS3 service can be provisioned in violation monitor (VM) or violation monitor and removal (VMR) modes. In VM mode, the C-bit errors are not corrected as in the P-bit option.

Quarter-hour and day registers are provided with provisionable threshold crossing alerts (TCAs). The TCAs are provisionable on a per-shelf basis. Severely errored frame seconds (SEFS) counts are also provided.

Ethernet performance monitoring

DMX provides PM capabilities for the 10/100T, 1G SX, and 1G LX ethernet interfaces. PM data is collected at each LAN and WAN interface in the network for both incoming and outgoing directions. The WAN interface provides a connection to a SONET Virtual Concatenation Group (VCG).

Listed below are the six PM parameters that provide PM data on all ethernet interfaces:

- **Dropped Frames (congestion)**

This parameter counts the number of incoming ethernet frames dropped at a specific LAN/WAN port due to buffer overflow. Buffer overflow occurs when the network is congested.
- **Dropped Frames (errors)**

This parameter counts the number incoming ethernet frames dropped at a LAN/WAN port due to a frame check sequence (FCS) error or another defect in the frame.
- **Incoming Number of Bytes**

This parameter counts the total number of bytes incoming to a LAN/WAN port.
- **Incoming Number of Frames**

This parameter counts the total number of ethernet frames incoming to a LAN/WAN port.
- **Outgoing Number of Bytes**

This parameter counts the total number of outgoing bytes transmitted by a specified LAN/WAN port.
- **Outgoing Number of Frames**

This parameters counts the total number of outgoing frames transmitted by a specified LAN/WAN port.

SNMP Parameters and Traps

Support of Simple Network Management Protocol (R3.0)

DMX makes use of Simple Network Management Protocol (SNMP). SNMP is the most common protocol used by data network management applications to query a management agent using a supported Management Information Base (MIB). SNMP operates at the OSI Application layer. The IP-based SNMP is the basis of most network management software, to the extent that today the phrase “managed device” implies SNMP compliance.

Parameters Supported

The DMX supports all of the following SNMP parameters.

Table 6-4 SNMP Parameters supported

SNMP Parameters
Administration Status (RFC2863)
Operational Status (RFC2863)
Total Bytes Recieved (RFC2863)
Frames Recieved (RFC2863)
Multicast Frames Recieved (RFC2863)
Broadcast Frames Recieved (RFC2863)
Recieved Frames Dropped (RFC2863)
Recieved Error Frames (RFC2863)
Bytes Sent (RFC2863)
Unicast Frames Sent (RFC2863)
Multicast Frames Sent (RFC2863)
Broadcast Frames Sent (RFC2863)
Traps Enabled or Disabled (RFC2863)
Time of Last Counter Discontinuity (RFC2863)
Fragements (RFC2358/RFC2665)
CRC Errors (RFC2358/RFC2665)
Collision (RFC2358/RFC2665)
Late Collision (RFC2358/RFC2665)

SNMP Parameters
Oversize Frames (RFC2358/RFC2665)
MAC Recieve Errors (RFC2358/RFC2665)
Duplex Status (RFC2358/RFC2665)
Flow Control Default Mode (RFC2358/RFC2665)
Flow Control Operational Mode (RFC2358/RFC2665)

Traps Supported The DMX supports all of the following SNMP traps.

Table 6-5 SNMP Traps supported

SNMP Traps
Link Up (RFC2863)
Link Down (RFC2863)
Loss of Signal on GbE or FE LAN Port (Ethernet Private MIB)
Incoming VCG Fail (VCG Private MIB)
Incoming VCG Loss of Alignment (VCG Private MIB)
Incoming VCG Loss of Frame Delineation (VCG Private MIB)
Incoming VCG Data Type Mismatch (VCG Private MIB)
Incoming STS -1 Loss of Frame (VCG Private MIB)
Incoming STS-1 Sequence Number Mismatch (VCG Private MIB)
Circuit Pack Not Allowed (Equipment Private MIB)
Illegal Circuit Pack Type (Equipment Private MIB)
FE-LAN Circuit Pack Failed (Equipment Private MIB)
GbE-LAN Circuit Pack Failed (Equipment Private MIB)
Circuit Pack Removed (Equipment Private MIB)
Circuit pack Inserted (Equipment Private MIB)

Performance Monitoring Data Storage

- Quarter-hour and current day registers** DMX provides current quarter-hour and current day registers for all accumulated performance parameters. The previous 8 hours of quarter-hour and previous day registers are also provided.
- Access** The DMX system can initialize these registers through the TL1 interfaces at any time, as well as retrieve and report their contents.

Performance Parameter Thresholds

Provisioning The current quarter-hour and current day thresholds for each parameter type are provisionable, on a per-shelf basis. If values other than the defaults are used, only one value for each parameter type needs to be set.

Threshold crossing alerts (TCAs) Whenever the current quarter-hour or the current day threshold for a given parameter is exceeded, DMX generates a threshold-crossing alert (TCA) that is entered into the performance monitoring exception report and reported to the OS through the TL1 interface.

TCA Transmission to OS

Overview The TCA information can be reported to the OS using any of the TL1 OS interfaces. TCAs can be used to trigger proactive maintenance activity.

TL1 access The TL1/X.25 or TL1 over TCP/IP OS interfaces should be used to derive full benefit from DMX's performance monitoring capabilities. The full set of PM data stored by DMX (TCAs and the contents of PM registers) is provided through any of the TL1 interfaces.

Provisioning

Overview

Purpose This section describes the many types of provisionable parameters available in DMX.

General DMX allows the user to customize many system characteristics through provisioning features. Provisioning parameters are set by software controls.

Contents The provisionable parameters described in this section include:

Default Provisioning	6 - 46
Remote Provisioning	6 - 47
Cross-Connect Provisioning	6 - 48
Automatic Provisioning on Circuit Pack Replacement	6 - 49
Port State Provisioning	6 - 50
Channel State Provisioning	6 - 51
Line State Provisioning	6 - 52



Default Provisioning

Default values Installation provisioning is minimized with thoughtfully chosen default values set in the factory. Every parameter has a factory default value. These factory defaults for software parameters are maintained in the SYSCTL circuit pack, and a single command is provided to restore all default values. All provisioning data is stored in nonvolatile memory to prevent data loss during power failures and maintenance operations.

Remote Provisioning

Overview Software control allows remote provisioning of DMX NEs. This feature is provided especially for provisioning parameters likely to change in service, in support of centralized operations practices.

Cross-Connect Provisioning

Overview The DMX can be provisioned for signal routing. Depending on the application, VT1.5, STS-1, STS-3(c), STS-12(c), or STS-48(c) signal cross-connections may be established to route traffic in a specific manner. Cross-connections may be bidirectional or unidirectional.

Typical cross-connections Any VT1.5 or STS-n signal may be provisioned for the following signal routes:

- Main to Main
- Main to Function Unit.
- Hairpinn (Function Unit to Function Unit).

VT1.5 and STS-n signals may be cross-connected in several ways. For bidirectional drop services, the “two-way” cross-connection is used to connect a like signal in the high-speed Main slot to any available time slot in any Function Unit slot equipped with low-speed OC-3, OC-12, OC-48, DS1, or DS3/EC-1 circuit packs. For unidirectional drop services, the “one-way” cross-connection is used to connect a like signal in the high-speed Main slot to any available time slot in any Function Unit slot equipped with low-speed OC-3, OC-12, OC-48, DS1, or DS3/EC-1 circuit packs.

STS-1 cross-connections to ethernet interfaces are also available. The “two-way” or “one-way” cross-connection is used for UPSR point-to-point ethernet applications. A mltp (data specific) cross-connect is used for multipoint ethernet applications.

The bidirectional or unidirectional pass-through cross-connect is used to pass VT1.5 or STS-n signals through the NE all on the same timeslot.

For more info For more information on cross-connections, refer to Chapter 5, “System Planning and Engineering.”

Automatic Provisioning on Circuit Pack Replacement

Overview Replacement of a failed circuit pack is simplified by automatic provisioning of the original circuit pack values. The SYSCTL circuit pack maintains a provisioning map of the entire shelf, so when a transmission pack is replaced, the SYSCTL circuit pack automatically downloads the correct values to the new circuit pack. Likewise, if the SYSCTL circuit pack is ever replaced, the correct provisioning data from every other circuit pack in the shelf is automatically uploaded to the new SYSCTL circuit pack's nonvolatile memory.

Port State Provisioning

Overview Port state provisioning is a feature provided on DMX NEs that can help suppress alarm reporting and performance monitoring by supporting multiple states for DS1, DS3, EC-1, and Ethernet LAN ports.

The states supported are as follows:

- automatic (AUTO)
- in-service (IS)
- not monitored (NMON).

Port states Ports without signals (undriven) are in the automatic state until changed to the in-service state when a signal is present. Commands allow a user to retrieve and change the state of a port to the not-monitored state or from the not-monitored state to the automatic state.

Channel State Provisioning

Overview Automatic channel state provisioning is a capability provided on DMX NEs that suppresses reporting of transient alarms and events during provisioning by supporting multiple states (AUTO, IS, NMON) for VT1.5, STS-1, STS-3(c), STS-12(c), STS-48(c) channels.

Automatic channel state provisioning While an end-to-end circuit is being set up, particularly during VT1.5 and STS-n cross-connect provisioning, several transient maintenance signals result. Without automatic channel state provisioning, these are reported as alarms and events. The technicians are expected to ignore these transient alarms and initiate corrective action only if the alarms persist after the provisioning is completed. To avoid the confusion created by this, DMX provides automatic channel state provisioning.

Channel states A VT1.5 or STS-n channel is kept in the default automatic (AUTO) state until the reception of a valid signal (a framed non-AIS or non-LOP) in that channel. While in AUTO state, no alarms or events are reported on the channel. On receiving a valid signal, which occurs when the end-to-end circuit is completely provisioned, the channel automatically changes to the in-service (IS) state, where it resumes normal alarm and event reporting. An additional state, not-monitored (NMON), is also supported in which alarm and event reporting is suppressed regardless of the validity of the signal being received on the channel. Like the port state provisioning capabilities already provided for physical ports like DS1, DS3, and EC-1, the user can submit commands to manually change a channel from IS or AUTO to NMON, and from NMON to AUTO. A user cannot manually change from AUTO or NMON to IS.

Line State Provisioning

Overview The state of the low-speed OC-3, OC-12, and OC-48 interfaces can be set manually to NMON or IS. On OLIUs with multiple ports (OC-3 and OC-12), the line state default is IS and alarms are suppressed. Users must manually set unused ports to NMON or those ports will be alarmed.

Reports

Overview

Purpose This section describes reports generated by DMX.

Contents Reports described in this section include:

Alarm and Status Reports	6 - 54
Performance Monitoring Reports	6 - 55
Maintenance History Reports	6 - 56
State Reports	6 - 57
Provisioning Reports	6 - 58
Version/Equipment List	6 - 59



Alarm and Status Reports

Overview The system provides alarm reports that list the active alarm and status conditions, including a remote alarm/status feature that summarizes alarms in other NEs in an alarm group. A description of the condition (for example, controller failure, incoming high-speed signal failure, synchronization hardware or reference failure, etc.) is included in the reports along with a time stamp indicating when the condition was detected, its severity, and whether it is service affecting or not. The option to display specified subsets of alarm conditions is provided (for example, critical alarms only).

Status conditions Status conditions include:

- Manually initiated abnormal conditions (for example, forced switch, manual lockouts, loopbacks, system testing)
- Incoming AIS detected
- ACO active.

A description of the status condition (for example, DS1 loopback active, DS3 facility loopback active, etc.) is included in the report along with a time stamp indicating when the condition began.

Performance Monitoring Reports

TCA summary report DMX provides a report that lists the number of SONET performance-monitoring parameters that have crossed their thresholds. This report provides a snapshot of the system performance level. If there is signal degradation, it is quickly pinpointed so that corrective action may be taken before customers are affected, thus supporting proactive maintenance. Threshold-crossing alerts (TCAs) are not reported on ethernet interfaces.

This report provides separate parameter summaries for each signal level in the system, including SONET section, line, and path, as well as dropped/incoming/outgoing ethernet bytes and frames. The parameter summaries show the user which performance status to request if they want further information.

Performance status reports These reports provide detailed information on the current and previous 8 hours in quarter-hour (15-minute) increments, as well as the current and previous day's performance. Threshold crossing alerts are clearly identified and the time the performance registers were last initialized is also shown. Any registers that may have been affected by this initialization are marked. There are separate reports for section, line, and path parameters, as well as ethernet parameters.

Maintenance History Reports

Overview A maintenance history report contains the following past conditions:

- alarms
- status
- protection switching
- user interface commands (e.g., provisioning, loopback request, manual protection, etc.)

Summary The maintenance history report contains time stamps indicating when each condition was detected and when it cleared, as well as when the command was entered. Note that any system controller reset clears all records in the log.

Reference

See the *DMX Access Multiplexer User Operations Guide*, 365-372-301, for details on the history log.

State Reports

Overview	The state report shows the protection state of all circuit packs installed in the system and the state of the individual low/high-speed channels.
Circuit pack states	The circuit pack state is reported as “active” or “standby.”
Path states	<p>The state of the individual VT1.5 /STS-n channels and paths may be one of the following:</p> <ul style="list-style-type: none">• not monitored (NMON)• in service (IS)• auto (AUTO). <p>The system reports this information on all interfaces. AUTO refers to a slot that is available for automatic provisioning. For VT1.5/STS-n channels and paths, the AUTO state would transition to the IS state if a good signal is detected.</p>
Port states	The state of individual ports, including those contained in multiport circuit packs (28DS1, 12DS3/EC1, Ethernet Interface packs, quad OC-3, dual OC-12, or OC-48), may be NMON, IS, or AUTO.
Line states	The state of individual lines may be IS or NMON (quad OC-3, dual OC-12, or OC-48).

Provisioning Reports

Overview The DMX provides a variety of provisioning reports that contain the current values of all electronically-provisionable parameters and hardware-selectable parameters (12DS3/EC1). For more information on the provisioning reports generated, refer to the *DMX Access Multiplexer User Operations Guide*, 365-372-301.

Version/Equipment List

Overview The DMX system provides a full inventory report on all hardware and software currently installed.

Information provided The version/equipment list provides the following information:

- Circuit pack name
- 10-character *CLEI* code
- 6-digit equipment catalog item (ECI)
- 10-character apparatus code
- 6-character series number
- 12-character serial number (includes date and location of manufacture)
- Program version (software generic) code
- Program versions in dormant area.

Administration

Overview

Purpose This section provides information on system administration.

Contents System administration considerations included in this section are:

Software Upgrades	6 - 61
IP Access for network management	6 - 62
Network Size	6 - 65
Security	6 - 66



Software Upgrades

Overview DMX provides an in-service software installation capability to update the generic program in local and remote systems. Upgrades are distributed on CD-ROMs containing the new software and an installation program. These software upgrades are the primary mechanism to add new feature enhancements to the in-service DMX network. All software upgrades are “in-service” and do not affect any provisionable parameters. For example, cross-connections are left unchanged by the software upgrade.

Software download In the DMX system, software download takes place in two stages. In the first stage, the new generic software is downloaded into a dormant “flash” area as a compressed file. In the second stage, the new generic is uncompressed and moved into an active “flash” space. During this process, the old release continues to run from random access memory (RAM). Installation is not service-affecting, so down time is limited to the reboot time.

Local installation procedure The procedure is straightforward. The technician connects a personal computer (PC) to the RS-232 front serial port on the local DMX, starts the installation program, and is prompted with a few warnings before the upgrade installation actually begins. After the technician confirms to proceed, the PC takes over the process and completes the installation.

Beginning in Release 2.0, installation may be performed via Lucent’s SNMS or PC-CIT over the IAO LAN interface using FTP. For more information on software download and upgrade via SNMS, refer to the *Subnetwork Management System (SNMS) User Guide*, 190-224-100.

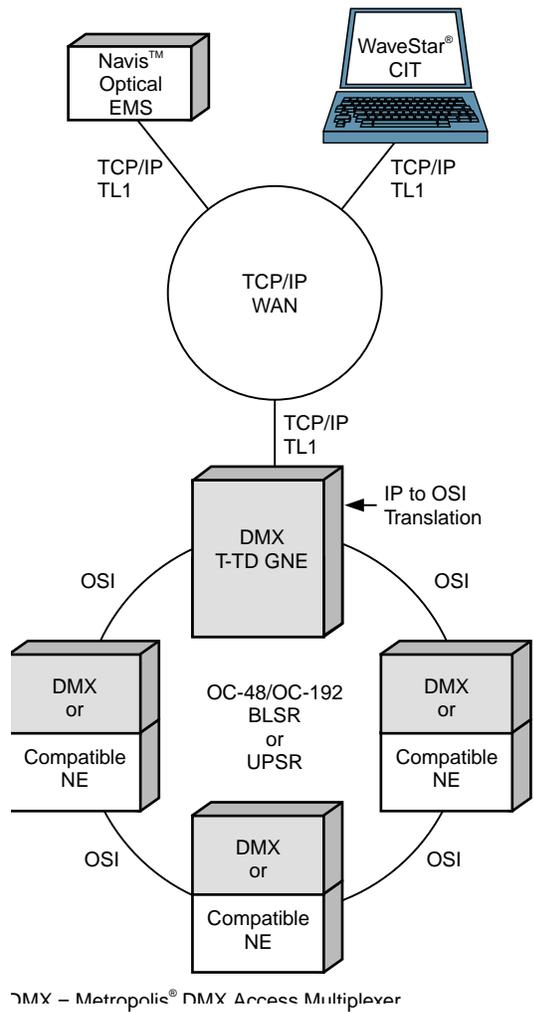
IP Access for network management

Overview For the purpose of network management, the DMX supports two types of IP Access. In one case, the DMX can serve as a TL1 Translation Device (T-TD) by acting as a gateway network element that allows an SNMS and/or PC-CIT to communicate to other network elements (NEs) through an IP access network. This capability allows you to send TL1 commands from an SNMS or PC-CIT located on a TCP/IP based network to various NEs connected on an OSI network. In the second instance, the DMX can functionally encapsulate IP packets within OSI packets to be transmitted through the OSI network to the proper NE. Thus the DMX supports IP based protocols such as FTP by providing end-to-end IP connectivity between OS and NE. This capability is called IP tunneling.

TL1 Translation

The DMX can copy the application information within an IP packet into an OSI packet. This translation is performed at the application layer. When acting as a TL1 translation device, the DMX system must be provisioned with a list of possible OSs. If an OS is not on the list residing within the system, a connection from that OS will not be accepted. When the DMX is used as a TL1 translation device it is referred to as the T-TD GNE (Gateway Network Element). The T-TD GNE provides the same functionality as the NCC TL1 TCP/IP gateway.

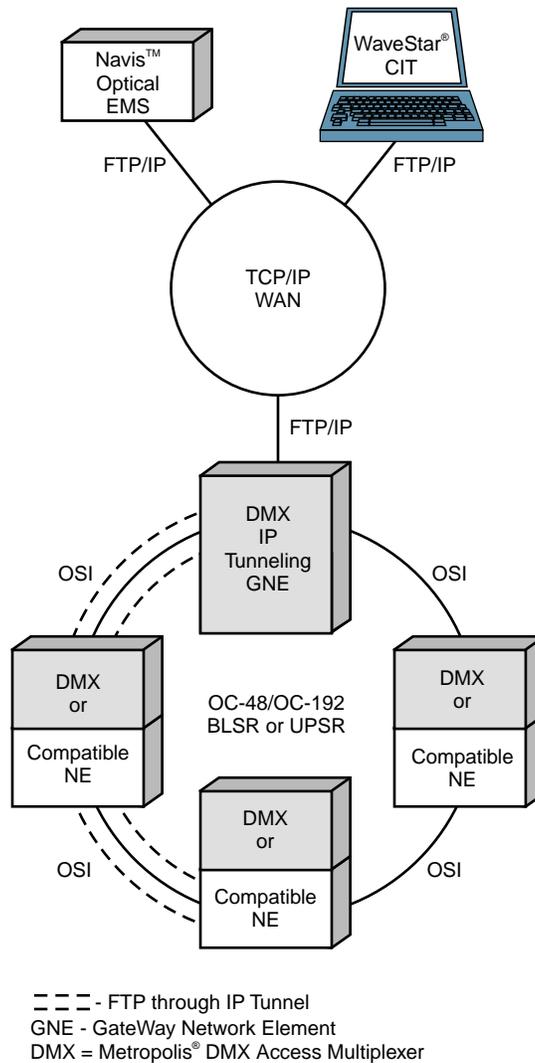
Figure 6-6 TL1 Translation Device



IP Tunneling

IP tunneling is used to perform end-to-end FTP through the IP and OSI portion of the network. In this instance the DMX serves as a gateway network element that encapsulates an IP packet within an OSI packet. When the final destination of the packet is reached, the IP packet is taken from within the OSI packet and processed by the TCP/IP stack. Thus, IP tunneling allows an SNMS and/or PC-CIT to reach NEs in an OSI based DCN network with FTP over IP. In this case, the end point of the IP tunnel is the actual end for the IP traffic. IP tunneling can be used for any IP based protocol, but the use will be limited to FTP for this release.

Figure 6-7 IP Tunneling



Network Size

Overview The maximum number of DMX NEs that Release 2.0 can support in a single subnetwork is 256 (50 per Level 1 area). Through IS-IS Level 2 Routing, larger networks may be supported for particular applications. There is no limitation on the size of networks formed by splitting a large network into a number of smaller maintenance networks by disabling the DCC between the networks. IS-IS Level 2 Routing can be done in-service without affecting transmission traffic.

Security

Overview DMX offers security against unauthorized access to the system functions. The use of security is provisionable for the front CIT port, the rear CIT (modem) port, the X.25 port, the IAO LAN port, and the DCC. In addition to this, the DCC can be disabled, thus securely isolating the DMX system from possible remote intrusion. A provisionable timeout is available for each access port that enables automatic termination of inactive or unattended sessions.

User types There are four types of users:

- Three **privileged user** accounts are reserved for system security administration.
- **General** users can select and maintain their own password.
- **Maintenance users** are allowed to perform basic maintenance functions. These users can select and maintain their own passwords.
- **Reports-only users** can display certain system information but cannot change provisioning or maintenance parameters.

Security features DMX provides security features such as 7-999 day password aging, customized login proprietary messages, and 150 user login IDs.

30-day password aging

This feature allows the customer to enable or disable the aging of a user's password. The maximum interval before a password must be changed is 999 days.

Customized login proprietary notice

This feature affords privileged users the opportunity to provision a proprietary banner, to be displayed upon login, to improve the system's security. The banner is displayed in conjunction with the Lucent Proprietary banner.

By default this feature is "disabled." When the banner is disabled, only the Lucent Proprietary notice appears upon login. If the banner is "enabled", the Lucent Proprietary notice is displayed first, followed by the customer-provisioned banner.

The banner has a maximum line number of 9 and a maximum character number of 450 (9 lines x 60 characters = 450).

150 users

DMX supports 150 user login IDs: 3 privileged users and 147 other user IDs with the general, maintenance, or reports-only privileges.



7 Ordering

Overview

Purpose This chapter contains information on ordering Metropolis DMX Access Multiplexer equipment and software. The information in this chapter tells you where to go for ordering information, and provides important sparing information and FIT rates relative to both circuit packs and other equipment.

Contents Ordering topics included in this chapter are:

Introduction	7 - 2
Engineering Drawings	7 - 3
Software and Documentation	7 - 4
Miscellaneous Equipment and Tools	7 - 7
Sparing Information for a Metropolis [®] DMX Access Multiplexer System	7 - 9
Failure Rates	7 - 10
Sparing Graph	7 - 13



Introduction

Overview Lucent has created a set of engineering drawings to facilitate the ordering of all products in the future. These drawings are updated for each planned Release, and contain all of the information needed to order DMX equipment. The information contained in the engineering drawings will not be duplicated anywhere in the interest of keeping all information current and consistent at all times. This chapter will explain how to make sure you are using the most current version of the engineering drawing and where to order it.

Software and Documentation ordering information is not included in the engineering drawings and is therefore included in this chapter. This chapter also contains important information regarding sparing information and FIT rates for all DMX equipment. Any information about particular pieces of equipment (i.e. the uses of various cables versus other) is meant to convey useful information that may/may not be contained in the engineering drawings. This information is meant to be used in conjunction with engineering drawings, but not to replace them.

How to order Equipment and software orders may be placed via Lucent's online ordering process. For more information, contact your Account Executive.



Engineering Drawings

Overview In the interest of ensuring that ordering information is always consistent and up-to-date, Lucent has created a set of engineering drawing meant to contain all information needed to order a DMX system.

Where to Obtain Engineering Drawings

The engineering drawing is included as an Appendix with each release of the Metropolis[®] DMX Access Multiplexer Applications and Planning Guide (refer to Appendix C of this document). However, the engineering drawing is likely to be updated more frequently than the Applications and Planning Guide. Therefore, it is possible to order the most current version of the engineering drawing individually from CIC. Whenever ordering equipment, first ensure that you have the most current version of ED8C871-10. You may do so by contacting CIC through one of the mediums detailed below.

How to order Engineering Drawings

The most up-to-date version of the Engineering drawing (ED8C871-10) may be obtained through CIC. There are 2 ways to obtain material from CIC:

- Got to www.lucentdocs.com and follow the link for Drawings. Enter the drawing number in the proper field (ED8C871-10).
 - Verify that the drawing you have is the same Issue number as the drawing on the site.
 - If it is not the same issue, follow the steps on the CIC website for ordering a new drawing.
 - If it is the same issue, the drawing is sufficient to help you configure an order.
- Contact CIC by phone: 1-800-582-3688

Software and Documentation

Overview This section provides software ordering information.

Software releases included in this section are:

- Release 2.0 Software
- Release 2.1 Software
- Release 3.0 Software
- Release 3.1 Software

Software ordering information

Listed below are some need-to-know items before ordering DMX software:

- DMX software is shipped separately from the hardware.
- Order one set of software for each shelf ordered. Software orders must be placed in addition to the hardware order to receive software.
- All system controller (SYSCTL) circuit packs are shipped without software loaded on them. Therefore, software loading must occur at or before installation.
- It may be desirable to have backup CD-ROMs for all releases on hand for backup or initial downloading.
- The software ordering table includes a cross-reference to comcodes where available.
- DMX software includes PC/CIT software.
- Initial Release software includes a CD containing the current documentation to accompany the DMX. Hardcopies of the most current documentation are available through CIC.

Available software The table below, lists the DMX software that may currently be ordered.

Table 7-1 Orderable Software

Comcode	Product Release	Description
109265926	R1.1	Initial Installation Software (CD-ROM and SRD)
109266007	R1.1	Upgrade Software (from R1.0 to R1.1) (CD-ROM and SRD)
109266049	R1.1	R1.1 Spare Software
109266130	R2.0	Initial Installation Software (CD-ROM and SRD)
109266189	R2.0	Upgrade Software (from R1.1 to R2.0) (CD-ROM and SRD)
109266213	R2.0	R2.0 Spare Software
109246322	R2.1	Initial Installation Software (CD-ROM and SRD)
109246330	R2.1	Upgrade Software (from R1.1 to R2.1) (CD-ROM and SRD)
109246348	R2.1	Upgrade Software (from R2.0 to R2.1.1) (CD-ROM and SRD)
109246363	R2.1	R2.1.1 Spare Software
109246389	R3.0	Initial Installation Software (CD-ROM and SRD)
109246454	R3.0	Upgrade Software (from R1.1 to R3.0) (CD-ROM and SRD)
109246629	R3.0	Upgrade Software (from R2.0 to R3.0) (CD-ROM and SRD)
109246645	R3.0	Upgrade Software (from R2.1 to R3.0) (CD-ROM and SRD)
109246652	R3.0	R3.0 Spare Software
TBS	R3.1	Initial Installation Software (CD-ROM and SRD)
TBS	R3.1	Upgrade Software (from Rx.x to R3.1) (CD-ROM and SRD)
TBS	R3.1	R3.1 Spare Software

Available documentation The table below, lists documentation that may currently be ordered. Documents that come with a shelf assembly order or a software order are noted.

Table 7-2 Orderable Documentation

Document Number	Title
365-372-301	<i>DMX Access Multiplexer User Operations Guide (Note 1)</i>
365-372-302	<i>DMX Access Multiplexer Alarm Messages and Trouble Clearing Guide</i>
365-372-305	<i>DMX Access Multiplexer Software Release Description (Note 2)</i>
365-372-304	<i>DMX Access Multiplexer Installation Manual</i>
365-372-306	<i>DMX Access Multiplexer Command Manual</i>
365-372-303	<i>WaveStar Product Family Operations Interworking Guide</i>
109246686 (comcode)	<i>DMX User Documentation CD, Release 3 (Note 2)</i>

Important! The comcodes for these documents is not supplied so as to limit confusion. This book, the Applications and Planning Guide, is not updated concurrently with the other documents listed in this table, but before them. As such, if comcodes were supplied here, it could result in confusion and the ordering of the wrong version of a document. Use the telephone number for CIC, provided on page 3 of this Chapter, to obtain the correct comcodes for the desired documents. The comcode for the User Documentation CD is supplied, but it is recommended that CIC be called to verify that the correct version of the CD is being ordered.

Table notes

1. The DMX Access Multiplexer User Operations Guide (in CD-ROM form) is shipped with the shelf assembly. The document may be ordered separately as well.
2. The DMX Access Multiplexer Software Release Description and User Documentation CD-ROM are shipped with a software order. The document and CD-ROM may not be ordered separately.



Miscellaneous Equipment and Tools

Lightguide build-outs DMX utilizes Lucent's state-of-the-art *AllWave ADVANTAGE*TM Fiber Optic Attenuators. These attenuators reduce optical power from the transmitter that can result in over-saturation of the receiver, have low reflection to meet stringent system requirements, and are backward-compatible with existing transmission systems. Unique to the AllWave ADVANTAGE optical connectivity solution (OCS), the new *LC*TM optic attenuators are designed to provide flat spectral loss across the full spectrum, allowing the attenuators to be used in the 1300 nm, 1400 nm, and 1500 nm bands. LC optical attenuators are ideal for networks deploying AllWave fiber, metropolitan or regional networks, applications supported by conventional single-mode optical fiber, multiservice network protocols, and DWDM networks.

The table below, lists the available LC-type lightguide build-out attenuators for the DMX.

Table 7-3 Lightguide Build-outs and Accessories

Description	Comcode	See note
LC Build-Out Attenuators		1
5 dB	108279381	
10 dB	108279431	
15 dB	108279480	
20 dB	108279530	
<i>Allwave ADVANTAGE</i> TM Fiber Optic Identification Kit	108622929	2

Table notes

1. The LC build-out attenuators listed are connector style PC (polished connectors) at the fiber end. These attenuators must be used on the receive side in all cases. For the LNW36 OC-3 and LNW46 OC-12 circuit packs, the specified attenuation may not be achieved if a SM-MM (single-mode-multi-mode) fiber signal is incoming to the LC SM-SM attenuator. In this case, a 15 dB attenuator, for example, may achieve an attenuation value less than the specified 15 dB.
2. The AllWave ADVANTAGE Fiber Optic Identification Kit includes labels for fiber optic apparatus products to identify Lucent AllWave Fiber paths. An instruction sheet is included with recommendations on how to install and use the labels.

Accessories The table below shows the miscellaneous accessories available for DMX.

Table 7-4 Miscellaneous Accessories

Product	Model/Description	Comcode	ITE#	Installation Order #
Optical Fiber Scope	Noyes OFS 300-200X	408197028	ITE-7129	33712900
2.5mm Universal Adapter Cap	For use with the Noyes OFS 300-200X	408197044	ITE-7129D1	33712901
1.25mm Universal Adapter Cap	For use with the Noyes OFS 300-200X	408197069	ITE-7129D2	33712902
Video Fiber Scope ¹	Noyes VFS-1	TBD	TBD	TBD
Individual, presaturated alcohol wipes	99% pure isopropyl alcohol	901375147	ITE-7136	33713600
CLETOP Cleaning Cassette	Type A Reel	901375154	ITE-7137	33713700
CLETOP Cleaning Cassette Replacement Reel	Type A Reel	901375014	ITE-7137 D1	33713701
Luminex Stick port cleaners	1.25 mm	901375030	ITE-7134	33713400
Luminex Stick port cleaners	2.5 mm	901375022	ITE-7135	33713500
Luminex Stick port cleaners	5.5" x 5.5"	408201226	R6033	23603300

Table notes

- 1.This equipment may not be necessary at all locations. It is to be used when the ports need to be verified for cleanliness. If care is exercised when cleaning fibers, the video scope may not be needed.
- 2.The equipment and material listed above has been tested and is proven effective. Substitution of equipment or materials is at the discretion of the user and is not recommended.



Sparing Information for a Metropolis[®] DMX Access Multiplexer System

Overview This section provides circuit pack sparing information for DMX.

Important! The number of spares for each code must be determined and maintained separately, based on the in-service population of the code at each location.

Lead time **Lead time (turnaround time)** the elapsed time between a known circuit pack/port unit failure at a given service location and the arrival of a repaired (or new) circuit pack/port unit at the location where spare circuit packs are stocked to maintain a spare circuit pack level consistent with the circuit pack population in service.

Important! Lead time should not be confused with mean time to repair (≤ 2 hours), which is the elapsed time between a known in-service circuit pack failure and when a spare circuit pack replacement is put into service.



Failure Rates

Circuit pack failure rates The table below provides the steady-state circuit pack failure rates for DMX.

Table 7-5 Circuit Pack Failure Rates

Circuit Pack	Apparatus Code	Slot(s)	Release	FIT Rate
System Controller (SYSCTL)	LNW1	CTL	1.0	5098 (7646 in OSP)
OC-192 OLIU	LNW56	M1, M2	2.1	9646
OC-192 OLIU	LNW58	M1, M2	2.1	9646
OC-192 OLIU	LNW521-559	M1, M2	3.1	TBD
OC-48 OLIU	LNW29	M1, M2	2.1	8259
OC-48 OLIU	LNW28	M1, M2	2.0	6921
OC-48 OLIU	LNW26	M1, M2	1.0	8452
OC-48 OLIU	LNW26B	M1, M2	2.0	6921
OC-48 OLIU	LNW27	M1, M2	2.1	8090
OC-48 OLIU	LNW31	A-D, G1, G2	2.0	5404
OC-48 OLIU	LNW76	M1, M2	2.1	7042
OC-48 OLIU	LNW77	M1, M2	2.0	5625
OC-48 OLIU	LNW121B-159B	M1, M2	2.0	6385
OC-48 OLIU	LNW221-259	M1, M2	2.1	8375
OC-48 OLIU	LNW421-459	A-D, G1, G2	3.0	TBD
OC-12 OLIU	LNW46	A-D, G1, G2	1.1	3111 (4667 in OSP)
OC-12 OLIU	LNW48	M1, M2	3.1	TBD
OC-3 OLIU	LNW36	A-D, G1, G2	1.1	4076 (6114 in OSP)
12DS3/EC1	LNW16	A-D	1.0	4520 (6780 in OSP)
48DS3/EC1	LNW19	A-D	3.1	TBD
12DS1/DS3 TransMUX	LNW18	A-D	3.0	TBD
28DS1	LNW6	A-D	1.0	6379 (9569 in OSP)
28DS1PM	LNW7	A-D	1.0	6379 (9569 in OSP)
56DS1PM	LNW8	A-D	3.1	TBD
10/100T	LNW66	A1, B1, C1, D1	1.1	6805
10/100T Private Line	LNW71	A1, B1, C1, D1	3.0	TBD

Circuit Pack	Apparatus Code	Slot(s)	Release	FIT Rate
10/100T with Ethernet Enhancements (CIR, PIR, Spanning Tree per VLAN)	LNW69	A1, B1, C1, D1, G1	3.1	TBD
1G SX	LNW67	A1, B1, C1, D1	1.1	10513
1G LX	LNW68	A1, B1, C1, D1, G1	1.1	14534
1G LX with Ethernet Enhancements	LNW70	A1, B1, C1, D1, G1	3.1	TBD
Apparatus Blank	177D	A-D, G1, G2	1.0	NA
Apparatus Blank	177E	M1, M2	1.0	NA

Notes

These FIT rates are subject to change.

Equipment failure rates The table below provides the steady-state equipment failure rates for DMX.

Table 7-6 Equipment Failure Rates

Equipment	Failure Rate (FIT)
Circuit Breaker	10
Fan Unit	1500

Important! Figure 7-1 applies to the equipment listed in the table above, as well as to the circuit packs and port units.



Sparing Graph

Overview This section provides guidelines and a procedure to determine the number of spares needed at each location. The number of spares for each circuit pack or port unit code must be determined and maintained separately, based on that code's in-service population at each given location.

Using the sparing graph Use the following procedure to determine how many spare circuit packs, port units, or other pieces of equipment are required for each code at each location to maintain 99.9% service continuity, given a 10-day lead time.

- 1 Locate the failure rate for the unit under consideration using Table 7-5 on page 7-10, or Table 7-6 on page 7-12.
- 2 Refer to the figure on the following page and select the curve that represents the nearest failure rate.
- 3 Follow the curve until it intersects the vertical line that represents the number of units in service at the given location.
- 4 Refer to the horizontal line immediately above the intersection. The number associated with this line is the minimum number of spares recommended for that location.
- 5 Repeat steps 1-4 for each circuit pack, port unit, and type of equipment listed in Table 7-5 on page 7-10, or Table 7-6 on page 7-12.

END OF STEPS

Example of using the graph

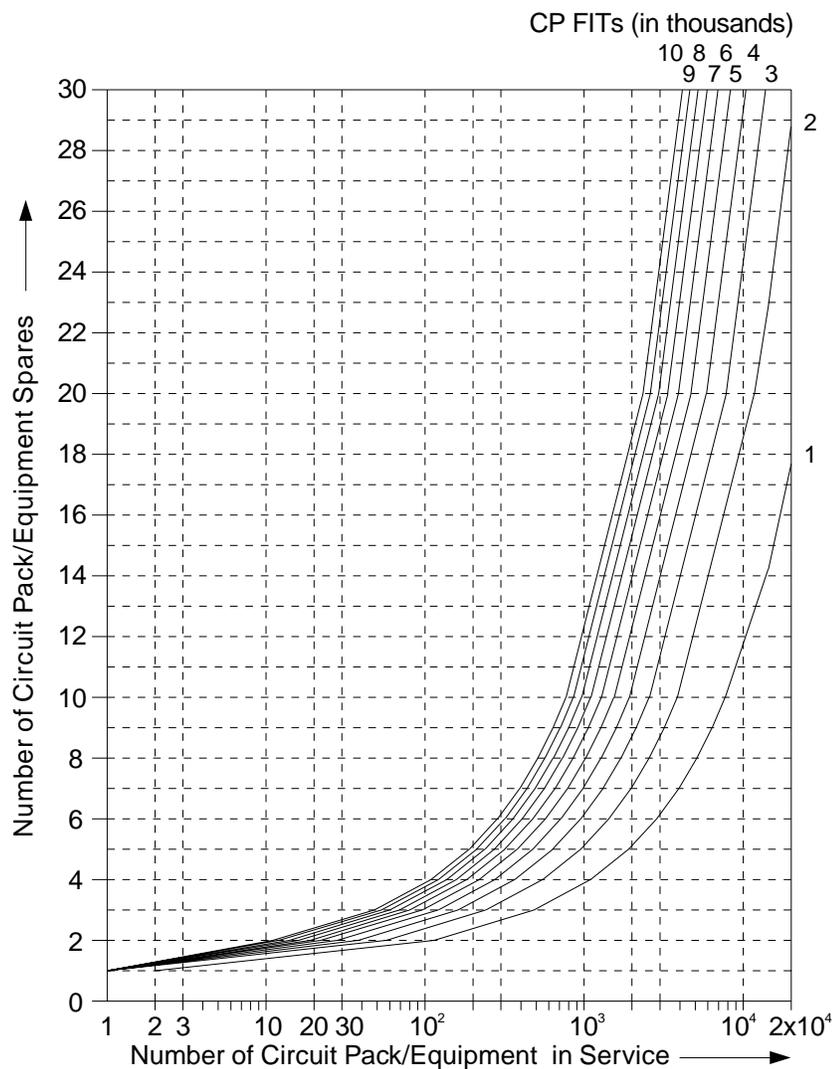
If there are 100 OC-12 OLIUs (failure rate of 3282) in service at a given location and your lead time is 10 days, then you should order and stock 3 spare OC-12 OLIUs port units for that location.



Sparing graph for 10-day lead time

Use the graph below to plan the number of spares necessary for the circuit packs, port units and pieces of common equipment used in DMX.

Figure 7-1 Sparing Graph for a 10-Day Lead Time





8 Product Support

Overview

Purpose This chapter describes the support services available to Lucent Technologies' customers.

Lucent Technologies offers a number of services to assist customers with Engineering, Installation and Technical Support of their networks. Additionally, Lucent Technologies offers product-specific training courses.

Contents The following topics are discussed in this chapter:

Worldwide Services	8 - 2
Training	8 - 4



Worldwide Services

Overview Lucent Worldwide Services provides a full life-cycle of services and solutions to help you plan, design, implement, and operate your network in today's rapidly changing and complex environment.

Engineering Services Engineering Services provide information and technical support to customers during the planning, implementation, and placement of equipment into new or existing networks. We determine the best, most economical equipment solution for a customer and help ensure equipment is configured correctly for the customer's network needs, works as specified, and is ready for installation on delivery. These services consist of the following:

- Equipment engineering
- Software engineering
- Site records
- Engineering consulting
- Additional engineering services (Network Realignment, System Capacity Planning, System Health Assessment, etc...)

Installation Services Lucent Technologies offers Installation Services focused on providing the technical support and resources customers need to efficiently and cost-effectively install their network equipment. We offer a variety of options that provide extensive support and deliver superior execution to help ensure the system hardware is installed, tested, and functioning as engineered and specified. Installation Services provides a complete flexible solution tailored to meet customers' specific needs. These services consist of the following:

- Equipment installation
- Specialized equipment installation
- Network connectivity services
- Installation support services

Technical Support

Lucent Technologies provides the following Technical Support Services:

- Remote Technical Support (RTS) - remote technical support to troubleshoot and resolve system problems.
- On-site Technical Support (OTS) - on-site assistance with operational issues and remedial maintenance.
- Repair and Replacement (R&R) - technical support services for equipment repair/return or parts replacement.
- Lucent OnLine Customer Support - online access to information and services that can help resolve technical support requests.

Important! Technical Support Services are available 24 hours a day, 7 days a week.

Customers inside the United States and Canada

Technical Support Services can be reached at **1-866-LUCENT8** (866-582-3688): *Prompt 1.*

Customers outside the United States

Technical Support Services can be reached at **+1-630-224-4672**: *Prompt 2.*

Web-Site

For additional information regarding Worldwide Services, refer to the Lucent Technologies' web-site at <http://www.lucent.com/products>

1. Click on **Browse the catalog**
2. Click on **Worldwide Services Solutions**
3. Select the desired service to display:
 - Engineering and Installation
 - Technical Support Services



Training

Overview Lucent Technologies offers a formal training curriculum to complement your product needs.

Registering for a course To review the available courses or to enroll in a training course at one of Lucent's corporate training centers,

- Within the United States,
 - Visit <https://www.lucent-product-training.com>
 - Call **1-888-LUCENT8** (888-582-3688): *Prompt 2.*
- Outside the continental United States,
 - Visit <https://www.lucent-product-training.com>
 - Contact your in-country training representative
 - Call: **+1-407-767-2798**
 - Fax: **+1-407-767-2677**

Suitcasing To arrange for a suitcase session at your facility,

- Within the United States, call **1-888-LUCENT8** (888-582-3688): *Prompt 2.*
- Outside the continental United States,
 - Contact your in-country training representative
 - Call: **+1-407-767-2798**
 - Fax: **+1-407-767-2677**





9 Reliability and Quality

Overview

Purpose This section provides the Lucent Technologies' quality policy, describes the reliability program, and describes the International Standards Organization (ISO) certification awarded to Lucent Technologies' Transmission Business Unit.

Contents The following reliability and quality information is included in this chapter:

Lucent's Commitment to Quality and Reliability	9 - 2
Reliability Specifications	9 - 3
Infant Mortality and Design Life	9 - 5
International Standards Organization (ISO) Certification	9 - 6
Warranty	9 - 7



Lucent's Commitment to Quality and Reliability

Statement *Quality excellence is the foundation for the management of our business and the keystone of our goal of customer satisfaction. It is, therefore, our policy to:*

- *Consistently provide products and services that meet the quality expectations of our customers.*
- *Actively pursue ever-improving quality through programs that enable each employee to do his or her job right the first time.*

Quality plan This Lucent Technologies Quality Policy guided the development of the DMX Access Multiplexer and will continue affecting this product throughout its life cycle. The primary tool ensuring product quality is the Quality Plan, used with the Lucent Technologies Transmission Systems Reliability Program.

Reliability Specifications

- Overview** Reliability is a key ingredient of the product life cycle beginning at the earliest planning stage. Major efforts at the start of the project were modeling system reliability, creating the project quality team (with representatives of all major activity areas), and writing and imposing the quality plan. A key part of the quality plan is the reliability plan.
- Design and development** During the design and development stage, reliability predictions, qualification and selection of components, definition of quality assurance audit standards, and prototyping of critical areas of the system ensured built-in reliability.
- Manufacturing and field deployment** During manufacturing and field deployment, techniques such as premanufacturing, qualification, production quality tracking, failure mode analysis, and feedback and correction further enhance the ongoing reliability improvement efforts on the DMX Access Multiplexer.
- Reliability requirements** The DMX Access Multiplexer meets all applicable Telcordia Technologies reliability requirements that cover transmission availability. The applicable Telcordia Technologies requirements and objectives were clarified through interactions with Telcordia Technologies during their audit of DMX. The basis for these requirements comes from GR-TSY-000418, "Generic Reliability Assurance Requirements for Fiber Optic Transport Systems." The methods and assumptions used to calculate the DMX reliability predictions are described in the following paragraphs. Each paragraph is devoted to one of the reliability parameters which must meet a Telcordia Technologies requirement or objective.
- Transmission availability** Telcordia Technologies requirements state that the probability of a hardware-caused outage on a two-way channel within a SONET multiplexer should be less than 1.75 minutes per year in a central office environment and 5.25 minutes per year in a remote terminal environment (GR-NWT-000418, Issue 1, December 1997). Telcordia Technologies objectives for outages are 0.25 minutes per year for the central office and 0.75 minutes per year for remote terminal environments (GR-NWT-000418, Issue 1, December 1997).
- The outage requirements and objectives apply to any part of the product needed to process an incoming high-speed (OC-48) or low-speed (DS1,

DS3, EC1, OC-3, OC-12) signal. An outage is defined, for this and all other outage requirements, as any 1-second interval with a bit error rate of 10^{-3} or worse (GR-499-CORE, Issue 2, December 1998, Section 2.1.2).

Markov modeling was used to calculate the predicted system outage. The analysis assumes a mean time to repair of 2 hours for the CO environment and 4 hours for the RT environment. Individual circuit pack failure rates used in the model were calculated using the method described in GR-TSY-000332, “*Reliability Prediction Procedure for Electronic Equipment (RPP)*.”



Infant Mortality and Design Life

Environmental stress testing

DMX circuit packs are subjected to an environmental stress testing (EST) program. The purpose of the program is to eliminate early life failures, conduct failure mode analysis on defective circuit packs, and use corrective action to make the product more reliable. All new circuit pack codes in manufacturing are subject to EST. However, based on field return data, when the early life failures for any circuit pack codes have been minimized and the infant mortality factor is below 2.5, these circuit pack codes may be subjected only to sampling EST.

International Standards Organization (ISO) Certification

- Overview** Lucent Technologies' Transmission Systems Business Unit received ISO 9001 certification for its Merrimack Valley manufacturing facility and associated development organization on September 15, 1992. Merrimack Valley manufactures systems for transporting data, voice, and images over public and private telecommunications networks. Major product lines consist of digital access and cross-connect systems, network multiplex systems, and lightwave systems.
- ISO 9001** ISO 9001 is an international quality standard recognized by more than 50 countries. ISO 9001 is the most comprehensive standard in the ISO 9000 series, requiring well-documented and implemented controls for design development, production, delivery, installation, and service. Its purpose is to ensure manufacturers produce products with consistently high levels of quality and service.

Warranty

- Hardware warranty** Lucent Technologies provides a one year hardware warranty on the DMX Access Multiplexer, effective from the date the unit is shipped.
- Lucent Technologies provides two contacts for hardware failure emergencies. The Repair and Return line is to be used when ever a piece of equipment has failed to the point that it requires repairs, or must be replaced. The only times the Hotline is to be used is in the event of a service outage or during the initial installation and turn-up of the DMX.
- Repair and Return: 1-800-255-1402
 - Emergency Hotline: 1-800-869-6757

- Software warranty** Lucent Technologies provides a one year software warranty on the DMX Access Multiplexer, effective when one of the following actions occurs (whichever comes first):
- date of customer's first service installation
 - date of customer's acceptance as identified in the purchase agreement
 - 30 days after shipment of the software generic.
- Lucent's warranty on any software release will not exceed 24 months after general availability (GA) of that release. All warranties pertain to the deployment of a release and do not apply to individual software licenses. For more warranty information, contact your local Lucent Technologies Account Executive.





10 Technical Specifications

Overview

Purpose This section contains the technical specifications for the DMX Access Multiplexer. The specifications for the OC-192 DWDM circuit packs are not included in this section, but will be made available in the near future.

Transmission interface standards The table below, lists the transmission interface standards for electrical, optical, and ethernet interfaces.

Table 10-1 Transmission Interface Standards

Interface	Standard	Comments
DS1/DS3/EC-1	ANSI T1.231-1997 GR-499-CORE, Issue 2, 1998	B8ZS/AMI option, SF/ESF (DS1) VMR, VM, or clear channel (DS3)
OC-3/OC-12/OC-48/ OC-192	GR-253-CORE, Issue 3, 2000 GR-496-CORE, Issue 1, 1998 GR-1400-CORE, Issue 3, 2001 ANSI T1.231-1997	
10/100T, 1G SX/LX	IEEE 802.3 IEEE 802.3 ANSI T1X1.5/2001-024R5 ITU G.7041	

Contents This chapter contains the following sections:

Electrical Interfaces	10 - 3
Optical Interfaces	10 - 10
System Performance	10 - 53
Operations Interfaces	10 - 71
Physical Specifications	10 - 83
External Equipment Specifications	10 - 89



Electrical Interfaces

Overview

Purpose This section contains the technical specifications for the low-speed electrical interfaces.

Contents This section provides information on the following interfaces:

28DS1 (LNW6), 28DS1PM (LNW7), and 56 DS1PM (LNW8)	10 - 4
12DS3/EC1 (LNW16) and 48DS3/EC1 (LNW19)	10 - 6
DS1/DS3 TransMUX (LNW18)	10 - 7
10/100T (10/100 Mbps) Ethernet (LNW66, LNW69, and LNW71)	10 - 8



28DS1 (LNW6), 28DS1PM (LNW7), and 56 DS1PM (LNW8)

Electrical specification The DS1 low-speed interface transmits and receives a standard electrical DS1 signal as specified in GR-499-CORE (1.544 Mb/s nominal rate, DSX-1 interconnect specification). Line coding is provisionable per DS1 port to alternate mark inversion (AMI) or AMI with bipolar 8-zero substitution (B8ZS).

Format specification The LNW6 provides clear channel transport of any DSX-1 compatible signal. There are no format constraints on the LNW6. The LNW7 and LNW8 circuit packs can be provisioned for the following DS1 formats: clear channel (default), superframe (SF), or extended superframe (ESF) as specified in GR-499-CORE, Section 10. In the case of SF or ESF format selections, DS1 performance monitoring information is collected by monitoring the associated DS1 framing format per *ANSI T1.231-1997*.

Alarm thresholding The following parameters are monitored on the LNW7 and LNW8 interfaces:

- Loss of signal (LOS): 28DS1 + 28DS1PM + 56DS1PM
- Bit error rate threshold (BER) based on line coding violations (CV-L): 28DS1PM and 56DS1PM only

The alarm level for the monitored parameters can be provisioned to critical (CR), major (MJ), minor (MN), or status. B8ZS and AMI coding violation failure thresholds are user settable to 10^{-3} through 10^{-8} .

DS1 Transmission Length When transmitting DS1 signals to a DSX panel, the Approximate Span Length is 655 feet.

When transmitting DS1 signals to another DS1 terminating device (such as a DMX) the Approximate Span Length is 1110 feet.

Loopbacks The following loopbacks are supported on the LNW7 and LNW8 interfaces:

- Per-port DS1 facility loopback
- Per-port DS1 terminal loopback.

Line build-outs (LBOs) Line build-outs are software-provisionable. The maximum distance depends on the cable type (maximum 665 feet).

Performance monitoring PM data is reported for DS1 signals when DMX is equipped with the 2 LNW7 or LNW8 circuit packs. For a detailed list of PM parameters and thresholds, refer to Table 10-15, SONET PM Parameters (10-62).

12DS3/EC1 (LNW16) and 48DS3/EC1 (LNW19)

Electrical specification (DS3) The low-speed DS3 interfaces transmit/receive a standard electrical DS3 signal as specified in GR-499-CORE, Section 9 (44.736 Mb/s rate, DSX-3 interconnect specification, bipolar 3-zero substitution (B3ZS) encoding). However, the signal does not have to contain a standard DS3 frame.

Electrical specification (EC-1) The EC-1 low-speed interfaces provide clear channel transport of any STS-1 signal compatible with the electrical STS-1 interface specification in GR-253-CORE, Issue 3. The EC-1 low-speed port can be provisioned to provide STS-1 path termination functions for a VT1.5 structured STS-1 with an asynchronous DS1 mapping.

The low-speed EC-1 interfaces transmit/receive a standard electrical EC-1 signal as specified in GR-253-CORE, Issue 3 (51.844 Mb/s rate, STSX-1 interconnect specification, bipolar 3-zero substitution (B3ZS) encoded and scrambled).

DS3/EC-1 Port Provisioning The LNW16 and LNW19 circuit packs enable you to provision DS3 or EC-1 service on a per-port basis. Thus, one of these circuit packs can host a variety of DS3 or EC-1 traffic.

DS3/EC-1 Transmission Length When transmitting DS3/EC1 signals to a DSX panel, the Approximate Span Length is 450 feet.

When transmitting DS3/EC1 signals to another DS3 terminating device (such as a DMX) the Approximate Span Length is 900 feet.



DS1/DS3 TransMUX (LNW18)

Electrical specification The TransMUX circuit pack provides 12 ports for DS3/DS1 service. DS3 interfaces transmit/receive a standard electrical DS3 signal as specified in GR-499-CORE, Section 9 (44.736 Mb/s rate, DSX-3 interconnect specification, bipolar 3-zero substitution (B3ZS) encoding).

The DS1 low-speed interface transmits and receives a standard electrical DS1 signal as specified in GR-499-CORE (1.544 Mb/s nominal rate, DSX-1 interconnect specification). Line coding is provisionable per DS1 port to alternate mark inversion (AMI) or AMI with bipolar 8-zero substitution (B8ZS).

Trans/MUX circuit pack DS1 and DS3 signals

DMX supports a 12-port Trans/MUX card that can collect various DS1 signals from around a ring and combine them into a channelized DS3 signal.

The Trans/MUX circuit pack functions in the following manner:

Transmit Functions

- Receives a B3ZS-encoded DS3 signal from a DSX-3
- Recovers DS3 clock and NRZ data
- Calculates parity errors on the DS3 input
- Demultiplexes the M13 or C-bit formatted DS3 signal into 28 DS1s
- Maps the 28 DS1s into VT1.5s and then into an STS-1
- Inserts STS-1 path overhead
- Provides the STS-1 signal to the OLIU circuit packs

Receive Functions

- Interprets the STS-1 pointer values
- Terminates the STS-1 path
- Disinterleaves the STS-1 signal into 28 VT1.5s and interprets VT pointer values
- Converts the VT1.5 signals to 28 DS1 signals
- Multiplexes the 28 DS1 signals to an M13 or C-bit formatted DS3 signal
- B3ZS encodes the outgoing DS3 signal
- Pre-equalizes the DS3 signal (with LBO) and transmits it to a DSX-3

□

10/100T (10/100 Mbps) Ethernet (LNW66, LNW69, and LNW71)

Electrical specification The 10/100T circuit packs provides a 24-port, 100BASE-TX, IEEE 802.3-compliant interface that is capable of spanning distances of 100 meters. The 10/100T port performs protocol transparent filtering and bridging of incoming media access control (MAC) frames. MAC frames with a destination address on the local bus are filtered by the 10/100T circuit packs to prevent unnecessary transmission of frames over the wide area network (WAN). The 10/100T interface auto-negotiates mode (full/half duplex) and speed (10/100 Mbps) when interfacing with other 802.3-compliant devices over twisted pair media. The 10/100T circuit packs must be housed in slot 1 of a Function Unit group and is not equipment protected. However, facility protection is provided through the WAN via SONET UPSR or through the IEEE 802.1D spanning tree algorithm.

The 10/100T ethernet interfaces comply with the following transmission standards:

- standard IEEE 802.1D for transparent bridging and spanning tree protection
- standard IEEE 802.3, Section 25 for 10/100 Mb autonegotiation (including flow control, full-duplex transmission, and half-duplex transmission).

Format specification The 10/100T circuit packs comply with the following formatting standards:

- standard IEEE 802.1Q VLANs
- standard *ANSI T1X1.5/2001-024R5* generic framing procedure (encapsulating ethernet frames and mapping them into a SONET payload).
- standard ITU G.7041 STS-1 virtual concatenation.

Performance monitoring

Performance monitoring capabilities are available on the 10/100T circuit packs, however Threshold Crossing Alerts (TCAs) are not supported. Monitored parameters include:

- Dropped Frames (congestion)
- Dropped Frames (errors)
- Incoming Number of Bytes
- Outgoing Number of Bytes
- Incoming Number of Frames
- Outgoing Number of Frames.

Optical Interfaces

Overview

Purpose This section contains technical specifications for the low- and high-speed DMX optical interfaces.

Contents The following optical interfaces are discussed in this section:

Quad OC-3 Low-speed OLIU (LNW36)	10 - 11
Dual OC-12 Low-speed OLIU (LNW46)	10 - 12
Dual OC-12 High-speed OLIU (LNW48)	10 - 13
OC-48 OLIU (DWDMs, LNW26, LNW26B, LNW27, LNW28, LNW29, LNW31, LNW76, and LNW77)	10 - 14
OC-192 OLIUs (LNW56 and LNW58)	10 - 16
SONET Optical Specifications: OC-3 and OC-12 OLIUs	10 - 18
SONET Optical Specifications: OC-48 OLIUs (LNW26, LNW26B, LNW27, LNW28, LNW29)	10 - 22
SONET Optical Specifications: OC-48 OLIU (LNW76 and LNW77)	10 - 25
OC-48 DWDM Optics (LNW121B- LNW159B, LNW221- LNW259, and LNW421-LNW459)	10 - 31
SONET Optical Specifications: OC-192 OLIU (LNW56 and LNW58)	10 - 36
1G SX (2-port 1000BASE-SX) Ethernet (LNW67)	10 - 39
1G LX (2-port 1000BASE-LX) Ethernet (LNW68)	10 - 45
1G SX/LX (4-port 1000BASE-SX/LX) Ethernet (LNW70)	10 - 51
Lightguide Jumpers and Buildouts	10 - 52



Quad OC-3 Low-speed OLIU (LNW36)

Optical specification The LNW36 OLIU photonics meet or exceed SONET OC-3, long-reach specifications (SONET LR-1 DFB). The distributed feedback (DFB) laser transmitter supplies a 1310 nm, scrambled non-return-to-zero (NRZ) coded signal (155.52 Mb/s).

The LNW36 OLIU long reach OC-3 interface supports span lengths up to 55 km and is OSP hardened. Refer to the SONET Optical Specifications: OC-3 and OC-12 OLIUs (10-18) section in this chapter for detailed system, transmitter, receiver, and link budget specifications.

Alarm thresholding The following parameters are monitored on the OC-3 interface:

- LOS
- LOF
- LOP
- AIS-L
- RDI-L (FERF)
- Path AIS
- Path Unequipped
- Signal degrade (BER)
- Signal fail (BER).

Performance monitoring SONET line and path performance monitoring complies with the standards outlined in GR-253-CORE. For detailed PM parameter thresholds on the OC-3 interface, refer to Table 10-15, SONET PM Parameters (10-62).

Dual OC-12 Low-speed OLIU (LNW46)

Optical specification The LNW46 photonics meet or exceed SONET OC-12, long-reach specifications (SONET LR-1 DFB category). The distributed feedback laser (DFB) supplies a 1310 nm, scrambled NRZ-coded signal (622.08 Mb/s). For direct optical loopbacks, at least 10 dB of optical attenuation is needed for the LNW46.

The LNW46 low-speed interface supports span lengths up to 53 km. Refer to the SONET Optical Specifications: OC-3 and OC-12 OLIUs (10-18) section in this chapter for detailed system, transmitter, receiver, and link budget specifications.

Alarm thresholding The following parameters are monitored at the low-speed OC-12 interface.

- LOF
- LOS
- LOP
- AIS-L
- RDI-L (FERF)
- Path AIS
- Path Unequipped
- Signal Degrade (BER)
- Signal Fail (BER).

Performance monitoring SONET line and path performance monitoring complies with the standards outlined in GR-253-CORE. For detailed PM parameter thresholds on the OC-12 interface, refer to Table 10-15, SONET PM Parameters (10-62).

Dual OC-12 High-speed OLIU (LNW48)

Optical specification The LNW48 photonics meet or exceed SONET OC-12 intermediate-reach specifications (SONET OC-12 IR-1 Fabry Perot [FP] category). The FP laser (FP is a Multi-Longitudinal Mode laser) supplies a 1310 nm, scrambled NRZ-coded signal (622.08 Mb/s).

The LNW48 high-speed interface supports span lengths up to 20 km and is OSP hardened. Refer to the SONET Optical Specifications: OC-3 and OC-12 OLIUs (10-18) section in this chapter for detailed system, transmitter, receiver, and link budget specifications.

Alarm thresholding The following parameters are monitored at the low-speed OC-12 high-speed (Network-side) interface.

- LOF
- LOS
- LOP
- AIS-L
- RDI-L (FERF)
- Path AIS
- Path Unequipped
- Signal Degrade (BER)
- Signal Fail (BER).

Performance monitoring SONET line and path performance monitoring complies with the standards outlined in GR-253-CORE. For detailed PM parameter thresholds on the OC-12 high-speed interface, refer to Table 10-15, SONET PM Parameters (10-62).

OC-48 OLIU (DWDMs, LNW26, LNW26B, LNW27, LNW28, LNW29, LNW31, LNW76, and LNW77)

Overview Refer to the following sections in this appendix for detailed system, transmitter, receiver, and link budget specifications.

- SONET Optical Specifications: OC-48 OLIUs (LNW26, LNW26B, LNW27, LNW28, LNW29) (10-22)
- SONET Optical Specifications: OC-48 OLIU (LNW76 and LNW77) (10-25)
- OC-48 DWDM Optics (LNW121B- LNW159B, LNW221- LNW259, and LNW421-LNW459) (10-31)

Optical specification **LNW26, LNW26B, LNW27, and LNW28**

The high-speed LNW26, LNW26B, LNW27, and LNW28 OC-48 meet or exceed SONET OC-48 1310 nm LR-1 specifications.

The LNW28 is hardened for outside plant (OSP) temperature ranges.

These interfaces supports span lengths up to 51 km (LNW28 supports spans of 49 km in OSP environments).

LNW29

The high-speed LNW29 meets or exceeds SONET OC-48 1550 LR-2 specifications.

These interfaces supports span lengths up to 81 km.

LNW31 and LNW77

The low-speed LNW31 and high-speed LWN77 meet or exceed SONET OC-48 1310 nm IR-1 specifications.

These interfaces support span lengths up to 20 km.

LNW76

The high-speed LNW76 meets or exceed SONET OC-48 1310 nm SR-1 specifications.

These interfaces support span lengths up to 2 km.

LNW121B through LNW159B, and LNW221 through LNW259

These are high-speed Dense Wavelength Division Multiplexing (DWDM) 100 GHz-spacing OLIUs that exceed SONET OC-48 1550 LR-2 specifications. The difference between the LNW121B-159B series and the LNW221- LNW259 is the size of the VT switch fabric. The LNW121B- LNW159 series can cross-connect VTs in any 12 of 48 selected STS-1s. LNW221- LNW259 can cross-connect VTs in all 48 STS-1s.

Without passive filters, these interfaces can support span lengths up to 85 km.

LNW421 through LNW459

These are low-speed Dense Wavelength Division Multiplexing (DWDM) 100 GHz-spacing OLIUs that exceed SONET OC-48 1550 LR-2 specifications. The low-speed LNW421- LNW459 series can cross-connect VTs in any 6 of 48 selected STS-1s.

Without passive filters, these interfaces can support span lengths up to 85 km.

Alarm thresholding

The following parameters are monitored on the OC-48 interface:

- LOS
- LOF
- LOP
- AIS-L
- RDI-L (FERF)
- Line AIS
- Path Unequipped
- Signal Degrade (BER)
- Signal Fail (BER).

Performance monitoring

SONET line and path performance monitoring complies with the standards outlined in GR-253-CORE. For detailed PM parameter thresholds on the OC-48 interface, refer to Table 10-15, SONET PM Parameters (10-62).

OC-192 OLIUs (LNW56 and LNW58)

Optical specification This section briefly detail s the optical specifications for the OC-192 circuit packs.

LNW56

These are high-speed, intermediate reach OLIUs that meet or exceed SONET OC-192 1550 IR-2 specifications. The LNW56 can cross-connect VTs in 48 STS-1s and bridge span lengths up to 40 km.

LNW58 (optical interface for intra-office applications)

These are high-speed, very short reach (VSR) OC-192 OLIUs that meet or exceed ITU G.693 VSR600-2R1 specifications. The LNW56 can cross-connect VTs in 48 STS-1s and bridge span lengths up to 600 meters.

Reference

Refer to the SONET Optical Specifications: OC-192 OLIU (LNW56 and LNW58) (10-36) section, in this chapter for detailed system, transmitter, receiver, and link budget specifications.

Alarm thresholding The following parameters are monitored on the OC-192 interface:

- LOS
- LOF
- LOP
- AIS-L
- RDI-L (FERF)
- Line AIS
- Path Unequipped
- Signal Degrade (BER)
- Signal Fail (BER).

Performance monitoring SONET line and path performance monitoring complies with the standards outlined in GR-253-CORE. For detailed PM parameter thresholds on the OC-192 interface, refer to Table 10-45, SONET PM Parameters (10-68).

SONET Optical Specifications: OC-3 and OC-12 OLIUs

Overview The following tables present the optical specifications for the OC-3 LNW36 OLIU and OC-12 LNW46 and LNW48 OLIUs.

System specifications The table below lists the LNW36, LNW46, and LNW48 OLIU system specifications.

Table 10-2 SONET Optical System Specifications

System Information	LNW36	LNW46	LNW48
Optical Line Rate	155.52 Mb/s	622.08 Mb/s	622.08 Mb/s
Optical Line Coding	Scrambled NRZ	Scrambled NRZ	Scrambled NRZ
Optical Wavelength	1310nm	1310 nm	1310 nm
Performance	SONET LR-1 (Long Reach)	SONET LR-1 (Long Reach)	SONET IR-1 (Intermediate Reach)
Temperature Range	OSP Hardened	OSP Hardened	OSP Hardened

Transmitter specifications The table below lists the LNW36, LNW46, and LNW48 OLIU transmitter information.

Table 10-3 SONET Optical Transmitter Information

Transmitter Info.	LNW36	LNW46	LNW48
Optical Device Temperature Controller	None	None	None
FDA Classification	Class I	Class I	Class I
Optical Source	Distributed Feed-Back (DFB) Laser / Fabry Perot (FP)	Distributed Feed-Back (DFB) Laser	Fabry Perot (FP) Laser
Faceplate Optical Connector	LC connector	LC connector	LC connector

Receiver specifications The table below lists the LNW36, LNW46, and LNW48 OLIU receiver information.

Table 10-4 SONET Optical Receiver Information

Receiver Information	LNW36	LNW46	LNW48
Optical Detector	InGaAsP PIN	InGaAsP PIN	InGaAsP PIN
Faceplate Optical Connector	LC connector	LC connector	LC connector

Link budgets The table below lists the LNW36, LNW46, and LNW48 OLIU link budgets.

Table 10-5 SONET Optical Specifications and Link Budgets

Parameter	LNW36 (Note1) OC-3 LR-1	LNW46 (Note 1) OC-12 LR-1	LNW48 (Note 1) OC-12 IR-1
Minimum Wavelength	1280 nm	1280 nm	1274 nm (1293 nm)
Maximum Wavelength	1335 nm	1335 nm	1356 nm (1334 nm)
Maximum Spectral Width ($\Delta\lambda_{20}$)	1.0 nm	1.0 nm	NA
Maximum RMS Spectral Width (σ)	NA	NA	2.5 nm (4.0 nm)
Maximum Transmitter Power	0.0 dBm	+2.0 dBm	-8.0 dBm
Minimum Transmitter Power	-5.0 dBm	-2.5 dBm	-15.0 dBm
Maximum Received Power (1×10^{-12} BER)	0.0 dBm	-7.0 dBm	-8.0 dBm
Minimum Received Power (1×10^{-12} BER)	-34.0 dBm	-30.5 dBm	-28.0 dBm
Minimum System Gain (see Note 2)	29.0 dB	28.0 dB	13.0 dB
Optical Path Penalty (see Note 3)	1.0 dB	1.0 dB	1.0 dB
Connector Loss (see Note 4)	1.5 dB	1.5 dB	1.5 dB
Unallocated Margin (see Note 5)	1.5 dB	1.5 dB	1.5 dB
Minimum Loss Budget (see Note 6)	0.0 dB	9.0 dB	0.0 dB
Maximum Loss Budget (see Note 7)	25.0 dB	24.0 dB	9.0 dB
Approximate Span Length (see Note 8)	55 km	53 km	20 km

Notes

1. All terminology consistent with GR-253-CORE, Issue 3. All values given are worst-case end-of-life (EOL)
2. The System Gain includes connector loss at the transmitter and

- receiver points S and R in GR-253-CORE, Issue 3.
3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1310 nm optics is 1.0 dB maximum.
 4. One additional connector (0.75 dB) on each end is assumed to connect station cable to outside plant.
 5. Additional unallocated margin, or safety margin, can be 0-3 dB. Typically, a 1.5 dB value is assumed.
 6. The LNW46 requires an external lightguide build-out (optical attenuator) as part of the connector assembly for optical loopbacks and for loss budgets less than 10 dB to avoid overloading the optical receiver.
 7. The stated maximum loss budget equals the System Gain, less the Optical Path Penalty, the Additional Connector Loss Margin, and the Additional Unallocated Margin. The resultant Maximum Loss Budget is available for station cable loss, transmission cable loss, and splice loss.
 8. The approximate Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.45 dB/km is used for 1310 nm optics. This estimate includes typical cable loss (0.40 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1310 nm OC-3 and OC-12 systems, dispersion is not a limiting factor, and the applications are attenuation-limited. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules.

□

SONET Optical Specifications: OC-48 OLIUs (LNW26, LNW26B, LNW27, LNW28, LNW29)

Overview The following tables present the optical specifications for the OC-48 OLIUs.

System specifications The table below lists the OC-48 OLIU system specifications.

Table 10-6 SONET Optical System Specifications

System Information	LNW26&26B	LNW27	LNW28	LNW29
Optical Line Rate	2.488 Gb/s			
Optical Line Coding	Scrambled NRZ			
Optical Wavelength	1310 nm			1550 nm
Performance	SONET LR-1 (Long Reach)			SONET LR-2 (Long Reach)
Temperature Range	Central Office (CO)	CO	OSP Hardened	CO

Transmitter specifications The table below lists the OC-48 OLIU transmitter information.

Table 10-7 SONET Optical Transmitter Information

Transmitter Info.	LNW26&26B	LNW27	LNW28	LNW29
Optical Device Temperature Controller	None			
FDA Classification	Class I			
Optical Source	Distributed Feed-Back (DFB) Laser			
Faceplate Optical Connector	LC connector			

Receiver Specifications The table below lists the OC-48 OLIU receiver information.

Table 10-8 SONET Optical Receiver Information

Receiver Information	LNW26&26B	LNW27	LNW28	LNW29
Optical Detector	APD			
Faceplate Optical Connector	LC connector			

Link budgets The table below lists the OC-48 OLIU link budgets.

Table 10-9 SONET Optical Specifications and Link Budgets

Parameter (NOTE 1)	LNW26& 26B OC-48 LR-1	LNW27 OC-48 LR-1	LNW28 OC-48 LR-1	LNW29 OC-48 LR-1
Minimum Wavelength	1280 nm	1280 nm	1280 nm	1500 nm
Maximum Wavelength	1335 nm	1335 nm	1335 nm	1580 nm
Maximum Spectral Width ($\Delta\lambda_{20}$)	1.0 nm	1.0 nm	1.0 nm	1.0 nm
Maximum Transmitter Power	+1.5 dBm	+1.5 dBm	+1.5 dBm	+3.0 dBm
Minimum Transmitter Power	-2.0 dBm	-2.0 dBm	-2.0 dBm	-2.0 dBm
Maximum Received Power (1×10^{-12} BER)	-8.0 dBm	-8.0 dBm	-8.0 dBm	-8.0 dBm
Minimum Received Power (1×10^{-12} BER)	-29.0 dBm	-29.0 dBm	-29.0/-28.0 dBm*	-29.0 dBm
Minimum System Gain (see Note 2)	27.0 dB	27.0 dB	27.0/26.0 dB*	27.0 dB
Dispersion	NA	NA	NA	1600 ps/nm
Optical Path Penalty (see Note 3)	1.0 dB	1.0 dB	1.0 dB	2.0 dB
Additional Connector Loss Margin (see Note 4)	1.5 dB	1.5 dB	1.5 dB	1.5 dB
Additional Unallocated Margin (see Note 5)	1.5 dB	1.5 dB	1.5 dB	1.5 dB
Minimum Loss Budget (see Note 6)	9.5 dB	9.5 dB	9.5 dB	11.0 dB
Maximum Loss Budget (see Note 7)	23.0 dB	23.0 dB	23.0/22.0* dB	22.0 dB
Approximate Span Length (see Note 7)	51 km	51 km	51/49 km*	81 km
*The LNW28 is an environmentally hardened OLIU (it is capable of operating in outside plant temperature ranges). The first number applies to deployments in standard CO applications; the second number applies to deployments where temperature excursions (found in OSP environments) may occur.				

Notes

1. All terminology is consistent with GR-253-CORE, Issue 3. All values are worst-case end of life (EOL).
2. The System Gain includes connector loss at the transmitter and receiver points S and R in GR-253-CORE, Issue 3.

3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1310 nm optics is 1.0 dB maximum. The optical path penalty for the 1550 nm optics is 2.0 maximum.
4. One additional connector (0.75 dB) on each end is assumed to connect station cable to outside plant.
5. Additional unallocated margin, or safety margin, can be 0-3 dB. Typically, a 1.5 dB value is assumed.
6. The LW26/LW26B, LW27, LW28, and LW29 require an external lightguide build-out (optical attenuator) as part of the connector assembly for optical loopbacks and for loss budgets less than 11 dB to avoid overloading the optical receiver.
7. The stated maximum loss budget equals the System Gain, less the Optical Path Penalty, the Additional Connector Loss Margin, and the Additional Unallocated Margin. The resultant Maximum Loss Budget is available for station cable loss, transmission cable loss, and splice loss.
8. The approximate Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.45 dB/km is used for 1310 nm optics. This estimate includes typical cable loss (0.40 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1310 nm OC-48 systems, dispersion is not a limiting factor, and the applications are attenuation-limited. For 1550 nm optics, an attenuation of 0.27 dB/km is used. Again, appropriate fiber-cable loss and numerous splice losses are included. For long-reach 1550nm applications, dispersion may be a limiting factor. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules.

□

SONET Optical Specifications: OC-48 OLIU (LNW76 and LNW77)

Overview The following tables present the optical specifications for the LNW76 and LNW77 OC-48 OLIUs.

System specifications The following table lists the LNW76 and LNW77 OC-48 OLIU system specifications.

Table 10-10 SONET Optical System Specifications

System Information	LNW76	LNW77
Optical Line Rate	2.488 Gb/s	2.488 Gb/s
Optical Line Coding	Scrambled NRZ	Scrambled NRZ
Optical Wavelength	1310 nm	1310 nm
Performance	SONET SR-1 (Short Reach)	SONET IR-1 (Intermediate Reach)
Temperature Range	Central Office (CO)	Central Office (CO)

Transmitter specifications The following table lists the LNW76 and LNW77 OC-48 OLIU transmitter information.

Table 10-11 SONET Optical Transmitter Information

Transmitter Info.	LNW76	LNW77
Optical Device Temperature Controller	None	None
FDA Classification	Class I	Class I
Optical Source	Fabry-Perot (FP) Laser	Distributed Feed-Back (DFB) Laser
Faceplate Optical Connector	LC connector	LC connector

Receiver specifications The following table lists the LNW76 and LNW77 OC-48 OLIU receiver information.

Table 10-12 SONET Optical Receiver Information

Receiver Information	LNW76	LNW77
Optical Detector	InGaAsP PIN	InGaAsP PIN
Faceplate Optical Connector	LC connector	LC connector

Link budgets The following table lists the LNW76 and LNW77 OC-48 OLIU link budgets.

Table 10-13 SONET Optical Specifications and Link Budgets

Parameter	LNW76 OC-48 SR-1	LNW77 OC-48 IR-1
Minimum Wavelength	1266 nm	1280 nm
Maximum Wavelength	1360 nm	1335 nm
Maximum Spectral Width ($\Delta\lambda_{20}$)	NA	1.0 nm
Maximum RMS Spectral Width (σ)	4.0 nm	NA
Maximum Transmitter Power	-3 dBm	0.0 dBm
Minimum Transmitter Power	-10 dBm	-5.0 dBm
Maximum Received Power (1×10^{-12} BER)	-3 dBm	0.0 dBm
Minimum Received Power (1×10^{-12} BER)	-18 dBm	-18.0 dBm
Minimum System Gain (see Note 2)	8 dB	13.0 dB
Optical Path Penalty (see Note 3)	1.0 dB	1.0 dB
Additional Connector Loss Margin (see Note 4)	1.5 dB	1.5 dB
Additional Unallocated Margin (see Note 5)	1.5 dB	1.5 dB
Minimum Loss Budget	0.0 dB	0.0 dB
Maximum Loss Budget (see Note 6)	4.0 dB	9.0 dB
Approximate Span Length (see Note 7)	2 km	20 km

NOTES

1. All terminology is consistent with GR-253-CORE, Issue 3. All values are worst-case end of life (EOL).
2. The System Gain includes connector loss at the transmitter and receiver points S and R in GR-253-CORE, Issue 3.
3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1310

- nm optics is normally 1.0 dB.
4. One additional connector (0.75 dB) on each end is assumed to connect station cable to outside plant.
 5. Additional unallocated margin, or safety margin, can be 0-3 dB. Typically, a 1.5 dB value is assumed.
 6. The stated maximum loss budget equals the System Gain, less the Optical Path Penalty, the Additional Connector Loss Margin, and the Additional Unallocated Margin. The resultant Maximum Loss Budget is available for station cable loss, transmission cable loss, and splice loss.
 7. The Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.45 dB/km is used for 1310 nm optics. This estimate includes typical cable loss (0.40 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1310 nm OC-48 systems, dispersion is not a limiting factor, and the applications are attenuation-limited. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules. However, the short-reach MLM (Multi-Longitudinal Mode-- also known as Fabry Perot [FP]) laser is only recommended for spans of up to 2 km.

□

SONET Optical Specifications: OC-48 Low-Speed OLIU (LNW31)

Overview The following tables present the optical specifications for the low-speed (tributary interface) OC-48 OLIUs.

System specifications The table below lists the low-speed OC-48 OLIU system specifications.

Table 10-14 SONET Optical System Specifications

System Information	LNW31
Optical Line Rate	2.488 Gb/s
Optical Line Coding	Scrambled NRZ
Optical Wavelength	1310 nm
Performance	SONET IR-1 (Intermediate Reach)
Temperature Range	CO

Transmitter specifications The table below lists the low-speed OC-48 OLIU transmitter information.

Table 10-15 SONET Optical Transmitter Information

Transmitter Info.	LNW31
Optical Device Temperature Controller	None
FDA Classification	Class I
Optical Source	Distributed Feed-Back (DFB) Laser
Faceplate Optical Connector	LC connector

Receiver Specifications The table below lists the low-speed OC-48 OLIU receiver information.

Table 10-16 SONET Optical Receiver Information

Receiver Information	LNW31
Optical Detector	PIN
Faceplate Optical Connector	LC connector

Link budgets The table below lists the low-speed OC-48 OLIU link budgets.

Table 10-17 Optical Specifications and Link Budgets

Parameter (NOTE 1)	LNW31 OC-48 IR-1
Minimum Wavelength	1260 nm
Maximum Wavelength	1360 nm
Maximum Spectral Width ($\Delta\lambda_{20}$)	1.0 nm
Maximum Transmitter Power	0.0 dBm
Minimum Transmitter Power	-5.0 dBm
Maximum Received Power (1×10^{-12} BER)	0.0 dBm
Minimum Received Power (1×10^{-12} BER)	-18.0 dBm
Minimum System Gain (see Note 2)	13.0 dB
Dispersion	NA
Optical Path Penalty (see Note 3)	1.0 dB
Additional Connector Loss Margin (see Note 4)	1.5 dB
Additional Unallocated Margin (see Note 5)	1.5 dB
Minimum Loss Budget (see Note 6)	0.0 dB
Maximum Loss Budget (see Note 7)	9.0 dB
Approximate Span Length (see Note 8)	20 km

Notes

1. All terminology is consistent with GR-253-CORE, Issue 3. All values are worst-case end of life (EOL).
2. The System Gain includes connector loss at the transmitter and receiver points S and R in GR-253-CORE, Issue 3.
3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1310 nm optics is 1.0 dB maximum. The optical path penalty for the 1550 nm optics is 2.0 dB maximum.
4. One additional connector (0.75 dB) on each end is assumed to connect station cable to outside plant.

5. Additional unallocated margin, or safety margin, can be 0-3 dB. Typically, a 1.5 dB value is assumed.
6. The LNW31 does not require an external lightguide build-out (optical attenuator) as part of the connector assembly for optical loopbacks.
7. The stated maximum loss budget equals the System Gain, less the Optical Path Penalty, the Additional Connector Loss Margin, and the Additional Unallocated Margin. The resultant Maximum Loss Budget is available for station cable loss, transmission cable loss, and splice loss.
8. The approximate Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.45 dB/km is used for 1310 nm optics. This estimate includes typical cable loss (0.40 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1310 nm OC-48 systems, dispersion is not a limiting factor, and the applications are attenuation-limited. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules.

□

OC-48 DWDM Optics (LNW121B- LNW159B, LNW221- LNW259, and LNW421-LNW459)

Overview The following tables present the optical specifications for the OC-48 DWDM circuit packs.

System specifications The following table lists the DWDM low-speed (tributary interface) and high-speed (network interface) system specifications.

Table 10-18 SONET Optical System Specifications

System Information	OC-48 low-speed DWDM Optics (LNW421-LNW459)	OC-48 high-speed DWDM Optics (LNW121B-159B & LNW221-259)
Optical Line Rate	2.488 Gb/s	2.488 Gb/s
Optical Line Coding	Scrambled NRZ	Scrambled NRZ
Optical Wavelength	1530 nm - 1560 nm	1530 nm - 1560 nm
Performance	Customized LR-2 (for DWDM)	Customized LR-2 (for DWDM)
Temperature Range	CO	CO

Transmitter specifications The following table lists the DWDM optics transmitter information.

Table 10-19 SONET Optical Transmitter Information

Transmitter Info.	OC-48 low-speed DWDM Optics (LNW421-LNW459)	OC-48 high-speed DWDM Optics (LNW121B-159B & LNW221-259)
Optical Device Temperature Controller/Thermo-Electric Cooler (TEC)	Yes	Yes
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
FDA Classification	Class I	Class I
Optical Source	Distributed Feed-Back (DFB) Laser or Externally Modulated Laser (EML)	Distributed Feed-Back (DFB) Laser or Externally Modulated Laser (EML)
Faceplate Optical Connector	LC connector	LC connector

Receiver specifications The following table lists the passive DWDM optics receiver information.

Table 10-20 SONET Optical Receiver Information

Receiver Information	OC-48 low-speed DWDM Optics (LNW421-LNW459)	OC-48 high-speed DWDM Optics (LNW121B-159B & LNW221-259)
Optical Detector	Avalanche Photodiode (APD)	Avalanche Photodiode (APD)
Faceplate Optical Connector	LC connector	LC connector

Operating wavelengths The table below lists the ITU channel numbers, operating wavelengths, and frequencies for the OC-48 DWDM OLIUs.

Table 10-21 OC-48 DWDM OLIUs Wavelength Plan

Port Unit	ITU Channel #	Wavelength (nm)	Frequency (Thz)
LNW121B, LNW221, & LNW421	21	1560.606	192.10
	22	1559.794	192.20
LNW123B, LNW223, & LNW423	23	1558.983	192.30
	24	1558.173	192.40
LNW125B, LNW225, & LNW425	25	1557.363	192.50
	26	1556.555	192.60
LNW127B, LNW127, & LNW427	27	1555.747	192.70
	28	1554.940	192.80
LNW131B, LNW231, & LNW431	31	1552.524	193.10
	32	1551.721	193.20
LNW133B, LNW233, & LNW433	33	1550.918	193.30
	34	1550.116	193.40
LNW135B, LNW235, & LNW435	35	1549.315	193.50
	36	1548.515	193.60
LNW137B, LNW237, & LNW437	37	1547.715	193.70
	38	1546.917	193.80
LNW143B, LNW243, & LNW443	42	1543.730	194.20
	43	1542.936	194.30
LNW145B, LNW245, & LNW445	44	1542.142	194.40
	45	1541.349	194.50
LNW147B, LNW247, & LNW447	46	1540.557	194.60
	47	1539.766	194.70
LNW149B, LNW249, & LNW449	48	1538.976	194.80
	49	1538.186	194.90
LNW153B, LNW253, & LNW453	52	1535.822	195.20
	53	1535.036	195.30
LNW155B, LNW255, & LNW455	54	1534.250	195.40
	55	1533.465	195.50
LNW157B, LNW257, & LNW457	56	1532.681	195.60
	57	1531.898	195.70
LNW159B, LNW259, & LNW459	58	1531.116	195.80
	59	1530.334	195.90

Optical requirements and loss budgets The table below lists the optical requirements and link budgets for the OC-48 DWDM OLIUs.

Table 10-22 Optical Requirements and Link Budgets for the OC-48 DWDM OLIUs

Parameter	LNW121B-159B, LNW221-259, LNW421-459
Interface Type (Note 1)	OC-48 Custom LR-2 for DWDM
DWDM Wavelength Range (100 GHz spacing)	1530.334-1560.606 nm
Maximum Spectral Width ($\Delta\lambda_{20}$)	0.5 nm
Maximum Transmitter Power	+2.0 dBm
Minimum Transmitter Power	-1.0 dBm
Maximum Received Power (1×10^{-10} BER)	-8.0 dBm
Minimum Received Power (1×10^{-10} BER)	-29.0 dBm
Minimum System Gain (see Note 2)	28.0 dB
Dispersion	1800 ps/nm
Optical Path Penalty (see Note 3)	2.0 dB
Additional Connector Loss Margin (see Note 4)	1.5 dB
Additional Unallocated Margin (see Note 5)	1.5 dB
Minimum Loss Budget (see Note 6)	10.0 dB
Maximum Loss Budget (see Note 7)	23.0 dB
Approximate Span Length (see Note 8)	85 km*
*This span length assumes no passive optical unit (POU) is being used.	

NOTES

1. All terminology is consistent with GR-253-CORE, Issue 3. All values are worst-case end of life (EOL).
2. The System Gain includes connector loss at the transmitter and receiver points S and R in GR-253-CORE, Issue 3.
3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1550 nm optics is normally 2.0 dB.
4. One additional connector (0.75 dB) on each end is assumed to connect

- station cable to outside plant.
5. Additional unallocated margin, or safety margin, can be 0-3 dB. Typically, a 1.5 dB value is assumed.
 6. The LNW 121B-159B, LNW221-259, and LNW421-459 series all require an external lightguide build-out (optical attenuator) as part of the connector assembly for optical loopbacks and for loss budgets less than 10 db to avoid overloading the optical receiver.
 7. The stated maximum loss budget equals the System Gain, less the Optical Path Penalty, the Additional Connector Loss Margin, and the Additional Unallocated Margin. The resultant Maximum Loss Budget is available for station cable loss, transmission cable loss, and splice loss. The stated maximum loss budget is conservative; i.e., if the additional connector loss margin and additional unallocated margin are not needed, an additional 3 dB budget is available.
 8. The Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.27 dB/km is used for 1550 nm optics. This estimate includes typical cable loss (0.22 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1550 nm OC-48 systems, dispersion can also be limiting factor. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules.



SONET Optical Specifications: OC-192 OLIU (LNW56 and LNW58)

Overview The following tables present the optical specifications for the OC-192 LNW56 and LNW58 OLIU.

System specifications The table below lists the OC-192 LNW56 and LNW58 OLIU system specifications.

Table 10-23 SONET Optical System Specifications

System Information	LNW56	LNW58
Optical Line Rate	9953.28 Mb/s	9953.28 Mb/s
Optical Line Coding	Scrambled NRZ	Scrambled NRZ
Optical Wavelength	1550 nm	1310 nm
Performance	SONET IR-2 (Intermediate Reach)	ITU-T G.693 “VSR 600-2R1” (Very Short Reach)
Temperature	CO	CO

Transmitter specifications The table below lists the OC-192 LNW56 and LNW58 OLIU transmitter information.

Table 10-24 SONET Optical Transmitter Information

Transmitter Info.	LNW56	LNW58
Optical Device Temperature Controller	None	None
FDA Classification	Class I	Class I
Optical Source	1550 nm EML Laser Structure	1310 nm, FP or DFB Laser Structure
Faceplate Optical Connector	LC connector	LC connector

Receiver specifications The table below lists the OC-192 LNW56 and LNW58 OLIU receiver information.

Table 10-25 SONET Optical Receiver Information

Receiver Information	LNW56	LNW58
Optical Detector	PIN Diode	PIN Diode
Faceplate Optical Connector	LC connector	LC connector

Link budgets The table below lists the OC-192 LNW56 and LNW58 OLIU link budgets.

Table 10-26 SONET Optical Specifications and Link Budgets

Parameter (Note 1)	LNW56 OC-192 IR-2	LNW58 VSR600-2R1
Minimum Wavelength	1530 nm	1260 nm
Maximum Wavelength	1565 nm	1360 nm
Maximum Spectral Width ($\Delta\lambda_{20}$)	1.0 nm	NA
Maximum RMS Spectral Width (σ)	NA	3.0 nm
Maximum Transmitter Power	+2.0 dBm	-1.0 dBm
Minimum Transmitter Power	-1.0 dBm	-6.0 dBm
Maximum Received Power (1×10^{-12} BER)	-1.0 dBm	-1.0 dBm
Minimum Received Power (1×10^{-12} BER)	-14.0 dBm	-11.0 dBm
Minimum System Gain (see Note 2)	13.0 dB	5.0 dB
Dispersion	800 ps/nm	NA
Optical Path Penalty (see Note 3)	2.0 dB	1.0 dB
Minimum Loss Budget (see Note 4)	3.0 dB	0.0 dB
Maximum Loss Budget (see Note 5)	11.0 dB	4.0 dB
Approximate Span Length (see Note 6)	40 km	600 meters

Notes

1. All terminology is consistent with GR-253-CORE, Issue 3. All values are worst-case end of life.

2. The System Gain includes connector loss at the transmitter and receiver points S and R in GR-253-CORE, Issue 3.
3. Optical path penalty includes effects of dispersion, reflection, and jitter that occur on the optical path. The optical path penalty for 1310 nm is a maximum of 1.0 dB. The optical path penalty for 1550 nm is a maximum of 2.0 dB.
4. The LNW56 requires an external lightguide build-out (optical attenuator) as part of the connector assembly for optical loopbacks and for loss budgets less than 3.0 dB to avoid overloading the optical receiver.
5. Maximum Loss Budget available for both station and transmission cable and splices.
6. The approximate Approximate Span Length values are calculated per an attenuation assumption. As a general rule, for attenuation-limited systems, an attenuation of 0.27 dB/km is used for 1550 nm optics. This estimate includes typical cable loss (0.22 dB/km) and up to 11 splice losses (0.2 dB per splice). For 1550 nm OC-192 systems, dispersion can also be limiting factor. Approximate Span Lengths can be calculated more precisely based on particular fiber and splice characteristics and local engineering rules. However, the VSR OC-192 LNW58 is recommended for spans of up to 600 meters only.

1G SX (2-port 1000BASE-SX) Ethernet (LNW67)

Optical specification The 1G SX circuit pack provides a short-reach, 2-port, 1000BASE-SX, IEEE 802.3-compliant interface. The LNW67 circuit pack performs protocol transparent filtering and bridging of incoming media access control (MAC) frames. MAC frames with a destination address on the local bus are filtered by the LNW67 to prevent unnecessary transmission of frames over the wide area network (WAN). The LNW67 must be housed in slot 1 of a Function Unit group and is not equipment protected. However, protection is provided via SONET UPSR or through the IEEE 802.1w spanning tree algorithm.

The LNW67 1G SX ethernet interface complies with the following transmission standards:

- standard IEEE 802.1w for transparent bridging and spanning tree protection
- standard IEEE 802.3 autonegotiation (for flow control).

System specifications The following are the 1G SX system specifications:

- Optical Line Rate: 1.25 Gb/s +/- 100 ppm
- Optical Line Coding: 8B/10B
- Performance: Short-reach.

Operating range The table below shows the operating range for the 1G SX optical ethernet interface. A 1000BASE-SX compliant transceiver supports both 50 μm and 62.5 μm fiber media types. A transceiver that exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g., a 50 μm solution operating at 600 m meets the minimum range requirement of 2 to 550 m).

Table 10-27 1G SX Operating Range Over Each Optical Fiber Type

Fiber Type	Modal Bandwidth @ 850 nm (minimum overfilled launch) (MHz-km)	Minimum Range (meters)
62.5 μm MMF	160	2 to 220
62.5 μm MMF	200	2 to 275
50 μm MMF	400	2 to 500
50 μm MMF	500	2 to 550
10 μm SMF	Not supported	Not supported

Transmitter specifications The table below shows 1G SX optical transmitter specifications. The 1000BASE-SX transmitter meets these specifications per measurement techniques define in IEEE 802.3, Section 38, Clause 6.

Table 10-28 1G SX Transmit Specifications

Description	62.5/50 μm MMF	Unit
Transmitter type	Shortwave Laser	
Signaling speed (range)	1.25 +/- 100 ppm	GBd
Wavelength (l, range)	770 to 860	nm
T_{rise}/T_{fall} (max; 20%-80%; $l > 830$ nm)	0.26	ns
T_{rise}/T_{fall} (max; 20%-80%; $l \leq 830$ nm)	0.21	ns
RMS spectral width (max)	0.85	nm
Average launch power (max)	Note 1	dBm
Average launch power (min)	-9.5	dBm
Average launch power of OFF transmitter (max) (Note 2)	-30	dBm
Extinction ratio (min)	9	dB
RIN (max)	-117	dB/Hz
Coupled Power Ratio (CPR) (min) (Note 3)	$9 < CPR$	dB

Table notes

- 1.The 1000BASE-SX launch power shall be the lesser of the class 1 safety limit as defined by IEEE 802.3, Section 38, Clause 7.2 or the average receiver power (maximum) defined by Table 10-8.
- 2.Examples of an OFF transmitter are as follows: no power supplied to the Physical Medium Dependent (PMD), laser shutdown for safety conditions, and activation of a “transmit disable” or other optional module laser shut-down conditions. During all conditions when the Physical Medium Attachment (PMA) is powered, the ac signal (data) into the transmit port will be valid encoded 8B/10B patterns (this is a requirement of the Physical Coding Sublayer [PCS]) except for short durations during system power-on-reset or diagnostics when the PMA is placed in a loopback mode.
- 3.Radial overfilled launches (described in IEEE 802.3, Section 38A, Clause 2) should be avoided even if they meet CPR ranges.

Receiver specifications The 1000BASE-SX receiver meets the specifications defined in the table below, per measurement techniques defined in IEEE 802.3, Section 38, Clause 6. The sampling instant is defined to occur at the eye center. The receive sensitivity includes the extinction ratio penalty.

Table 10-29 1G SX Receive Specifications

Description	62.5 μm MMF	50 μm MMF	Unit
Signaling speed (range)	1.25 +/- 100 ppm	1.25 +/- 100 ppm	GBd
Wavelength (range)	770 to 860	770 to 860	nm
Average receive power (max)	0	0	dBm
Receive sensitivity	-17	-17	dBm
Return loss (min)	12	12	dB
Stressed receive sensitivity (Notes 1 and 2)	-12.5	-13.5	dBm
Vertical eye-closure penalty (Note 3)	2.60	2.20	dB
Receive electrical 3 dB upper cutoff frequency (max)	1500	1500	MHz

Table notes

- 1.Measured with conformance test signal at TP3 (see IEEE 802.3, Section 38.6.11) for BER at the eye center.
- 2.Measured with a transmit signal having a 9 dB extinction ratio. If another extinction ratio is used, the stressed receive sensitivity should be corrected for the extinction ratio penalty.
- 3.Vertical eye-closure penalty is a test condition for measuring stressed receive sensitivity. It is not a required characteristic of the receiver.

Link budgets The worst-case power budget and link penalties for a 1000BASE-SX channel are shown in the table below.

Table 10-30 1G SX Link Budgets and Penalties

Parameter	62.5 μm MMF		50 μm MMF		Unit
	160	200	400	500	
Modal bandwidth as measured at 850 nm (minimum, overfilled launch)	160	200	400	500	MHz-km
Link power budget	7.5	7.5	7.5	7.5	dB
Operating distance	220	275	500	550	m
Channel insertion loss (Notes 1 and 2)	2.38	2.60	3.37	3.56	dB
Link power penalties (Note 2)	4.27	4.29	4.07	3.57	dB
Unallocated margin in link power budget (Note 2)	0.84	0.60	0.05	0.37	dB

Table notes

1. Operating distances used to calculate the channel insertion loss are the maximum values specified in Table 10-6.
2. A wavelength of 830 nm is used to calculate the channel insertion loss, link power penalties, and unallocated margin.

Format specification The LNW67 1G SX ethernet interface complies with the following formatting standards:

- standard IEEE 802.1Q VLAN encapsulation (user assigned or network assigned)
- standard ANSI T1X1.5/2001-024R5 generic framing procedure (encapsulating ethernet frames mapping them into a SONET payload)
- standard ITU G.704.1 STS-1 virtual concatenation.

Performance monitoring Performance monitoring capabilities are available on the 1G SX interface, however Threshold Crossing Alerts (TCAs) are not supported. Monitored parameters include:

- Dropped Frames (congestion)
- Dropped Frames (errors)
- Incoming Number of Bytes
- Outgoing Number of Bytes
- Incoming Number of Frames
- Outgoing Number of Frames.

1G LX (2-port 1000BASE-LX) Ethernet (LNW68)

Optical specification The 1G LX circuit pack provides a long-reach, 2-port, 1000BASE-LX, IEEE 802.3-compliant interface. The LNW68 circuit pack performs protocol transparent filtering and bridging of incoming media access control (MAC) frames. MAC frames with a destination address on the local bus are filtered by the LNW68 to prevent unnecessary transmission of frames over the wide area network (WAN). The LNW68 must be housed in slot 1 of a Function Unit group and is not equipment protected. However, protection is provided via SONET UPSR or through the IEEE 802.1w spanning tree algorithm.

The LNW68 1G LX ethernet interface complies with the following transmission standards:

- standard IEEE 802.1w for transparent bridging and spanning tree protection
- standard IEEE 802.3 autonegotiation (for flow control).

System specifications The following are the 1G LX system specifications:

- Optical Line Rate: 1.25 Gb/s +/- 100 ppm
- Optical Line Coding: 8B/10B
- Performance: Long-reach.

Operating range The table below shows the operating range for the 1G LX optical ethernet interface. A 1000BASE-LX compliant transceiver supports 50 μm , 62.5 μm , 10 μm fiber media types. A transceiver that exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g., a 50 μm solution operating at 5500 m meets the minimum range requirement of 2 to 5000 m).

Table 10-31 1G LX Operating Range Over Each Optical Fiber Type

Fiber Type	Modal Bandwidth @ 1300 nm (minimum overfilled launch) (MHz-km)	Minimum Range (meters)
62.5 μm MMF	500	2 to 550
50 μm MMF	400	2 to 550
50 μm MMF	500	2 to 550
10 μm SMF	N/A	2 to 10,000

Transmitter specifications The table below describes the transmit specifications for LNW68. The 1000BASE-SX transmitter meets these specifications per measurement techniques define in IEEE 802.3, Section 38, Clause 6.

Table 10-32 1G LX Transmit Specifications

Description	62.5 μ m MMF	50 μ m MMF	10 μ m SMF	Unit
Transmitter type	Longwave Laser			
Signaling speed (range)	1.25 +/- 100 ppm			GBd
Wavelength (l, range)	1270 to 1335			nm
T _{rise} /T _{fall} (max; 20%-80% response time)	0.26			ns
RMS spectral width (max)	4			nm
Average launch power (max)	-3			dBm
Average launch power (min)	-11.5	-11.5	-11.0	dBm
Average launch power of OFF transmitter (max)	-30			dBm
Extinction ratio (min)	9			dB
RIN (max)	-120			dB/Hz
Coupled Power Ratio (CPR) (min) (Note 1)	28 < CPR < 40	12 < CPR < 20	N/A	dB

Table notes

1. Due to dual media (single-mode and multimode) support of the 1G LX transmitter, fulfillment of this specification requires a single-mode fiber offset-launch mode-conditioning patch cord (as described in IEEE 802.3, Section 38.11.4) for MMF and SMF operation. This patch cord is not used for single-mode operation.

Receiver specifications The 1000BASE-LX receiver meets the specifications defined in the table below, per measurement techniques defined in IEEE 802.3, Section 38.6. The sampling instant is defined to occur at the eye center. The receive sensitivity includes the extinction ratio penalty.

Table 10-33 1G LX Receive Specifications

Description	62.5 μm MMF	Unit
Signaling speed (range)	1.25 +/- 100 ppm	GBd
Wavelength (range)	1270 to 1355	nm
Average receive power (max)	-3	dBm
Receive sensitivity	-19	dBm
Return loss (min)	12	dB
Stressed receive sensitivity (Notes 1 and 2)	-14.4	dBm
Vertical eye-closure penalty (Note 3)	2.60	dB
Receive electrical 3 dB upper cutoff frequency (max)	1500	MHz

Table notes

1. Measured with conformance test signal at TP3 (see IEEE 802.3, Section 38.6.11) for BER at the eye center.
2. Measured with a transmit signal having a 9 dB extinction ratio. If another extinction ratio is used, the stressed receive sensitivity should be corrected for the extinction ratio penalty.
3. Vertical eye-closure penalty is a test condition for measuring stressed receive sensitivity. It is not a required characteristic of the receiver.

Link budgets The worst-case power budget and link penalties for a 1000BASE-LX channel are shown in the table below.

Table 10-34 1G LX Link Budgets and Penalties

Parameter	62.5 μm MMF	50 μm MMF	50 μm SMF	10 μm SMF	Unit
Modal bandwidth as measured at 850 nm (minimum, overfilled launch)	500	400	500	N/A	MHz-km
Link power budget	7.5	7.5	7.5	8.0	dB
Operating distance	550	550	550	10,000	m
Channel insertion loss (Notes 1, 2, and 3)	2.35	2.35	2.35	4.57	dB
Link power penalties (Notes 2 and 3)	3.48	5.08	3.96	3.27	dB
Unallocated margin in link power budget (Note 2 and 3)	1.67	0.07	1.19	0.16	dB

Table notes

1. Operating distances used to calculate the channel insertion loss are the maximum values specified in Table 10-10.
2. A wavelength of 1270 nm is used to calculate the channel insertion loss, link power penalties, and unallocated margin.
2. These figures are actually better than specified here, and will be updated in a future release.

Format specification The LNW68 1G LX ethernet interface complies with the following formatting standards:

- standard IEEE 802.1Q VLAN encapsulation (user assigned or network assigned)
- standard ANSI T1X1.5/2001-024R5 generic framing procedure (encapsulating ethernet frames and mapping them into SONET format)
- standard ITU G.7041 STS-1 virtual concatenation.

Performance monitoring Threshold Crossing Alerts (TCAs) are not supported on the 1G LX interface, however PM capabilities are available including:

- Dropped Frames (congestion)
- Dropped Frames (errors)
- Incoming Number of Bytes
- Outgoing Number of Bytes
- Incoming Number of Frames
- Outgoing Number of Frames.

1G SX/LX (4-port 1000BASE-SX/LX) Ethernet (LNW70)

Optical specification The 1G SX/LX circuit pack provides a short- or long-reach, 4-port, 1000BASE-SX/LX, IEEE 802.3-compliant interface.

Pluggable Optics The LNW70 features pluggable optics which enable it to function as both an SX (short-reach) and LX (long-reach) interface. The card is shipped with no optics module installed. Depending on the customer's order, a set of either SX or LX optics, which can be plugged into the LNW70 circuit pack, are included.

These optics conform to the same standards as those specified in the 2 previous sections for 1000BASE-SX and 1000BASE-LX interfaces respectively. Therefore, please refer to the previous 2 sections of this Chapter to obtain the specifications for the SX and LX interfaces supported on the LNW70 circuit pack.



Lightguide Jumpers and Buildouts

- Overview** The DMX provides standard LC-type connectors on all optical interfaces. 5 dB, 10 dB, 15 dB, and 20 dB attenuating build-outs are supported.
- Single-mode jumpers** The OC-3, OC-12, OC-48, OC-192, and 1G LX lightguide interfaces use single-mode jumpers for connecting to and from the outside plant *LGX* panel and the DMX.
- Multi-mode jumpers** The 1G SX interface must use multi-mode jumpers.
- Build-outs** DMX supports the use of single-mode to single-mode (SM-SM) fiber exclusively, except on the 1G SX interface.
- Reference** For more information, including a complete list of available jumpers and build-outs, refer to the Miscellaneous Equipment and Tools section in Chapter 7, Ordering.

System Performance

Overview

Purpose This section provides performance specifications for the DMX Access Multiplexer.

Contents The following performance specifications are discussed in this section:

SONET Overhead Bytes	10 - 54
Wander/Jitter	10 - 55
Signal Performance	10 - 56
Synchronization	10 - 57
Protection Switching	10 - 59
Transient Performance	10 - 60
Transmission Delay	10 - 61
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SONET Overhead Bytes

- Overview** DMX uses SONET transport and path overhead bytes as specified in GR-253-CORE.
- V4 byte** The reserved V4 byte in the VT1.5 superframe is sometimes used for internal error detection in a DMX shelf. This internal usage of the V4 byte may cause the value of a transmitted V4 byte to vary. The DMX always ignores the value of the V4 byte received from another network element as required by GR-253-CORE.

Wander/Jitter

Maximum time interval error (MTIE)	For SONET optical interfaces, the maximum time interval error (MTIE) does not exceed 60 nanoseconds phase variation when timed with a wander-free reference.
Wander requirements	Wander transfer, tolerance, and generation requirements are met as specified in GR-253-CORE.
Jitter requirements	Jitter transfer, tolerance, and generation requirements are met as specified in GR-253-CORE and GR-499-CORE.
Short-term stability	The SONET interfaces meet the T1.101 OC-N output short-term stability mask as specified in GR-253-CORE, Section 5.

Signal Performance

Overview The following specifications apply to the standard networks defined in GR-499-CORE, Issue 3.

DS1 rate For systems interfacing at the DS1 rate, the number of errored seconds during a 7-hour, one-way loopback test, is less than 10.

DS3 rate For systems interfacing at the DS3 rate, the number of errored seconds during a 2-hour, one-way loopback test, is less than 29.

BER The BER is less than 2×10^{-10} for both the DS1 and DS3 rates. Burst-errored seconds are excluded.

Burst-errored seconds The frequency of burst-errored seconds, other than those caused by protection switching induced by hard equipment failures, averages less than 4 per day.

Synchronization

Overview The embedded Stratum 3 Timing Generator meets the specifications of GR-253-CORE, SONET Transport Systems Generic Criteria. The timing generator function is embedded in the 1x1 protected optical interface circuit packs in the main slot pair.

Timing modes The timing generator supports four timing modes:

- **External timing**

Locked to an external Stratum 3 (+/- 4.6 ppm) or better DS1 reference.

- **Line timing**

Locked to recovered clock from an OC-N signal (from Main OC-48/OC-192 only).

- **Free running**

Timing derived from high-stability temperature-compensated voltage-controlled crystal oscillator (TCVCXO) with a long-term accuracy of +/- 4.6 ppm and temperature stability of -40° C to +65° C.

- **Holdover**

Timing derived from the internal oscillator in the case of an unprotected synchronization reference failure. In this instance, the Stratum Timing Generator switches to “holdover mode” and continues to provide system timing, using the internal oscillator to maintain the last known good reference frequency. If the DS1 timing output is enabled for network synchronization, DS1 AIS will be inserted on detection of unprotected optical reference failure. In holdover mode, the accuracy is +/- .37 ppm over the full -40 to +65° C temperature range.

- **DS1 timing outputs**

In addition, each timing generator (main circuit pack) provides a single DS1 sync output derived from a received optical interface signal (OC-N). These DS1 timing outputs may be used to provide a timing reference signal to a local BITS clock (see Chapter 4 of this document).

DS1 timing functions The DS1 timing reference inputs and outputs meet the specifications of GR-499-CORE for DS1 interfaces and GR-253-CORE for timing references. The following are the DS1 timing functions:

- Two DS1 timing reference inputs
- Two DS1 timing reference outputs
- Software-provisionable line build-outs for DS1 timing outputs (up to 655 feet depending on cable type)
- Alarms (Out of Frame, AIS, BER).

Protection Switching

1+1 networks DMX complies with SONET 1+1 unidirectional nonrevertive protection switching requirements as specified in GR-253-CORE. Automatic line switches are initiated by signal fail and signal degrade conditions on the received OC-3/OC-12 low-speed optical signal and are completed within 50 milliseconds of a signal failure. The signal's BER is calculated from violations of the SONET line overhead B2 parity bytes. Signal fail is declared for incoming LOS, LOF, line AIS, or a BER exceeding 10^{-3} , while a BER exceeding a provisionable threshold between 10^{-5} and 10^{-9} causes a signal degrade to be declared. Manual switch commands are available through the local and remote operations interfaces.

High-speed UPSR networks Path protection rings feed a SONET payload (STS or virtual tributary [VT]) from the ring entry point, simultaneously in both rotations of the ring, to the signal's ring exit point. The node that terminates the signal from the ring monitors both ring rotations and is responsible for selecting the signal that has the highest quality based on LOS, LOF, LOP, path unequipped, path AIS, and path BER performance. On pass-through paths, all detected hard failures (LOS, LOF, LOP, line AIS, or STS-1 path AIS) result in VT AIS insertion in the outgoing signals. This allows the terminating node to be aware of the failure and to switch to protection. Protection switching is completed within 50 milliseconds of failure detection.

Under normal conditions, both incoming SONET path signals to the switch selection point are of high quality, and the signal can be selected from either ring. A failure or transmission degradation on one of the rings requires that the other ring path be selected. The DMX provides nonrevertive switching to minimize the impact on critical customer services by giving the service provider control, when and if the critical service should revert to a particular ring. A manual path protection switching command allows switching back to the original path for ease of ring maintenance.

Low-speed UPSR networks On low-speed SONET optical interfaces (OC-3/12), UPSR is optional and protection switching is provisionable (UPSR or 1+1) on a per-line basis.

Transient Performance

Power loss restart After system shutdown due to power loss, the system will exhibit a 2-second error free transmission interval which begins within 1 minute of restoration of power.

Transmission start-up on signal application The system, after having no signal applied for greater than 1 minute at the DSX-n interface, will exhibit a 2-second error free transmission interval which begins within 5 seconds of the reapplication of a signal.

Transmission Delay

One-way transmission delay The table below, lists the worst-case measured one-way transmission delay (microseconds) between DMX interfaces.

Table 10-35 Transmission Delay in Microseconds (µm)

Interface	OC-n		EC1		DS1		DS3
	VT	STS-n	VT	STS-1	VT	STS-1	STS-1
Cross-Connect	VT	STS-n	VT	STS-1	VT	STS-1	STS-1
OC-n	50	25	50	25	100	100	25
EC-1	50	25	-	-	-	-	-
DS1	100	100	-	-	-	-	-
DS3	N/A	25	-	-	-	-	-



Performance Monitoring

Overview DMX performance monitoring complies with GR-253-CORE and ANSI T1.231-1997 specifications for SONET and asynchronous networks.

SONET PM parameters The table below lists the provisionable threshold range for monitored parameters and, in brackets, the default thresholds. Thresholding of any parameter(s) can be disabled.

Table 10-36 SONET PM Parameters

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-48 Section	SE Frame Seconds (SEFS)	1-63 [63]	1-4095 [30]
OC-12 Section	SE Frame Seconds (SEFS)	1-63 [10]	1-4095 [30]
OC-3 Section	SE Frame Seconds (SEFS)	1-63 [10]	1-4095 [30]
OC-48 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [531504]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
OC-12 Line	Coding Violations (CV)	1-55365 [5537]	1-5315040 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
OC-3 Line	Coding Violations (CV)	1-13841 [1384]	1-1328736 [132874]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095[60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]
	Line Protection Switch Counts (PSC-L)	1-63 [2]	1-255 [4]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]
EC-1 Line	Coding Violations (CV)	1-4613 [461]	1-442848 [44285]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
	STS Pointer Justification Counts (PJC)	1-65535 [60]	1-9999999 [5760]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
DS3 Line	CV-L Coding Violations	1-16383 [40]	1-1048575 [3820]
	Errored Seconds, Line (ES-L)	1-900 [25]	1-65535 [250]
	Severely Errored Seconds, Line (SES-L)	1-63 [4]	1-4095 [40]
DS1 Line	ES-L Line Errored Seconds	1-900 [65]	1-65535 [648]
STS-1 Path	Coding Violations (CV)	1-4510 [451]	1-432960 [43296]
	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Errored Seconds Type A (ESA)	1-900 [30]	1-65535 [90]
	Errored Seconds Type B (ESB)	1-900 [30]	1-65535 [90]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds	1-63 [30]	1-4095 [90]
DS3 Path	P-Bit Error Counts	1-4026 [403]	1-386500 [38650]
	SE Frame Seconds (SEFS)	1-63 [10]	1-4095 [30]
Enhanced DS3 Path for P-Bits, F&M Bits, and C-Bits from Fiber and DSX	Coding Violations (CV)	1-16383 [40]	1-1048575 [3820]
	ES-P Errored Seconds	1-900 [25]	1-65535 [250]
	SES-P Severely Errored Seconds	1-63 [4]	1-4095 [40]
	UAS-P Unavailable Seconds	1-63 [10]	1-4095 [10]
	SE Frame Seconds	1-63 [2]	1-4095 [8]
DS1 Path	ES-P Errored Seconds	1-900 [65]	1-65535 [648]
	SES-P Severely Errored Seconds	1-63 [10]	1-4095 [100]
	UAS-P Unavailable Seconds	1-63 [10]	1-4095 [10]
	ES-PFE Errored Seconds	1-900 [65]	1-65535 [648]
	SES-PFE Severely Errored Seconds	1-63 [10]	1-4095 [100]
	UAS-PFE Unavailable Seconds	1-63 [10]	1-4095 [10]
	CV-P (SF) Coding Violations	1-16383 [72]	1-1048575 [691]
	CV-P (ESF) Coding Violations	1-16383 [13296]	1-1048575 [132960]
	CV-PFE Coding Violations	1-16383 [13196]	1-1048575 [132960]

Parameter Definition		Threshold Range (Default)	
Facility	Measure	Current Quarter Hour	Current Day
VT1.5 Path	Errored Seconds (ES)	1-900 [40]	1-65535 [900]
	Severely Errored Seconds (SES)	1-63 [20]	1-4095 [60]
	Unavailable Seconds (UAS)	1-63 [30]	1-4095 [90]

Ethernet parameters DMX provides PM capabilities for the 10/100T, 1G SX, and 1G LX ethernet interfaces. PM data is collected at each LAN and WAN interface in the network for both incoming and outgoing directions and is stored in quarter-hour and day bins. The WAN interface provides a connection to a SONET Virtual Concatenation Group (VCG). Provisionable threshold crossing alerts (TCAs) are not supported on the ethernet interfaces. Listed below are the six PM parameters that provide PM data on all ethernet interfaces:

- **Dropped Frames (congestion)**
Counts the number of incoming ethernet frames dropped at a specific LAN/WAN port due to buffer overflow. Buffer overflow occurs when the network is congested.
- **Dropped Frames (errors)**
Counts the number of incoming ethernet frames dropped at a LAN/WAN port due to a frame check sequence (FCS) error or another defect in the frame.
- **Incoming Number of Bytes**
Counts the total number of bytes incoming to a LAN/WAN port.
- **Incoming Number of Frames**
Counts the total number of ethernet frames incoming to a LAN/WAN port.
- **Outgoing Number of Bytes**
Counts the total number of outgoing bytes transmitted by a specified LAN/WAN port.
- **Outgoing Number of Frames**
Counts the total number of outgoing frames transmitted by a specified LAN/WAN port.

Operations Interfaces

Overview

Purpose This section presents the operation interfaces that are required to support technician access to the system and allow alarms and status information generated by the system to be reported. The operation interfaces include the CIT interface, IAO LAN (via OSI or TCP/IP), SYSCTL faceplate LEDs, and equipment indicators. DMX supports office alarms, user-definable miscellaneous discretes, and TL1/X.25.

Contents The following operation interfaces are discussed in this section:

Craft Interface Terminal (PC-CIT)	10 - 72
TL1/LAN	10 - 74
Personal Computer Specifications for Software Download	10 - 75
LEDs, Indicators, and Office Alarms	10 - 76
TL1/X.25 Interface	10 - 77



Craft Interface Terminal (PC-CIT)

Overview The DMX PC-CIT is the primary tool used to interface with the DMX. It is a personal computer (PC) with the DMX user-interface software installed. The DMX PC-CIT is compatible with PCs running Microsoft Windows XP, NT and Windows 2000. The PC-CIT also provides a user-friendly TL1 command builder interface.

Minimum requirements It is anticipated that most customers will dedicate a lap-top PC to run the DMX PC-CIT applications software. However, a properly configured desktop PC will also suffice.

The following list shows the minimum requirements for the customer-provided PC with recommended Windows operating system.

- Microsoft Windows XP, 2000 or NT 4.0 Operating System with service pack 4. The customer is responsible for ensuring that the PC remains virus -free.
 - Pentium 266 MHz processor; Pentium III 500 MHz processor is recommended for optimum performance
 - 128 MB RAM minimum, 256 recommended
 - One-gigabyte hard-disk drive with at least 150 megabytes of free space. The DMX PC-CIT application requires 50 MB, and the installation requires 30MB. In addition, each copy of the NE generic requires an additional 60 MB.
 - CD-ROM drive
 - SVGA monitor 800x 600 resolution (1024 x 768 recommended)
 - 10 BASE-T LAN interface
- Pin Designations/signals are:

- -1 TD+
- -2 TD-
- -3 RD+
- -6 RD-

PC-CIT and Windows requirements

The following table illustrates the Windows operating system requirements for DMX PC-CITs.

DMX port/ Windows Guidelines	Serial Port	OSI/TCP-IP LAN Port
Windows NT	X	X
Windows 98 and 2000	X	--

TL1/LAN

Overview DMX supports a TL1 over TCP/IP interface or TL1 over OSI LAN interface for communication between a DMX NE and an Element Management System (EMS) of a Network Management System (NMS). TL1 over TCP/IP LAN complies with requirements specified in IEEE 802.3 and NSIF-AR-9806-088R11.

TL1 translation device (T-TD Gateway) The T-TD is a device that translates TL1 messages over a TCP/IP connection to a TL1 over OSI association, providing a TL1 TCP-OSI gateway. The T-TD, when used in conjunction with the PC-CIT, is an open system interconnection (OSI) proxy that accepts TCP/IP connections and sets up matching OSI connections. This requires the support of the TCP/IP stack and the seven-layer OSI stack.

Front IAO LAN interface The DMX provides an RJ45-compatible front IAO LAN interface that is intended for use with a local PC. This interface will support a TL1/TCP gateway via an IEEE 802.3-compliant interface with a graphical user interface (GUI) in future releases.

Rear IAO LAN interface TL1 over TCP/IP or TL1 over OSI LAN is supported via an RJ45-compatible IAO LAN rear interface (R1.1) on the DMX, enabling the DMX to connect with any NMS possessing a compatible TCP/IP or OSI interface (such as the SNMS or the PC-CIT). This allows TL1 communication over a data network between several different NEs. For instance, Lucent's Subnetwork Management System (SNMS) can communicate with a DDM-2000 that is on the same network as the DMX connected to the SNMS via the rear IAO LAN interface. The IAO LAN complies with OSI requirements as specified in GR-253-CORE, Section 8.

SONET DCC The SONET DCC provides TL1 over OSI connections with remote NEs in a subnetwork.



Personal Computer Specifications for Software Download

Specifications The PC used for software download should have:

- Windows NT or 2000
- CD-ROM drive for CD-ROM download.

Compatible modems A compatible modem must meet the following minimum requirements:

- 300, 1200, 2400, 4800, 9600, 19,200 or 115,000 baud
- Full duplex
- 8 data bits
- No parity bits
- 1 start bit
- 1 stop bit
- No flow control.

LEDs, Indicators, and Office Alarms

SYSCTL Faceplate The LNW1 SYSCTL circuit pack faceplate contains the following push-button switches and LEDs:

- FAULT LED
- Critical (CR) LED
- Major (MJ) LED
- Minor (MN) LED
- Abnormal (ABN) LED
- Far End Activity (FE) LED
- Near End Activity (NE) LED
- Alarm Cut-Off/Test (ACO) LED
- ACO/TEST (ACO SW) button
- Select (SEL) button
- Update/Initialize (UPD INIT) button
- 7-segment numeric display

The seven segment numeric display is used to identify the remote system presently displayed on the local user panel.

A green PWR ON LED is lighted when the shelf is receiving -48 V power. A green ACO LED is lighted when the ACO function is active.

The SEL, ACO SW, and UPD INIT push-buttons are provided to control system operation.

Equipment indicators A red LED FAULT indicator is provided on all circuit packs. A green LED ACTIVE indicator is provided on all 1x1 protected circuit packs to indicate which circuit packs are actively carrying traffic.

Office Alarms The office alarms interface is a set of discrete relays that control office audible and visual alarms. Separate relays handle CR, MJ, and MN alarms. Each contact closure is rated at 1 A, 60 V maximum. The CR and MJ alarms can be wire-ORed. The CR alarm relays are fail safe against unprotected power failures.

TL1/X.25 Interface

Overview DMX supports a TL1/X.25 interface via a rear-access, synchronous, **EIA-232-D (V.24)** port capable of speeds up to 115,000 baud (at least 9600 baud is recommended to avoid TL1/X.25 output buffer overflow).

The DMX automatically assumes the role of a TL1/X.25 GNE when its X.25 interface is connected. TL1 commands *RTRV-SYS* and *RTRV-STATE-X25* indicate if DMX is an active TL1/X.25 GNE.

A TL1 *RTRV-STATE-X25* command addressed to a DMX TL1/X.25 GNE retrieves the status of the X.25 communications, including the X.25 packet size and an X.25 event history. TL1 command *ENT-SYS* can be used to provision the X.25 packet size.

TL1 Messages Reference The *Metropolis[®] DMX Access Multiplexer Operations Systems Engineering Guide (TL1 Message Guide)*, 365-372-306, specifies the supported TL1 messages in detail.

X.25 Virtual Circuits (VCs) The X.25 circuits between a DMX TL1/X.25 GNE and the OSs may be transported via an X.25 packet network, dedicated private line, or circuit-switched network at the user's option. Multiple DMX X.25 Physical links may be combined through an external X.25 concentrator, but that would be independent of the DMX shelf or bay.

A DMX TL1/X.25 GNE supports up to 9 permanent virtual circuits (PVCs) or up to 9 switched virtual circuits (SVCs). Any combination of PVCs and SVCs is supported, but no more than a total of 9 VC are allowed. The DMX TL1/X.25 GNE default VC assignments are shown in the table below.

Table 10-37 TL1/X.25 Interface Default VC Assignments

PVC ID*	SVC ID*	Logical Group #	Logical Channel #	Default TL1 Messages (ACID)
1		0	1	Command/Responses (tl1peercomm)
2		0	2	Autonomous Maintenance Messages and Command/Responses (tl1maintenance)
3		0	3	Autonomous Provisioning Messages (REPT DBCHG) and Command/Responses (tl1memoryadministration)
	1	0	16	Command/Responses (tl1peercomm)
	2	0	17	Command/Responses (tl1peercomm)
	3	0	18	Command/Responses (tl1peercomm)
	4	0	19	Command/Responses (tl1peercomm)
	5	0	20	Command/Responses (tl1peercomm)
	6	0	21	Command/Responses (tl1peercomm)
* Default Values				

X.25 Packet Layer At the packet layer, DMX is configured as a passive data-terminating equipment (DTE) with the following parameters as shown in the table below.

Table 10-38 X.25 Packet Layer Parameters

Parameter	Value
Packet Size	128 bytes or 256 bytes
Window Size	2 packets
D bit support	NO
M bit support*	YES
* DMX uses the M bit when more than one packet is required to output a TL1 message.	

For SVC facilities, the parameters listed in the following table should be set to the specified values for communication to take place.

Table 10-39 X.25 Packet Layer Parameters for SVC Facilities

Parameter	Value
Window negotiation	2
Packet size negotiation	7 (128 bytes), 8 (256 bytes) ^(a)
Modulo	8
Reverse charging	Don't care ^(b)
Closed user group	Don't care

Notes

- (a) DMX accepts this facility only if it matches DMX's provisioned X.25 packet size. Otherwise, the call will be cleared.
- (b) The DMX always accepts the call request packet should these facilities be present, but it does not attempt to validate the information.

X.25 Link layer At the link layer, DMX uses the standard link access procedure “B” (LAPB) protocol with the following parameters as shown in the table below.

Table 10-40 LAPB Link Layer Parameters

Parameter	Value
Maximum Frame Size	2104 bits
Modulo	8
Window Size	7 frames
n2	7 retries
T1	3 seconds
T3*	20 seconds
* DMX uses synchronous, full duplex, continuous carrier communication.	

X.25 Pin connections

DMX uses synchronous, full duplex, continuous carrier communication. Data rates of up to 115,000 baud are supported, and at least 9600 baud are recommended (to avoid TL1/X.25 output buffer overflow). The rear X.25 port is configured as DTE, using the pin connections specified in the table below.

Table 10-41 EIA-232-D (V-24) Pin Connections

Pin	Description
2	Transmitted Data (TD)
3	Received Data (RD)
4	Request to Send (RTS)
5	Clear to Send (CTS)
6	DCE Ready (DSR)
7	Signal Ground (SG)
8	Received Line Signal Detector (DCD)
15	Transmitter Signal Element Timing (DCE to DTE) (TC)
17	Receiver Signal Element Timing (DCE to DTE) (RC)
20	DTE Ready (DTR) (always on when DMX is powered)



User-Setable Miscellaneous Discrete Interface

Overview The user-setable miscellaneous discrete interface allows an operations system (OS) to control and monitor equipment collocated with the DMX through a set of input and output contact closures. Miscellaneous discrete environmental inputs can monitor conditions like open doors or high temperature, miscellaneous discrete outputs control equipment such as fans and generators. The status of the miscellaneous discrete environmental inputs can be queried on demand via the DMX PC-CIT. DMX collects miscellaneous discrete alarms and automatically sends them to the operations system (OS).

External customer equipment Any external customer equipment to be monitored by DMX must provide the electrical equivalent of a contact closure across the corresponding environmental input wiring pairs. The contact closure must be capable of passing at least 10 mA of drive current.

Power source The power source to enable the control of external customer equipment may have a voltage range from a minimum of 3 V to a maximum of 72 V. DMX provides a unidirectional opto-isolator connection across each corresponding control output wiring pair. The load current across each control output wiring pair must be limited by the external customer equipment and must not exceed 35 mA.

Reference For detailed wiring information, refer to the *Metropolis[®] DMX Access Multiplexer Installation Manual*, 365-372-304 and *Metropolis[®] DMX Access Multiplexer Application Schematic*, SD8C500-01.



Physical Specifications

Overview

Purpose This section provides DMX physical characteristics, including environmental and power specifications.

Contents The following specifications are included in this section:

Physical Specifications	10 - 84
Environmental Specifications	10 - 85
Power Specifications	10 - 87



Physical Specifications

Shelf physical characteristics

The standard DMX shelf has the following characteristics (dimensions including Fan Unit in parentheses):

- Width: 17.6 inches (17.6)
- Height: 16 inches (19.5)
- Depth (front to back): 15 inches (15)
- Weight (Max.): 20 pounds.

DMX High Capacity shelf physical characteristics

The DMX High Capacity shelf has the following characteristics:

- Width: 17.6 inches
- Height: 19 inches (includes integral fan unit)
- Depth (front to back): 13.75 inches
- Weight (with circuit packs): 57 pounds
- Weight (without circuit packs): 38 pounds



Environmental Specifications

Temperature and humidity The DMX shelf meets Telcordia Technologies' Network Equipment Building System ("*NEBS Generic Equipment Requirements*," GR-63-CORE) requirements for use in CO environments.

A Fan Assembly is required above the standard DMX shelf in any environment except an outside cabinet (with ventilation) application. The DMX High Capacity shelf has a fan unit built into the bottom of the shelf.

The DMX is environmentally hardened and will function at temperatures of -40°C to +65°C and humidity of 5 to 95 percent (noncondensing) in all TDM applications when equipped with the LNW28 circuit pack. In all other applications the DMX functions at temperatures of 0°C to +50°C.

EMC requirements The DMX has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residence is likely to cause harmful interference in which case the user will be required to correct the interference at the user's own expense.

- Earthquake requirements** DMX meets the earthquake requirements defined in Telcordia Technologies GR-63-CORE and Pacific Bell Standard PBS-000-102PT.
- Fire resistance** DMX meets ignitability requirements specified in *ANSI T1.307-1997*. In addition, the DMX meets the fire resistance requirements of *UL 60950, 3rd Edition*.
- Underwriters Laboratories** The DMX is *UL* recognized for restricted access installations in business and customer premises applications installed in accordance with Articles 110-16 and 110-17 of the *National Electric Code, ANSI/NFPA Number 70-87*. Other installations exempt from the requirements of the National Electric Code may be engineered according to the accepted practices of the local telecommunications utility.
- Canadian Standards Association** The DMX has been certified by the Canadian Standards Association per standard CAN/CSA-C22.2 Number 60950-00.



Power Specifications

Power supply The table below lists DMX power requirements.

Table 10-42 DMX Power Supply Requirements

Item	Description
Voltage range, all components	-40.0V to -60V
Power Feeders	two -48V power feeders [BREAKER (A) and BREAKER (B)]
Circuit Breakers (two per shelf)	20.0A

The following table lists DMX High Capacity shelf power requirements.

Table 10-43 DMX High Capacity Shelf Power Supply Requirements

Item	Description
Voltage range, all components	-40.0V to -60.0V
Power Feeders	two -48V power feeders [BREAKER (A) and BREAKER (B)]
Circuit Breakers (two per shelf)	30.0 A

Circuit breakers DMX uses on-board power conversion eliminating the need for slots for bulk power converters. Two independent -48V office power feeders (A and B) enter the shelf through connectors and are filtered and distributed to the circuit packs through circuit breakers. Power conversion is performed through modular power converters located on the circuit packs. In each circuit pack, the feeders are diode ORed, fused, filtered, and regulated by the board-mounted power modules. This provides the required redundancy in case of the loss of one feeder or circuit breaker. The green Power LEDs located next to each circuit breaker (A and B) indicate power is being fed to the breaker.

Current drains The following table provides the maximum and average current drain requirements for a shelf.

Table 10-44 Shelf Current Drains

Shelf	Current Drains per Feeder in Amperes			
	Average @ -48V	Maximum @ -48V	Average @ -40V	Maximum @ -40V
DMX Shelf	6.3	14.5	7.5	17.5
DMX High Capacity Shelf	6.3	23.0	7.5	27.5

The following table provides the maximum and average current drain requirements for a bay equipped with four shelves.

Table 10-45 Bay Current Drains

Bay	Current Drains per Feeder in Amperes			
	Average @ -48V	Maximum @ -48V	Average @ -40V	Maximum @ -40V
Bay equipped with four DMX Shelves	25.2	58.0	30.0	70.0
Bay equipped with four DMX High Capacity Shelves	25.2	92.0	30.0	110.0

External Equipment Specifications

Overview

Purpose This section provides DMX physical characteristics, including environmental and power specifications.

Contents The following specifications are included in this section:

Physical Specifications	10 - 84
Environmental Specifications	10 - 85
Power Specifications	10 - 87



External Optical Amplifier

Overview The following tables present the optical specifications for the external optical amplifier.

Optical specifications The table below lists the optical specifications for the amplifier.

Table 10-46 Optical specifications

Parameter	Minimum	Maximum (or basic value if there is no min/max measurement.
Wavelength Range	1530 nm	1563 nm
Input Power Range	-27 dBm	4 dBm
Output Power		17 dBm
Signal Gain	13 dB	22 dB
Noise	7.0 (for 22 dB Gain)	16.0 (for 13 dB Gain)
Signal Gain	13 dB	22 dB
FDA Classification		Class IM (viewing the laser output with optical instruments can pose an eye hazard.
Polarization Mode Dispersion		0.5 ps @ -20 dBm input
Faceplate Optical Connector		SC-UPC connector
Faceplate Optical Connector		SC-UPC connector

Performance Monitoring and Alarms The below is a list of the alarms and alarm thresholds reported on the amplifier.

- Degradation of input signal
- Loss of input signal
- Excessive pump current
- EDFA case temperature out of range
- Degredation of output signal
- Loss of output signal
- Excessive TEC current
- Gain out of range





Glossary

Acronyms and Abbreviations

1G
Gigabit

- A**
- ABN**
Abnormal (status condition)

 - ACO**
Alarm Cutoff

 - ACO/SW**
Alarm Cutoff and Test

 - ADM**
Add/Drop Multiplexer

 - AGNE**
Alarm Gateway Network Element

 - AIS**
Alarm Indication Signal

 - AMI**
Alternate Mark Inversion

 - ANSI**
American National Standards Institute

 - APS**
Automatic Protection Switch

ARM

Access Resource Manager

AS&C

Alarm, Status, and Control

ASCII

American Standard Code for Information Interchange

ASN.1

Abstract Syntax Notation 1

ASNE

Alarm Server Network Element

ATM

Asynchronous Transfer Mode

Auto

Automatic

AUXCTL

Auxiliary Control

B B3ZS

Bipolar 3-Zero Substitution

B8ZS

Bipolar 8-Zero Substitution

BDFB

Battery Distribution and Fuse Bay

BER

Bit Error Ratio

BIP

Bit Interleaved Parity

BITS

Building Integrated Timing Supply

BRI
Basic Rate Interface

C **CC**
Clear Channel

CCITT
International Telephone and Telegraph Consultative Committee

CEV
Controlled Environment Vault

CD-ROM
Compact Disk, Read-Only Memory

CDTU
Channel and Drop Test Unit

CIT
Craft Interface Terminal

CLEC
Competitive Local Exchange Carrier

CLF
Carrier Line Failure Status

CMISE
Common Management Information Service Element

CMOS
Complementary Metal Oxide Semiconductor

CMTS
Cable Modem Termination System

CO
Central Office

CP
Circuit Pack

CPE

Customer Premises Equipment

CR

Critical (alarm status)

CSA

Carrier Serving Area

CSU

Channel Service Unit

CTL

Control

CTS

Customer Technical Support

CV

Coding Violation

CVFE

Coding Violation Far End

D DCC

Data Communications Channel

DCE

Data Communications Equipment

DCS

Data Collection System

DEMUX

Demultiplexer

DLC

Digital Loop Carrier

DNS

Data Networking Services

DPLL

Digital Phase-Locked Loop

DRI

Dual Ring Interworking

DS1

Digital Signal Level 1

DS3

Digital Signal Level 3

DSL

Digital Subscriber Line

DSLAM

Digital Subscriber Line Access Multiplexer

DSNE

Directory Services Network Element

DSX

Digital Cross-Connect Panel

DT

Distant Terminal

DTE

Data Terminating Equipment

E EC-1

Electrical Carrier Level 1

ECI

Equipment Catalog Item

EEPROM

Electrically-Erasable Programmable Read-Only Memory

EIA

Electronic Industries Association

EMC

Electromagnetic Compatibility

EMI

Electromagnetic Interference

EOOF

Excessive Out of Frame

EPROM

Erasable Programmable Read-Only Memory

EQ

Equipped (memory administrative state)

ES

Errored Seconds

ESD

Electrostatic Discharge

ESF

Extended Super Frame

EST

Environmental Stress Testing

F FCC

Federal Communications Commission

FDDI

Fiber Distribution Data Interface

FE

Far End

FE ACTY

Far End Activity

FEBE

Far End Block Error

FE ID

Far End Identification

FEPROM

Flash EPROM

FERF

Far End Receive Failure

FE SEL

Far End Select

FIT

Failures in 10^{-9} hours of operation.

G GbE

Gigabit Ethernet

GNE

Gateway Network Element

GR

Telcordia Technologies General Requirement

GTP

General Telemetry Processor

GUI

Graphical User Interface

H HECI

Humans Equipment Catalog Item

HFC

Hybrid Fiber Coaxial

I IAO LAN

Intra-Office Local Area Network

IC

Internal Clock

ID

Identifier

IEC

International Electrotechnology Commission

IMF

Infant Mortality Factor

INC

Incoming Status

I/O

Input/Output

IP

Internet Protocol

IR

Intermediate Reach

IS

In Service

ISCI

Intershelf control Interface

ISI

Intershelf Interface

ISDN

Integrated Services Digital Network

ISO

International Standards Organization

ISP

Internet Service Provider

IVHS

Intelligent Vehicle Highway System

-
- L** **LAN**
Local Area Network
- LAPD**
Link Access Procedure "D"
- LBO**
Line Build Out
- LCN**
Local Communications Network
- LEC**
Local Exchange Carrier
- LED**
Light-Emitting Diode
- LOF**
Loss of Frame
- LOP**
Loss of Pointer
- LOS**
Loss of Signal
- LR**
Long Reach
- LS**
Low Speed

-
- M** **MD**
Mediation Device
- MJ**
Major Alarm
- MM**
Multimode

MML

huMan-Machine Language

MN

Minor Alarm

MPEG

Moving Picture Experts Group

MSDT

Multi-Services Distant Terminal

MSO

Metropolitan Serving Office

MTBF

Mean Time Between Failures

MTBMA

Mean Time Between Maintenance Activities

Mult

Multipling

MUX

Multiplex

MXBIU

Multiplexer and Backplane Interface Unit

N NAP

Network Access Point

NE

Near End

NE

Network Element

NE ACTY

Near-End Activity

NEBS

Network Equipment-Building System

nm

Nanometer (10^{-9} meters)

NMA

Network Monitoring and Analysis

NMON

Not Monitored (provisioning state)

NRZ

Nonreturn to Zero

NNI

Network-Network Interface

NSA

Not Service Affecting

NSAP

Network Services Access Point

NTF

No Trouble Found

O OAM&P

Operations, Administration, Maintenance, and Provisioning

OC-1

Optical Carrier Level 1 Signal (51.84 Mb/s)

OC-3

Optical Carrier Level 3 Signal (155 Mb/s)

OC-12

Optical Carrier Level 12 Signal (622 Mb/s)

OC-48

Optical Carrier Level 48 Signal

OLIU

Optical Line Interface Unit

OOF

Out of Frame

OOL

Out of Lock

OPS/INE

Operations System/Intelligent Network Element

OS

Operations System

OSGNE

Operations System Gateway Network Element

OSI

Open Systems Interconnection

OSMINE

Operations Systems Modifications for the Integration of Network Elements

OSP

Outside Plant

P P-bit

Performance Bit

PC

Personal Computer

PCU

Power Conversion Unit

PID

Program Identification

PINFET

Positive Intrinsic Negative Field Effect Transistor

PJC

Pointer Justification Count

PLL

Phase-Locked Loop

PM

Performance Monitoring

PMN

Power Minor Alarm

POH

Path Overhead

POP

Points of Presence

POTS

Plain Old Telephone Service

PRM

Performance Report Message

PROTN

Protection

PRS

Primary Reference Source

PSU

Power Supply Unit

PVC

Permanent Virtual Circuit

PWR

Power

R RAM

Random Access Memory

RDC

Regional Data Center

RPP

Reliability Prediction Procedure (described in Telcordia Technologies TR-NWT-00032)

RT

Remote Terminal

RTAC

Lucent Regional Technical Assistance Center (1-800-225-RTAC)

RZ

Return to Zero

S SA

Service Affecting

SCADA

Supervisory Control and Data Acquisition

SD

Signal Degrade

SDH

Synchronous Digital Hierarchy

SEFS

Severely Errored Frame Seconds

SEO

Single-Ended Operations

SES

Severely Errored Seconds

SF

Super Frame (format for DS1 signal)

SID

System Identification

SLA

Service Level Agreements

SLIM

Subscriber Loop Interface Module

SM

Single Mode

SONET

Synchronous Optical NETWORK

SPE

Synchronous Payload Envelope

SQU

Sync Quality Unknown

SRD

Software Release Description

STS, STS-n

Synchronous Transport Signal

STM

Synchronous Transfer Mode

STS-1 SPE

STS-1 Synchronous Payload Envelope

STS-3c

Synchronous Transport Level 3 Concatenated Signal

STS-12c

Synchronous Transport Level 12 Concatenated Signal

SYSCTL

System Controller (circuit pack)

T T1X1 and T1M1

The ANSI committees responsible for telecommunications standards

TA

Telcordia Technologies Technical Advisory

TABS

Telemetry Asynchronous Byte Serial (Protocol)

TARP

Target ID Address Resolution Protocol

TCA

Threshold-Crossing Alert

TCP/IP

Transmission Control Protocol/Internet Protocol

TCVCXO

Temperature-Compensated Voltage-Controlled Crystal Oscillator

TDM

Time Division Multiplexing

TID

Target Identifier

TIRKS

Trunk Integrated Record Keeping System

TG3

Stratum 3 Timing Generator

TL1

Transaction Language 1

TLB

Timing Looped Back

TOP

Task Oriented Practice

TR

Telcordia Technologies Technical Requirement

TSA

Time Slot Assignment

TSI

Time Slot Interchange

TSO

Technical Support Organization

U UAS

Unavailable Seconds

UNI

User Network Interface

UOC

Universal Optical Connector

UPD/INIT

Update/Intialize

UPSR

Unidirectional Path Switched Rings

V VF

Voice Frequency

VLAN

Virtual Local Area Network

VLSI

Very Large Scale Integration

VM

Violation Monitor

VMR

Violation Monitor and Removal

VoIP

Voice over Internet Protocol

VONU

Virtual Optical Network Unit

VPN

Virtual Private Network

VT

Virtual Tributary

VT1.5

Virtual Tributary 1.5 (1.728 Mb/s)

VT-G

Virtual Tributary Group

W WAN

Wide Area Network



Glossary

Terms and Definitions

0x1

See Ring (0x1) Low-Speed Interface.

1+1

The 1+1 protection switching architecture protects against failures of the optical transmit/receive equipment and their connecting fiber facility. One bidirectional interface (two fibers plus associated OLIUs on each end) is designated "service," and the other is designated "protection." In each direction, identical signals are transmitted on the service and protection lines ("dual-fed"). The receiving equipment monitors the incoming service and protection lines independently, and selects traffic from one line (the "active" line) based on performance criteria and technician/OS control. In 1+1 both service and protection lines could be active at the same time (service in one direction, protection in the other).

1xN, 1x1

1xN protection switching pertains to circuit pack protection that provides a redundant signal path through the DMX 2.5G Multiplexer (it does not cover protection switching of an optical facility; see "1+1"). In 1xN switching, a group of N service circuit packs share a single spare protection circuit pack. 1x1 is a special case of 1xN, with N=1. In 1x1 only one is active at a time.

A Active

Active identifies a 1+1 protected OC-N line which is currently selected by the receiver at either end as the payload carrying signal or a 1x1 or 1xN protected circuit pack that is currently carrying service. (See Standby).

AGNE - Alarm Gateway Network Element

A defined NE in an alarm group through which members of the alarm group exchange information.

AIS - Alarm Indication Signal

A code transmitted downstream in a digital network that shows that an upstream failure has been detected and alarmed.

AMI - Alternate Mark Inversion

A line code that employs a ternary signal to convey binary digits, in which successive binary ones are represented by signal elements that are normally of alternating, positive and negative polarity but equal in amplitude, and in which binary zeros are represented by signal elements that have zero amplitude.

ASCII - American Standard Code for Information Interchange

A standard 8-bit code used for exchanging information among data processing systems and associated equipment.

Auto

One possible state of a DS1 or DS3 port. In this state, the port will automatically be put "in service" if a good signal is detected coming from the DSX panel.

Automatic Protection Switch

A feature that allows another synchronization source to be automatically selected and the synchronization source provisioning to be automatically reconfigured in the event of a synchronization source failure or network synchronization change, for example, a fiber cut.

Available Time

In performance monitoring, the 1-second intervals.

B B3ZS - Bipolar 3-Zero Substitution

A line coding method that replaces a string of three zeros with a sequence of symbols having some special characteristic.

B8ZS - Bipolar 8-Zero Substitution

A line coding method that replaces a string of eight zeros with a sequence of symbols having some special characteristic.

Backbone Ring

A host ring.

BER - Bit Error Rate

The ratio of bits received in error to the total bits sent.

BIP - Bit Interleaved Parity

A method of error monitoring over a specified number of bits, that is BIP-3 or BIP-

8.

BITS - Building Integrated Timing Supply

A single clock that provides all the DS1 and DS0 synchronization references required by clocks in a building.

Broadband

Any communications channel with greater bandwidth than a voice channel; sometimes used synonymously with wideband.

C CC - Clear Channel

A provisionable mode for the DS3 output that causes parity violations not to be monitored or corrected before the DS3 signal is encoded.

CCITT - International Telephone and Telegraph Consultative Committee

An international advisory committee under United Nations' sponsorship that has composed and recommended for adoption worldwide standards for international communications. Recently changed to the International Telecommunications Union Telecommunications Standards Sector (ITU-TSS).

Channel

A logical signal within a port. For example, for an EC-1 port, there is one STS-1 channel and sometimes 28 VT1.5 channels. See Port.

Channel State Provisioning

A feature that allows a user to suppress reporting of alarms and events during provisioning by supporting multiple states (automatic, in-service and not monitored) for VT1.5 and STS-1 channels. See Port State Provisioning.

CLEC - Competitive Local Exchange Carrier

Company that provides local phone services in competition with RBOCs.

CV - Coding Violation

A performance monitoring parameter.

CVFE - Coding Violation Far-End

An indication returned to the transmitting terminal that an errored block has been detected at the receiving terminal.

D DACS III-2000

Digital Access and Cross-Connect System that provides clear channel switching at either the DS3 or the STS-1 rates, eliminating the need for manual DSXs.

DACS IV-2000

Digital Access and Cross-Connect System that provides electronic DS3/STS-1 or DS1/VT1.5 cross-connect capability, eliminating the need for manual DSXs.

DCC - Data Communications Channel

The embedded overhead communications channel in the SONET line. It is used for end-to-end communications and maintenance. It carries alarm, control, and status information between network elements in a SONET network.

DCE - Data Communications Equipment

In a data station, the equipment that provides the signal conversion and coding between the data terminal equipment (DTE) and the line. The DCE may be separate equipment or an integral part of the DTE or of intermediate equipment. A DCE may perform other functions usually performed at the network end of the line.

DDM-2000

Lucent's next generation network multiplexers that multiplex DS1, DS3, or EC-1 inputs into EC-1, OC-1, OC-3, or OC-12 outputs.

Default Provisioning

The parameter values that are preprogrammed as shipped from the factory.

Demultiplexing

A process applied to a multiplexed signal for recovering signals combined within it and for restoring the distinct individual channels of these signals.

DEMUX - Demultiplexer

The DEMUX direction is from the fiber toward the DSX.

Digital Multiplexer

Equipment that combines time-division multiplexing several digital signals into a single composite digital signal.

DRI - Dual Ring Interworking

Two ring networks interconnected at two common nodes.

Drop and Continue

A technique that allows redundant signal appearances at two central offices in a DRI network, allowing protection against central office failures.

DS1

Digital Signal Level 1 (1.544 Mb/s)

DS1(28) Circuit Pack

The DS1(28) circuit pack interfaces to the DSX-1 panel.

DS3

Digital Signal Level 3 (44.736 Mb/s).

DS3/EC-1 Circuit Pack

The DS3/EC-1 circuit pack interfaces to the DSX-3 panel.

DSn - Digital Signal Rate n

One of the possible digital signal rates at DMX 2.5G Multiplexer interfaces: DS1 (1.544 Mb/s) or DS3 (44.736 Mb/s).

DSNE - Directory Services Network Element

A designated network element that is responsible for administering a database that maps network element names (TIDs) to addresses (NSAPs - network service access points) in an OSI subnetwork. There can be one DSNE per ring. Can also be a GNE.

DSX - Digital Cross-Connect Panel

A panel designed to interconnect to equipment that operates at a designated rate. For example, a DSX-3 interconnects equipment operating at the DS3 rate.

DTE - Data Terminating Equipment

That part of a data station that serves as a data source (originates data for transmission), a data sink (accepts transmitted data), or both.

Dual Homing

A network topology in which two OC-3 or OC-12 shelves serve as DMX 2.5G Multiplexer hosts supporting up to 16 OC-3 rings or 4 OC-12 rings. Each DMX 2.5G Multiplexer ring is interconnected between the two separate hosts.

E EC-1, EC-n - Electrical Carrier

The basic logical building block signal with a rate of 51.840 Mb/s for an EC-1 signal and a rate of n times 51.840 Mb/s for an EC-n signal. An EC-1 signal can be built in two ways: A DS1 can be mapped into a VT1.5 signal and 28 VT1.5 signals multiplexed into an EC-1 (VT1.5 based EC-1), or a DS3 can be mapped directly into an EC-1 (DS3 based EC-1).

ECI - Equipment Catalog Item

The bar code number on the faceplate of each circuit pack used by some inventory systems.

ES - Errored Seconds

A performance monitoring parameter.

ESF - Extended Super Frame

The format for a DS1 signal.

F FE - Far End

Any other network element in a maintenance subnetwork other than the one the user is at or working on. Also called remote.

FE ACTY - Far End Activity

An LED on the SYSCTL circuit pack faceplate.

FEBE - Far End Block Error

An indication returned to the near-end transmitting node that an errored block has been detected at the far end.

FE ID - Far End Identification

The 7-segment display on the faceplate of the SYSCTL circuit pack.

FEPROM - Flash EPROM

A new technology that combines the nonvolatility of EPROM with the in-circuit reprogrammability of EEPROM (electrically-erasable PROM).

FERF - Far End Receive Failure

An indication returned to the transmitting terminal that the receiving terminal has detected an incoming section failure.

FE SEL - Far End Select

An LED on the faceplate of the SYSCTL circuit pack.

FIT

Failures in 10^{-9} hours of operation.

Free Running

An operating condition of a clock in which its local oscillator is not locked to an internal synchronization reference and is using no storage techniques to sustain its accuracy.

FT-2000

Lucent's SONET OC-48 Lightwave System.

Function Unit

Refers to any one of a number of different circuit packs that can reside in the A, B, C, or D function unit slots on the DMX 2.5G Multiplexer.

G GNE - Gateway Network Element

A network element that has an active X.25 link. Can also be a DSNE.

H Hairpin Routing

A cross-connection between function units (inter-function unit). For example, function unit C to function units A, B, or D. Also, a cross-connection within the same function unit (intra-function unit). Cross-connections go through Main, but no bandwidth or time slots are taken from the backbone ring. Eliminates need for another shelf.

Holdover

An operating condition of a network element in which its local oscillator is not locked to any synchronization reference but is using storage techniques to maintain its accuracy with respect to the last known frequency comparison with a synchronization reference.

HFC - Hybrid Fiber Coaxial

Technology using coaxial and fiber cable to transport data services in addition to television channels.

I IC - Internal Clock

Used in synchronization messaging.

ID

See shelf ID and site ID.

IR - Intermediate Reach

A term used to describe distances of 15 to 40 km between optical transmitter and receiver without regeneration. See long reach.

IS - In Service

One possible state of a DS1, DS3, or EC-1 port. Other possible states are "auto" (automatic) and "nmon" (not monitored).

J Jitter

Timing jitter is defined as short-term variations of the significant instants of a

digital signal from their ideal positions in time.

L LBO - Line Build Out

An equalizer network between the DMX 2.5G Multiplexer and the DSX panel. It guarantees the proper signal level and shape at the DSX panel.

LED - Light Emitting Diode

Used on a circuit pack faceplate to show failure (red) or service state. It is also used to show the alarm and status condition of the system.

Line Timing

The capability to directly derive clock timing from an incoming OC-N signal while providing the user the capability to provision whether switching to an alternate OC-N from a different source (as opposed to entering holdover) will occur if the OC-N currently used as the timing reference for that NE becomes unsuitable as a reference. For example, intermediate nodes in a linear network are line timed. See Loop Timing.

Local

See Near-End.

Locked Cross-Connection

This is a variation of the ring cross-connection that allows the user to lock the path selector to a specified rotation of the ring. Any signal received from the other rotation of the ring is ignored.

LOF - Loss of Frame

A failure to synchronize to an incoming signal.

Loop Timing

Loop timing is a special case of line timing. It applies to NEs that have only one OC-N interface. For example, terminating nodes in a linear network are loop timed. See Line Timing.

LOP - Loss of Pointer

A failure to extract good data from an STS-1 payload.

LOS - Loss of Signal

The complete absence of an incoming signal.

LR - Long Reach

A term used to describe distances of 40 km or more between optical transmitter and receiver without regeneration. See Intermediate Reach.

M Main

The two slots (M-1 and M-2) on the DMX 2.5G Multiplexer shelf in which the OC-48 OLIU circuit packs are installed.

Midspan Meet

The capability to interface between two lightwave terminals of different vendors. This applies to high-speed optical interfaces.

Multiplexing

The process of combining several distinct digital signals into a single composite digital signal.

Mult - Multipling

The cascading of signals in a bay. In the MULT mode, the DS1 external reference can be cascaded to other shelves in a bay using Mult cables. Normally starting with the bottom shelf (Number 1) and working towards the top of the bay.

N NE - Near End

The network element the user is at or working on. Also called local.

NE - Network Element

The basic building block of a telecommunications equipment within a telecommunication network that meets SONET standards. Typical internal attributes of a network element include: one or more high- and low-speed transmission ports, built-in intelligence, synchronization and timing capability, and access interfaces for use by technicians and/or operation systems. In addition, a network element may also include a time slot interchanger.

NE ACTY - Near End Activity

An LED on the faceplate of the SYSCTL circuit pack.

NMA - Network Monitoring and Analysis

An operations system designed by Telcordia Technologies which is used to monitor network facilities.

NMON - Not Monitored

A provisioning state for equipment that is not monitored or alarmed.

Node

In SONET, a node is a line terminating element.

Non-Revertive

A protection switching mode in which, after a protection switch occurs, the equipment remains in its current configuration after any failure conditions that caused a protection switch to occur clear or after any external switch commands are reset. See Revertive.

NSAP - Network Services Access Point

An address that identifies a network element. Used for maintenance subnetwork communication using the OSI protocol.

O OC, OC-n - Optical Carrier

The optical signal that results from an optical inversion of an STS signal; that is, OC-1 from STS-1 and OC-n from STS-n.

OC-1

Optical Carrier Level 1 Signal (51.844 Mb/s).

OC-3

Optical Carrier Level 3 Signal (155 Mb/s).

OC-3c (STS-3c)

Optical Carrier Level 3 Concatenated Signal. Low-speed broadband equivalent to three STS-1s linked together with a single path overhead.

OC-12

Optical Carrier Level 12 Signal (622 Mb/s).

OC-12c (STS-12c)

Optical Carrier Level 12 Concatenated Signal. High-speed broadband equivalent to twelve STS-1s linked together with a single path overhead.

OC-48

Optical Carrier Level 48 Signal.

Operations Interface

Any interface that provides information on the system performance or control. These include the equipment LEDs, SYSCTL faceplate, and office alarms.

OS - Operations System

A central computer-based system used to provide operations, administration, and maintenance functions.

OSI - Open Systems Interconnection

Referring to the OSI reference model, a logical structure for network operations standardized by the International Standards Organization (ISO).

OSGNE - Operations System Gateway Network Element

An OSGNE serves as a single interface to the OS for NEs in the same subnetwork using X.25 interfaces.

P Pass Through

Paths that are cross-connected directly across an intermediate node in a ring network.

Plesiochronous Network

A network that contains multiple maintenance subnetworks, each internally synchronous and all operating at the same nominal frequency, but whose timing may be slightly different at any particular instant. For example, in SONET networks, each timing traceable to their own Stratum 1 clock are considered plesiochronous with respect to each other.

PM - Performance Monitoring

Measures the quality of service and identifies degrading or marginally operating systems (before an alarm would be generated).

Port

The physical, electrical, or optical interface on a system. For example, DS1, DS3, EC-1, OC-3, OC-12, and OC-48. *See Channel.*

Port State Provisioning

A feature that allows a user to suppress alarm reporting and performance monitoring during provisioning by supporting multiple states (automatic, in-service, and not monitored) for low-speed ports. *See Channel State Provisioning.*

Proactive Maintenance

Refers to the process of detecting degrading conditions not severe enough to initiate protection switching or alarming, but indicative of an impending signal fail or signal degrade defect (for example, performance monitoring).

Protection Line

As defined by the SONET standard, the protection line is the pair of fibers (one transmit and one receive) that carry the SONET APS channel (K1 and K2 bytes in the SONET line overhead). On a DMX 2.5G Multiplexer, a protection line is a pair of fibers that terminate an OLIU circuit pack in the Main-2, A-2, B-2, C-2, or D-2

slots. *See Service Line.*

Product Family 2000

Lucent's line of SONET standard network products providing total network solutions.

PSTN - Public Switched Telephone Network

The network that provides public telephone service.

R Reactive Maintenance

Refers to detecting defects/failures and clearing them.

Remote

See Far-End (FE).

Revertive

A protection switching mode in which, after a protection switch occurs, the equipment returns to the nominal configuration (that is, the service equipment is active, and the protection equipment is standby) after the clearing of any failure conditions that caused a protection switch to occur or after any external switch commands are reset. *See Non-Revertive.*

Ring

A configuration of nodes comprised of network elements connected in a circular fashion. Under normal conditions, each node is interconnected with its neighbor and includes capacity for transmission in either direction between adjacent nodes. Path switched rings use a head-end bridge and tail-end switch. Line switched rings actively reroute traffic over a protection line.

Ring (0x1) Low-Speed Interface

Formerly referred to as dual 0x1 or single 0x1. In ring applications, the DMX 2.5G Multiplexer may use a 0x1 interface, meaning both fibers carry service, as opposed to a linear (1+1) low-speed interface where one fiber is used for service and other for protection. *See 1+1.*

RPP - Reliability Prediction Procedure

Described in Telcordia Technologies TR-NWT-00032.

RT - Remote Terminal

An unstaffed equipment enclosure that may have a controlled or uncontrolled environment.

S S3-TG - Stratum 3 Timing Generator

The timing generator circuit pack, located in the OC-48 OLIU circuit pack, generates clock signals for distribution to the transmit circuits. It operates in the free-running, loop-timing, phase-lock, and holdover modes.

Self-Healing

Ring architecture in which two or more fibers are used to provide route diversity. Node failures only affect traffic dropped at the failed node.

SEO - Single-Ended Operations

The maintenance capability that provides remote access to all DMX 2.5G Multiplexer systems from a single location over the DCC.

Service Line

On a DMX 2.5G Multiplexer system, a service (or "working") line is a pair of fibers (one transmit and one receive) that terminate on an OLIU circuit pack in the Main-1, A-1, B-1, C-1, or D-1 slots. As defined by the SONET standard, the SONET APS channel is not defined on a service line. *See Protection Line.*

SES - Severely Errored Seconds

This performance monitoring parameter is a second in which a signal fail occurs, or more than a preset amount of coding violations (dependent on the type of signal) occurs.

SF - Super Frame

The format for DS1 signals.

Shelf ID

A switch-settable parameter with values from 1 to 8. Used to log into a selected shelf in a by using the CIT.

Single 0x1 Cross-Connection

In a dual-homed application, the DMX 2.5G Multiplexer uses a single 0x1 cross-connection to map the VT1.5 channels between the DDM-2000 FiberReach, OC-3 Multiplexer, or OC-12 Multiplexer and the DMX 2.5G Multiplexer rings. This single 0x1 architecture maps low speed to high speed on a specified ring rotation. The high speed to low speed drop is made on the same specified ring with no path switching. Protection is provided at the VT1.5 end points.

Single Homing

A network topology in which a single DDM-2000 FiberReach, OC-3 Multiplexer, or OC-12 Multiplexer serves as a DMX 2.5G Multiplexer host supporting up to six

OC-3 or OC-12 rings.

Site ID

A switch-settable parameter with values from 1 to 8. Displayed on the SYSCTL circuit pack to indicate to which site the faceplate alarms and LEDs apply.

Standby

Standby identifies a 1+1 protected OC-N line which is not currently selected by the receiver at either end as the payload carrying signal, or 1x1 or 1xN protected circuit pack that is not currently carrying service. *See Active.*

Status

The indication of a short-term change in the system.

STS, STS-n - Synchronous Transport Signal

The basic building block signal with a rate of 51.840 Mb/s for an STS-1 signal and a rate of n times 51.840 Mb/s for an STS-n signal.

STS-1 SPE - STS-1 Synchronous Payload Envelope

A 125-microsecond frame structure composed of STS path overhead and the STS-1 payload.

STS-3c

Synchronous Transport Level 3 Concatenated Signal. *See OC-3c.*

Subnetwork

Group of SONET network elements that share a SONET data communications channel.

Synchronization Messaging

SONET synchronization messaging is used to communicate the quality of network timing, internal timing status, and timing states throughout a subnetwork.

SYSCTL - System Controller

The system controller circuit pack that provides overall administrative control of the terminal.

T T1X1 and T1M1

The ANSI committees responsible for telecommunications standards.

TCA - Threshold Crossing Alert

A condition set when a performance monitoring counter exceeds a user-selected threshold. A TCA does not generate an alarm but is available on demand through

the CIT and causes a message to be sent to NMA via the X.25/TL1 interface.

TL1 - Transaction Language 1

A Telcordia Technologies machine-to-machine communications language that is a subset of ITU-TSS, formerly CCITT's, human-machine language.

U UAS - Unavailable Seconds

In performance monitoring, the count of seconds in which a signal is declared failed or, in which, 10 consecutively severely errored seconds (SES) occurred, until the time when 10 consecutive non-SES occur.

Unidirectional

A protection switching mode in which the system at each end of an optical span monitors both service and protection lines and independently chooses the best signal (unless overridden by an equipment failure or by an external request, such as a forced switch or lockout). In a system that uses unidirectional line switching, both the service and protection lines may be active simultaneously, with one line carrying traffic in one direction and other line carrying traffic in the other direction. For a 1+1 protection scheme the K1 and K2 bytes in the SONET line overhead are used to convey to the far end which line the near-end receiver has chosen, so that an "active" indication may be made at the far end.

UOC - Univeral Optical Connector

Receptacles on the faceplate of some OLIUs that accept *ST*, *SC*, or *FC* connectors.

UPD/INIT

A push-button on the SYSCTL faceplate.

V VM - Violation Monitor

A mode of the DS3 circuit pack in which it will monitor but not remove P-bit parity violations on the DS3 signal from the received fiber.

VMR - Violation Monitor and Removal

A mode of the DS3 circuit pack in which it will monitor and remove P-bit parity violations on the DS3 signal received from the fiber.

VT - Virtual Tributary

A structure designed for transport and switching of a sub-DS3 payload.

VT1.5

A 1.728 Mb/s virtual tributary.

VT-G - Virtual Tributary Group

A 9-row by 12-column SONET structure (108 bytes) that carries one or more VTs of the same size. Seven VT groups (756 bytes) are byte-interleaved within the VT-organized STS-1 synchronous payload envelope

W WaveStar Product Family

Lucent's next generation line of network products.

Z Zero Code Suppression

A technique used to reduce the number of consecutive zeros in a line-codes signal (B3ZS for DS3 signals and B8ZS for DS1 signals).



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