Lucent Technologies
Bell Labs Innovations

WaveStar™ TM 1
Terminal Multiplexer

Applications and Planning Guide

an InfoWare® Product WaveStar™ TM 1

365-372-100
Issue 2
July 1999

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Product Support

For a list of product support telephone numbers and/or web sites refer to Chapter 8, *Product Support*.

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Introduction to the APG

Introduction

This Applications and Planning Guide (APG) provides the following information about the WaveStar™ TM 1 Terminal Multiplexer, Release 2.0:

- Features
- Network Topologies
- Product Description
- Operations and Maintenance
- System Engineering
- Product Support
- Technical Specifications

Intended Audience

The WaveStar™ TM 1 Applications and Planning Guide is written primarily for network planners and engineers. In addition, others needing specific information about the features, applications, operations, and engineering of the WaveStar™ TM 1 may find the information in this manual useful.

Reason for Reissue

This Applications and Planning Guide, Issue 2, of the WaveStar™ TM 1 SDH Terminal Multiplexer, replaces Issue 1. It has been updated with information on the features in Release 2.0.

Using the APG

Introduction

This section describes the information provided in each chapter.

Chapter Descriptions

Table 1 describes the type of information in each chapter.

Table 1. Chapter Descriptions

Chapter	Title	Description
Preface	About This Document	Describes the Guide's purpose, intended audience, and organization References related documentation Feedback and comments on the APG
1	System Overview	Describes the product family Lists Release 2.0 features
2	Features	Describes features available in Release 2.0
3	Network Topologies	Describes applications possible with WaveStar™ TM 1 Terminal Multiplexer
4	Product Description	Describes the hardware and configurations available for the product
5	System Planning and Engineering	Provides synchronization and planning information necessary for system deployment
6	Operations, Administration, Maintenance, & Provisioning	Describes OAM&P features such as: alarms, operation interfaces, performance monitoring, and security
7	Ordering	Reserved for ordering information
8	Product Support	Describes engineering and installation services Explains documentation and technical support Lists training courses

Chapter	Title	Description
9	Quality and Reliability	Provides the Lucent Technologies quality policy Lists reliability specifications
10	Technical Specifications	Lists the technical specifications for the WaveStar™ TM 1
Appendix	Glossary	Defines telecommunications terms

Commenting on the APG

Introduction

Because customer satisfaction is extremely important to Lucent Technologies, every attempt is made to encourage feedback from information product customers.

Customer Comment Form

A customer comment form is located immediately following the title page of this document. If you would like to comment, please fill out the form and fax it to the number provided on the form.

Address for Comments

If the customer comment form is missing, or additional space is required, send or fax comments to:

Lucent Technologies Inc.
Customer Training and Information Products
Room 20-3V6
1600 Osgood Street
North Andover, MA 01945
USA

Fax: 1-978-960-1214

System Overview

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Network Access Solutions

Introduction

The WaveStar™ TM 1 Terminal Multiplexer provides customers with a simple and inexpensive solution to accessing the SDH network.

System Description

The WaveStar™ TM 1 is an SDH STM-1 Terminal Multiplexer optimized to provide various 2 Mbit/s services to business and residential customers. The WaveStar™ TM 1 is a One Card STM-1 Access Multiplexer able to multiplex plesiochronous tributary signals into a 155 Mbit/s STM-1 optical aggregate signal.

In the Access Network, the WaveStar™ TM 1 can be installed at the customer premises for fiber-to-the-business applications, enabling either point-to-point or star configurations (see Chapter 3). Other applications include LAN-to-LAN traffic on campus networks or WANs.

Options

The WaveStar™ TM 1 is available in an unprotected version only. It is capable of multiplexing up to sixteen 2 Mbit/s signals into a single STM-1 signal. The WaveStar™ TM 1 is available solely in the terminal multiplexer configuration.

Operations

The WaveStar™ TM 1 can be remotely and locally controlled, monitored, and configured via a central Network Element Management System (ITM-SC). It can also be monitored and configured locally and remotely (remotely to another WaveStar™ TM 1) via a craft interface terminal operating with ITM-CIT software.

Deployment

The WaveStar™ TM 1 is deployed at the customer premises in a lockable wall-mounted enclosure.

The WaveStar™ SDH Product Family

Lucent Products

Lucent Technologies offers a wide range of SDH products designed to provide total network solutions. WaveStar™ products are designed to offer telecommunications service providers advanced services and revenue-generating capabilities.

Product Family

The WaveStar™ product family offers a series of products designed to bring customers' networks forward into the next century. The WaveStar™ product family and other related products include:

- WaveStar™ TM 1 Terminal Multiplexer
  (Described in this APG)
- WaveStar™ AM 1 Add/Drop Multiplexer
  A compact and cost-effective SDH multiplexer, the WaveStar™ AM 1 is optimized to provide various 2 Mbit/s and 34 Mbit/s services to residential and business customers.
- WaveStar™ ADM 16/1 Multiplexer
  The WaveStar™ ADM 16/1 is our next-generation SDH multiplexer and transport system and is able to multiplex PDH and SDH bit rates to higher levels up to 2.5 Gbit/s (STM-16).
- WaveStar™ ADM 4/1 Multiplexer
  A compact and cost-effective SDH multiplexer. The WaveStar™ ADM 4/1 can be used in different configurations such as terminal multiplexer, add/drop multiplexer and repeater, and can be used in the dual-terminal mode.
- ISM-2000
  The Intelligent Synchronous Multiplexer (ISM) is a versatile multiplexer primarily designed to flexibly multiplex signals of 2, 34, 140, or 155 Mbit/s tributaries into STM-1 or STM-4 signals.
- PHASE
  PHASE is the flexible and modular SDH product family. The system can easily be configured as a terminal multiplexer, linear and ring add/drop multiplexer, as well as a local cross-connect with the same basic range of hardware units.

Product Family Interworking

The WaveStar™ TM 1 Terminal Multiplexer has been designed for interworking, via the DCC, with all the above Lucent products.

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Features

Introduction

This chapter provides information on the WaveStar™ TM 1 Terminal Multiplexer features and their use in an STM-1 Access Network System.

Feature List

Key features of the WaveStar™ TM 1 include the following:

- Up to sixteen 2 Mbit/s interface ports
  - G.703 interface
  - G.704/G.706 interface
- Local software downloading
- Remote software downloading
- Performance Monitoring
- Single fiber pair working
- Simple and rapid installation
- Space-efficient for installations within street cabinets or on customer premises
- Supported by the user-friendly Integrated Transmission Management (ITM) network management and element management systems
- Optional AC/DC converter
- Optional DC/DC converter
- 4 Miscellaneous Discrete Inputs (MDI)

Feature Descriptions

Transmission Interfaces

The WaveStar™ TM 1 can support up to sixteen 2 Mbit/s tributary interfaces, while the aggregate side of the WaveStar™ TM 1 supports an STM-1 optical interface according to G.957.

Local/Remote Software Downloading

The WaveStar™ TM 1 Release 2.0 software can be downloaded locally, via ITM-CIT, or remotely via the ITM-SC. (Note that units presently deployed running Release 1.0 must be upgraded *locally* to Release 2.0. Subsequent releases may be done remotely.)

(Continued on next page)

Features, *continued*

Feature Descriptions

Performance Monitoring

Performance monitoring information can be derived from the overhead bytes (SOH, POH of each VC) and analyzed in accordance with ITU-T Recommendations G.784 and G.826. It is stored in the database of the WaveStar™ TM 1. This information can be transmitted to the management center upon request. The parameters monitored are SES, ES, BBE, and UAS.

Single Fiber Pair Working

The WaveStar™ TM 1 is equipped with one STM-1 optical line interface (transmit and receive). This interface is a 1310 nm short-haul optical interface compliant with ITU-T Recommendation G.957 S.1.1.

Space Efficient Installation

Due to the compactness and space-efficiency of the WaveStar™ TM 1, it is ideally suited for wall-mounted applications in offices at the customer premises.

Integrated Transmission Management (ITM) Support

The WaveStar™ TM 1 is supported by the ITM network management systems. This includes the local ITM-CIT PC-based software for interfacing at the network element, and ITM-SC network management software for integrated management of an entire transport network.

Optional AC/DC Converter

An optional AC/DC converter, 90-264V (47-63 Hz) to -48 VDC, is available in a separate enclosure.

Optional DC/DC Converter

An optional DC/DC converter, -24 to -48 VDC, is available in a separate enclosure.

Miscellaneous Discrete Inputs

The miscellaneous discrete inputs (MDIs) are intended for customer use. They can be used to collect status information from other transmission equipment or non-transmission equipment such as power supply systems, open door detectors, or fire detectors.

Synchronization and Timing

Synchronization

Synchronization of the WaveStar™ TM 1 Terminal Multiplexer can be either STM-1 line interface timing or via one of the 2 Mbit/s data inputs. Re-synchronization of 2 Mbit/s ports is also featured.

Timing Modes

Timing for the WaveStar™ TM 1 can be referenced to the 155.52 Mbit/s optical STM-1 input line, or any one of the sixteen 2.048 Mbit/s E1 input tributaries. The timing circuitry will not accept a reference input from an external office station clock input.

The WaveStar™ TM 1 can operate in the Free Running, Hold-Over, or Locked modes.

Operations, Administration, Maintenance, and Provisioning

OAM&P Features

The WaveStar™ TM 1 supports supervision of in-station alarms via an LED on the wall-mountable enclosure or via a local Craft Interface Terminal (ITM-CIT). Remote access is via the Network Management System (ITM-SC).

The WaveStar™ TM 1 also offers external alarm input interfaces, providing for connection to external equipment. This offers the possibility to collect in-station alarms via these alarm inputs.

See Chapter 6, *Operations, Administration, Maintenance, and Provisioning,* for more information.

Standards Compliance

Introduction

Lucent Technologies' WaveStar™ TM 1 complies with all the relevant SDH ETSI and ITU-T standards.

SDH Interface

The STM-1 aggregate optical interface is compliant with ITU-T Recommendation G.957 S.1.1.

Plesiochronous Interface

The 2 Mbit/s tributary interfaces are compliant with ITU-T Recommendations G.703.

Equipment Standards

Environmental conditions are in compliance with ETSI 300 019 Class 3.1E.

EMC requirements are compliant with EN 300 386-2.

Performance Monitoring

Performance monitoring features are compliant with ITU-T G.826 and G.784.

Network Topologies

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  - Unprotected Star Application 3

Applications

Introduction

This chapter illustrates two applications of the WaveStar™ TM 1: Point-to-Point and Unprotected Spur.

Point-to-Point Application

The Point-to-Point application illustrated in Figure 3-1 is an example of the simplest way of transporting E1s over an SDH STM-1 link. At the central node as well as the user node the WaveStar™ TM 1s can transport up to sixteen 2 Mbit/s signals efficiently and economically. This application is well suited for LAN-to-LAN traffic on campus networks or between business locations requiring cost-effective and reliable communications. Management requirements of this application are minimal and once installed the system requires no periodic maintenance. Management of the WaveStar™ TM 1 can be done remotely via ITM-SC, or locally and remotely (remotely to another WaveStar™ TM 1) via ITM-CIT.

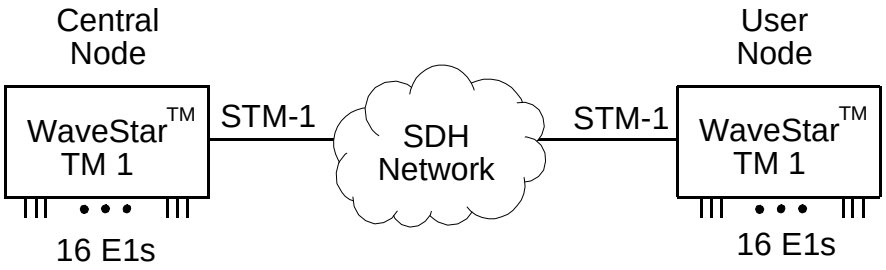

Figure 3-1. Point-to-Point Application

Applications, *continued*

Unprotected Star Application

The Unprotected Star application illustrated in Figure 3-2 is a typical example of the cost sensitive application where a simple point-to-point link without protection is sufficient. Due to the cost sensitivity of this application, no flexible solution in terms of connectivity, protection, or upgrade with further interfaces is planned. The feature set is limited to essential customer needs. The central goal of this application is an inexpensive and reliable system in which grooming of the WaveStar™ TM 1's E1s can be done in the host ADM on the access ring. Management of the WaveStar™ TM 1 can be done remotely via ITM-SC, or locally and remotely (remotely to another WaveStar™ TM 1) via ITM-CIT.

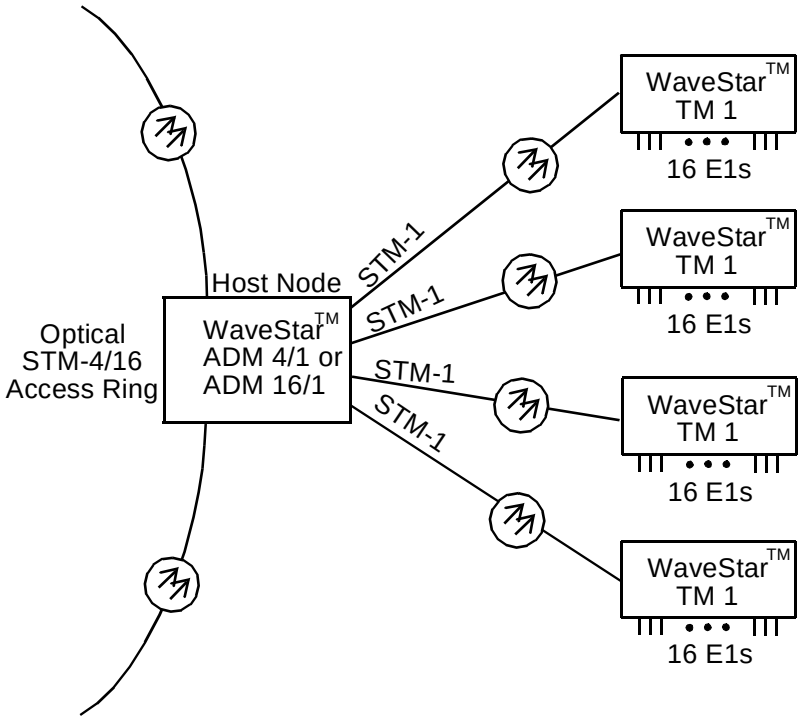

Figure 3-2. Unprotected Star Application

Product Description

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Hardware Overview

Introduction

This chapter provides a hardware description of the WaveStar™ TM 1 Terminal Multiplexer.

Hardware Description

The WaveStar™ TM 1 is a compact and cost-effective STM-1 multiplexer designed to be installed at the customer's premises for fiber-to-the-business applications. Its space-efficient design allows for wall-mounting within controlled environment locations (e.g. interior closet). Only 300 x 240 x 50 mm (H x W x D), the lockable wall-mounted unit contains the following:

- WaveStar™ TM 1 motherboard
- One STM-1 optical line interface pair (transmit/receive) with type SC connector
- Sixteen 2 Mbit/s electrical tributary interfaces with RJ45 connectors suitable for symmetrical twisted pair cables with an impedance of 120Ω
- F-interface (RJ45) for the Craft Interface Terminal (CIT)
- Single Power Feed via a protected terminal block
- Two LEDs (Red, Green) to indicate the status of the unit
- Four Miscellaneous Discrete Inputs (MDIs)

Optional Hardware

Optional hardware (not shown) for the WaveStar™ TM 1 is as follows:

- Optional external 90-264V AC/DC power converter
- Optional external -24 to -48 DC/DC power converter
- Optional 120Ω to 75Ω adapters

(Continued on next page)

Hardware Overview, *continued*

Figure

Figure 4-1 is an illustration of the WaveStar™ TM 1 lockable wall-mounted cabinet.

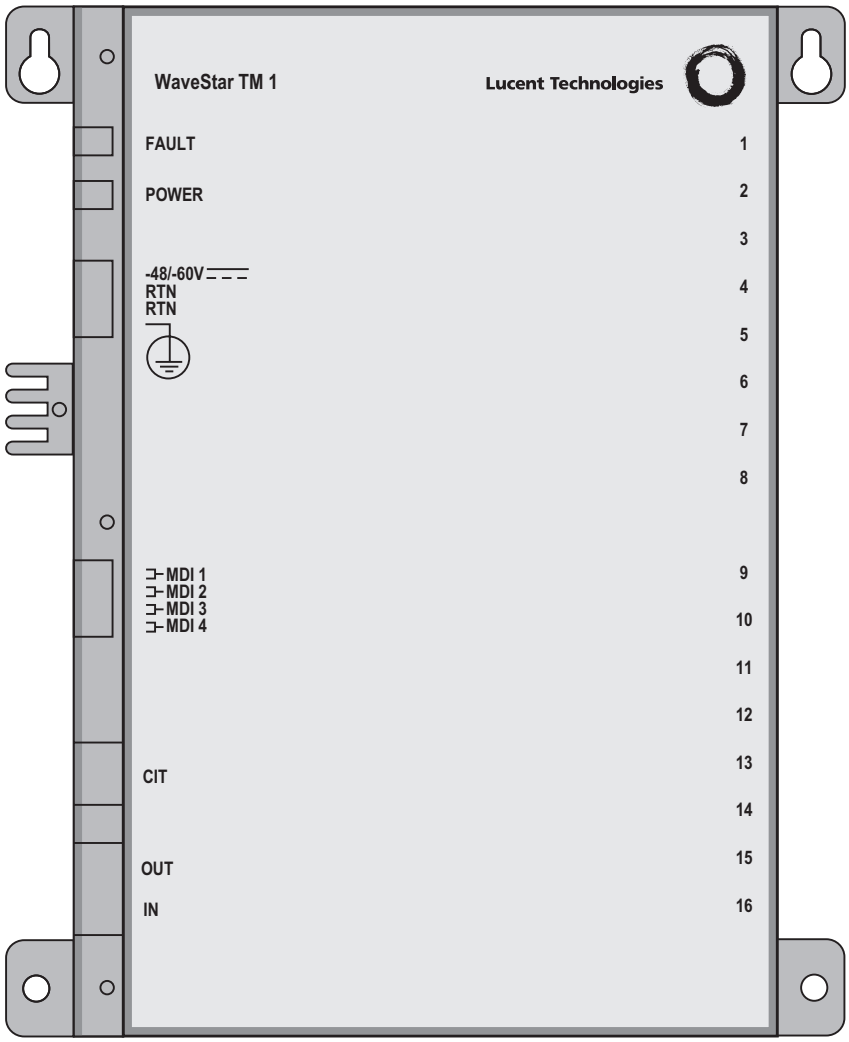

Figure 4-1. WaveStar™ TM 1 Terminal Multiplexer

System Planning and Engineering

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  - Introduction 2
  - Planning Considerations 2

General Planning Information

Introduction

The following is a high level overview of planning considerations for the WaveStar™ TM 1 Terminal Multiplexer.

Planning Considerations

When planning your system with the WaveStar™ TM 1, the following items should be considered:

- Capacity — one STM-1 optical interface, sixteen 2 Mbit/s E1 interfaces
- Synchronization — STM-1 line interface timing or via a 2 Mbit/s data input
- Operations System — remote management with ITM-SC and local and remote (remote limited to other WaveStar™ TM 1s) with ITM-CIT
- Power — single -48/-60 VDC power feed, power consumption below 20 watts
- Optional external 90-264V (47-63 Hz) AC/DC power converter
- Optional external -24 to -48 DC/DC power converter
- Growth — limited to additional WaveStar™ TM 1 units only

Operations, Administration, Maintenance, and Provisioning

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Operations Overview

Introduction

This chapter describes the OAM&P of the WaveStar™ TM 1. It includes the following:

- Operations Interfaces
- Maintenance supervision
- Performance monitoring (G.826 and G.784.)
- Self-restoration after power failure
- System alarm indicators
- 4 MDI contacts

Operations Interfaces and Administration

The WaveStar™ TM 1 has been configured for remote and local operations management via the Lucent Technologies' Integrated Transport Management (ITM) Network Management system. Remote management can be via the STM-1 DCC and the ITM-SC* software or locally via ITM-CIT. Local connections are via an RJ45 connector mounted on the WaveStar™ TM 1 unit and PC-based ITM-CIT software.

Maintenance

Transmission and equipment fault supervision is monitored remotely via the ITM-SC and locally via LEDs on the unit and via the ITM-CIT. The local ITM-CIT may also be used to remotely access other WaveStar™ TM 1 nodes in the network.

(Continued on next page)

* Note that ITM-SC software for the WaveStar™ TM 1 and WaveStar™ AM 1 will be available two months prior to the existing ITM-SC software being updated to include these products. Therefore, management of an SDH network containing the WaveStar™ TM 1 or WaveStar™ AM 1 may require two separate platforms of ITM-SC during this two-month period (October 31, 1999 to December 31, 1999).

Operations Overview, *continued*

Performance Monitoring

Provisioning and retrieval of performance monitoring parameters are derived from the overhead bytes (SOH, POH of each VC) and are in accordance with ITU-T Recommendations G.874 and G.826. This is accomplished via ITM-SC and ITM-CIT. Performance threshold counts are user settable.

The following parameters are monitored:

- Severely Errored Seconds (SES)
- Errored Seconds (ES)
- Background Block Errors (BBE)
- UnAvailable Seconds (UAS)

Self-restoration

The WaveStar™ TM 1 will restore to its prior state after a power failure.

System Alarm Indicators

The WaveStar™ TM 1 supports two LEDs which provide the following maintenance information:

- 1 Green LED to indicate power
- 1 Red LED to indicate signal failure or unit fault

Miscellaneous Discrete Inputs

The WaveStar™ TM 1 will provide four miscellaneous discrete inputs (MDIs) that can be used to monitor the status of external alarm-points to be assigned by the customer.

Ordering

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NOTE:
Chapter 7 has been reserved for ordering. There will be no ordering information in this manual. Contact your Lucent Technologies Account Representative for further information.

Product Support

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Technical Assistance

Introduction

Many of our customers have established their own support procedures. These procedures usually involve escalation within their own companies. However, some issues may require additional assistance from Lucent Technologies.

Lucent Technologies has been and continues to be committed to providing excellence in technical customer support for its products and services. Therefore, we provide a hierarchical support structure ready and available to solve any WaveStar™ TM 1 technical issue.

When additional technical assistance is needed, use the appropriate contact information in Table 8-1. (Note that accessing a Lucent Technologies' web site may require the assistance of Lucent personnel.)

Table 8-1. WaveStar™ TM 1 Technical Support Contacts

Customer Location	Initial Lucent Technologies Contact Location
International	URL address of Lucent homepage: http://www.lucent.com
	URL address of CTS homepage: http://hzswww.nl.lucent.com/cts/ (May require assistance of Lucent personnel.)
Peoples Republic of China	Lucent Technologies China, Beijing (86) 10 6522 5566 ext. 4046 Lucent Technologies China, Guangzhou (86) 20 8331 1600 ext. 328 Lucent Technologies China, Shanghai (86) 21 6470 5858

Training

Relevant Courses

Contact Customer Training and Information Products (CTIP) on 1-888-LUCENT8 (1-888-582-3688), prompt #2, for course information or to enroll in training courses. The following WaveStar™ TM 1 related courses are available:

- TR5967 — WaveStar™ ADM 16/1 Overview
- TR5966 — WaveStar™ ADM 16/1 Operations & Maintenance
- TR5881 — WaveStar™ ADM 4/1 Operations & Maintenance

The following related courses are available:

- TR5951 — SDH Introduction
- OC3100 — Synchronous Digital Hierarchy (SDH).

Documentation Set

Introduction

The Lucent Technologies documents listed in this section provide additional information about the WaveStar™ TM 1 Terminal Multiplexer.

Document List

Table 8-2 lists the documents included in the WaveStar™ TM 1 documentation set:

Table 8-2. WaveStar™ TM 1 Documentation Set

Document Number	Title	Date Available
365-372-100	*WaveStar™ TM 1 Applications and Planning Guide*	7/99
365-372-101	*WaveStar™ TM 1 User Guide*	11/99

Documentation Ordering Information

How to Order Documentation

The following provides the information necessary to order documents or product drawings.

Mail your order to ...	OR call ...
Lucent Technologies Inc. Customer Information Center Attn: Order Entry Section 2855 N. Franklin Road P.O. Box 19901 Indianapolis, Indiana, USA 46219	Within USA or Canada: 1-888 LUCENT-8 (1-888-582-3688) 24-hour/day toll free FAX: 1-800-566-9568
	From Asia/Pacific Region and China: +1-317-322-6411 From Caribbean/Latin America Region and Canada: +1-317-322-6646 From Europe, Middle East, and Africa: +1-317-322-6416 FAX: +1-317-322-6699
A check, money order, purchase order number, or charge number *VISA*[a] bank card, *American Express*[b] card services, or *MasterCard*[c] bank card is required with all orders. Make checks payable to Lucent Technologies.	

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Standard Warranty

Introduction

The warranty period for a defective product repaired under warranty is three months, or the unexpired term of the new product warranty period, whichever is longer.

If Lucent Technologies Optical Networking Group (ONG) does *not* install the product, the warranty term begins on the date the product is shipped. If Lucent Technologies' ONG installs the product, the warranty term begins when the installation is complete. All support services provided by Lucent Technologies ONG will be provided by way of a separate Technical Support Contract (TSC) which *will be* a component of the *initial* SDH product sale. Beyond this warranty time frame, a separate extended-warranty contract must be agreed to by both the Lucent Technologies' ONG and the customer at an *additional* and *specified* price.

The customer may make a warranty claim only if the customer has paid the full contracted price and has complied with all other obligations under this warranty agreement.

Hardware

WaveStar™ TM 1 hardware has a standard warranty of five years. The product is warranted to be free from defects directly resulting from material and/or construction faults and conforms to the product's specifications referenced in Lucent Technologies' ONG documentation and as agreed to in the "Customer Purchase Agreement."

This warranty does not extend to damage resulting from natural wear and tear, incorrect, careless or incompetent treatment, exceeding environmental conditions (for example, air conditioning, humidity, etc.) by the customer, incorrect storage, or external causes such as fire or flooding.

Software

WaveStar™ TM 1 software has a standard warranty period of one year beginning on the day the product is first shipped. Lucent Technologies' ONG shall remedy to the best of its ability any malfunction free of charge, if the product software does not meet the functional specification. A warranty claim is possible only and so far as the customer demonstrates that the operational use of the product software essentially deviates from the functional specification.

(Continued on next page)

Standard Warranty, *continued*

Software

The warranty does not imply that the product software will run uninterrupted or error-free. This warranty does not extend to damage resulting from incorrect, careless or incompetent treatment by the customer, incorrect storage or external causes such as fire or flooding. Lucent Technologies' ONG also has the right to grant Right To Use (RTU) licenses for its software.

Discontinued Availability

Lucent Technologies' ONG reserves the right to notify the customer in advance of the intention to Discontinue the Availability (DA) of a product. Lucent Technologies' ONG also reserves the right to offer a Technical Support Contract (TSC) to make repair and technical support services available for an additional period of time after a product has been discontinued. All TSC services will be at a specified price dependent on the terms and conditions of the contract.

The rights and obligations of Lucent Technologies' ONG and the customer shall neither be assigned nor delegated without prior written consent of the other party, except that Lucent Technologies' ONG may assign its obligations to any of its affiliates or non-Lucent Technologies contractors without further consent by the customer.

Warranty Transfer

The entitlements of this warranty are *not* transferable.

Standard Repair

Introduction

If Lucent Technologies' ONG determines that a product is not defective or is in conformance, the customer shall pay Lucent Technologies' ONG the costs of handling, inspecting, testing, and transporting the product and, if applicable, travel and related expenses.

Repair Interval

Lucent Technologies' ONG repair locations set their own standards for return intervals. On average, the minimum time to return repairs to the customer is 14 days from the receipt of the product by the repair location. The maximum time to return repairs to the customer can range from 50 to 180 days.

Out-of-Warranty Provisions

For any activity associated with repair or replacement of hardware and/or software systems that is determined by Lucent Technologies' ONG to be out of warranty, materials an labor will be billed at Lucent Technologies' ONG list price (time-and-materials plus additional incurred expenses), or in accordance with a separate Technical Support Contract.

International Repair and Service

The customer or the customer's in-country representative should send a description of the material to be returned for repair or service including the quantity, comcodes, and serial numbers (if available) to the Lucent Technologies' Charlotte Service Center.

After the Charlotte Service Center receives the repair information, they will assign an order number and fax an Authorization To Repair Form to the customer or the customer's in-country representative. The material can then be consigned and shipped to:

Lucent Technologies
Charlotte Service Center
6701-A Northpark Blvd.
Charlotte, NC 28216 USA
Attn: International Repair
Notify: Hipage Co. (704) 357-3050

(Continued on next page)

Standard Repair, *continued*

International Repair and Service (*continued*)

After the material has been shipped, the following information should be faxed to the Charlotte Service Center:

- Customer's return address
- Customer contact name, telephone number, and fax number
- Value of material
- Identification of any hazardous equipment or material
- Shipping information including the date of shipment, air waybill, carrier name, flight number, number of cartons, and weight of material.

When the material arrives at the Charlotte Service Center, it is entered into the Repair, Service, and Return database for tracking purposes, to verify shipment and quantities, and to determine the appropriate repair location. The material is then shipped to the appropriate repair location.

The repair location will repair the material and then ship it back to the Charlotte Service Center. If it is determined that an item is not repairable and the item is under factory warranty, a replacement will be sent. If the item is out of factory warranty, the customer will advise their Country Desk Representative if they would like to order a replacement.

The Charlotte Service Center will prepare the paperwork for exporting the material, and ship the material to the customer. When available, the Charlotte Service Center will fax the shipping information to the customer or the customer's in-country representative.

Upon receipt of the material, the customer or the customer's in-country representative should send the Charlotte Service Center the order numbers of the material received and the date the material was received. The Charlotte Service Center will then close the order on the Repair, Service, and Return database.

Quality and Reliability

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Lucent's Commitment to Quality and Reliability

Overview

This section provides the Lucent Technologies' quality policy, describes the reliability program, and describes the International Organization for Standardization certification awarded to Lucent Technologies' Optical Networking Group.

Quality Policy

Lucent Technologies is committed to achieving sustained business excellence by integrating quality principles and methods into all we do at every level of our company to:

- **Anticipate and meet** customer needs and exceed their expectations, every time
- **Relentlessly improve how we work**—to deliver the world's best and most innovative communications solutions—faster and more cost-effectively than our competitors

Quality Principles

- **Customer value**—Drive actions from a desire to serve customers. Know current and emerging needs. Understand why customers buy from us and why they don't, and act on that knowledge to deliver superior value.
- **Partnership**—Build long-term relationships with customers and strategic suppliers based on shared objectives.
- **Leadership**—Develop leaders who set high expectations, live by Lucent Values, and create an environment for serving customers and achieving business excellence.
- **Ownership**—Become personally involved in the success of the business. Turn good ideas into better ways of doing business—working together, taking prudent risks, learning from mistakes and implementing improvements based on what we learn.
- **Process**—Manage work with a focus on results—improving efficiency and productivity, delivering value to customers, and creating financial rewards for shareowners.
- **Improvement**—Make the plan-do-check-act cycle the way we operate—to achieve both continuous and breakthrough improvements in cost, cycle time, and quality.

(Continued on next page)

Lucent's Commitment to Quality and Reliability, *continued*

Quality Policy

- **Management by Fact**—Know what you want. Measure what you get. Act on the difference.
- **Results Orientation**—Establish and meet both short- and long-term commitments to all key stakeholders—customers, employees, shareholders, suppliers, partners, and society.

Shared Methods

- **Policy Deployment—**To set, deploy, and reach goals and align efforts company wide.
- **Process Management—**To manage, improve, and streamline how we work to deliver greater value to customers.
- **Problem Solving—**To close the gaps that separate us from our goal to be the industry leader.
- **Benchmarking—**To set meaningful standards and learn from the successful practices of best-in-class companies.
- **Management System Assessment—**To improve the way we manage the business through systematic evaluation, feedback, and action.

—Richard A. McGinn, Chairman and CEO

This Lucent Technologies Quality Policy guided the development of the WaveStar™ TM 1 Terminal Multiplexer and will continue affecting this product throughout its lifetime. The primary tool ensuring product quality is the Quality Plan, used with Lucent Technologies Optical Networking Group Reliability Program.

Reliability Program

Program Description

Reliability is a key ingredient of the life cycle, beginning at the earliest planning stage. Major efforts at the start of the project were system reliability modeling, 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.

During the design and developmental 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.

During manufacturing and field deployment, techniques such as premanufacturing, qualification, production quality tracking, failure mode analysis, feedback, and correction further enhances the ongoing reliability of the WaveStar™ TM 1.

International Standards Organization (ISO) Certification

ISO 9001

Lucent Technologies' Optical Networking Group has received ISO 9001 certification for its Merrimack Valley manufacturing facility and associated development organizations. 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 (DACS-II, III, IV, VI), network multiplex systems (DDM-2000), lightwave systems (FT-2000), as well as a growing family of WaveStar™ products.

ISO 9001 is an internationally recognized quality standard which is the key fundamental of a well designed quality system. 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.

Technical Specifications

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Overview

Introduction

This chapter contains the technical specifications for the WaveStar™ TM 1 Terminal Multiplexer.

System Specifications

Optical Interface

- A 155 Mbit/s G.957/S-1.1 short-haul optical interface with an attenuation range from 0 to 12 dB ($1x10^{-10}$ sensitivity) at an operating wavelength of 1310 nm.
- The STM-1 optical access is via an SC-type connector.

Tributary Interface

- Interface at 2048 Kbit/s ± 50 ppm, HDB3 coded and conforming to G.703-6, asynchronously mapped via VC-12 in TU-12.
- The 2 Mbit/s electrical interface access is via a RJ45 connector suitable for symmetrical twisted pair cables with an impedance of 120 Ω.

Mapping

- The WaveStar™ TM 1 supports an AU4 <-> VC4 <-> TUG3 <-> TUG2 <-> TU12 <-> VC12 fixed mapping scheme for each VC12 created and terminated in the system.

Power Specifications

- Input Voltage, -48/-60 VDC
- Power Consumption, less than 20 watts
- External 90-264V (47-63 Hz) AC/DC converter (optional)
- External -24 to -48 DC/DC converter (optional)
- The system optionally supports the grounding philosophy according to ETSI Requirements 300 253 (battery return connected to ground).

Equipment Dimensions

- Dimensions (H x W x D) 300 x 240 x 50 mm for wall mounting applications.
- Weight approx. 2.5 Kg

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System Specifications, *continued*

Supervision Interface

- F-interface for Craft Interface Terminal (CIT) via RJ45 connector.
- The interface conforms to V.10/RS-232C.

Synchronization and Timing

- Synchronization can be derived from the incoming STM-1 signal
- Synchronization can be derived from an incoming 2 Mbit/s data input
- Re-synchronization of the 2 Mbit/s ports is supported
- Support of SSM byte according to ETSI ETS 300 417-6

Environmental Conditions

- Compliant with ETS 300 019-2-3 Class 3.1E
- ETSI EMC - The system meets the requirements of EN 300 386-2 for equipment installed in locations other than telecom centers
- The system operates with convection cooling.

Performance Monitoring

- Performance monitoring is in accordance with ITU-T G.826 and G.784.
- The following four parameters are available to estimate the error performance of a path:
  - SES: number of Severely Errored Seconds in the received signal
  - ES: number of Errored Seconds in the received signal
  - BBE: number of Background Block Errors in the received signal
  - UAS: number of UnAvailable Seconds in the received signal.
- Monitoring can be done on the incoming STM-1 optical interface of the WaveStar™ TM 1 unit
- Monitoring can be done on any incoming VC-12 terminating in the unit
- Performance monitoring data is stored in one current and sixteen recent 15 minute registers, and one current and one recent 24 hour registers
- Threshold reports are generated when user-settable performance parameters are exceeded during 15 minute and 24 hour periods

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System Specifications, *continued*

System Reliability The WaveStar™ TM 1 reliability predictions follow:

TM 1	
FITS	MTBF
3500	32

1. Calculations are based on the Reliability Information Notebook, 7th Edition (RIN-7), Lucent Technologies, August 1995. All components evaluated at 40° C ambient and 50 percent electrical stress.
2. FITS is the number of failures per billion hours of operation (10^9).
3. Mean Time Between Failures (MTBF) in years.

Glossary

A

Add/Drop Multiplexer (ADM)
: The term for a synchronous network element capable of combining signals of different rates and having those signals added to or dropped from the stream.

Alarm
: Visible or audible signal indicating that an equipment failure or significant event/condition has occurred.

Alarm Cut-Off and Test (ACO/TST)
: The name of a pushbutton on the user panel used to silence audible alarms.

Alarm Indication Signal (AIS)
: A code transmitted downstream in a digital network that indicates that an upstream failure has been detected and alarmed if the upstream alarm has not been suppressed.

Alarm Severity
: An attribute defining the priority of the alarm message. The way alarms are processed depends on the severity.

Alarm Suppression
: Selective removal of alarm messages from being forwarded to the GUI or to network management layer OSs.

Alarm Throttling
: A feature that automatically or manually suppresses autonomous messages that are not priority alarms.

Alternate Mark Inversion (AMI)
: A line code that employs a ternary signal to convert binary digits, in which successive binary ones are represented by signal elements that are normally of alternative positive and negative polarity but equal in amplitude and in which binary zeros are represented by signal elements that have zero amplitude.

American Standard Code for Information Interchange (ASCII)
: A standard 7-bit code that represents letters, numbers, punctuation marks, and special characters in the interchange of data among computing and communications equipment.

Asynchronous
: The essential characteristic of time-scales or signals such that their corresponding significant instants do not necessarily occur at the same average rate.

Asynchronous Transfer Mode (ATM)
: A high-speed transmission technology characterized by high bandwidth and low delay. It utilizes a packet switching and multiplexing technique which allocates bandwidth on demand.

Attribute
Alarm indication level: critical, major, minor, or no alarm.

Automatic Protection Switch
A protection switch that occurs automatically in response to an automatically detected fault condition.

Autonomous Message
A message transmitted from the controlled Network Element to the ITM-SC which was not a response to an ITM-SC originated command.

B

Bandwidth
The difference in Hz between the highest and lowest frequencies in a transmission channel. The data rate that can be carried by a given communications circuit.

Baud Rate
Transmission rate of data (bits per second) on a network link.

Bidirectional Line
A transmission path consisting of two fibers that handle traffic in both the transmit and receive directions.

Bidirectional Line-Switched Ring (BLSR)
A bidirectional ring in which protection switching is accomplished by switching working traffic into protection time slots in the line going in the opposite direction around the ring.

Bidirectional Ring
A ring in which both directions of traffic between any two nodes travel through the same network elements (although in opposite directions).

Bidirectional Switch
Protection switching performed in both the transmit and receive directions.

Bit
The smallest unit of information in a computer, with a value of either 0 or 1.

Bit Error Rate (BER)
The ratio of error bits received to the total number of bits transmitted.

Bit Error Rate Threshold
The point at which an alarm is issued for bit errors.

Bit Interleaved Parity-n (BIP-n)
A method of error monitoring over a specified number of bits (BIP-3 or BIP-8).

Broadband Communications
Voice, data, and/or video communications at greater than 2 Mb/s rates.

Byte
Refers to a group of eight consecutive binary digits.

C

Cell Relay
Fixed length cells. For example, ATM with 53 octets.

Central Office (CO)
A building where common carriers terminate customer circuits.

Channel
A sub-unit of transmission capacity within a defined higher level of transmission capacity.

Circuit
A set of transmission channels through one or more network elements that provides transmission of signals between two points, to support a single communications path.

Clear Channel (CC)
A digital circuit where no framing or control bits are required, thus making the full bandwidth available for communications.

Closed Ring Network
A network formed of a ring-shaped configuration of network elements. Each network element connects to two others, one on each side.

Coding Violation (CV)
A performance monitoring parameter indicating bipolar violations of the signal have occurred.

Collocated
System elements that are located in the same location.

Concatenation
A procedure whereby multiple virtual containers are associated one with each other resulting in a combined capacity that can be used as a single container across which bit sequence integrity is maintained.

Consultative Committee for the International Telephone and Telegraph (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).

Craft Interface Terminal (CIT)
The user interface terminal used by craft personnel to communicate with the network element.

Critical (CR)
Alarm that indicates a severe, service-affecting condition.

Cross-Connection
Path-level connections between input and output tributaries or specific ports within a single NE. Cross-connections are made in a consistent way even though there are various types of ports and various types of port protection. Cross-Connections are reconfigurable interconnections between tributaries of transmission interfaces.

D

Data Communications Channel (DCC)
The embedded overhead communications channel in the synchronous line, used for end-to-end communications and maintenance. The DCC carries alarm, control, and status information between network elements in a synchronous network.

Default
An operation or value that the system or application assumes, unless a user makes an explicit choice.

Demultiplexing
A process applied to a multiplexed signal for recovering signals combined within it and for restoring the distinct individual channels of these signals.

Digital Multiplexer
Equipment that combines by time-division multiplexing several digital signals into a single composite digital signal.

Downstream
At or towards the destination of the considered transmission stream, for example, looking in the same direction of transmission.

Drop and Continue
A circuit configuration that provides redundant signal appearances at the outputs of two network elements in a ring. Can be used for Dual Ring Interworking (DRI) and for video distribution applications."

Drop-Down Menu
A menu that is displayed from a menu bar.

DS1 Signal
Signal with a data rate of 1.544 Mb/s.

DS3 Signal
A logical or electrical B3ZS signal with a data rate of 44.736 Mb/s.

Dual Ring Interworking (DRI)
Provides path-level protection for selected circuits that are dual interconnected between two rings. The self-healing mechanisms of the two rings remain independent and together protect against simultaneous single failures on both rings (not affecting the interconnections). The DRI protection additionally protects against failures in either of the interconnections between the rings, whether the failure is a facility or interconnection node.

E

Electrical Carrier, Level 1 (EC-1)
An electrical interface signal at the SONET rate of STS-1.

Electromagnetic Compatibility (EMC)
A measure of equipment tolerance to external electromagnetic fields.

Electromagnetic Interference (EMI)
High-energy, electrically induced magnetic fields that cause data corruption in cables passing through the fields.

Electrostatic Discharge (ESD)
Static electrical energy potentially harmful to circuit packs and humans.

Errored Seconds (ES)
A performance monitoring parameter. ES “type A” is a second with exactly one error; ES “type B” is a second with more than one and less than the number of errors in a severely errored second for the given signal. ES by itself means the sum of the type A and type B ESs.

Event
A significant change. Events in controlled Network Elements include signal failures, equipment failures, signals exceeding thresholds, and protection switch activity. When an event occurs in a controlled Network Element, the controlled Network Element will generate an alarm or status message and send it to the management system.

Externally Timed
An operating condition of a clock in which it is locked to an external reference and is using time constants that are altered to quickly bring the local oscillator’s frequency into approximate agreement with the synchronization reference frequency.

F

Far End (FE)
Any other network element in a maintenance subnetwork other than the one the user is at or working on. Also called remote.

Far-End Block Error (FEBE)
An indication returned to the transmitting node that an errored block has been detected at the receiving node. A block is a specified grouping of bits.

Far-End Receive Failure (FERF)
An indication returned to a transmitting Network Element that the receiving Network Element has detected an incoming section failure. Also known as RDI.

Folded Rings
Folded (collapsed) rings are rings without fiber diversity. The terminology derives from the image of folding a ring into a linear segment.

Frame
The smallest block of digital data being transmitted.

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.

G

Gateway Network Element (GNE)
A network element that passes information between other network elements and management systems through a data communication network.

H

High Level Data Link Control (HDLC)
OSI reference model datalink layer protocol.

Holdover
An operating condition of a clock in which its local oscillator is not locked to an external reference but is using storage techniques to maintain its accuracy with respect to the last known frequency comparison with a synchronization reference.

Human Machine Language (MML)
A standard language developed by the ITU for describing the interaction between humans and dumb terminals.

I

In-Service (IS)
A memory administrative state for ports. IS refers to a port that is fully monitored and alarmed.

Integrated Transport Management Network Module (ITM NM)
Lucent Technologies' integrated network management system that provides a broad end-to-end view of the SONET network.

J

Jitter
Short term variations of amplitude and frequency components of a digital signal from their ideal position in time.

L

Lightguide Build-Out (LBO)
An attenuating (signal-reducing) element used to keep an optical output signal strength within desired limits.

Line
A transmission medium, together with the associated equipment, required to provide the means of transporting information between two consecutive network elements. One network element originates the line signal; the other terminates it.

Line Build Out (LBO)
An equalizer network that guarantees the proper signal level and shape at the DSX panel.

Line Protection
The optical interfaces can be protected by line protection. Line protection switching protects against failures of line facilities, including the interfaces at both ends of a line, the optical fibers, and any equipment between the two ends. Line protection includes protection of equipment failures.

Line Timing
Refers to a network element that derives its timing from an incoming OC-N/STM-N signal.

Link
The mapping between in-ports and out-ports. It specifies how components are connected to one another.

Local Area Network (LAN)
A communications network that covers a limited geographic area, is privately owned and user administered, is mostly used for internal transfer of information within a business, is normally contained within a single building or adjacent group of buildings, and transmits data at a very rapid speed.

Loopback
Type of diagnostic test used to compare an original transmitted signal with the resulting received signal. A loopback is established when the received optical or electrical external transmission signal is sent from a port or tributary input directly back toward the output.

Loop Timing
A special case of line timing. It applies to network elements that have only one OC-N/STM-N interface. For example, terminating nodes in a linear network are loop timed.

Loss of Frame (LOF)
A failure to synchronize to an incoming signal.

Loss of Pointer (LOP)
A failure to extract good data from a signal payload.

Loss of Signal (LOS)
The complete absence of an incoming signal.

M

Major
Indicates a service-affecting failure, main or unit controller failure, or power supply failure.

Mapping
The logical association of one set of values, such as addresses on one network, with quantities or values of another set, such as devices or addresses on another network.

Minor
Indicates a non-service-affecting failure of equipment or facility.

Miscellaneous Discrete Interface
Allows an operations system to control and monitor equipment collocated within a set of input and output contact closures.

N

Network Element (NE)
A node in a telecommunication network that supports network transport services and is directly manageable by a management system.

Network Service Access Point (NSAP) Address
: Network Service Access Point Address (used in the OSI network layer 3). An automatically assigned number that uniquely identifies a Network Element for the purposes of routing DCC messages.

Node
: Defined as all equipment that is controlled by one system controller. A node is not always direct manageable by a management system. A node may also be defined as any network element in a network.

O

Open Systems Interconnection (OSI)
: Referring to the OSI reference model, a logical structure for network operations standardized by the International Standards Organization (ISO).

Operations Interface
: Any interface providing you with information on the system behavior or control. These include the equipment LEDs, user panel, CIT, office alarms, and all telemetry interfaces.

Operations Interworking (OI)
: The capability to access, operate, provision, and administer remote systems through craft interface access from any site in a SONET/SDH network or from a centralized operations system.

Operations System (OS)
: A central computer-based system used to provide operations, administration, and maintenance functions.

Optical Carrier n (OC-n)
: An optical carrier signal at the SONET rate of n, where n equals 1, 3, 12, 48, or 192. The basic rate of an OC-1 signal is 51.84 Mb/s, equivalent to an STS-1, with other values of N direct multiples of this basic rate.

Optical Carrier nc (Concatenated)
: An optical carrier signal at the SONET rate of n, where n equals 3, 12, or 48. The OC-3c signal is constructed by concatenating three STS-1 signals into an OC-3c. These three STS-1s are linked together with a single path overhead (rather than three) which increases the total available payload bandwidth over that of the three individual STS-1s.

Orderwire (OW)
: A dedicated voice-grade line for communications between maintenance and repair personnel.

Outage
: A disruption of service that lasts for more than 1 second.

P

Parameter
A variable that is given a value for a specified application. A constant, variable, or expression that is used to pass values between components.

Parity Check
Tests whether the number of ones (or zeros) in an array of binary bits is odd or even; used to determine that the received signal is the same as the transmitted signal.

Pass-Through
Paths that are cross-connected directly across an intermediate node in a network.

Path
A logical connection between the point at which a standard frame format for the signal at the given rate is assembled, and the point at which the standard frame format for the signal is disassembled.

Path Overhead (POH)
Informational bytes assigned to, and transported with the payload until the payload is demultiplexed. It provides for integrity of communication between the point of assembly of a virtual container and its point of disassembly.

Path Terminating Equipment
Network elements in which the path overhead is terminated.

Performance Monitoring (PM)
Measures the quality of service and identifies degrading or marginally operating systems (before an alarm would be generated).

Plesiochronous Network
A network that contains multiple subnetworks, each internally synchronous and all operating at the same nominal frequency, but whose timing may be slightly different at any particular instant.

Port (also called Line)
The physical interface , consisting of both an input and output, where an electrical or optical transmission interface is connected to the system and may be used to carry traffic between network elements. The words “port” and “line” may often be used synonymously. “Port” emphasizes the physical interface, and “line” emphasizes the interconnection. Either may be used to identify the signal being carried.

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.

Protection
Extra capacity (channels, circuit packs) in transmission equipment that is not intended to be used for service, but rather to serve as backup against equipment failures.

Q

R

Receive-Direction
The direction towards the Network Element.

Remote Network Element
Any Network Element that is connected to the referenced Network Element through either an electrical or optical link. It may be the adjacent node on a ring, or N nodes away from the reference. It also may be at the same physical location but is usually at another (remote) site.

Return to Zero
A code form having two information states (termed zero and one) and having a third state or an at-rest condition to which the signal returns during each period.

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 the protection capacity.

S

Section
The portion of a transmission facility, including terminating points, between a terminal network element and a line-terminating network element, or two line-terminating network elements.

Self-Healing
A network's ability to automatically recover from the failure of one or more of its components.

Severely Errored Seconds (SES)
This performance monitoring parameter is a second in which a signal failure occurs, or more than a preset amount of coding violations (dependent on the type of signal) occurs.

Single-Mode Fiber (SM)
An 8-µm diameter low-loss, long-span optical fiber typically operating at either 1310 nm, 1550 nm, or both.

Site Address
The unique address for a Network Element.

Software Backup
: The process of saving an image of the current network element's databases, which are contained in its NVM, to a remote location. The remote location could be the WaveStar CIT or an OS.

Software Download
: The process of transferring a generic (full or partial) or provisioned database from a remote entity to the target network element's memory. The remote entity may be the WaveStar CIT or an OS. The download procedure uses bulk transfer to move an uninterpreted binary file into the network element.

Software ID
: Number that provides the software version information for the system.

Span
: An uninterrupted bidirectional fiber section between two network elements.

STS-1
: The basic building block logical signal in the SONET standard with a data rate of 51.84 Mb/s.

Subnetwork
: A group of interconnected/interrelated Network Elements. The most common connotation is a synchronous network in which the Network Elements have data communications channel (DCC) connectivity.

Supervisor
: A user of the application with supervisor user priviliges.

Synchronization Messaging
: Synchronization messaging is used to communicate the quality of network timing, internal timing status, and timing states throughout a subnetwork.

Synchronous
: The essential characteristic of time scales or signals such that their corresponding significant instances occur at precisely the same average rate, generally traceable to a single Stratum-1 source.

Synchronous Digital Hierarchy (SDH)
: A hierarchical set of digital transport structures, standardized for the transport of suitable adapted payloads over transmission networks.

Synchronous Network
: The synchronization of transmission systems with synchronous payloads to a master (network) clock that can be traced to a reference clock.

Synchronous Optical Network (SONET)
: The North American standard for the rates and formats that defines optical signals and their constituents.

Synchronous Transport Module, Level n (STM-n)
: A building block information structure that supports SDH section layer connections, where n represents a multiple of 155.52 Mb/s. Normally n=1, 4, 16, or 64.

Synchronous Transport Signal (STS, STS-n)
The basic logical building block signal for SONET with a rate of 51.84 Mb/s for an STS-1 signal and a rate of n times 51.84 Mb/s for an STS-n signal.

T

T1
A carrier system that transmits at the rate of 1.544 Mb/s (a DS1 signal).

T3
A carrier system that transmits at the rate of 44.736 Mbps (a DS3 signal).

Threshold-Crossing Alert (TCA)
A message type sent from a Network Element that indicates that a certain performance monitoring parameter has exceeded a specified threshold.

Through Timing
Refers to a network element that derives its transmit timing in the east direction from a received line signal in the east direction and its transmit timing in the west direction from a received line signal in the west direction.

Time Division Multiplexing (TDM)
A technique for transmitting a number of separate data, voice, and/or video signals simultaneously over one communications medium by interleaving a portion of each signal one after another.

Transaction Language One (TL1)
A machine-to-machine communications language that is a subset of ITU's human-machine language.

Transmit-Direction
The direction outwards from the Network Element.

True Wave™ Optical Fiber
Lucent Technologies' fiber generally called non-zero dispersion-shift fiber, with a controlled amount of chromatic dispersion designed for amplified systems in the 1550/1310 nm range.

U

Unavailable Seconds (UAS)
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.

Upstream
At or towards the source of the considered transmission stream, for example, looking in the opposite direction of transmission.

V

Virtual Circuit
A logical connection through a data communication (for example, X.25) network.

Voice Frequency (VF) Circuit
A 64 kilobit per second digitized signal.

Volatile Memory
Type of memory that is lost if electrical power is interrupted.

W

Wide Area Network (WAN)
A communication network that uses common-carrier provided lines and covers an extended geographical area.

Wideband Communications
Voice, data, and/or video communication at digital rates from 64 kb/s to 2 Mb/s.

X

X.25 Interface / Protocol
The ITU packet-switched interface standard for terminal access that specifies three protocol layers: physical, link, and packet for connection to a packet-switched data network.

X-Terminal
Workstation that can support an X-Windows interface.