Lucent Technologies
Bell Labs Innovations

WaveStar® TDM 2.5G (OC-48)/ 10G(OC-192) (2-Fiber) Release 6.0.5/6.1.5

Applications and Planning Guide

365-371-527
CC109205054
Issue a
March 2002

Notice

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.

Trademarks

Limited warranty

Warranty, support and trouble escalation procedures have been established on a per country basis.

Contact your Lucent Technologies account representative for details.

Website

Lucent Technologies can be found at http://www.lucent.com/

Lucent Technologies values your comments!

Lucent Technologies
Bell Labs Innovations

Advanced Services Operations System Center User Reference, Release 6.05/6.1.5
Center User Reference
365-371-527 Issue a Date: March 2002

Lucent Technologies welcomes your comments on this information product. Your opinion is of great value and helps us to improve.

1. Was the information product:

	Yes	*No*	*Not applicable*
In the language of your choice?	☐	☐	☐
In the desired media (paper, CD-ROM, etc.)?	☐	☐	☐
Available when you needed it?	☐	☐	☐

Please provide any additional comments:

____

____

2. Please rate the effectiveness of this information product:

	Excellent	*More than satisfactory*	*Satisfactory*	*Less than satisfactory*	*Unsatisfactory*	*Not applicable*
Ease of use	☐	☐	☐	☐	☐	☐
Level of detail	☐	☐	☐	☐	☐	☐
Readability and clarity	☐	☐	☐	☐	☐	☐
Organization	☐	☐	☐	☐	☐	☐
Completeness	☐	☐	☐	☐	☐	☐
Technical accuracy	☐	☐	☐	☐	☐	☐
Quality of translation	☐	☐	☐	☐	☐	☐
Appearance	☐	☐	☐	☐	☐	☐

If your response to any of the above questions is "*Less than satisfactory*" or "*Unsatisfactory,*" please explain your rating.

____

____

3. If you could change one thing about this information product, what would it be?

____

____

4. Please write any other comments about this information product:

____

____

Please complete the following if we may contact you for clarification or to address your concerns:

Name: ____________________ Date: ____________________

Company/organization: ____________________ Telephone number: ____________________

Address: ____

Email address: ____________________ Job function: ____________________

If you choose to complete this form online, go to http://www.lucent-info.com/comments
Otherwise fax to 407 767 2760 (U.S.) or +1 407 767 2760 (outside the U.S.) or email comments to ctiphotline@lucent.com

Contents

List of Figures

4 Product Description

List of Tables

xxv

8 Product Support

9 Quality and Reliability

10 Technical Specifications

A A SONET Overview

About this information product

Overview

Purpose

This Applications and Planning Guide (APG) provides the following information about WaveStar TDM 2.5G/10G, Release 6.05/6.1.5:

- Features
- Applications
- Product description
- Operations and maintenance
- System engineering
- Product support
- Technical and reliability specifications

□

Reason for reissue

The TDM 2.5G/10G (2-Fiber) R6.0.5/6.1.5 system is an extremely versatile high-speed SONET system that supports a large number of applications, topologies, and interfaces. The system supports various protected and un-protected equipment and topology schemes - to cost effectively and reliably transport, cross-connect, terminate, and protect (as necessary) large amounts of, and diverse types of services. The system is highly scaleable, and can be deployed as a standalone OC-48 or OC-192 system. In-service upgrades are supported to grow from a stand-alone OC-48 ring to an OC-192 ring. The system supports a wide range of optical transmission capabilities to ensure the most cost effective solutions for both short and long distance (span) applications, and to maximize fiber utilization. The system also interworks with numerous existing and embedded network equipment and Operations Support systems.

The WaveStar TDM 2.5G/10G (2-Fiber) system consists of one 10G (high-speed) shelf and one to four 2.5G (low-speed tributary) shelves. Each shelf can be ordered individually, or together as the WaveStar TDM 2.5G/10G (2-Fiber) system. When the 2.5G (low-speed tributary) shelf is ordered and used by itself (stand-alone OC-48 application), it is referred to as the 2.5G Application. The 10G Application requires the high-speed shelf and a minimum of one low-speed tributary shelf.

This document is a new issue that includes applications, ordering, and planning information for the WaveStar TDM 2.5G/10G (2-Fiber), for both 2.5G and 10G applications. This document also contains information covering all the new features supported by the WaveStar TDM 2.5G/10G (2-Fiber) R6.0.5/6.1.5.

Some of these new features include:

- 768x768 STS-1 switch fabric (for 10G high-speed shelf)
- Mixed switch fabrics interworking (for example, the 576x576 and 768x768 STS-1 switch fabrics can be used in different nodes throughout a 10G ring)
- OC-192 system support for 4 low-speed tributary shelves
- OC-192 BLSR Non-Preemptible Unprotected Traffic (STS-1 NPPA)
- Gigabit Ethernet features and enhancements
  - GE1/LX2 Gigabit Ethernet interface port unit (1310 nm long reach interface)
  - Full VLAN list support
  - VLAN ID transparency
  - Gigabit LCAS/VBA basic services

- Performance monitoring
- Auto-negotiation bypass

- Remote Network Element Status (RNES)/Alarm Gateway Network Element (AGNE) - remote alarm activity features
- Enhanced security screen feature
- RTRV ABN Command

Intended audience

The *WaveStar TDM 2.5G/10G (2-Fiber) Applications and Planning, Guide* is primarily for network planners and engineers. In addition, others who need specific information about the features, applications, operation, and engineering of WaveStar TDM 2.5G/10G (2-Fiber) may find the information in this manual useful.

Conventions used

This section lists common conventions maintained throughout this document.

Typographical conventions

The following typographical conventions are used throughout this document:

- A **BOLD** face type is used for emphasis
- A `Courier` font identifies WaveStar CIT menu-option displays and user responses

Related documentation

The Lucent Technologies documents listed in this section provide additional information about WaveStar TDM 2.5G/10G (2-Fiber).

Document List

The following table lists the documents included in the WaveStar TDM 2.5G/10G (2-Fiber) documentation set.

Document Number	Title	Comcode
365-371-527	*WaveStar TDM 2.5G/10G (2-Fiber) Applications and Planning Guide (APG)*	109205054
365-371-528	WaveStar TDM 2.5G/10G (2-Fiber) *User Operations Guide (UOG)*	109205062
365-371-529	*WaveStar TDM 2.5G/10G (2-Fiber) Alarm Messages and Trouble Clearing Guide (AMTCG)*	109205070
365-371-206	*WaveStar TDM 2.5G/10G (2-Fiber) Installation Manual and System Turn-up Services (IMSTS)*	109151738
365-371-530	*WaveStar TDM 2.5G/10G (2-Fiber) Operations Systems EngineeringGuide (OSEG)*	109205088
* Use Comcode for ordering	*WaveStar TDM 2.5G/10G, Release 6.05/6.1.5 Software Release Description (SRD)*	109166835
* Use Comcode for ordering	WaveStar TDM 2.5G/10G, Release 6.05/6.1.5 *Documentation CD-ROM (*contains the *User Operations Guide* and the *Alarm Messages and Trouble Clearing Guide)*	109205096

Notes

* These items are shipped initially with the software. If you need to order these items anytime after initial shipment of the product and software, contact Software Manufacturing.

Description of documentation set

This section briefly describes the documents that are included in the *WaveStar TDM 2.5G/10G (2-Fiber)* documentation set.

Installation Manual and System Turn-up Services (IMSTS)

The WaveStar TDM 2.5G/10G (2-Fiber) Installation Manual and System Turn-up Services (IMSTS) is a step-by-step guide to system installation and setup. It also includes information needed for pre-installation site planning and post-installation acceptance testing.

Applications and Planning Guide (APG)

The *WaveStar TDM 2.5G/10G (2-Fiber) Applications and Planning Guide (APG)* is for use by network planners, analysts and managers. It is also for use by the Lucent Account Team. It presents a detailed overview of the system, describes its applications, gives planning requirements, engineering rules, ordering information, and technical specifications.

Alarm Messages and Trouble Clearing Guide (AMTCG)

The WaveStar TDM 2.5G/10G (2-Fiber) *Alarm Messages and Trouble Clearing Guide* provides detailed information on maintenance and trouble clearing, a list of the systems’s alarm messages, and procedures for routine maintenance, troubleshooting, diagnostics, and component replacement.

User Operations Guide (UOG)

The *WaveStar TDM 2.5G/10G (2-Fiber) User Operations Guide* provides step-by-step information for use in daily system operations. The manual demonstrates how to perform system provisioning, operations, maintenance, and administrative tasks.

Operations Systems Engineering Guide (OSEG)

The *WaveStar TDM 2.5G/10G (2-Fiber) Operations Systems Engineering Guide* provides detailed information on TL1 commands, messages, and error codes.

Software Release Description (SRD)

The *WaveStar TDM 2.5G/10G (2-Fiber) Software Release Description* provides software installation information and describes release-specific software details.

Chapter descriptions

The table below briefly describes the type of information found in each chapter.

Chapter Title	Description
About This Information Product	Describes the guide's purpose, intended audience, and organization Lists related documentation Explains how to comment on this document
Chapter 1, Introduction to WaveStar TDM 2.5G/10G (2-Fiber)	Presents network application solutions Provides a high-level product overview Describes the product family Lists features
Chapter 2, Features	Describes the features
Chapter 3, Network Topologies	Describes some of the main network topologies possible with WaveStar TDM 2.5G/10G (2-Fiber)
Chapter 4, Product Description	Provides a functional overview of the system Describes the hardware and configurations available for the product
Chapter 5, Operations, Administration, Maintenance, and Provisioning	Describes OAM&P features (such as alarms, operation interfaces, security, and performance monitoring)
Chapter 6, System Planning and Engineering	Provides planning information necessary to deploy the system
Chapter 7, Ordering	Provides information about the ordering options Discusses the use of a sparing graph
Chapter 8, Product Support	Describes engineering, installation, and technical support services Lists training contact and product-specific course information.
Chapter 9, Quality and Reliability	Provides the Lucent Technologies quality policy Lists the reliability specifications
Chapter 10, Technical Specifications	Lists the technical specifications
Appendix A, A SONET Overview	Describes the North American standard for optical signal rates and formats
Appendix B, Port Unit Data Sheets	Describes the port units (transmission circuit packs) used in WaveStar TDM 2.5G/10G (2-Fiber)
Abbreviations and Acronyms	Expands common telecommunication abbreviations and acronyms
Glossary	Defines telecommunication terms
Index	Lists specific subjects and their corresponding page numbers

Documentation ordering information

This section describes how to order

- Additional copies of this document
- Electronic documentation (CD-ROMs)
- Product drawings from the Lucent Technologies Lucent Learning (LL) organization

Ordering Standard Documentation

The table below provides the information necessary for commercial customers to order standard documents or request placement on the standing order list (for reissues of any document). You can order by mail, internet, telephone, or fax.

<table>
<tr><th>Mailing and Internet Addresses</th><th>Telephone Numbers/
E-mail Addresses</th><th>Fax Numbers</th></tr>
<tr><td rowspan="2">Mailing Address:
Lucent Technologies Inc.
Lucent Learning
Attention: Order Entry
2855 N. Franklin Road
P.O. Box 19901
Indianapolis, IN 46219

Internet Address for Commercial Customers:
http://www.lucentdocs.com
Internet Address for Lucent Associates:
http://www.cic.lucent.com</td><td>Within USA:
For within the USA:
• Telephone: 1-888 LUCENT-8 (1-888-582-3688)
• E-mail: cicorders@lucent.com</td><td>1-800-566-9568</td></tr>
<tr><td>Outside USA:
For Europe, The Middle East, Africa (EMEA);
Asia, Pacific Region and China;
Caribbean, Latin America (CALA):
• Telephone: 1-317-322-6416
• E-mail: intlorders@lucent.com
For Canada, North American Region:
• Telephone:1-317-322-6615
• E-mail: intlnaorders@lucent.com</td><td>1-317-322-6699</td></tr>
</table>

Methods of Payment for Commercial Customers

The methods of payment for commercial customers are as follows:

- **Orders totaling $1,000 or less –** A credit card is required for orders totaling $1,000 or less. Visa®, MasterCard®, and American Express® are accepted. Prepayment by check is also acceptable. (Visa is a registered trademark of VISA International Service Association. MasterCard is a registered trademark of MasterCard International Incorporated. American Express is a registered trademark of American Express Company.)
- **Orders totaling over $1,000 –** Orders totaling over $1,000 may be paid for using credit card, check, or invoice upon receipt of a purchase order. Purchase orders may be faxed or mailed using the information provided above.

Ordering CD-ROMs

Documentation for WaveStar TDM 2.5G/10G (2-Fiber) is available on CD-ROM. The table below lists the contacts for specific information about CD-ROM documentation.

IF you wish to...	**THEN contact...**
order an annual subscription	Your Account Executive.
obtain pricing information	Lucent Technologies Lucent Learning. Contact information is provided in the table on page xxxii.
obtain a list of documents available on CD-ROM	

Ordering Drawings

To order any of the drawings listed in the following table, contact the Lucent CIC organization. Contact information is provided in the "Ordering Standard Documentation" section earlier in this chapter.

Available Drawings

The table below lists the drawings available from the Lucent CIC organization. These drawings provide valuable product information.

Drawing Number	Title
ED8C789-10	Typical Bay Arrangements, Ordering Information, Cabling and Floor Plan Data Sheet
ED8C789-15	Installer's Cabling Plan for WaveStar TDM 2.5G Shelves
ED8C789-16	Installer's Cabling Plan for WaveStar TDM 10G Bays
ED8C789-30	WaveStar TDM 2.5G Shelf Assembly
ED8C789-31	WaveStar TDM 10G Shelf Assembly
ED8C789-32	*WaveStar TDM 2.5G/10G (2-Fiber)* Circuit Pack Ordering
ED8C789-33	*WaveStar TDM 2.5G/10G (2-Fiber)* Panel Closing Details
ED9C280-31	DS3 Connector Panel (External Mount)
ED8C789-34	DS3 Kit DS3 Connector Panel (Internal Mount and Rear Mount)
ED8C789-35	*WaveStar TDM 2.5G/10G (2-Fiber)* Bay
365-371-202	Software Ordering Guide (Release 4 and later)

How to comment

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

Customer Comment Form

A customer comment form is located immediately after the title page of this document. 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, send or fax comments about this document to:

Lucent Technologies Inc.
Lucent Learning
Building 21, Room 3A-06
1600 Osgood Street
North Andover, MA 01845

Fax: 1-978-960-6835

1 Introduction to WaveStar TDM 2.5G/10G (2-Fiber)

Overview

Purpose

This chapter provides a high-level introduction to the WaveStar TDM 2.5G/10G, Release 6 system, referred to in this document as WaveStar TDM 2.5G/10G (2-Fiber). It also contains useful information about the WaveStar® product family and the applications of the WaveStar TDM 2.5G/10G, Release 6.

□

WaveStar TDM 2.5G/10G, Release 6

Overview

The WaveStar TDM 2.5G/10G, Release 6 add/drop multiplexer supports high-capacity, self-healing transport by means of a SONET-standard OC-192 (high-speed shelf) or OC-48 (low-speed shelf) line rate signal, in a SONET-standard 2-fiber Bidirectional Line-Switched Ring (BLSR) or Unidirectional Path-Switched Ring (for use in applications). The WaveStar TDM 2.5G/10G (2-Fiber) architecture follows a platform architecture foundation that is the integration of physical, software infrastructure, transmission, timing, and maintenance architectures.

Two system options

WaveStar TDM 2.5G/10G (2-Fiber) provides two basic system options: a stand-alone 2.5G shelf, and a system that includes one high-speed 10G (OC-192) shelf and one to four low-speed, tributary 2.5G shelves. When the tributary shelf is used as a stand-alone application, it is referred to as the 2.5G Application. An in-service upgrade is available for migrating from a single shelf 2.5G system to a 10G system. For example, an OC-48 2-fiber BLSR can be upgraded to an OC-192 2-fiber BLSR

Low-speed shelf capacity

Each low-speed 2.5G shelf supports up to 384 STS-1 equivalents of interface capacity for any mix of OC-48, OC-12, OC-3, GE1, and DS3/EC-1 interfaces including zero to four OC-48 2-fiber BLSRs or UPSRs, or zero to sixteen OC-12 UPSRs.

High-speed shelf capacity

The high-speed shelf supports up to 384 STS-1 equivalents of interface capacity. This capacity can be used to support one OC-192 2-Fiber BLSR, or one OC-192 UPSR, or two unprotected OC-192 ports.

Direct interconnection to other rings

The traffic from any ring can be directly interconnected to other rings without using the additional add/drop ports and cabling that would be needed to connect rings in separate network elements.

576x576 STS-1 switch fabric

With the 576x576 STS-1 switch fabric in the high-speed shelf, the system supports one or two low-speed tributary shelves. The cross-connection capacity allows non-blocking connectivity between all 384 STS-1 equivalents of the interface capacity within each shelf, and, in addition, up to 192 STS-1 equivalents of non-blocking connectivity between the high-speed shelf and the low-speed shelves. This is sufficient, with any combination of optical and electrical interfaces in the low-speed shelves, to support full add/drop of all the working (protected) traffic carried by an OC-192 ring.

768x768 STS-1 switch fabric

Using the 768x768 STS-1 switch fabric (in the high-speed shelf), the system supports one to four low-speed tributary shelves. The cross-connection capacity allows non-blocking connectivity between all 384 STS-1 equivalents of the interface capacity within each shelf, and, in addition, up to 384 STS-1 equivalents of non-blocking connectivity between the high-speed shelf and the low-speed shelves. This is sufficient, with any combination of optical and electrical interfaces in the low-speed shelves, to support full add/drop of all the traffic carried by an OC-192 ring, including both the working (protected) and the protection access (unprotected) traffic in an OC-192 BLSR, or all the traffic carried by two unprotected OC-192 ports.

In-service upgrade from 576x576 to 768x768 STS-1 switch fabric

An in-service upgrade from the 576x576 STS-1 switch fabric to the 768x768 STS-1 switch fabric is available for increasing the cross-connection capacity and supporting additional low-speed shelves.

During the upgrade the two SWITCH/STS576 circuit packs are replaced with two SWITCH/STS768 circuit packs, and 2 of the 4 PPROC/STS192 circuit packs are replaced with two PPROC/STS384 circuit packs.

Customer needs

The major customer need addressed by the WaveStar TDM 2.5G/10G, Release 6 add/drop multiplexer is the need to provide a cost-effective, flexible, and upgradable system. Other customer needs met by WaveStar TDM 2.5G/10G (2-Fiber) include:

- Reduced cost.
- Greater add/drop termination capacity.
- Efficient bandwidth management.
- Relief of fiber exhaust.
- In-service upgrade from a single shelf 2.5G system to a 10G system; for example, an OC-48 2-fiber BLSR can be upgraded to an OC-192 2-fiber BLSR.
- Operational efficiency.
- Preservation of embedded fiber base.
- Reduction in network costs.

Customer benefits

Major customer benefits realized with the WaveStar TDM 2.5G/10G, Release 6 include:

Smaller footprint

Compact size provides substantial reduction in floor space and hence lower cost.

Investment Protection

Investment protection through interworking with embedded base.

Interoperability

The WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with the following products for various applications and interface rates. Chapter 3 provides more details.

- DDM-2000 OC-3 and DDM-2000 OC-12
- FT-2000 OC-48 Lightwave System
- Lucent Technologies Metropolis™ DMX Access Multiplexer
- Tellabs TITAN 5500
- Fujitsu FLM-150, FLM-600, and FLM-2400
- Nortel S/DMS
- Various DWDM products using compatible optics (port units)
- Various operations support systems
- WaveStar family user interface application

Key features

The following list summarizes the key features of WaveStar TDM 2.5G/10G, Release 6:

- Two configuration options:
  - 2.5G system consisting of one 2.5G shelf.
  - WaveStar TDM 2.5G/10G (2-Fiber) system consisting of one 10G (OC-192) shelf and up to four low-speed, tributary 2.5G shelves.
- Two switch fabric options for the high-speed shelf:
  - 576x576 STS-1 switch fabric – supports up to two low-speed, tributary shelves.
  - 768x768 STS-1 switch fabric – supports up to four low-speed, tributary shelves.
- Mixed switch fabrics interworking: For example, the two switch fabrics can be mixed throughout different nodes in a ring network.
- In-service upgrade from the 576x576 STS-1 switch fabric to 768x768 STS-1 switch fabric.
- In-service upgrade from Release 5 to Release 6.
- Provisionable SS bits.
- Two 2-port Gigabit Ethernet interfaces (GE1/SX2 and GE1/LX2 port units).
- OC-192 BLSR Non-preemptible Unprotected Traffic (STS-1 NPPA).
- Flexible port unit mixing: GE1, DS3/EC-1, OC-3, OC-12, and OC-48, including zero to four OC-48 BLSRs or UPSRs on each 2.5G shelf. Also, zero to sixteen OC-12 UPSRs are supported.
- Interface capacity of up to 384 STS-1 equivalents on each shelf, providing capacity for full add/drop of all the protected traffic carried by any one (or more) of the rings.
- Add/drop traffic from any ring can be directly interconnected to other rings without using additional ports.
- Fully flexible SONET STS-1 granular TSA/TSI.
- Transport of STM-1, STM-4, and STM-16 VC payloads (VC-3 high order, VC-4 and VC4-4c, and VC4-16c) over SONET interfaces (OC-3, OC-12, OC-48, and OC-192).
- ANSI and Telcordia standards compliant operations.
- OS and CIT access using TCP/IP or OSI protocols.

- Graphical User Interface (GUI) on the WaveStar Craft Interface Terminal (CIT) for use at the system location and remotely.
- TL1 operations interface.
- RNES/AGNE remote alarm activity features.
- Backup for provisioned data.
- Internal optical amplifiers for OC-192 applications that reach beyond 60 km.
- Support for applications with Lucent External Optical Amplifier system.
- Compatible optics for:
  - Lucent Technologies Metropolis™ Enhanced Optical Networks (EON) (16 wavelengths at OC-48).
  - Lucent Technologies WaveStar® OLS 1.6T (400G) (80 wavelengths at OC-48 and 40 wavelengths at OC-192).
  - Passive DWDM Optics Units (16 wavelengths at OC-48 and 32 wavelengths at OC-192).
- OC-192 extended/intermediate reach 1.5 micron optics.
- OC-192 long reach 1.5 micron optics.
- OC-192 very long reach 1.5 micron optics.
- OC-48 very short reach 1.3 micron optics.
- OC-48 long reach 1.3 and 1.5 micron optics.
- OC-3 and OC-12 long and intermediate/short reach 1.3 micron optics.
- OC-3 intermediate/short reach 1.3 micron optics (8 ports).
- DS3/EC-1 transmission interface (0x1 and 1xN) protected.
- Automatic Laser Shutdown (ALS) on long-reach and very long-reach OC-192 interfaces.
- OSI level 2 routing (up to 50 level 1 areas).
- Choice of internal, rear-mounted, or external DS3 connector panel mounting arrangements.
- OC-48, OC-12, OC-3 0x1 or linear 1+1 facility protection (bidirectional, revertive and nonrevertive; unidirectional, nonrevertive).
- Interworking with various Lucent and other vendors’ products.
- OC-192 line timing (with SSM), up to 8 line references from the OC-192 system.

- OC-48 line timing (with SSM), up to 6 line references when using only the OC-48 low-speed (tributary) shelf.
- OC-12 line timing (with SSM).
- OC-3 line timing (with SSM).
- Fixed rate and adaptive rate (pipe mode) tributary operation:
  - STS-48c cross-connections (fixed mode).
  - STS-48 cross-connections (pipe mode).
  - STS-12c cross-connections (fixed mode).
  - STS-12 cross-connections (pipe mode).
  - STS-3c cross-connections (fixed mode).
  - STS-3 cross-connections (pipe mode).
- DCCr (section) and DCCm (line) channel on all supported optical interfaces.
- At least 32 section/line DCC channels simultaneously.
- 1+1 protection available for all DCC channels (unidirectional and non-revertive).
- SONET section, line and path (terminated and intermediate) and DS3 performance monitoring.
- FTTD-FTP/FTAM gateway.
- ANSI/Bellcore compliant DRI (Drop and Continue method) with interconnected rings (OC-48 or OC-192 BLSR interfaces).
- DS1 timing outputs.

The WaveStar Product Family

Overview

Lucent Technologies offers the industry’s widest range of high-quality transport systems and related services designed to total network solutions. Included in this offering is the WaveStar family of products. The WaveStar product family offers telecommunications service providers advanced services and revenue-generating capabilities.

Family members

The WaveStar product family includes the following:

- WaveStar BandWidth Manager (SONET/SDH)
- WaveStar TDM 2.5G/10G (2-Fiber) (SONET)
- WaveStar TDM 10G STM-64 (2-Fiber) (SDH)
- WaveStar OLS 1.6T (400G) (SONET)
- WaveStar OLS 1.6T (800G) (SDH)
- WaveStar AM 1 (SDH)
- WaveStar TM 1 (SDH)
- WaveStar Add/Drop Multiplexer 16/1 (SDH)
- WaveStar Add/Drop Multiplexer 4/1 (SDH)
- WaveStar DACS 4/4/1 (SDH)
- WaveStar Digital Video System (SONET/SDH)
- WaveStar Subnetwork Management System (SONET/SDH)

WaveStar product family features

The WaveStar product family offers customers the following:

- Synchronous optical network (SONET) based services
- Synchronous digital hierarchy (SDH) based services
- Scalable cross-connect, multiplex, and transport services
- Network consolidation and reliability
- Interoperability with products of other vendors
- Coordination of network element and element management services

□

WaveStar TDM 2.5G/10G, Release 6 System Description

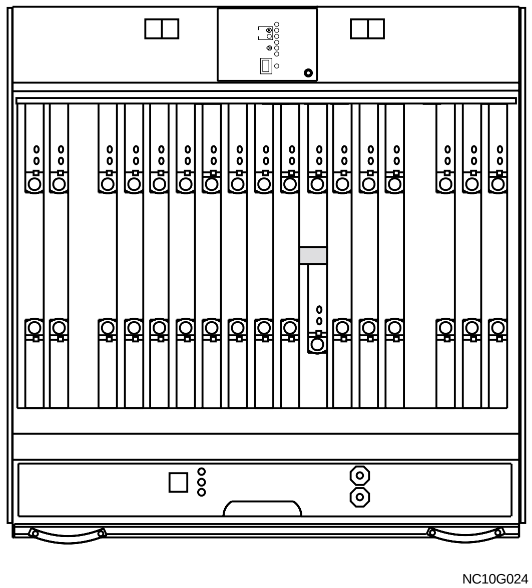
Overview

Two options are available. The first option is a 2.5G terminal consisting of one shelf. The second option is a multi-shelf system, consisting of a high-speed (OC-192) shelf and one to four low-speed, tributary 2.5G (OC-48) shelves.

WaveStar TDM 2.5G/10G (2-Fiber) high-speed shelf

The following figure shows the high-speed shelf, which contains two OC-192 port units, the switch fabric, and related circuit packs.

Figure 1-1 WaveStar TDM 2.5G/10G (2-Fiber) High-Speed Shelf



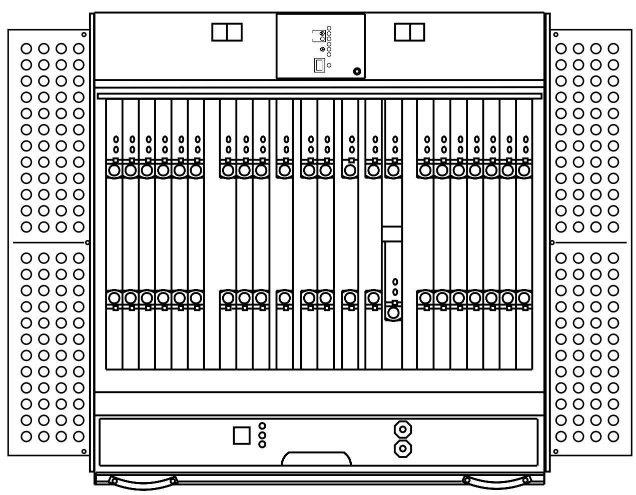
WaveStar TDM 2.5G/10G (2-Fiber) low-speed (tributary) shelf

The WaveStar TDM 2.5G/10G, Release 6 low-speed tributary shelf is a WaveStar 2.5G system that interfaces to and from OC-48, OC-12, OC-3, GE1, EC-1, and DS3 lines. Each low-speed shelf has 16 slots that support flexible optical and electrical port unit mixing, and can be mounted in a standard bay frame without requiring other equipment to be mounted nearby.

Up to three low-speed shelves or up to two low-speed shelves and a high-speed shelf can be mounted in one 7-foot bay frame. If an internally mounted Dispersion Compensation Module (DCM) Holder Tray or internally mounted DS3 connector panels are used, up to two low-speed shelves or one low-speed shelf and a high-speed shelf can be mounted in one 7-foot bay frame. See Chapter 4 for information about system options.

The following figure shows the WaveStar TDM 2.5G/10G, Release 6 low-speed shelf with the optional DS3/EC1 connector panels mounted externally. These panels are required for shelves that contain DS3/EC1 port units.

Figure 1-2 WaveStar TDM 2.5G/10G (2-Fiber) Low-Speed Shelf with External DS3/EC1 Connectors



NC-2.5GAPOG-046

The three options for mounting these panels is externally (shown), internally, or in the rear of the WaveStar TDM 2.5G/10G (2-Fiber) shelf. [The rear-mounted panel adds 4 inches to the rear of the WaveStar TDM 2.5G/10G (2-Fiber) shelf.]

The amount of traffic that can be added to/dropped from interfaces from a pair of low-speed shelves to the high-speed shelf is subject to the limit of 192 STS-1s per low-speed shelf or per pair of low-speed shelves. There is no limit on connecting traffic between tributary ports within a low-speed shelf.

Reference

For more information on inter-shelf capacity, see the WaveStar TDM 2.5G (OC-48)/10G (OC-192) (2-Fiber) Applications and Planning Guide, Chapter 6, "System Planning and Engineering."

For more information concerning the physical make-up of the system, system options, and DS3/EC1 connector panel mounting arrangements, see Chapter 4, "Product Description".

WaveStar TDM 2.5G/10G, Release 6 system

The WaveStar TDM 2.5G/10G, Release 6 system is an economical solution to providing 10G (OC-192) and 2.5G (OC-48) SONET service with a full complement of optical (GE1, OC-3, OC-12, and OC-48) and electrical (DS3 and EC-1) interfaces, as well as a full complement of service quality options, from unprotected 0x1, 1+1 point to point, to 2-fiber BLSRs and UPSRs. Each low-speed shelf accommodates electrical connector panels for DS3/EC1 connections and has 16 circuit pack slots.

Transmission interfaces

The WaveStar TDM 2.5G/10G, Release 6 system includes the following optical and electrical port units.

Optical interfaces

OC-192 port units are available in 1.5µ wavelength (intermediate, extended- intermediate, long reach, and very long reach).

Each OC-192 port unit contains one bidirectional port. Two OC-192 port units are necessary to terminate one OC-192 2-fiber BLSR or UPSR.

OC-48 port units are available in two wavelengths:

- 1.3µ wavelength (very short reach and long reach)
- 1.5µ wavelength (long reach)

Each OC-48 port unit contains one bidirectional port. Two OC-48 port units are necessary to terminate one OC-48 2-fiber BLSR or UPSR.

The OC-12 and OC-3 port units (short, intermediate, and long-reach) are available for 1.3µ wavelength single-mode fiber applications. The OC-12 port units provide two bidirectional ports. The OC-3 port units provide four or eight (intermediate/short reach only) bidirectional ports.

Gigabit Ethernet interface

Gigabit Ethernet port unit has 2 bidirectional ports per circuit pack. Two types of circuit packs are available, one for short haul applications with SX ports (850 nm) and one for long haul applications with LX ports (1310 nm).

Electrical interfaces

The DS3EC1/8 port units are capable of transmitting and receiving signals at the DS3 and/or EC-1 rate. Each port unit contains eight independent bidirectional ports.

Control and synchronization

The WaveStar TDM 2.5G/10G, Release 6 uses a single control system and a 1+1 protected synchronization system. Provisionable synchronization modes are available, including line timing.

Switch capacity

The WaveStar TDM 2.5G/10G (2-Fiber) supports the option of either of the following switch fabrics in the high-speed shelf:

- 576x576 STS-1 switch fabric
- 768x768 STS-1 switch fabric

It also supports an additional 576x576 STS-1 switch fabric in each low-speed shelf.

In-service upgrade from the 576x576 to 768x768 STS-1 switch fabric

An in-service upgrade from the 576x576 STS-1 switch fabric to the 768x768 STS-1 switch fabric is available for increasing the cross-connection capacity and supporting additional low-speed shelves.

During the upgrade the two SWITCH/STS576 circuit packs are replaced with two SWITCH/STS768 circuit packs, and 2 of the 4 PPROC/STS192 circuit packs are replaced with two PPROC/STS384 circuit packs.

576x576 STS-1 switch fabric

The 576x576 STS-1 switch fabric in each shelf of the WaveStar TDM 2.5G/10G (2-Fiber) supports:

- Simultaneous cross-connections from each of up to 576 STS-1 equivalent inputs to any of up to 576 STS-1 equivalent outputs.
- Up to 384 STS-1 equivalent one-way cross-connections between inputs and outputs in the same shelf. The remaining 192 STS-1 equivalents are used for cross-connections between the low-speed shelves and the high-speed shelf.

768x768 STS-1 switch fabric

The 768x768 STS-1 switch fabric in the high-speed shelf of the WaveStar TDM 2.5G/10G (2-Fiber) supports:

- Simultaneous cross-connections from each of up to 768 STS-1 equivalent inputs to any of up to 768 STS-1 equivalent outputs.
- Up to 384 STS-1 equivalent one-way cross-connections between inputs and outputs in the same shelf. The remaining 384 STS-1 equivalents are used for cross-connections between the low-speed shelves and the high-speed shelf.

Operations interfaces

The operations interfaces to the WaveStar TDM 2.5G/10G, Release 6 provide data, alarm, and status information on service and equipment. Operations interfaces include a WaveStar® craft interface terminal (WaveStar® CIT), user panels, circuit pack/port unit faceplates, circuit breakers, an office alarm interface, and interfaces to OS systems.

WaveStar CIT

The WaveStar CIT is a personal computer (PC) equipped with the *Windows NT* ™operating system or the *Windows 2000* ™ operating system and loaded with WaveStar CIT software. The WaveStar CIT software includes a graphical user interface (GUI) that can be used to access local and remote network elements via an intraoffice LAN. OS-based software, for example, subnetwork management system (SNMS) provides an alternate method of remote maintenance from an external center.

The WaveStar CIT allows a user to perform the following tasks:

- Establish and/or remove networks and network components
- Maintain cross-connections
- Generate network reports
- Perform provisioning
- Clear network troubles
- Monitor and report network alarms/performance
- Add to and/or drop from both optical and electrical interfaces
- Create nonblocking cross-connections between facilities
- Software download, back-up, and restore

□

Applications

Overview

WaveStar TDM 2.5G/10G (2-Fiber) increases reliability, lowers costs, increases revenues, and supports flexible growth paths in a wide range of applications. Network topologies that use WaveStar TDM 2.5G/10G (2-Fiber) are listed below and described in Chapter 3, “Network Topologies.”

Increased reliability

The following topologies increase network reliability:

- Bidirectional line-switched ring protection
- Unidirectional path-switched ring protection
- Dual ring interworking
- Folded rings
- Path-in-line
- Restoration through protection access

Traffic consolidation

WaveStar TDM 2.5G/10G (2-Fiber) lowers transport costs by supporting

- Ring interconnections
- Flexible optical hubbing architecture, termination of multiple ring and/or linear interfaces
- Hubbing for various ring, 1+1, and 0x1 terminations
- Loop feeders
- Electrical DS3/EC-1 terminations directly on the 2.5G/10G network element

Ring closure and ring transport

WaveStar TDM 2.5G/10G (2-Fiber) can lower transport costs by closing WaveStar TDM 2.5G OC-48 2-fiber rings over WaveStar TDM 2.5G/10G (2-Fiber) rings. The backbone capacity of the WaveStar TDM 2.5G/10G (2-Fiber) can be used to transport traffic to/from DDM-2000 nodes. The OC-48 Backbone capacity of the low-speed shelf can be used to close a partial ring of DDM-2000 and FT-2000 nodes. Also, you can use the WaveStar TDM 2.5G/10G (2-Fiber) to terminate multiple OC-48 BLSRs, OC-48 UPSRs, and OC-12 UPSRs.

Avoiding fiber exhaust

WaveStar TDM 2.5G/10G (2-Fiber) is compatible with Lucent Technologies OLS systems and can use OC-48 and OC-192 dense wavelength division multiplexing (DWDM) to gain capacity on existing fibers. Also, the WaveStar TDM 2.5G/10G (2-Fiber) supports compatible optics for Passive Optics Units (16 wavelengths at the OC-48 rate and 32 wavelengths at the OC-192 rate) to gain capacity on existing fibers. The OLS systems provide increased distance, and the passive optics units provide lower cost.

In addition, you can replace a WaveStar TDM 2.5G or upgrade it to a WaveStar TDM 10G, and create OC-192 2-fiber BLSR "express rings" to bypass exhausted fibers in existing OC-48 BLSRs.

Interface mixing

WaveStar TDM 2.5G/10G (2-Fiber) can lower costs in an environment where there is a mixture of DS3, EC-1, OC-3, OC-12, OC-48, GE1 and OC-192 traffic. WaveStar TDM 2.5G/10G (2-Fiber) provides universal port unit slots in which you can use a mixture of transmission interfaces up to the capacity of the shelves.

Increased Shelf Fill

By supporting mixtures of interfaces, WaveStar TDM 2.5G/10G (2-Fiber) allows you to take full advantage of the shelf capacity and have fewer shelves with unfilled slots.

End-to-End Interface Mixing

You can use a mixture of transmission interfaces in WaveStar TDM 2.5G/10G (2-Fiber) shelves at both ends of a line.

Flexible growth paths

WaveStar TDM 2.5G/10G (2-Fiber) supports a variety of possible growth paths for evolving to full add/drop ring topologies from

- In-service upgrade from a single shelf 2.5G system to a 10G system; for example, an OC-48 2-fiber BLSR can be upgraded to an OC-192 2-fiber BLSR.
- Express rings.
- Folded rings.
- 0% add/drop nodes.

□

Features

Major Features

Major features of WaveStar TDM 2.5G/10G (2-Fiber), are listed below. Chapter 2, “Features,” and Chapter 4, “Product Description,” provide descriptions.

Transmission Interfaces

- 1.5µ intermediate reach OC-192 port unit
- 1.5µ extended intermediate reach OC-192 port unit
- 1.5µ long reach OC-192 port units
- 1.5µ very long reach OC-192 port units
- OC-192 optics compatible for applications with the low-cost Passive Optics Units (POU); 32 different wavelengths
- OC-192 optics compatible for applications with the WaveStar® Optical Line System (OLS) 1.6T; 40 different wavelengths
- 1.3µ very short reach OC-48 port units
- 1.3µ and 1.5µ long reach OC-48 port units
- OC-48 optics compatible for applications with the low-cost Passive Optics Units (POU); 16 different wavelengths
- OC-48 optics compatible for applications with the Metropolis EON (16 wavelengths)
- OC-48 optics compatible for applications with the WaveStar® Optical Line System (OLS) 1.6T (80 different wavelengths)
- 1.3µ OC-12 short and long reach port units
- 1.3µ OC-3 short reach port units (4 ports)
- 1.3µ OC-3 intermediate/short reach port units (8 ports)
- 1.3µ OC-3 long reach port units (4 ports)
- DS3EC1/8 port units (8 ports)
- Gigabit Ethernet Interface (GE1) port units (short and long reach)
- Universal optical connectors

Protection

- OC-192 and OC-48 2-fiber BLSR protection
- OC-192, OC-48, and OC-12 UPSR (STS-1 path) protection
- OC-48, OC-12, OC-3 linear 1+1 facility protection (bidirectional, both revertive and nonrevertive)
- OC-192, OC-48, OC-12, OC-3 0x1
- GE1 0x1
- OC-192 BLSR Non-preemptible Unprotected Traffic (STS-1 NPPA)
- User provisionable DCC protection mode
- Non-revertive timing hardware protection

Administration and Provisioning

- STS-1, STS-3, STS-12, and STS-48 cross-connection rates, including support for STS-Nc rate signals
- Provisionable SS bits
- In-band and out-of-band forward error correction (FEC) for OC-192 port units
- Two-way, one-way, bridging, and dual ring interworking (DRI) cross-connection topologies
- Rolling cross-connections for all supported signals
- Red-lined cross-connections
- Near and Far-side facility loopbacks
- Equipment inventory
- Security
- TCP/IP and OSI access to LAN and DCC interface
- Remote software downloads
- Remote Network Element Status (RNES)
- Alarm Gateway Network Element (AGNE)
- WaveStar Craft Interface Terminal (CIT)
- DCCr (section) and DCCm (line) channels on all optical interfaces
- Login and Password aging
- NE (network element) based inactivity logout

Maintenance

- Automatic Laser Shutdown (ALS) on long-reach and very long-reach OC-192 interfaces
- Threshold Crossing Alert (TCA) reporting
- Circuit provisioning audits
- Operations interworking
- Full TL1 command/message set
- STS-1 path trace
- Software backup and restoration
- Standard SONET transmission maintenance signals
- SONET section and line performance monitoring
- DS3 performance monitoring
- Advanced NVM/DB consistency checks
- PM Bin access

Synchronization

- DS1 timing outputs
- OC-192 line timing (with SSM), up to 8 line references from the OC-192 system
- OC-48 line timing (with SSM), up to 6 line references when using only the OC-48 low-speed (tributary) shelf
- OC-3, OC-12, OC-48, and OC-192 S1 byte synchronization messaging
- Synchronization mode auto reconfiguration based on S1 byte (SONET only)

FT-2000 Dual Bay Frame and DS3 Connector Panel Mounting Options

- Mounting of tributary, low-speed shelf in FT-2000 dual bay frame
- Internal- horizontal DS3/STS-1 connector panel mounting arrangement
- External- vertical DS3/STS-1 connector panel mounting arrangement
- Rear mounting arrangement for DS3/STS-1 connector panels

□

2 Features

Overview

Purpose

This section describes features supported in the WaveStar TDM 2.5G/10G (2-Fiber). The sections below contain information concerning hardware, software, and system relevant features.

Transmission Interfaces

Overview

The TDM 2.5G/10G (2-Fiber) Release 6 add/drop multiplexer is an extremely versatile high speed SONET system that supports long haul, backbone, metro, interoffice, optical hubbing, and access applications. The system supports a SONET line rate of 9.953 Gb/s on its high-speed shelf, which can be equipped with up to two OC-192 port units, to support OC-192 2-fiber BLSR or UPSR or 0x1 applications. On the low-speed tributary shelf, a number of port units are available, and many protected and unprotected equipment and topologies are supported. The tributary shelf can also be deployed as stand-alone OC-48 system (2.5G application), supporting a SONET line rate of 2.488 Gb/s. The WaveStar TDM 2.5G/10G (2-Fiber) is highly scalable. For example, an in-service upgrade is supported for migrating from an OC-48 2-fiber BLSR to an OC-192 2-fiber BLSR. Additionally, OC-192 and OC-48 compatible optics are supported to allow the cost-effective deployment of multiplex and DWDM architectures.

Incoming traffic from a BLSR can be transmitted or “dropped” to circuit packs on the low-speed, tributary shelves. These port units, in turn, transmit the traffic on to connected outgoing lines. Similarly, traffic coming into the tributary shelves can be “added” to the outgoing traffic on the BLSR.

Port unit slots for transmission circuit packs

Each WaveStar TDM 2.5G/10G (2-Fiber) tributary shelf supports 16 port unit slots (for transmission interface circuit packs). The transmission interface circuit packs support DS3, EC-1, OC-3, OC-12, GE1, and OC-48 signals and can be installed up to the limits of the shelf capacity and according to the port location rules (described in Chapter 6, “System Planning and Engineering”).

The WaveStar TDM 2.5G/10G (2-Fiber) can transport synchronous digital hierarchy (SDH) STM-N payloads, although it does not fully support the SDH features that the WaveStar® TDM 10G (STM-64) supports (such as SDH protection and performance monitoring).

OC192 port units

The OC192 port units support 2-fiber BLSRs or UPSRs on the high-speed shelf.

The OC192/STM64/1.5VLR1 (very long reach) port unit supports standard SONET signals over 1.5µ fiber for spans of up to 120 km with Forward Error Correction (FEC).

The OC192/STM64/1.5LR1 (long reach) port unit supports standard SONET signals over 1.5µ fiber for spans of up to 80 km with FEC.

The OC192/STM64/1.5IR1 (extended, intermediate reach) port unit supports standard SONET signals over 1.5µ fiber for spans of up to 60 km with FEC.

The OC192/STM64/1.5ISR1 (intermediate reach) port unit supports standard SONET signals over 1.5µ fiber for spans of up to 50 km with FEC (Forward Error Correction) and up to 40 km without FEC.

The Passive DWDM OC-192 compatible optics port units, OC192/STM64/POU9590 through OC192/STM64/POU9220, support transmission of up to 32 different OC-192 wavelengths in the 1.5µ range on a single fiber, when used with the Lucent Technologies Passive Optics Units (DWDM filter units), for spans of up to 36 km (with FEC). Transmission of up 16 different OC-192 wavelengths on one fiber is supported for spans of 50 km (with FEC), using the appropriate port units and Passive Optics Units. Transmission for longer spans is possible using optical amplifiers

The other series of the WaveStar TDM 2.5G/10G (2-Fiber) OC-192 compatible optics, OC192/STM64/WDM9580 through OC192/STM64/WDM9190, supports transmission of up to 40 different OC-192 wavelengths in the 1.5µ range on one fiber, when used in applications with WaveStar® Optical Line System (OLS) 1.6T system.

Each port supports GR-253 compliant SONET signals over single mode fiber, and can carry STS-1, STS-3c, STS-12c, and STS-48c payloads.

OC48 port units

Each OC48 port unit can support STS-1, STS-3, STS-12, and STS-48 payloads.

The OC48/STM16/1.3LR1 port unit provides one OC-48 port and supports standard SONET signals over 1.3µ fiber for spans of up to 51 km.

The OC-48/STM16/1.5LR1 port unit provides one OC-48 port and supports standard SONET signals over 1.5µ fiber for spans of up to 80 km.

OC48/STM16/1.3VSR1 port unit provides one OC-48 port and supports standard SONET signals over 1.3µ fiber for spans of up to 2 km.

The Passive DWDM OC-48 compatible optics port units, OC48/STM16/POU9590 through OC48/STM16/POU9210, are available in 16 different OC-48 wavelengths in 1.5µ range to support Passive DWDM applications with the Lucent Technologies Passive Optics Units (DWDM filter units). Transmission distances of up to 65 km are supported using these OC-48 compatible optics and the appropriate Passive Optics Units.

The two other series of WaveStar TDM 2.5G/10G (2-Fiber) OC-48 compatible optics are used for DWDM applications, with the Metropolis EON or the WaveStar® OLS 1.6T. The OC48/STM16/DWDM01 through OC48/STM16/DWDM16 port units, 16 different OC-48 wavelengths, are used in DWDM applications with Metropolis EON. The OC48/STM16/WDM9585 through OC48/STM16/WDM9190 port units, 80 different OC-48 wavelengths, are used in DWDM applications with the WaveStar® 1.6T. Transmission distances, for the spans carrying the multi-wavelength DWDM signals are specified in the appropriate Metropolis EON or WaveStar® OLS 1.6T documentation.

The OC-48 port units support 2-fiber bidirectional line switched rings (BLSRs) as well as 1+1 bidirectional or unidirectional, revertive or nonrevertive facility protection on the low-speed shelves. The OC-48 port units also support UPSR and 0x1 protection schemes. Each low-speed shelf supports up to 8 OC-48 interfaces (4 OC-48 UPSRs, 4 OC-48 BLSRs, 4 OC-48 1+1 unidirectional, nonrevertive protected interfaces, and 8 0x1 OC-48 interfaces). The OC-48 port units also support 1+1 unidirectional, nonrevertive protection.

Each port supports GR-253 compliant SONET signals over single mode fiber, and can carry STS-1, STS-3c, STS-12c, and STS-48c payloads.

OC12 port units

The OC12/STM4/1.3LR2 and OC12/STM4/1.3SR2 port units each provide two OC-12 ports. OC-12 traffic can be optionally protected by 1+1 protection (bidirectional or unidirectional; revertive or nonrevertive). The OC-12 port units also support UPSR (STS-1 path switched) functionality and 0x1 protection schemes. Each OC-12 port can carry STS-1, STS-3c, and STS-12c payloads.

OC3 port units

The OC3/STM1/1.3LR4 and OC3/STM1/1.3SR4 port units each provide four OC-3 ports. The OC3/STM1/1.3IR-SR8 port units provide 8 OC-3 ports. Each port supports GR-253-compliant SONET signals over single-mode fiber and can carry STS-1 or STS-3c payloads. OC-3 traffic can be optionally protected by bidirectional 1+1 protection (revertive or nonrevertive) or 0x1 protection schemes. The OC-3 port units also support 1+1 unidirectional, nonrevertive protection. Each OC-3 port can carry STS-1 and STS-3c payloads.

DS3/EC-1 port units

The DS3EC1/8 port unit provides eight GR-253-compliant DS3 ports. Each port provisioned as EC-1 supports STS-1 path overhead to and from the SONET signal. DS3EC1/8 port units can be provisioned for 1xN equipment protection for DS3 signals (where $N \leq 12$).

The ports support the following types of DS3 signal formatting:

- C-bit parity DS3 signals
- M23 formatted DS3 signals (as defined in T1.107)
- Unframed and clear channel DS3 signals
- Framed

The DS3EC1/8 port units also support EC-1 (Electrical Carrier-1) signals provisioned for 0x1 or 1xN protection.

Gigabit Ethernet

The following Gigabit Ethernet features are available:

Port Units

The GE1/SX2 port unit provides two Gigabit Ethernet (GE1) ports. Each port supports IEEE 802.3-compliant Ethernet signals over multi mode fibers. All connections to the 1000BASE-SX Ethernet interface on the GE1/SX2 port unit require Dual SC Connectors.

The GE1/LX2 port unit also provides two Gigabit Ethernet (GE1) ports. Each port supports IEEE 802.3–compliant Ethernet signals over single mode or multi mode fibers. All connections to the 1000BASE-LX Ethernet interface on the GE1/LX2 port unit require Dual SC Connectors.

LCAS/VBA

The WaveStar TDM 2.5G/10G (2-Fiber) supports the technique of, previously known as variable bandwidth allocation (VBA), for Gigabit Ethernet transport. Link capacity adjustment scheme (LCAS) defines a synchronization protocol between two termination points of a virtual concatenated path that allows in-service dynamic sizing of the STSn-xv bandwidth available for Ethernet over SONET transmission. This bandwidth change can occur either in response to a failure condition on one member or a change in bandwidth requirement at a NE (provisioning action). In case of a failure, the bandwidth will be restored automatically after the failure clears. The size of the STS1-xv is increased or decreased in steps of one STS1.

The provisioning is performed by connecting/disconnecting paths to/from the Ethernet tributary card.

Ethernet Performance Monitoring

It is possible to monitor byte and packet related performance parameters on any LAN port and any WAN port. The following counters are supported for each port:

- Outgoing number of Mbytes
- Dropped frames – errors
- Incoming number of Mbytes

Full VLAN List Support

The system supports 4093 VLANs per GE1 circuit pack in IEEE VLAN tagging mode. The VLANs must be unique per port.

VLAN ID Transparency

The system supports promiscuous/buffering repeater mode forwarding all Ethernet packets between one external LAN port and one internal WAN port without address filtering, address learning, spanning tree algorithm nor VLAN support. This mode can be selected per GE1 port.

Auto-Negotiation Bypass

Normally, if an equipment with the auto-negotiation function enabled is connected to a link partner with the auto-negotiation function disabled, then the auto-negotiating equipment will declare an auto-negotiation error and will consider the link as down. Therefore, a two-way communication cannot be established.

"Auto-negotiation bypass" solves that problem. The functionality is as follows: if the system detects that the link partner is available but does not support auto-negotiation, then it bypasses the auto-negotiation and establishes the interface with a fixed configuration: Full-Duplex and Flow Control enabled. Moreover, no auto-negotiation error is detected.

Interface mixing

The WaveStar TDM 2.5G/10G (2-Fiber) add/drop multiplexer supports up to 16 port units in the universal port unit slots within each low-speed shelf, in addition to the OC-192 port units in the high-speed shelf. These port units can be combinations of DS3EC1, OC-3, OC-12, GE1/SX2, GE1/LX2, and OC-48 port units.

The numbers of add/drop port units of a single type needed to terminate all the working traffic in an OC-192 2-fiber ring (up to 192 STS-1 equivalents) are:

- 24 DS3EC1/8 port units. With 1xN protection, if N = 12 protected (electrical) port units, 192 ports support 192 STS-1 equivalents. With 1xN protection, one protection DS3EC1/8 port unit must also be installed in the EPRN slot of each tributary shelf for a total of 26 DS3EC1/8 port units.
- 16 OC3/STM1 (8 port) port units. With 1+1 protection, 8 service and 8 protection, 64 ports support 192 STS-1 equivalents.
- 32 OC3/STM1 (4 port) port units. With 1+1 protection, 16 service and 16 protection, 64 ports support 192 STS-1 equivalents.
- 16 OC12/STM4 (2-port) port units. With 1+1 protection, 8 service and 8 protection, 16 ports support 192 STS-1 equivalents.
- 8 OC48/STM16 port units. With BLSR protection, 4 west and 4 east, 8 ports support 192 STS-1 equivalents.
- 8 GE1/SX2, 8 GE1/LX2, or a mix up to 8 total GE1/SX2 and GE1/LX2 port units per each low-speed (tributary) shelf in a WaveStar TDM 2.5G/10G (2-Fiber) system. When using the low-speed shelf as a stand-alone 2.5G application, the 2.5G shelf supports a maximum of 6 GE1/SX2 port units (at least 4 slots must be occupied by OC48/STM16 port units in a stand-alone 2.5G application). With BLSR or UPSR protection, 8 west and 8 east, 16 ports support $\geq$192 STS-1 equivalents (a maximum of 12 ports supported by a stand-alone 2.5G application).

Important! The system can also add or drop traffic from the protection access channels of a BLSR onto the same ports. OC-3, OC-12, and OC-48 also support unprotected (0x1) traffic, which can double the amount of working capacity. To add/drop all the working traffic plus all the protection access traffic or to add/drop unprotected traffic requires twice these numbers of add/drop ports.

Universal optical connectors

WaveStar TDM 2.5G/10G (2-Fiber) OC-192 and OC-48 port units are equipped with 0 dB SC-type connectors and are also capable of operating with FC-type and ST-type connectors. The LEY23AE, LEY101AE-180AE, and LEY 201AE-240AE port units are shipped equipped with LC-type connectors. The connectors are available in kits that provide several values of optical attenuation.

Large Distributed STS-1 Cross Connect Switch Fabric/s, Large Interface Capacity

Each low-speed shelf supports up to 384 STS-1 equivalents of interface capacity which can be used to support a mix of OC-48 BLSR, OC-48 UPSR, OC-48 1+1, OC-48 0x1, OC-12 UPSR, OC-12 1+1, OC-12 0x1, OC-3 1+1, OC-3 0x1, DS3, EC-1, and/or Gigabit Ethernet ports. (The 1xN equipment protection for DS3/EC-1 port units is separate, not a part of this interface capacity.) The high-speed shelf supports up to 384 STS-1 equivalents of interface capacity which can be used to support one OC-192 2-Fiber BLSR, or one OC-192 UPSR, or two 0x1 (unprotected) OC-192 ports.

768 x 768 STS-1 switch fabric, support for up to 4 low speed tributary shelves

With the 768 x 768 STS-1 switch fabric, the system supports one to four low-speed tributary shelves. The cross-connection capacity of the system allows non-blocking connectivity between all 384 STS-1 equivalents of the interface capacity within each shelf, and, in addition, up to 384 STS-1 equivalents of non-blocking connectivity between the high-speed shelf and the low-speed shelves. This is sufficient, with any combination of optical and electrical interfaces in the low-speed shelves, to support full add/drop of all the traffic carried by an OC-192 ring, including both the working (protected) and the protection access (unprotected) traffic in an OC-192 BLSR, or all the traffic carried by two unprotected OC-192 ports. The 768x768 STS-1 switch fabric and 384 STS-1 pointer processor circuit packs are used only in the high speed shelf. Chapter 4 provides details on the hardware required to implement the 768x768 STS-1 switch fabric in the high-speed shelf.

576x576 STS-1 switch fabric, support for up to two low-speed shelves

With the 576 x 576 STS-1 switch fabric and 192 STS-1 pointer processor in the high-speed shelf, the system supports one or two low-speed tributary shelves. The cross-connection capacity of the system allows non-blocking connectivity between all 384 STS-1 equivalents of the interface capacity within each shelf, and, in addition, up to 192 STS-1 equivalents of non-blocking connectivity between the high-speed shelf and the low-speed shelves. This is sufficient, with any combination of optical and electrical interfaces in the low-speed shelves, to support full add/drop of all the working (protected) traffic carried by an OC-192 BLSR or UPSR.

Hairpinning

The 576 by 576 STS-1 switch fabric is also used in the low speed shelf (or 2.5G stand-alone application). Full hairpinning capability on each low speed tributary shelf is supported allowing the most efficient use of bandwidth. STS-1 level signals can be cross connected between any ports on the low speed tributary shelf.

Note:

> The WaveStar TDM 2.5G/10G (2-Fiber) supports STS-1, STS-3, STS-3c, STS-12, STS-12c, STS-48, and STS-48c cross connects.

The user provisions cross-connections only for the working (protected) traffic and any additional unprotected traffic carried by 0x1 ports or by BLSR protection access. Since the additional connections between working and protection tributaries for BLSR, UPSR, and 1+1 port protection are made automatically by the system within each shelf, they are not counted in the utilization of the cross-connection capacity between the high-speed and low-speed shelves.

Total transmission capacity

The total transmission capacity for a system with 2 low-speed shelves is 1152 STS-1 equivalents. For a system with 4 low-speed shelves it is 1920 STS-1 equivalents.

Mixed switch fabrics interworking

The 576x576 and the 768x768 STS-1 switch fabrics can be used in different 10G nodes, mixed in a network, allowing for the most cost effective use of hardware and utilization of interface capacity. For example, in a four node OC-192 2F BLSR, three of the OC-192 nodes can be equipped with the 576 x 576 STS-1 switch fabric in their high speed shelves, and the fourth OC-192 node can be equipped with the 768x768 STS-1 switch fabric in its high speed shelf. Chapter 4 provides details on how to equip the high-speed shelf to support the 768x768 or 576x576 STS-1 switch fabric.

□

Upgrades

In-service upgrade from WaveStar TDM 2.5G to WaveStar TDM 10G

The WaveStar TDM 2.5G/10G (2-Fiber) system supports an in-service upgrade from a 2.5G application, single OC-48 2-fiber BLSR, to the 10G application, an OC-192 2-fiber BLSR. This feature facilitates network planning by allowing the possibility for seamless future growth. The single-shelf 2.5G system can be upgraded if the physical space has been provided in the bay. At installation time, the customer must decide whether or not to leave physical space for any future expansion that may be anticipated.

In-service upgrade from 576x576 to 768x768 STS-1 switch fabric

The switch fabric in the high-speed shelf can be upgraded, while the system is in-service, from the 576x576 STS-1 switch fabric to the 768x768 STS-1 switch fabric. The 768x768 STS-1 switch fabric doubles the inter-shelf cross-connection capacity (between the high-speed shelf and the low-speed shelves) from 192 STS-1 equivalents to 384 STS-1 equivalents. The larger cross-connection capacity, in the high-speed shelf allows the system to support up to 4 low-speed shelves. During the upgrade the two SWITCH/STS576 circuit packs are replaced with two SWITCH/STS768 circuit packs, and 2 of the 4 PPROC/STS192 circuit packs are replaced with two PPROC/STS384 circuit packs.

For a system with only one low-speed shelf before the upgrade (or a system installed initially with the 768x768 STS-1 switch fabric), the additional 192 STS-1 equivalents of inter-shelf connection capacity can be used for connections between the high-speed shelf and a second low-speed shelf. This is useful to terminate all 384 STS-1 equivalents of traffic that can be carried in 2 unprotected (0x1) OC-192 ports, or all of both the working and protection access traffic in an OC-192 2-Fiber BLSR. It is also useful for interconnecting more traffic between different low-speed shelves via the high-speed shelf.

For any system, whether upgraded or installed initially with the 768x768 STS-1 switch fabric in the high-speed shelf, the additional 192 STS-1 equivalents of inter-shelf connection capacity increases the number of low-speed shelves supported from 2 to 4. The original 192 STS-1 equivalents of inter-shelf connection capacity can be either dedicated to one low-speed shelf or shared by a pair of low-speed shelves; and the additional inter-shelf capacity can also be either dedicated to another low-speed shelf or shared by a second pair. Only the first pair of low-speed shelves can be used to add/drop all traffic from an OC-192 UPSR, but otherwise the transmission capabilities of each low-speed shelf are the same. The pairing of shelves is determined by cabling, not by the order in which the shelves are added.

□

Internal and External Optical Amplifiers

Internal Optical Amplifiers

For those OC-192 long distance applications over 60 km (loss budget exceeds 18 dB), the WaveStar TDM 2.5G/10G (2-Fiber) system supports two in-shelf optical amplifier units, the Optical Booster Amplifier (OBA) and the Optical Booster/Pre-Amplifier (OBPA). The OBA and OBPA allow the system to support OC-192 applications up to 80 km and up to 120 km, respectively, on SMF - eliminating the need for additional equipment, such as 0% add/drop terminals or regenerators.

The OBA, the SEN3AE, can be paired with various OC-192 optical port units, typically the LEY69AE, to support applications up to 80 km on SMF.

The OBPA, the SEN4AE, supports applications up to 120 km on SMF. The SEN4AE provides an OBA type function, and also provides a pre-amplifier function. The SEN4AE pre-amplifier receiver filter is frequency dependent, and must operate at a wavelength of 1552.52 nm, therefore, the SEN4AE must be paired with a LEY295AE or LEY228AE OC-192 port unit.

External Optical Amplifiers

For those applications in which the OBA and OBPA are already in use or cannot be used, Lucent Technologies offers a stand-alone External Optical Amplifier (OA) system. This system can be used for both OC-48 and OC-192 applications.

The WaveStar TDM 2.5G/10G (2-Fiber) and the External OA system can be combined to support single span, single frequency, applications of up to 170 km and 140 km, for OC-48 and OC-192 rates, respectively. Deploying OAs at multiple sites, intermediate sites and end points, allows transmission of information of up to 500 km, for single wavelength applications using SMF, with five 100 km spans.

The OAs support unidirectional operation, the optical signal is amplified in one direction.

More information on the External OA system and its applications can be found in Chapter 3.

The loss and dispersion characteristics [chromatic dispersion (CD) and Polarization Mode Dispersion (PMD)] for optical equipment and fiber must be considered for all network designs. The signal to noise (S/N) ratio may also need to be calculated for applications. Dispersion Compensation Modules (DCMs) may or may not be required depending on the fiber route characteristics, the optical line rate being amplified, and optical characteristics of the all equipment. Greater span distances can be achieved, and DCMs can be eliminated or reduced in number when Lucent Technologies TrueWave (non zero dispersion shifted) fiber is used.

It is assumed that the PMD requirements for a specific application, are consistent with those requirements specified in ITU-T.691 for OC-48 applications, and Telecordia GR 1377 for OC-192 applications.

□

Compatible OC-48 and OC-192 optics for DWDM applications

To ensure the most cost effective utilization of fiber and relief from fiber exhaust problems, the WaveStar TDM 2.5G/10G (2-Fiber) Release 6 systems supports compatible optics, both at the OC-48 and OC-192 rates, for DWDM applications with the Lucent Technologies Metropolis™ EON system, the Lucent Technologies WaveStar® OLS 1.6T system, and Lucent Technologies Passive Optics Units (a family of Passive DWDM Filter Units).

The WaveStar TDM 2.5G/10G (2-Fiber) OC-48 and OC-192 compatible optics include:

- 16 different OC-48 wavelengths, in the 1.5 micron range, for use in applications with the Lucent Technologies Metropolis™ EON system
- 40 different OC-192 wavelengths, and 80 different OC-48 wavelengths, in the 1.5 micron range, for applications with the Lucent Technologies WaveStar® Optical Line System (OLS) 1.6T system.
- 32 different OC-192 wavelengths, and 16 different OC-48 wavelengths, in the 1.5 micron range, for applications with the Lucent Technologies Passive Optics Units (POUs) in Passive DWDM applications

The use of compatible optics in the WaveStar TDM 2.5G/10G (2-Fiber), ensures no Optical Translator Units (OTUs) are required in, or external to, the DWDM system. This provides significant cost and floor space savings.

More information on Lucent Technologies Passive Optics Units (POUs) is provided in the next section “Passive Optics Units.”

□

Passive Optics Units (Passive DWDM Filter Units)

Overview

Lucent Technologies Passive Optics Units (POUs) are a family of Passive WDM and DWDM filter units that complement Lucent Technologies overall product offerings, to provide the most cost-effective transport of signals over a fiber, to maximize fiber and network utilization, and to relieve fiber exhaust conditions.

Passive optics units

The 4 POUs are:

- 16CH-MUX
- 16CH-DMUX
- 16CH-MUXINT
- 16CH-DMUXINT

Passive optics description

These 4 units combine multiple signals, of different wavelengths, onto a single fiber. Each MUX/DMUX pair supports the optical combining of 16 signals of different wavelengths onto one fiber in one direction (16 wavelength unidirectional application), or the optical combining of 8 wavelengths from 2 directions (8 east to west and 8 west to east) onto one fiber (8 wavelength bidirectional application).

The 4 POUs can be combined to support 32 wavelength unidirectional or 16 wavelength bidirectional applications. In these applications, the wavelengths for the 16CH-MUX and 16CH-DMUX pair are interleaved with the other 16 wavelengths from the 16CH-MUXINT and 16CH-DMUXINT pair. The “INT” denotes interleaver.

Applications supported

The following applications are supported with the POUs and the WaveStar TDM 2.5G/10G (2-Fiber) R6 system equipped with Passive DWDM compatible optics:

- Unidirectional transport of up to 16, OC-192 and/or OC-48, wavelengths on one fiber using the 16CH-MUX and the 16CH-DMUX
- Bidirectional transport of up to 8, OC-192 and/or OC-48, wavelengths on one fiber using the 16CH-MUX and the 16CH-DMUX
- Unidirectional transport of up to 16 OC-192 wavelengths on one fiber using the 16CH-MUXINT and the 16CH-DMUXINT
- Unidirectional transport of up to 32 OC-192 wavelengths on one fiber using the 16CH-MUX, 16CH-DMUX, 16CH-MUXINT, and 16CH-DMUXINT

- Bidirectional transport of up to 16 OC-192 wavelengths on one fiber using the 16CH-MUX, 16CH-DMUX, 16CH-MUXINT, and 16CH-DMUXINT

Power, operations, and software support

The POUs do **not** require power, software, or operations support.

Protection and alarming functions

Protection schemes and alarming functions can be performed by the multiplexers or DCS systems connected to the POUs.

□

Administration and Provisioning

Overview

Specialized “craftspeople” perform administration and provisioning for a network. This section summarizes the major administration and provisioning features. For more detailed information, consult the *WaveStar TDM 2.5G/10G, Release 6 User Operations Guide*, the *WaveStar TDM 2.5G/10G (2-Fiber), Release 6 Alarm Messages and Trouble Clearing Guide*, and the *WaveStar TDM 2.5G/10G, Release 6 Operations Systems Engineering Guide*.

Fixed rate tributary operation

WaveStar TDM 2.5G/10G (2-Fiber) supports both fixed and adaptive rate tributary operation. In fixed rate operation, the user provisions tributaries for the expected signal rates. The system uses this provisioned information for cross-connection rate validation and for fault handling (e.g. loss of pointer) when signals are not received at these rates.

Adaptive rate (pipe) tributary operation

WaveStar TDM 2.5G/10G (2-Fiber) supports both fixed and adaptive rate tributary operation. In adaptive rate operation, the user does not provision tributaries for expected signal rates. In this mode the system identifies and adjusts to transitions in the signal rates.

Signal Rates

The WaveStar TDM 2.5G/10G (2-Fiber) cross connects STS-1, STS-3, STS-12, and STS-48 signals. The WaveStar TDM 2.5G/10G (2-Fiber) also supports STS-Nc rate signals (e.g. STS-3c, STS-12c, STS-48c). The signals are treated as clear channel SPEs (Synchronous Payload Envelopes) by the cross-connect fabric. The path payload and the path overhead are cross-connected transparently as a unit.

DS3/STS-1

The system handles signals to and from DS3 ports by means of STS-1 cross- connections. This supports DS3/STS-1 gateway cross-connections between DS3 interfaces and SONET interfaces. DS3 signals are handled transparently (that is, no bits are altered).

Two-way cross-connections

A two-way cross-connection is created by connecting both directions of traffic between two tributaries. You can create these for any of the supported SONET signal rates between ports having compatible mappings. The signals are treated as clear-channel Synchronous Payload Envelopes (SPEs) by the cross-connect fabric. That is, the path payload and path overhead are cross-connected transparently as a unit.

One-way cross-connections

One-way cross-connections can be made for all supported SONET signal rates between any tributaries on any ports with appropriate mappings. The corresponding signal in the other direction of either tributary at either port can be independently cross-connected or terminated with no cross-connection. In the latter case, the system inserts an appropriate idle/unequipped signal at the output.

DRI cross-connections

WaveStar TDM 2.5G/10G (2-Fiber) dual node ring interworking (DRI) cross-connection complies with ANSI T1.105.01 and Telcordia GR-253-CORE, GR-1230-CORE, and GR-1400-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 Bidirectional Line Switched Ring.

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. Such connections are used for dual node ring interworking with the drop and continue method. WaveStar TDM 2.5G/10G (2-Fiber) 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.

Red-lined cross-connections

WaveStar TDM 2.5G/10G (2-Fiber) supports a “red-line” parameter. This provides a higher level of security for specified cross-connections.

Rolling cross-connections

The WaveStar TDM 2.5G/10G (2-Fiber) provides the capability to change the location or source of either the input or output tributary of a given facility, without affecting service. The WaveStar TDM 2.5G/10G (2-Fiber) 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 or output tributary to the corresponding input or output tributary

In Release 5 and later releases, rolling an existing cross-connection from a virtual concatenated group (VCG) tributary to another tributary is not supported.

Nonrevertive timing hardware protection

The WaveStar TDM 2.5G/10G (2-Fiber) master clock hardware is 1+1 protected by means of nonrevertive automatic protection switching.

Equipment inventory

WaveStar TDM 2.5G/10G (2-Fiber) automatically maintains an inventory of the following information:

- Type, version, and serial number of each installed circuit pack
- Software release
- Enabled features

You can obtain this information by an inventory request command.

Security

WaveStar TDM 2.5G/10G (2-Fiber) uses logins, passwords, authentication, and access levels to protect against unauthorized access. It also keeps a log.

OSI LAN and DCC interfaces

WaveStar TDM 2.5G/10G (2-Fiber) also communicates with remote logins, operations systems, and management systems by means of standard 7-layer OSI protocol over a LAN and over DCC channels. The OSI or TCP/IP protocol can be used directly with the WaveStar TDM 2.5G/10G (2-Fiber). If there is a Lucent Technologies NCC (Network Communications Controller) on the LAN, then WaveStar TDM 2.5G/10G (2-Fiber) can communicate with X.25 or TCP/IP links by way of the NCC.

DCCr and/or DCCm channels on all optical interfaces

The WaveStar TDM 2.5G/10G (2-Fiber) supports both section and line DCC channels on OC-3, OC-12, OC-48, and OC-192 interfaces. A port can be provisioned to support either DCCr (section) or DCCm (line) signals, or both.

The WaveStar TDM 2.5G/10G (2-Fiber) supports at least 32 DCCr/DCCm signals per shelf.

DCC protection

The DCC protection switch mode can be applied to both DCCr and DCCm, for any optical interface rate. DCC signals can be 1+1 protected.

Remote software downloads

WaveStar TDM 2.5G/10G (2-Fiber) can download software from the WaveStar Craft Interface Terminal (CIT), from an Element Management System or from a Network Management System. Software downloading does not affect transmission or operations. Installing the newly downloaded software may affect operations but does not affect transmission.

WaveStar CIT

Operations, administration, maintenance, and provisioning (OAM&P) activities are performed using either the WaveStar CIT or the operations system interface. The WaveStar CIT is a customer-supplied Pentium™ 266 MHz processor with Microsoft *Windows NT*™ or Microsoft *Windows 2000*™software running the WaveStar Graphical User Interface (GUI) software. You can plug this PC into a WaveStar TDM 2.5G/10G (2-Fiber) user panel or use it at a remote location to access WaveStar TDM 2.5G/10G (2-Fiber) by means of a WAN (Wide Area Network). You can use the WaveStar CIT to run a full-featured GUI or TL1 scripts. Using the GUI, a craftsperson can access all WaveStar TDM 2.5G/10G (2-Fiber) software functions and context-sensitive help.

IP Access

The WaveStar TDM 2.5G/10G (2-Fiber) supports three types of IP Access. In one case, the WaveStar TDM 2.5G/10G (2-Fiber) can serve as a TL1 Translation Device (T-TD) by being a gateway network element that allows an SNMS and/or CIT to communicate to other network elements (NEs) on an OSI network through an IP access network. In the second instance, the WaveStar TDM 2.5G/10G (2-Fiber) 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. In the third instance WaveStar TDM 2.5G/10G (2-Fiber) is configured as an FTTD-FTP/FTAM gateway.

TL1 Translation

The WaveStar TDM 2.5G/10G (2-Fiber) 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. For each application, a specific gateway is needed. Separate gateways can be provided by a single WaveStar TDM 2.5G/10G (2-Fiber).

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 WaveStar TDM 2.5G/10G (2-Fiber) 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 an SNMS 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.

FTAM-FTP gateway (FT-TD)

WaveStar TDM 2.5G/10G (2-Fiber) supports the FTAM-FTP gateway functionality, allowing file transfers across a mixed OSI and TCP/IP network. The FTAM-FTP gateway is used in a mixed OSI and IP network, where the access DCN is IP and the NEs being managed are in a OSI network. The FTAM-FTP gateway translates FTAM (File Transfer and Management) over OSI presentation to FTP over TCP-IP. The FTAM-FTP gateway is also referenced as FT-TD (File Transfer Translation Device).

Login aging

The WaveStar TDM 2.5G/10G (2-Fiber) supports login aging on all user logins. Login aging deletes a user's login if he/she has not logged into the system within or during a provisionable length of time. The login aging time limit is provisionable.

Password aging

The WaveStar TDM 2.5G/10G (2-Fiber) supports password aging on all user logins. Password aging requires a user with an expired password to select a new password before logging into the system. The password aging time limit is provisionable.

NE based inactivity logout

The WaveStar TDM 2.5G/10G (2-Fiber) is capable of automatically logging out users on an operations interface after a provisionable period of inactivity. The automatic logout is performed by the NE (Network Element), not by the CIT.

Advanced NVM/DB consistency checks

The WaveStar TDM 2.5G/10G (2-Fiber) checks the NVM (Non-Volatile Memory) for empty, corrupt, or incorrect database (e.g., from another system) upon startup. This preliminary check safeguards the system against loss of transmission due to inadvertent procedural errors by the crafts person.

Remote NE Status (RNES)/Alarm Gateway Network Element (AGNE)

The WaveStar TDM 2.5G/10G (2-Fiber) supports the ability to detect and share alarm, condition, and miscellaneous discrete information between local and remote NEs, that are part of the same Alarm Group. Provisioning RNES enables an NE to become a member of an Alarm Group. Within an Alarm Group, at least one NE must be provisioned as an AGNE. The AGNE exchanges information to and from NEs in its Alarm Group, via the DCC. The AGNE broadcasts all alarm and status information from one NE to all of the other NEs in the same alarm group to activate remote far-end summary alarm reports and remote office alarms for each NE in the alarm group. Remote alarm activity includes the activation of User Panel LEDs, and generation of audible and visual office alarms. Depending on provisioning, a NE in an alarm group can:

- Notify the AGNE of any alarm/status changes
- Notify the Alarm Gateway Network Element (AGNE) of any miscellaneous discrete changes
- Know the alarm/status of all members of the same alarm group
- Know the status of miscellaneous discrete information for all members of the same 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 groups can be nodes in a ring, nodes of a linear extension, or any other logical grouping of NEs such as a maintenance group or geographical group. All members within the same alarm group share NE status information. Information is not shared with NEs of other alarm groups.

The RNES/AGNE feature is supported on other Lucent Technologies products, such as DDM-2000 Release 15. Products that support the RNES/AGNE feature can share remote alarm information, provided they are provisioned to be in the same alarm group.

For more information, see Chapter 5.

OC-192 and OC-48 BLSR Preemptible Protection Access

Half of the STS-1 tributaries in a BLSR are normally used to carry working (protected) traffic and the other half to provide the protection. By assigning cross-connections to the protection tributaries themselves, you can carry extra traffic on the protection tributaries. When a protection switch is active in the BLSR, the protection capacity is used to protect the working traffic, and the extra traffic is preempted (lost). Preemptible protection access provides additional capacity for traffic that does not require protection and can be preempted during a protection switch. Applications include optional revenue-generating services that are lower priority and less expensive for the end user than protected service, and mesh network restoration.

OC-192 BLSR Non-preemptible Unprotected Traffic (STS-1 NPPA)

Non-preemptible Unprotected Traffic (NUT, also known as Non-Preemptible Protection Access, NPPA) can be provisioned for STS-1 timeslots around a 2-Fiber BLSR to exclude individual working tributaries and their corresponding protection tributaries from BLSR protection switching. For applications where the traffic does not need to be protected by the BLSR (but also must not be preempted by BLSR protection switching), NUT enables a BLSR to carry more traffic than by using the working tributaries alone. Applications include traffic already protected at the path level (UPSR or SONET Logical Ring, e.g. Path-in-Line), and traffic between ATM or IP routers or other equipment supporting mesh network restoration that is already fast enough for the users. NUT effectively doubles the capacity available for such traffic while allowing it to be mixed with the protected working traffic also carried by the same BLSR. You can choose, for each STS-1 of traffic, whether to provide protection or to lower the cost by increasing bandwidth efficiency

The operation of the NUT feature is disabled in a BLSR if not all nodes in that BLSR support it.

□

Maintenance

Performance monitoring

WaveStar TDM 2.5G/10G (2-Fiber) monitors SONET and DS3 performance parameters on-board the transmission interfaces, so monitoring can be full time for each signal without requiring any additional cross-connect capacity.

Automatic laser shutdown

WaveStar TDM 2.5G/10G (2-Fiber) supports Automatic Laser Shutdown (ALS) on certain long-reach and very long-reach OC-192 interfaces. ALS is activated whenever (due to a cable break or otherwise) the signal no longer arrives at the receiver. When an LOS defect is present at the receive end of a section, the adjacent transmitter sending signals in the opposite direction is automatically shut down. The deactivation time from the moment the LOS defect is first detected is between 500 and 800 milliseconds. When the cable break is repaired, a restart procedure will make sure the transmitters are turned back on again.

This feature is designed to be used when the

- OBA is paired with the LEY69AE or LEY97AE
- OBPA is paired with the LEY228AE

Refer to Table 7-11 for other possible pairings of port units with the OBA and OBPA for applications where ALS is not required.

Threshold crossing alert reporting

WaveStar TDM 2.5G/10G (2-Fiber) supports user-defined Threshold Crossing Alert (TCA) values (with range checking) for supported PM parameters and provides autonomous alerts to the operations interface when a supported PM parameter exceeds a provisioned threshold value.

SONET section and line performance monitoring

The WaveStar TDM 2.5G/10G (2-Fiber) supports monitoring of section and line performance monitoring parameters. TCAs are reported when threshold crossings for parameters have been exceeded.

The PM parameters supported include the following:

- SONET section and line
- SONET terminated path
- SONET path intermediate

J0 Byte- section trace

The system can generate and monitor an STS-N section trace message on the SONET port J0 using read\write access.

PM bin access

The WaveStar TDM 2.5G/10G (2-Fiber) supports access to 15-minute and 24-hour bins for retrieval of detailed PM information concerning both SONET Intermediate path and SONET Terminated path parameters.

DS3 performance monitoring

The WaveStar TDM 2.5G/10G (2-Fiber) supports both line and intermediate path performance monitoring on DS3 signals.

Provisioning audits

WaveStar TDM 2.5G/10G (2-Fiber) automatically maintains a record of the provisioned state of each transmit and receive port on each port unit (transmission circuit pack).

Operations interworking

WaveStar TDM 2.5G/10G (2-Fiber) uses OC-3 and OC-12 optical extensions to support operations interworking with FT-2000 and DDM-2000. WaveStar TDM 2.5G/10G (2-Fiber) uses OC-48 optical extensions to support operations interworking with FT-2000. Earlier FT-2000 and DDM-2000 systems must be upgraded to support TARP. The interworking provides routing of messages across the DCC in support of user access, OS access, and element management. DDM-2000 OC-3 UPSR interfaces to WaveStar TDM 2.5G/10G (2-Fiber) linear 1+1 interfaces require the use of Release 15 of the DDM-2000.

Full TL1 command/message set

WaveStar TDM 2.5G/10G (2-Fiber) supports the full TL1 command and message set. The WaveStar CIT converts user inputs at the GUI into the corresponding TL1 commands and converts TL1 responses and messages into the GUI displays. The system also allows you to set up a list of TL1 commands to use.

STS-1 path trace

WaveStar TDM 2.5G/10G (2-Fiber) can generate an STS-1 path trace message for DS3/STS-1 gateways in compliance with Telcordia GR-253 and can retrieve the STS-1 path trace for any SONET signals.

Facility Loopbacks

The WaveStar TDM 2.5G/10G (2-Fiber) system supports facility loopbacks on a port or a set of ports for both electrical and optical signals. Loopbacks allow for testing of cabling and system operation as well as troubleshooting during factory system tests, and channel growth. Near-side facility loopbacks are used during system installation and channel growth activities to test the integrity of cabling and connections to the new NE. Far-side facility loopbacks can be employed during system installation and channel growth activities to test the integrity of paths through the WaveStar TDM 2.5G/10G (2-Fiber) system itself.

User Settable Miscellaneous Discretes

The user-definable miscellaneous discrete interface transports alarm and status information from co-located equipment at remote sites. At each remote site, a total of 8 alarm/status inputs (in each WaveStar

TDM 2.5G/10G (2-Fiber) are available to monitor environmental conditions like open doors or high temperature. A change in the monitored condition generates an autonomous alarm/status message.

Each user-assignable input is provisionable with a name and a status condition or a MN, MJ, or CR alarm.

Eight control outputs are also provided at each remote site to control auxiliary equipment like generators and pumps.

The 8 miscellaneous discrete inputs and outputs, MDIs/MDOs, are supported on a system node basis for stand-alone 2.5G applications and 10G applications. For example, a 10G node with 4 tributary shelves supports 8 MDIs and 8 MDOs.

Enhanced Security Screen

The login banner is provisionable7.

RTRV-ABN

RTRV-ABN will report any of the following abnormal conditions as indicated by the ABN LED:

- Protection lockouts (low speed, line, timing packs)
- Forced switch (low speed, line, clock mode)
- Manual switch (low speed, line, timing packs) except manual line switch when terminal is configured for 1+1
- Forced or manual timing reference switch
- Active loopbacks

□

Interworking

Interworking with products for various applications and interface rates

The WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with the following products for various applications and interface rates. Chapter 3 provides more details.

- DDM-2000 OC-3 and DDM-2000 OC-12
- FT-2000 OC-48 Lightwave System
- Metropolis DMX
- Tellabs TITAN 5500
- Fujitsu FLM-150, FLM-600, and FLM-2400
- Nortel S/DMS
- Various DWDM products using compatible optics (port units)
- Various operations support systems
- WaveStar family user interface application

Provisionable SS bits

The WaveStar TDM 2.5G/10G (2-Fiber) provisionable SS bits feature allows users to provision the value of SS bits 5 and 6. These are the SS bits that are transmitted in the first H1 pointer byte of an STS- Nc signal. Present SONET (Telcordia) and SDH (ITU-T) standards require that these bits be ignored by the receiving equipment. However, some older, embedded SONET and SDH equipment may not ignore these bits.

Provisioning the SS bits to 00 (overwrite enabled) can allow interworking with older embedded SONET equipment. Provisioning the SS bits to 10 (overwrite disabled) can allow interworking with older embedded SDH equipment.

Note:

The SS bits are provisionable on a per shelf basis.

□

Synchronization

DS1 timing outputs

The WaveStar TDM 2.5G/10G (2-Fiber) provides two DS1 timing outputs that can be used by any system that can support DS1 signals as a timing reference. DS1 timing outputs are based on a single synchronization reference signal from a single optical line (either OC-48 or OC-192). The choice of OC-N/STM-M is provisionable by the user. Timing outputs are signals indicating whether or not the signals being transmitted by the system are synchronized with the larger network. Timing outputs also indicate whether or not the system is receiving the proper information, based on reference signals, to remain synchronized with the network. For example, when the timing reference signal fails, the DS1 outputs will indicate DS1 AIS.

OC-192 line timing

The WaveStar TDM 2.5G/10G (2-Fiber) accepts timing references from up to eight OC-192/STM-64 lines. The WaveStar TDM 2.5G/10G (2-Fiber) monitors SSMs (Synchronization Status Messages) that notify the system if a reference signal is acceptable or unacceptable. If a reference signal is unacceptable the system re-configures itself to use the next assigned reference source. If no other sources are available, the system goes into holdover mode. A signal is deemed unacceptable when the incoming SSM is below Stratum 3. The WaveStar TDM 2.5G/10G (2-Fiber) system supports the reconfiguration of up to eight DS1/E1 inputs and two line references. The system is restricted to eight line references.

OC-48 line timing

The WaveStar TDM 2.5G/10G (2-Fiber) accepts timing references from up to six OC-48/STM-16 lines. The WaveStar TDM 2.5G/10G (2-Fiber) monitors SSMs (Synchronization Status Messages) that notify the system if a reference signal is acceptable or unacceptable. If a reference signal is unacceptable the system re-configures itself to use the next assigned reference source. If no other sources are available, the system goes into holdover mode. A signal is deemed unacceptable when the incoming SSM is below Stratum 3. The WaveStar TDM 2.5G/10G (2-Fiber) system supports the reconfiguration of up to eight DS1/E1 inputs and six OC-48 line references. The system is restricted to two line references from the main low-speed (tributary) shelf only.

OC-3/12 line timing

The WaveStar TDM 2.5G/10G (2-Fiber) accepts timing references from up to two OC-3 or OC-12 lines. The WaveStar TDM 2.5G/10G (2-Fiber) monitors SSMs (Synchronization Status Messages) that notify the system if a reference signal is acceptable or unacceptable. If a reference signal is unacceptable the system re-configures itself to use the next assigned reference source. If no other sources are available, the system goes into holdover mode. A signal is deemed unacceptable when the incoming SSM is below Stratum 3. The WaveStar TDM 2.5G/10G (2-Fiber) system supports the reconfiguration of up to two DS1/E1 inputs and two line references. Also, the timing references can only be gathered from port units in even slots and the references must be assigned to the 1st port on the port units in these even slots.

Incoming/outgoing SSMs

Standard synchronization status messages (SSMs) are transported on the
S1 Byte. The transmission of SSMs on the S1 Byte is required on all OC-192, OC-48, OC-12, and OC-3 lines. Incoming SSMs are used to monitor the acceptability of timing references. If an SSM reads below Stratum 3, the line reference is deemed to be unacceptable. SSMs are determined according to SONET (ANSI, Telcordia) standards.

Automatic reconfiguration of synchronization mode

The WaveStar TDM 2.5G/10G (2-Fiber) supports the automatic reconfiguration of the synchronization mode based on incoming SSMs. When an incoming SSM is deemed to be unacceptable, the system reconfigures itself to use the next assigned reference signal source. If no other sources are available, or of a high enough quality, the system goes into holdover mode. The WaveStar TDM 2.5G/10G (2-Fiber) supports the automatic reconfiguration of up to two DS1/E1 inputs and two line references.

□

Shelf Mounting Options

Overview

This section describes the various mounting options for individual shelves and DS3 connector panels for the WaveStar TDM 2.5G/10G (2-Fiber).

Internal DS3/STS-1 connector panels

The WaveStar TDM 2.5G/10G (2-Fiber) provides an internal mounting capability for DS3/STS-1 connector panels. This internal mounting arrangement uses top/bottom mounting, and restricts the bay to two tributary (low-speed) shelves per bay.

External DS3/STS-1 connector panels

The WaveStar TDM 2.5G/10G (2-Fiber) provides an external mounting capability for DS3/STS-1 connector panels. This external mounting arrangement uses vertical mounting, and allows you to mount 3 tributary (low-speed) shelves in a single bay. The external connector panels attach to the two sides of the shelf like wings and require additional space (4 to 5 inches) between bay frames.

Rear mounted DS3/STS-1 connector panels

The WaveStar TDM 2.5G/10G (2-Fiber) provides a rear-mount capability for DS3/STS-1 connector panels. This rear-mount arrangement secures the connector panels vertically, on the back of the tributary (low-speed) shelf. With this arrangement, three shelves can fit in one 7-foot bay.

Mounting of tributary shelf in an FT-2000 OC-48 Lightwave System Dual Bay Frame

You can replace one or two HSS/LSS FT-2000 OC-48 Lightwave System shelves with WaveStar TDM 2.5G/10G (2-Fiber) tributary shelves-- in the same FT-2000 Dual Bay Frame. This provides the capability to upgrade from the FT-2000 to the WaveStar TDM 2.5G/10G (2-Fiber) 2.5G application without disturbing a current floor plan layout.

☐

3 Network Topologies

Overview

Purpose This chapter describes network topologies in which WaveStar TDM 2.5G/10G (2-Fiber) is used to increase reliability, lower costs, increase revenues, and provide growth paths.

Applications The table below lists the topologies described in this chapter in terms of the applications for which they can provide solutions.

Applications and Topologies

Applications	**Topologies**
Increasing Reliability	2-Fiber BLSRs
	UPSRs
	Dual Node Ring Interworking
Increase Revenues	Gigabit Ethernet Interface
	Broadband Transport
	Backbone
	Loop Feeder
	Restoration Through Protection Access
Lowering Costs and Providing for Growth	Hairpinning
	Optical Hubbing Topologies
	Dense Wavelength Division Multiplexing (DWDM)
	Increased Span Length: Internal Optical Amplifiers
	Increased Span Length: External Optical Amplifiers
	DDM-2000 Linear Interfaces
	Path-in-Line
	Interface Mixing
	Multiple Rings
	Express Rings
	Mesh Networks
	Folded Rings
	0% Add/Drop Node

Applications	Topologies
Interworking Capabilities	Lucent Products: FT-2000, DDM-2000, WaveStar BandWidth Manager, Metropolis™ DMX, earlier releases of WaveStar TDM 2.5G/10G (2-Fiber)
	Tellabs Titan 5550
	Fujitsu Products: FLM-150, FLM-600, and FLM-2400
	Nortel S/DMS
	SDH Transport

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. Additionally, you can use the protection capacity to provide unprotected transport for extra traffic when no failures are present.

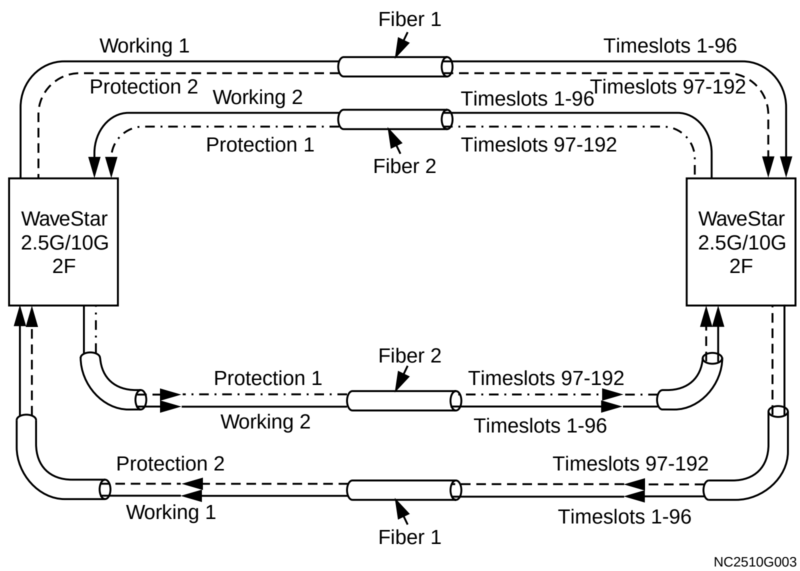
The 10G application of the WaveStar TDM 2.5G/10G (2-Fiber) supports one high-speed OC-192 2-fiber BLSR on the high-speed shelf and up to four OC-48 2-fiber BLSRs on each tributary (low-speed) shelf. The 2.5G application supports up to four OC-48 2-fiber BLSRs on a single shelf.

For both the 2.5G (OC-48) and 10G (OC-192) applications, it is recommended that not more than two OC-48 BLSRs on one shelf share the same fiber route. This minimizes the likelihood of simultaneous failures and insures that SONET restoration and protection switch times are met.

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 3-1 Traffic Capacity in an OC-192 2-Fiber BLSR



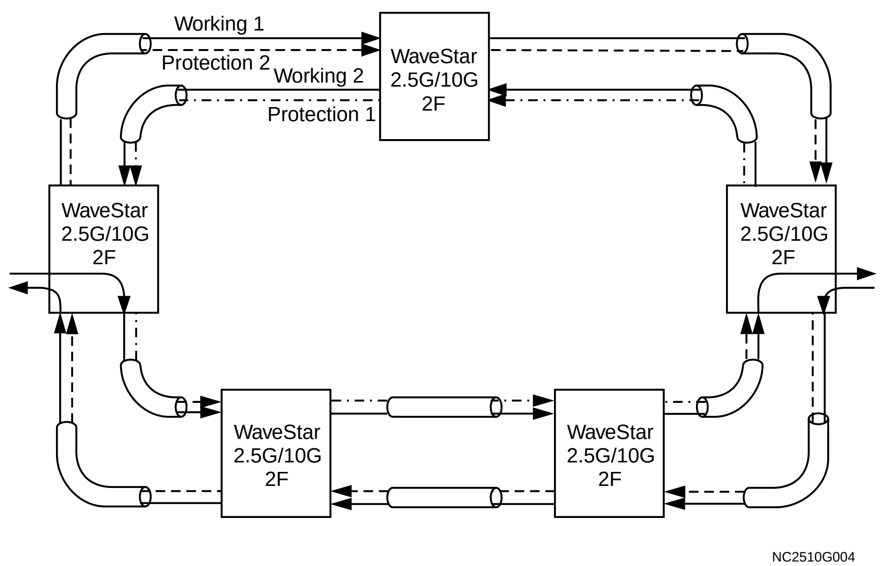
Self-healing rings

WaveStar TDM 2.5G/10G (2-Fiber) 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.)

2-fiber BLSR traffic flow

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

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



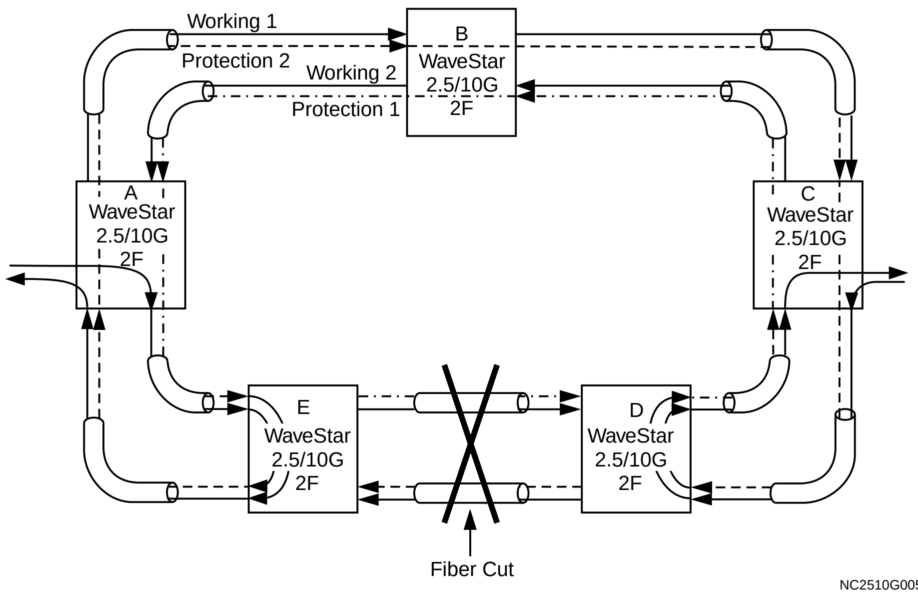
Protection switching

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



Protection traffic flow

In Figure 3-3, 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.

□

Unidirectional Path-Switched Rings (UPSRs)

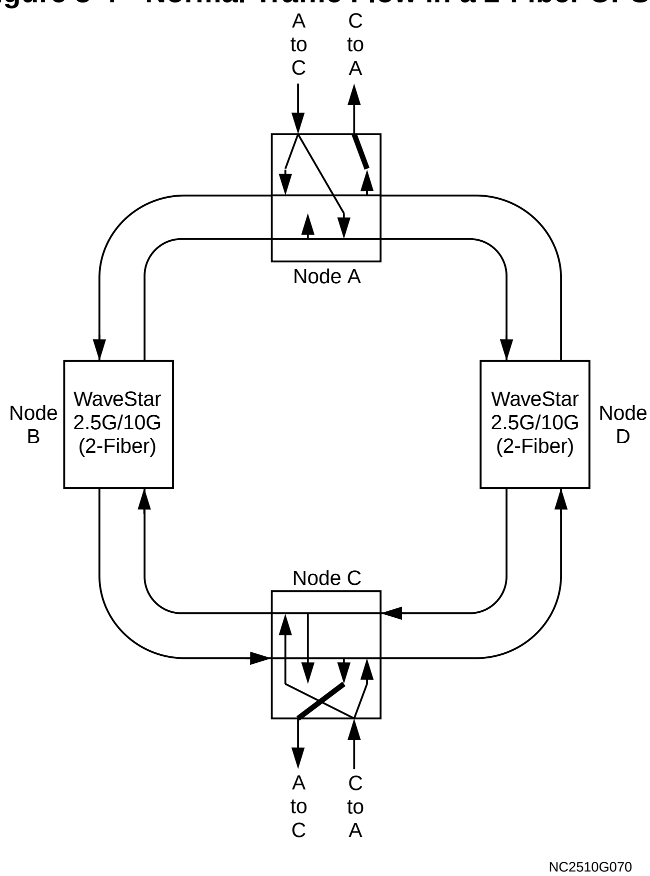
Overview

A Unidirectional Path Switched Ring (UPSR) is a self-healing ring configuration in which traffic is sent onto both rotations (both fibers) of the ring in opposite directions. The term “unidirectional” refers to the fact that every signal is normally selected from the same direction (either counter-clockwise or clockwise). “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.

2-Fiber UPSR traffic flow

UPSRs operate as shown in the figure below. Again, traffic is sent onto both rotations (both fibers) of the ring in opposite directions. At the receiving node, the signal with the highest level of 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 WaveStar TDM 2.5G/10G (2-Fiber) time slot interchange (TSI) capabilities make the provisioning of add/drop and pass-through traffic quick and easy.

Figure 3-4 Normal Traffic Flow in a 2-Fiber UPSR

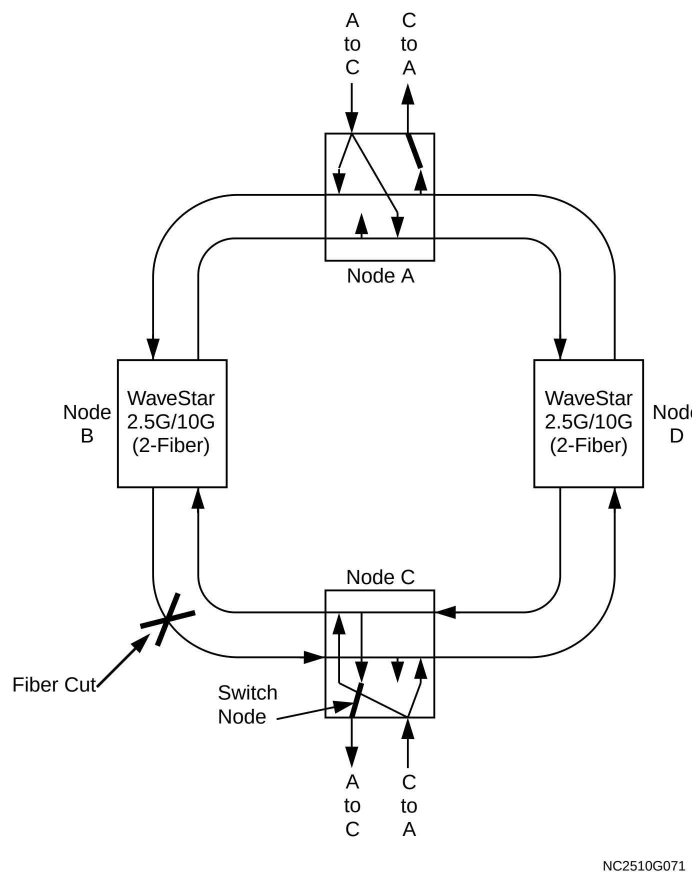


Important! The WaveStar TDM 2.5G/10G (2-Fiber) supports one OC-192 UPSR in the high speed shelf. The WaveStar TDM 2.5G/10G (2-Fiber) supports zero to four OC-48 UPSRs or zero to sixteen OC-12 UPSRs on a single low-speed (2.5G) shelf. Also, the mixing of BLSR, UPSR, and other interfaces is supported in the same shelf. UPSR traffic can only be dropped to the first and second tributary shelves.

Self-healing rings

WaveStar TDM 2.5G/10G (2-Fiber) 2-fiber UPSRs are self-healing in that transport is automatically restored after node or fiber failures. The self-healing nature of a path switched ring is shown in the figure below. In this instance, the fiber cut occurring between nodes B and C causes node C to switch from the counter-clockwise ring to the clockwise ring; thus maintaining service between nodes A and C.

Figure 3-5 Path Switch in a UPSR



Hairpinning Capability

Overview

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-192 BLSR. The cross-connection capability of connecting any input to any output on the same shelf or on different tributary shelves, 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, or STS-48c level back out to other remote sites without consuming any capacity on the OC-192 BLSR.

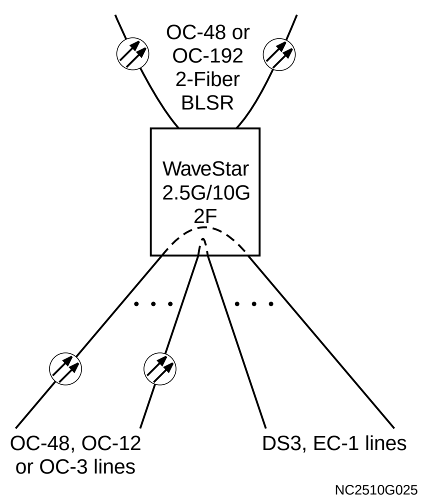
Hairpinning is also supported in 2.5G applications. In addition to adding and dropping traffic to/from the high-speed OC-48 BLSR(s), 2.5G applications support cross-connections between low-speed ports.

WaveStar TDM 2.5G/10G (2-Fiber) can operate without a high-speed OC-192 BLSR, for example, to function as a small optical cross-connect system. For information on the minimum complement of circuit packs, see Chapter 4, "Product Description."

Hairpinning example

The figure below shows a topology in which traffic is hairpinned among OC-48, OC-12, OC-3, EC-1, and DS3 low-speed tributary interfaces.

Figure 3-6 Hairpinning Example



□

Optical Hubbing Topologies

Overview

An NE is a hub when it is a collection point for lower transmission rate signals. If the lower rate signals are optical and from remote sites, the NE is performing remote optical hubbing.

Optical hubbing example

The WaveStar TDM 2.5G/10G (2-Fiber) provides an extremely versatile platform for hubbing applications, typically found in metro applications where signals from remote sites are transported optically to a hub node. The hub node is connected to a higher speed backbone or other metro network. Using WaveStar TDM 2.5G/10G (2-Fiber) as a hub can lower transport costs by consolidating large amounts, and diverse types of traffic at the hub. For example, OC-48 (2F BLSR, UPSR, 1+1, 0x1), OC-12 (UPSR, 1+1, 0x1), OC-3 (1+1, 0x1), DS3, EC-1, and GE1 traffic can be consolidated at a hub for transport at OC-192 (2F BLSR, UPSR, or 0x1). OC-12 (UPSR, 1+1, 0x1), OC-3 (1+1, 0x1), DS3, EC-1, and GE1 traffic can also be consolidated onto an OC-48 (2F BLSR, UPSR, 1+1, 0x1). OC-3 (1+1, 0x1), DS3, and EC-1 traffic can be consolidated onto an OC-12 (UPSR, 1+1, 0x1). Also, traffic can be added/dropped at the hub, and/or hairpinned from one remote optical connection to another remote optical connection without ever being cross connected with the higher speed backbone.

Table 3-1, Maximum Interface Capacity When Interface Rates Are Not Mixed (page 3-14), outlines the maximum interface capacity of a WaveStar TDM 2.5G/10G (2-Fiber) when interface rates are not mixed. For example, a WaveStar TDM 2.5G/10G (2-Fiber) OC-192 system with two low speed tributary shelves can terminate, 8 OC-48 2F BLSRs, or 8 OC-48 UPSRs, or a combination of up to 8 2F BLSRs and UPSRs.

Table 3-1 Maximum Interface Capacity When Interface Rates Are Not Mixed

Interface and Protection Type	One Low-Speed Tributary Shelf (stand-alone 2.5G)	2 Low-Speed Tributary Shelves (576x576 STS-1 Switch Fabric in High-Speed Shelf)	4 Low-Speed Tributary Shelves (768x768 STS-1 Switch Fabric in High-Speed Shelf)
OC-48 2F BLSR, UPSR (STS-1 path), 1+1	4	8	16
OC-48 0x1	8	16	32
OC-12 UPSR (STS-1 path), 1+1	16	32	64
OC-12 0x1	32	64	128
OC-3 1+1 (using OC3/STM4/1.3IR-SR8)	64	128	256
OC-3 0x1 (using OC3/STM4/1.3IR-SR8)	128	256	512
DS3s or EC-1s or a mix (1:12 per shelf, or 0x1)	96	192	384
Gigabit Ethernet	16	32	64

The WaveStar TDM 2.5G/10G (2-Fiber) does support mixing of interfaces and protection types in the low speed tributary (or stand-alone 2.5G) shelf. When interface rates are mixed, the interface capacity of a hub depends on how the interfaces (port unit cards) are mixed.

NOTE:

> Traffic from an OC-192 UPSR cannot be terminated in shelves 3 and 4.

In addition to lowering transport costs by consolidating large amounts, and diverse types of traffic at the hub, other features of the WaveStar TDM 2.5G/10G (2-Fiber) provide additional benefits for hubbing applications. Some examples include:

- Interworking capabilities allow network consolidation of existing embedded base equipment (for example, termination of FT-2000 2F BLSRs, and termination of Metropolis™ DMX UPSRs that have STS-1 path switching).
- Interworking capabilities allow network consolidation for multi-vendor applications.
- OC-48 and OC-192 compatible optics are available for various DWDM applications allowing customers to maximize fiber utilization, and reduce equipment costs by deploying cost effective multiplex/DWDM network architectures.
- The full hairpinning capability on each low speed tributary (2.5G stand-alone) shelf allows the most efficient use of bandwidth. STS-1 level signals can be cross connected between any ports on the low speed tributary shelf, which reduces the need to use additional switch fabrics or deploy external equipment (for example, cross connects and DSXs.). More specifically, hairpinning allows:
  – Cross-connecting of traffic between the OC-3, OC-12, and OC-48 linear and/or ring interfaces coming into the hub, without ever using the cross connect fabric in the high speed shelf.
  – Traffic to be directly interconnected between multiple remote networks, saving the cost of additional ports and cabling that would be needed if the traffic is terminated on separate network elements.
  – The grooming of traffic from multiple remote networks into common OC-N or GE1 handoffs. This reduces the number of interfaces on both the WaveStar TDM 2.5G/10G (2-Fiber) and the other equipment.
- STS-1, STS-3, STS-3c, STS-12, STS-12c, STS-48, and STS-48c cross connects are all supported, which allows a wide range of applications.
- In-service upgrade from a single OC-48 2-fiber BLSR ring to an OC-192 2-fiber BLSR ring is supported, allowing the initial deployment of low cost OC-48 architectures for low volume traffic areas, with the ability to grow the network in-service as traffic demands increase.
- 100% add/drop of all OC-192 2-Fiber BLSR working traffic is supported in one bay.

- With protection access traffic, 100% add/drop of all OC-192 BLSR protection access traffic is supported in one bay when optical low-speed interfaces are used. With electrical interfaces, two bays are required.

Details on interworking and DWDM applications using compatible optics are provided later in this section.

The next two figures show the WaveStar TDM 2.5G/10G (2-Fiber) used in optical hubbing applications.

Figure 3-7, Optical Hubbing – Simple Metro Hub with Linear Extensions (page 3-16) shows the WaveStar TDM 2.5G/10G (2-Fiber) used in a simple metro hub application where linear 1+1 OC-3, OC-12, and OC-48 traffic from two DDM-2000 systems and one WaveStar TDM 2.5G/10G (2-Fiber) system is connected to a TDM 2.5G/10G (2-Fiber) hub node. The hub node is also part of a higher speed network, in this case an OC-192 2F BLSR. This type of architecture is used to consolidate traffic from access networks onto backbone or metro interoffice networks, to add/drop traffic from remote sites to a hub site, and to cross connect traffic between remote sites using the hairpinning capability of the WaveStar TDM 2.5G/10G (2-Fiber) located at the hub site.

Figure 3-7 Optical Hubbing – Simple Metro Hub with Linear Extensions

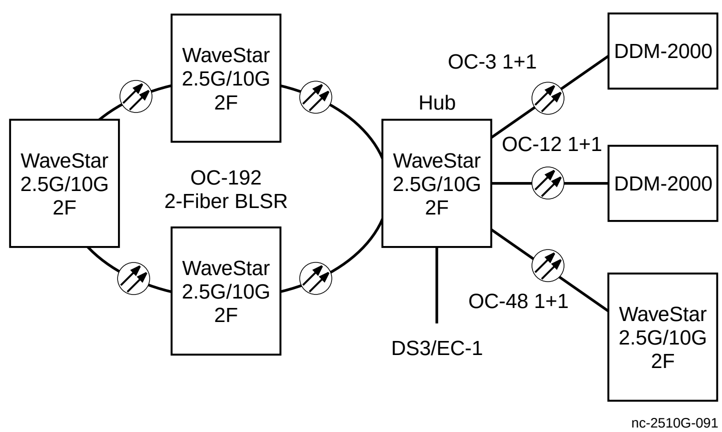
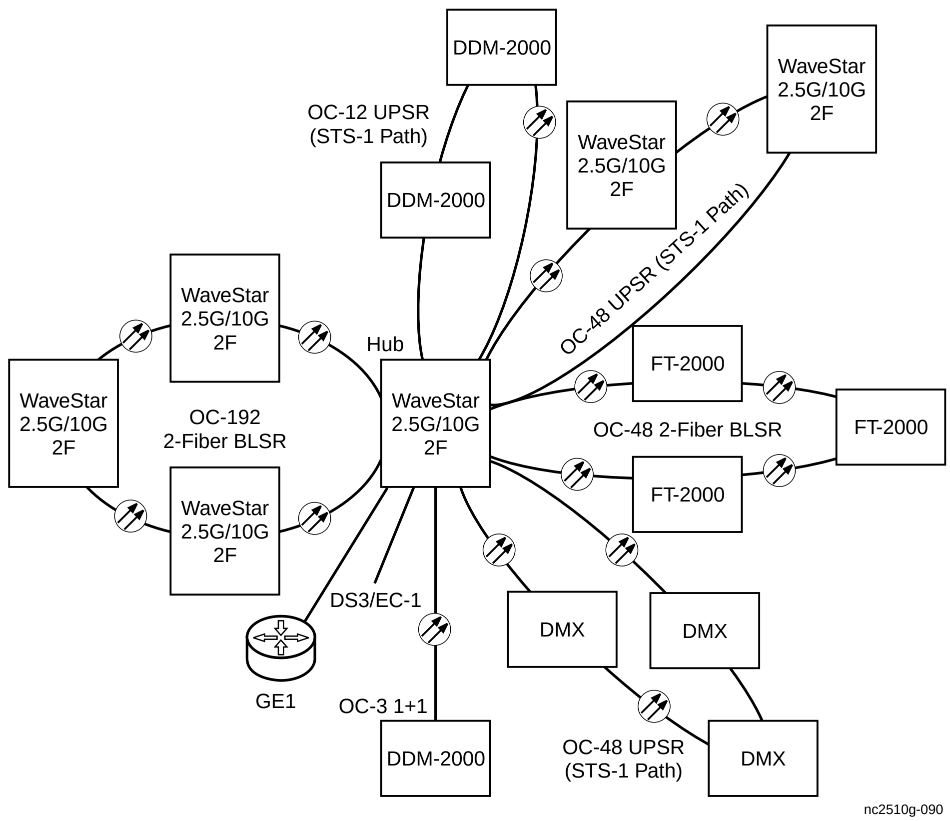


Figure 3-8, Optical Hubbing – Metro Hub Networking Example (page 3-17) shows the WaveStar TDM 2.5G/10G (2-Fiber) used in a metro hub application where traffic from various NEs, using various protection schemes, and with various interfaces (OC-3, OC-12, OC-48) is terminated at a WaveStar TDM 2.5G/10G (2-Fiber) hub node. In this case, more than just 1+1 traffic is coming into the hub site from remote sites. Ring (2F BLSR and UPSRs with STS-1 path switching) and linear 1+1 traffic is being terminated at the hub. This traffic is consolidated with Gigabit Ethernet and DS3/EC-1 traffic, which is added/dropped at the hub site. The TDM 2.5G/10G (2-Fiber) hub node is also part of an OC-192 2F BLSR. This type of architecture is used to consolidate traffic from access and/or metro networks onto high speed backbone networks, to add/drop traffic from various remote sites to a hub site, and to cross connect traffic between remote sites using the hairpinning capability of the WaveStar TDM 2.5G/10G (2-Fiber) located at the hub site.

Figure 3-8 Optical Hubbing – Metro Hub Networking Example



Since any of the rings or linear interfaces shown in either figure, can be used in either access or the backbone networks, the hub may be part of more than just one access and/or backbone network.

Note:

For OC-192 applications, the WaveStar TDM 2.5G/10G (2-Fiber) can be used as an OC-192 2F BLSR, UPSR, single 0x1, or dual 0x1 system.

DWDM

Overview

Dense wavelength division multiplexing (DWDM) is the optical combining of four or more different optical wavelengths onto a single fiber. DWDM increases the circuit-carrying capacity of lightguide cable by carrying multiple signals of different wavelengths simultaneously over a single fiber. DWDM provides a cost-effective way to utilize the huge carrying capacity of fiber and relieve fiber exhaust problems.

DWDM-compatible options

To ensure the most cost-effective DWDM network architectures, are deployed, the WaveStar TDM 2.5G/10G, Release 6 system supports compatible OC-48 and OC-192 optics (port units), for use in a wide array of DWDM applications:

- 16 different OC-48 wavelengths (OC48/STM16/DWDM), in the 1.5 micron range, for use in applications with the Lucent Technologies Metropolis™ EON system
- 40 different OC-192 wavelengths (OC192/STM64/WDM), and 80 different OC-48 wavelengths (OC48/STM16/WDM), in the 1.5 micron range, for use in applications with the Lucent Technologies WaveStar® OLS 1.6T system
- 32 different OC-192 wavelengths (OC192/STM64/POU), and 16 different OC-48 wavelengths (OC48/STM16/POU), in the 1.5 micron range, for use in applications with the Lucent Passive Optics Units (POUs) in Passive DWDM applications

These compatible port units ensure that **no** Optical Translator Units (OTUs) are required in, or external to, the DWDM system. The result is significant savings in cost and floor space.

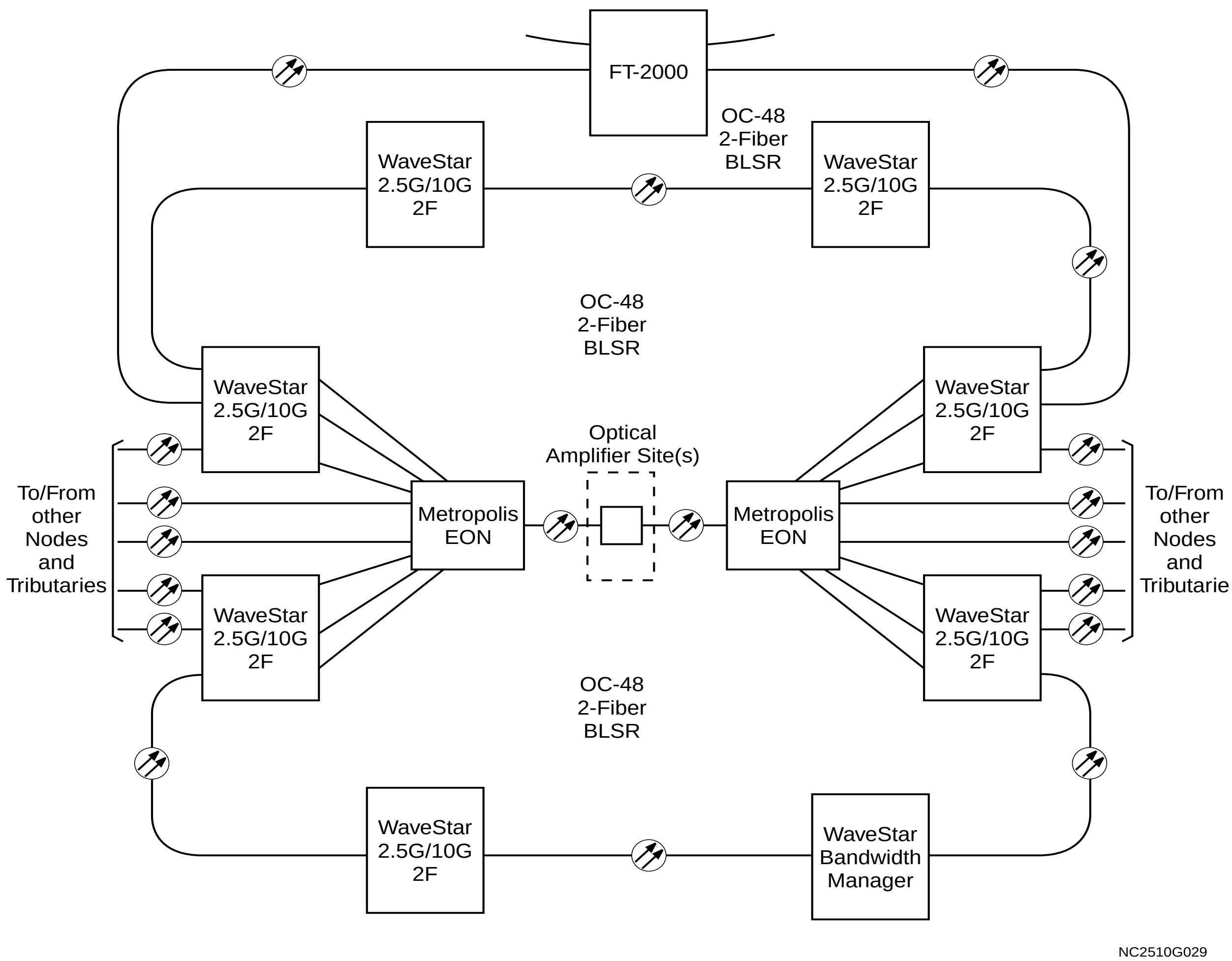
The compatible optical port unit codes are listed in Chapter 7, “Ordering.” Information on passive optics, and the POUs are located throughout this document.

More information about the Lucent Technologies Metropolis™ EON, and the Lucent WaveStar® OLS 1.6T can be found in the *Applications and Planning Guides* for these products.

Examples of topologies using DWDM-compatible port units

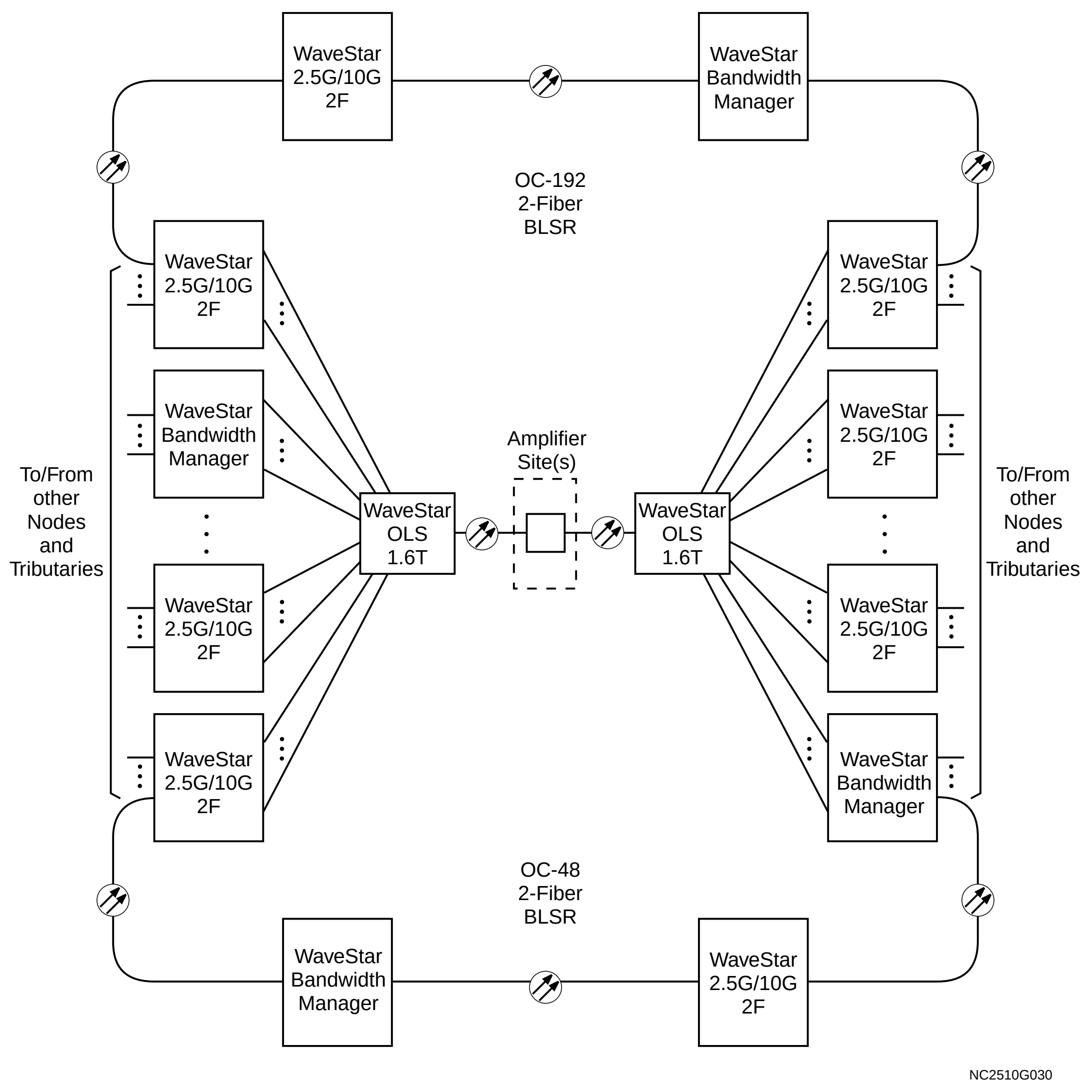
The figure below shows multiple WaveStar TDM 2.5G/10G (2-Fiber) systems equipped with compatible optics (port units) and interfacing with the Lucent Technologies Metropolis™ EON system, to transport multiple OC-48 ring segments over a single fiber span. (One line in the figure represents 2 fibers.) The WaveStar TDM 2.5G/10G (2-Fiber) compatible optics for this application are available in 16 different OC-48 wavelengths, and eliminate the need for OTUs on the Metropolis™ EON system.

Figure 3-9 Metropolis EON (OLS 40G) with WaveStar TDM 2.5G/10G (2-Fiber)



The figure below shows a WaveStar TDM 2.5G/10G (2-Fiber) system equipped with compatible optics (port units), interfacing with the Lucent Technologies WaveStar® OLS 1.6T system, to transmit ring segments over a single fiber span. (One line in the figure represents 2 fibers.) The WaveStar TDM 2.5G/10G (2-Fiber) compatible optics (port units) for this application are available in 40 different OC-192 wavelengths, and 80 different OC-48 wavelengths. The use of compatible optics eliminate the need for OTUs when the WaveStar TDM 2.5G/10G (2-Fiber) is connected to the WaveStar® OLS 1.6T system.

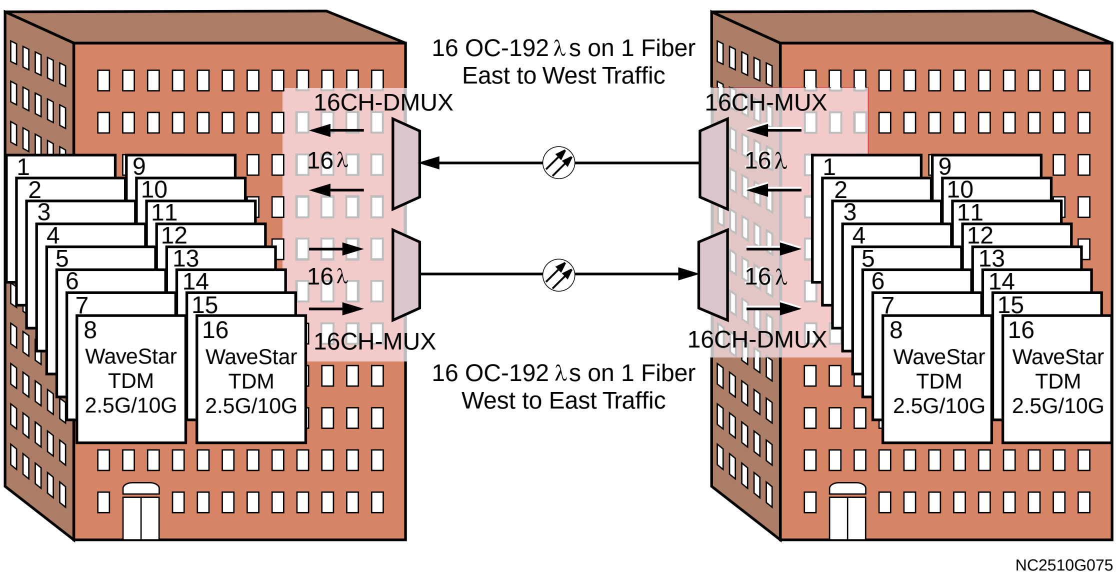
Figure 3-10 WaveStar® OLS 1.6T with WaveStar TDM 2.5G/10G (2-Fiber)



The figure below shows a typical metro application of the WaveStar TDM 2.5G/10G (2-Fiber) system, equipped with Passive DWDM compatible optics (port units), and interfacing with the 16CH-MUX and 16CH-DMUX Passive Optics Units (POUs). This network topology supports the cost-effective transport of multiple OC-192 wavelength (λ) signals, between two sites, on a fiber (one fiber for each direction). This application is supported for OC-48 signals as well.

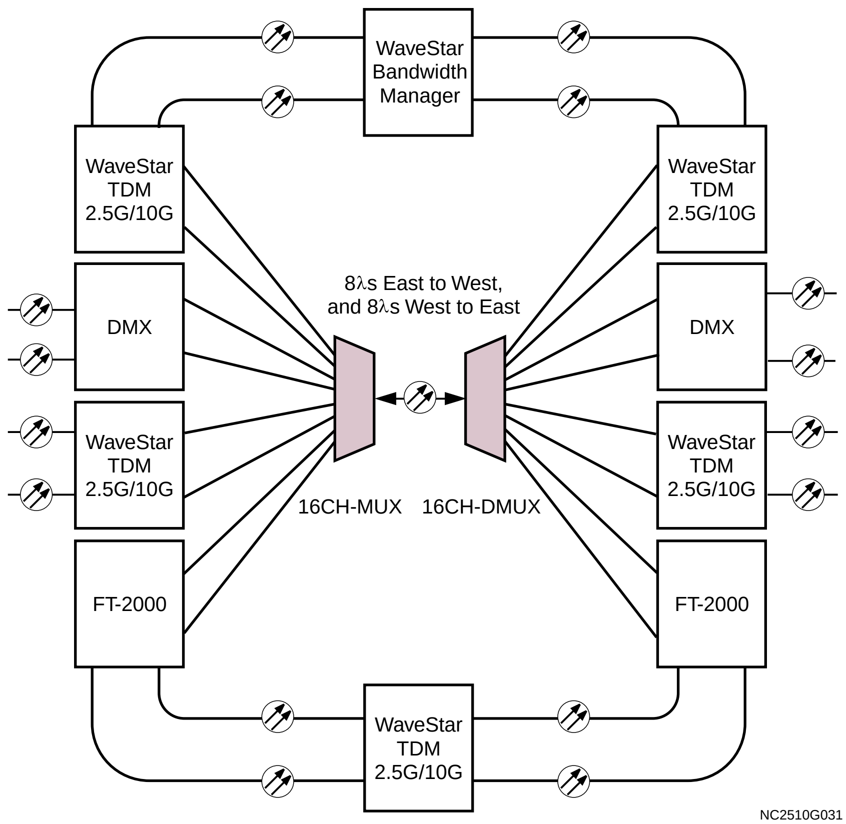
Up to 32 OC-192 signals, of different wavelengths, can be transported on one fiber, unidirectionally, when all four POUs are used with the WaveStar TDM 2.5G/10G (2-Fiber).

Figure 3-11 Unidirectional Transport of 16 Wavelengths with WaveStar TDM 2.5G/10G (2-Fiber) Systems and Lucent Passive Optics Units (POUs)



The figure below shows a bidirectional transport application using the POUs, in this case the16CH-MUX and 16CH-DMUX units. The POUs are connected with other Lucent products which are equipped with Passive DWDM compatible optics, to transmit and receive information over one fiber. In the topology shown, up to 8 wavelengths (λs) can be used for east to west traffic, and the other 8 wavelengths can used for west to east traffic.

Figure 3-12 Bidirectional Transport of 8 Wavelengths In each Direction On One Fiber Using POUs and Lucent Network Elements



Increased Span Length: Internal Optical Amplifiers

Overview

For those OC-192 long distance applications over 60 km (loss budget exceeds 18 dB), the WaveStar TDM 2.5G/10G (2-Fiber) system supports two in-shelf optical amplifier units, the Optical Booster Amplifier (OBA) and the Optical Booster/Pre-Amplifier (OBPA). The OBA and OBPA allow the system to support OC-192 applications up 80 km and up to 120 km, respectively, on SMF - eliminating the need for additional equipment, such as 0% add/drop terminals or regenerators.

Concept

The OBA, the SEN3AE, can be paired with various OC-192 optical port units, typically the LEY69AE, to support applications up to 80 km. The OC-192 transmitter output from the LEY69AE is connected to the input of the OBA, and is amplified. The output of the OBA is connected to the fiber in the network. At the receiver side, the fiber from network is connected directly to the receiver on LEY69AE OC-192 port unit. The OBA is not part of the port unit receiver side architecture

The OBPA, the SEN4AE, supports applications up to 120 km on SMF. The SEN4AE provides an OBA type function, and also provides a preamplifier function. The pre-amplifier function provides amplification of the optical signal received from the network fiber. The "pre-amplified" output of the SEN4AE is the input to the receiver of the OC-192 port unit. The SEN4AE receiver filter is frequency dependent, and must operate at a wavelength of 1552.52 nm, therefore the SEN4AE must be paired with a LEY295AE or LEY228AE.

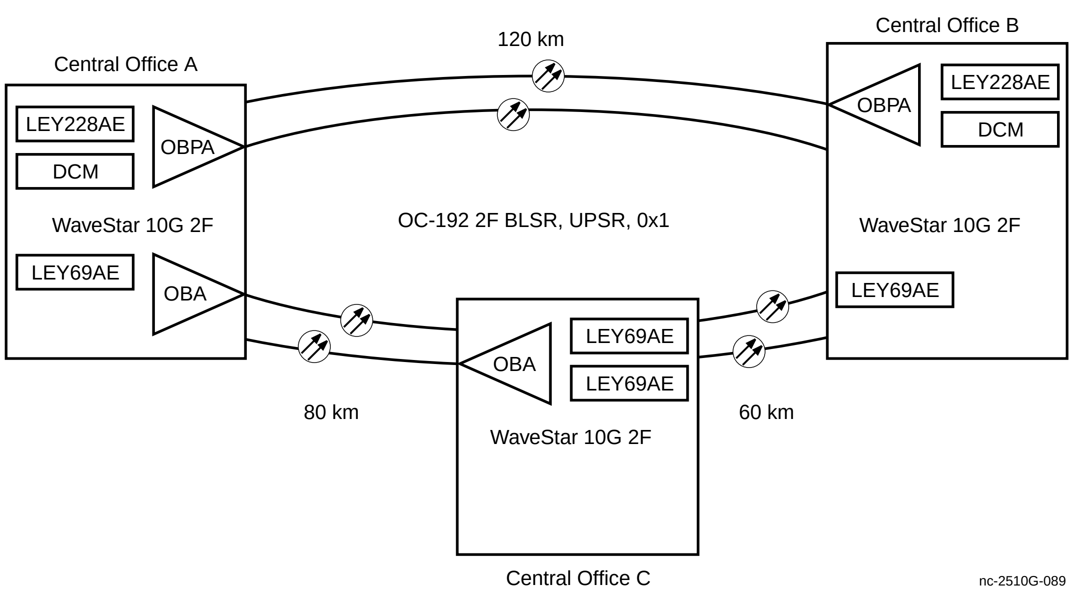
The OBA and OBPA port units can be mounted in slots 2 and/or 16 of the 10G high-speed shelf.

The loss and dispersion characteristics [chromatic dispersion (CD) and polarization mode dispersion (PMD)] for optical equipment and fiber must be considered for all network designs. The signal to noise (S/N) ratio may also need to be calculated for applications. DCMs may or may not be required depending on the fiber route characteristics, the optical line rate being amplified, and optical characteristics of all equipment. Greater span distances can be achieved, and DCMs can be eliminated or reduced in number when Lucent TrueWave (non zero dispersion shifted) fiber is used.

It is assumed that the PMD requirements for a specific application, are consistent with those requirements specified in ITU-T.691 for OC-48 applications, and Telecordia GR 1377 for OC-192 applications.

The figure below shows how the OBA (SEN3AE) and OBPA (SEN4AE) can be used to extend the span distance for OC-192 applications on single-mode fiber (SMF). The use of the OBA and/or OBPA can eliminate the need for additional equipment, such as 0% add/drop terminals or regenerators.

Figure 3-13 WaveStar TDM 2.5G/10G (2-Fiber) OBA and OBPA Applications



In this application, the OBPA (SEN4AE) is paired with the LEY228AE. The LEY295AE could have been used instead of the LEY228AE. DCMs are required for this SMF application. The use of TrueWave fiber would eliminate the need for DCMs in this application, and would also allow for longer transmission distances.

DCMs are connected between the LEY228AE transmitter and the OBPA (SEN4AE) circuit pack in the transmit direction, and between the OBPA (SEN4AE) and the receiver of the LEY228AE in the receive direction.

□

Increased Span Length: External Optical Amplifiers (OAs)

Overview

For those applications in which the OBA and OBPA are already in use or cannot be used, Lucent Technologies offers a stand-alone External Optical Amplifier (OA) system. This system can be used for both OC-48 and OC-192 applications. The External OA system is stand-alone one shelf system that supports up to 6 OAs.

Concept

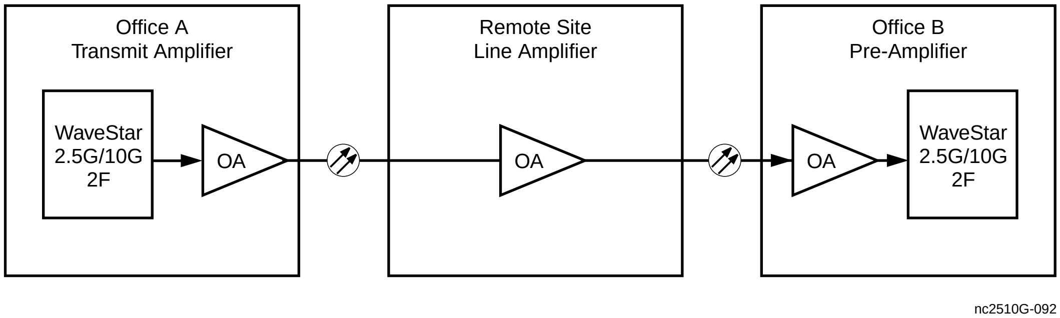
The Lucent External OA system can be equipped with up to 6 OAs (in one shelf). There are basically three basic categories of OAs, transmit amplifiers, line amplifiers, and pre-amplifiers. Within a category, there are multiple OAs available. The appropriate OA can be selected for the particular application.

The loss and dispersion characteristics (CD and PMD) for optical equipment and fiber must be considered for all network designs. The S/N ratio may also need to be calculated for applications. DCMs may or may not be required depending on the fiber route characteristics, the optical line rate being amplified, and optical characteristics of the all equipment. Greater span distances can be achieved, and DCMs can be eliminated or reduced in number when Lucent TrueWave (non zero dispersion shifted) fiber is used.

It is assumed that the PMD requirements for a specific application, are consistent with those requirements specified in ITU-T.691 for OC-48 applications, and Telecordia GR1377 for OC-192 applications.

The next figure is a block diagram depicting how the three categories of OAs could be used. DCMs are not shown in this figure below.

Figure 3-14 External Optical Amplifiers, Application Block Diagram (West to East Traffic)



The OAs support unidirectional operation, the optical signal is amplified in one direction. In the figure above, the west to east transmission direction is shown.

NOTE:

> The External OA applications supported, and defined in this document, are for single frequency/wavelength applications, meaning the optical signal amplified is not a mutliwavelength WDM signal. Information concerning solutions for amplifying multi-wavelength WDM signals can be obtained from your Lucent Account Executive

Transmit amplifiers provide a function similar to the OBA. For a range of optical input power levels, from an optical port unit, the signal is amplified. The output power is a set level. There are four transmit amplifiers available, units with outputs of 10, 13, 16, and 19 dBm (typical). The amplifier wavelength range is 1530 to 1560 nm. Applications are supported for a single wavelength in this range.

Line amplifiers are typically located at remote sites to provide a gain function. Three line amplifiers are available. Two of the amplifiers have an operating wavelength range 1530 to 1560 nm, and have maximum gains of +30 dB and +33 dB, respectively. The third amplifier has an operating wavelength range of 1548 to 1560 nm, and provides a maximum gain of +30 dB. The third line amplifier allows for mid stage insertion of a DCM. Applications are supported for any single wavelength defined within the operating wavelength range.

Pre-amplifiers provide a pre-amplifier, gain function before the receiver of a port unit. Pre-amplifiers are available with different gain levels. The pre-amplifiers that provide a maximum gain of 23 dB have an operating wavelength range of 1530 to 1560 nm. Applications are supported for a single wavelength in this range. The two types of pre-amplifiers with higher maximum gains, 23 and 28 dB respectively, utilize narrow band filters. Wavelengths supported with the narrow band filters, include but are not limited to, 1557.38 nm, 1552.52 nm, 1549.31 nm, 1541.35 nm, and 1533.47 nm. When the pre-amplifiers that have narrow band filters are used, the appropriate optical port unit must also be used. For example, if the pre-amplifier used, requires a wavelength of 1552.52 nm, then the LEY295AE or LEY228AE port units must be used to transmit the appropriate wavelength signal for OC-192 applications.

The appropriate OA should be selected for the application. Not all categories of OAs are needed for every application. Many applications required the use of just transmit amplifiers, or transmit amplifiers and pre-amplifiers.

If a transmit amplifier, and a pre-amplifier with 1552.52 nm narrow band filter are used for an OC-192 application, the application supported is analogous to using the SEN4AE for an OC-192 application.

The OAs are equipped with FC connectors.

The external OA shelf is available in a NEBS 3 compliant version, and can be used for controlled environmental applications. Power units are available for -48 VDC, 110 VAC, and 220VAC applications.

The external OA system provides alarm/status LEDs on the OA circuit packs, relays closures, and can be used with an external telemetry system if desired. On a span basis, protection schemes and alarming functions can be performed by the multiplexers or DCS systems connected to the External OA system.

The external OA system can also be equipped with up to 12 transponders. Each transponder takes up 1 slot in the shelf. An OA takes up two slots.

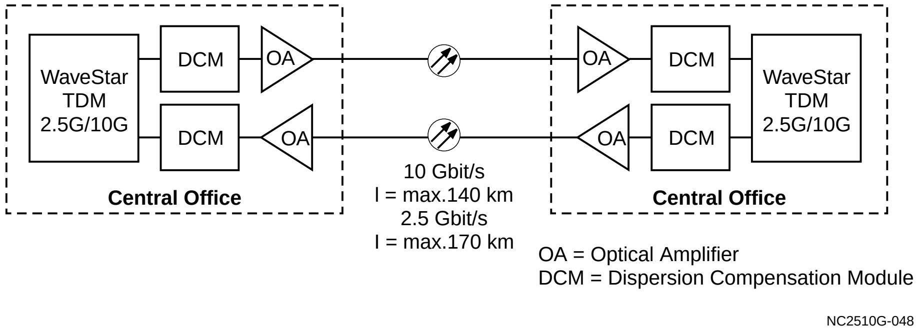
For information on the external OA system and its applications; and solutions for long distance multi-wavelength applications, contact your Lucent Account Executive.

Applications

Many single frequency/wavelength applications can be supported with the external OA system and WaveStar TDM 2.5G/10G (2-Fiber). Two possible applications are shown in the figures below

The WaveStar TDM 2.5G/10G (2-Fiber) and external OA system can be combined to support single span, single frequency, applications of up to 170 km and up to 140 km, for OC-48 and OC-192 rates, respectively. This application is shown in Figure 3-15, External Optical Amplifier Single Span Application (page 3-28). In this application, transmit amplifiers and pre-amplifier are used.

Figure 3-15 External Optical Amplifier Single Span Application



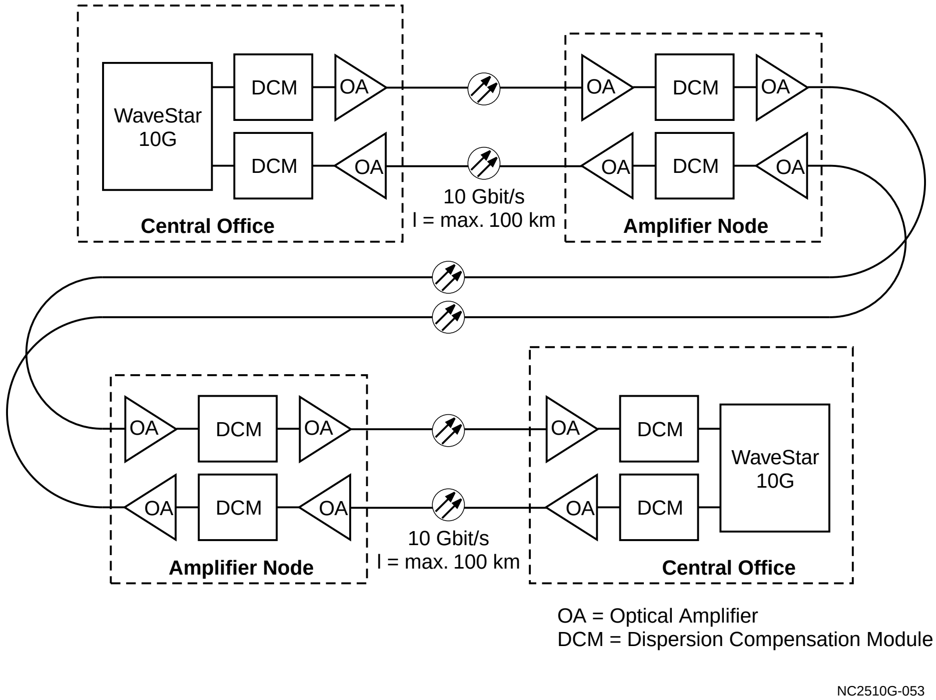
The WaveStar TDM 2.5G/10G (2-Fiber) and the External OA system can be combined to support very long distance transport, single frequency, OC-192 and OC-48 applications. Deploying OAs at multiple sites, intermediate sites and end points, allows transmission of information of up to 500 km, for OC-192 single wavelength applications, using SMF, via five 100 km spans. Figure 3-16, External Optical Amplifier Multispan Application (page 3-29) shows this type of application for a 300 km application, with 3 spans. In this application, transmit amplifiers, line amplifiers, and pre-amplifiers are used.

For information on the External OA system and its applications; and solutions for long distance multi-wavelength applications, contact your Lucent Account Executive.

The loss and dispersion characteristics (CD and PMD) for optical equipment and fiber must be considered for all network designs. The S/N ratio may also need to be calculated for applications. DCMs may or may not be required depending on the fiber route characteristics, the optical line rate being amplified, and optical characteristics of the all equipment. Greater span distances can be achieved, and Dispersion Compensation Modules (DCMs) can be eliminated or reduced in number when Lucent TrueWave (non zero dispersion shifted) fiber is used.

It is assumed that the PMD requirements for a specific application, are consistent with those requirements specified in ITU-T.691 for OC-48 applications, and Telecordia GR1377 for OC-192 applications.

Figure 3-16 External Optical Amplifier Multispan Application



Gigabit Ethernet Interfaces

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) supports two Gigabit Ethernet interfaces, the GE1/SX2 and GE1/LX2 port units. The GE1/SX2 port unit conforms to the standards outlined in IEEE 802.3, and supports the 1000BASE-SX interface. The GE1/LX2 port unit also conforms to the standards outlined in IEEE 802.3, and supports the 1000BASE-LX interface.

Capabilities

The GE1/SX2 and GE1/LX2 port units allow transport of Gigabit Ethernet signals over SONET networks by encapsulating ethernet packets in virtually concatenated STSs. The GE1/SX2 and GE1/LX2 port units support point-to-point connectivity.

Each GE1/SX2 port unit offers two 1000BASE-SX Ethernet LAN ports. Each GE1/LX2 port unit offers two 1000BASE-LX Ethernet LAN ports. Each port, on both port units, supports two Ethernet lines (one transmit and one receive, allowing full duplex operation). Each line can be associated with a virtual concatenated link over the SONET network (also called “WAN link”). The capacity per Gigabit Ethernet line is user provisionable to a maximum of 21 STS-1s. All connections to the 1000BASE-SX Ethernet interface on the GE1/SX2 port unit or to the 1000BASE-LX Ethernet interface on the GE1/LX2 port unit require Dual SC Connectors.

Virtual Concatenation

STS-1 concatenation can be used for the transport of payloads that do not fit into a single STS-1. Two methods for STS-1 concatenation are defined, contiguous and virtual concatenation. Both methods provide concatenated bandwidth of X times Container-N at the path termination. The difference is the transport between the path termination. Contiguous concatenation maintains the contiguous bandwidth throughout the whole transport. It requires concatenation functionality at each network element. Virtual concatenation breaks the contiguous bandwidth into individual STSs, transports these STSs and recombines them to a contiguous functionality only at the path termination equipment i.e. the GE1/SX2 or the GE1/LX2 Gigabit Ethernet port unit.

The H4 POH byte is used for the sequence and multiframe indication specific for virtual concatenation.

Due to different propagation delay of the STS-1s, a differential delay will occur between the individual STS-1s. This differential delay has to be compensated and the individual STS-1s have to be realigned for access to the contiguous payload area. The realignment process compensates at least a differential delay of a maximum of 32 ms between the fastest and slowest STS-1.

LCAS

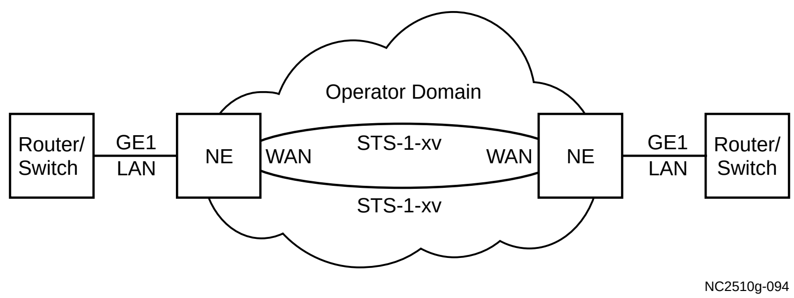
Link capacity adjustment scheme (LCAS) allows the flexible resizing of the bundle: in-service bandwidth reprovisioning changes and automatic fall-down in case of failure on single STS-1s (due to network or equipment failures or differential delay out of range). The objective is to have only short traffic hits during LCAS bandwidth changes comparable to those imposed by path or ring switching (UPSR or BLSR).

Point-to-point connectivity

The following two figures show possible point-to-point Gigabit Ethernet (GE1) network applications.

UPSR or BLSR protection

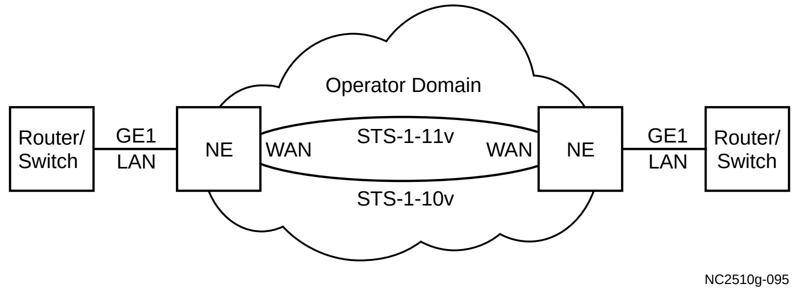
Protection of the individual STS-1s that form the STS-1-Xv is possible via UPSR and BLSR protection schemes. In STS-1-Xv, the v represents the virtual concatenated group and X represents the number of STS-1 signals in that group.



LCAS-based protection

If that protection scheme is used, half of the STS-1s of the virtual concatenated group is routed over one fiber, the other half over another fiber. If one fiber fails, about half of the GE1 WAN bandwidth is maintained during failures.

If BLSR is available (optional), half of the STS-1s of the virtual group are routed via preemptible protection access bandwidth.



Bridge Modes

The Ethernet Gigabit circuit pack supports two modes of bridge operation: VLAN tagging or repeater mode. The mode can be provisioned per LAN/WAN port pair.

VLAN Tagging

Customer identification and isolation on WAN ports is performed through VLAN tagging. In case the end user frames are untagged, a default LAN port based VLAN tag will be prepended to the end user frames. The FCS field is recalculated. In case the end user frames are already tagged those will be matched against the “valid VLAN list”. Unmatched frames will be discarded.

VLAN features include

- Learning bridge
- Quality of service

The VLAN tag is a 4 byte tag, formatted as a regular IEEE802.1Q VLAN tag. For detailed information of VLAN tag structure, refer to IEEE802.1Q, section 9.3.

A VLAN tag will always be present on WAN links although not strictly needed in point to point applications. The benefit is interworking with bridges supporting LAN based VPNs and VLAN trunking with multiple end users sharing one SONET path.

Repeater Mode

In the repeater mode the functionality is targeted at “transparent EtherNET transport”, with as few as possible provisioning items by the service provider.

The features of the repeater mode are:

- Point-to-point topology
- No MAC address learning

- No spanning tree protocol
- No quality of service
- No VLAN ingress filtering or classification for end-customer tagged or untagged frames
- No VLAN tag inserted on the WAN link for untagged frames
- Ethernet performance monitoring per port is still applicable
- Flow control is still applicable.

□

Interworking Capabilities

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with various Lucent PF-2000, WaveStar, and Metropolis family products, as well as with other vendors' products; for various applications and at various interface rates. The following table provides a high level summary of the interworking capabilities of the WaveStar TDM 2.5G/10G (2-Fiber) system.

Product	Interface Rate and Protection
DDM-2000 OC-3 Release 15 (R15), DDM-2000 OC-12 R7	OC-12 (UPSR - STS-1 path, 1+1, 0x1), OC-3 (1+1, 0x1)
FT-2000 OC-48 Lightwave System R9.1	OC-48 (2F BLSR), OC-12 (1+1, 0x1), OC-3 (1+1, 0x1)
WaveStar BWM R4.0	OC-192 (2F BLSR), OC-48 (2F BLSR, 1+1), OC-12 (1+1, 0x1), OC-3 (1+1, 0x1)
Metropolis™ DMX (Release 1.1)	OC-48 (UPSR - STS-1 path), OC-12 (UPSR - STS-1 path, 1+1, 0x1), OC-3 (1+1, 0x1)
Tellabs TITAN 5500 R6	OC-12 (1+1, 0x1), OC-3 (1+1, 0x1)
Fujitsu FLM-150 R14.2, FLM-600 R14.2	OC-12 (1+1, 0x1), OC-3 (1+1, 0x1)
Fujitsu FLM-2400 R15	OC-48 (UPSR - STS-1 path), OC-12 (UPSR - STS-1 path)
Nortel S/DMS R14.2	OC-48 (1+1, 0x1), OC-12 (1+1, 0x1), OC-3 (1+1, 0x1) (DCC pass through only)

Important:

Provisioning of SS bits may be required for interworking.
Interworking, and the level of interworking varies between products, and by product release.
DDM-2000 and FT-2000 software releases are TARP-compliant software releases.
Fixed east-west cabling is required for the FT-2000 system
The table is not all inclusive of all product releases that may allow interworking, including previous releases.

Contact your Lucent Account Executive to obtain the latest interworking information.

Topologies showing the various interworking capabilities of the WaveStar TDM 2.5G/10G (2-Fiber) are in this section. Information about DWDM applications using compatible optics, and hubbing applications is located earlier in this chapter.

Interworking with BandWidth Manager and FT-2000 OC-48 Lightwave System

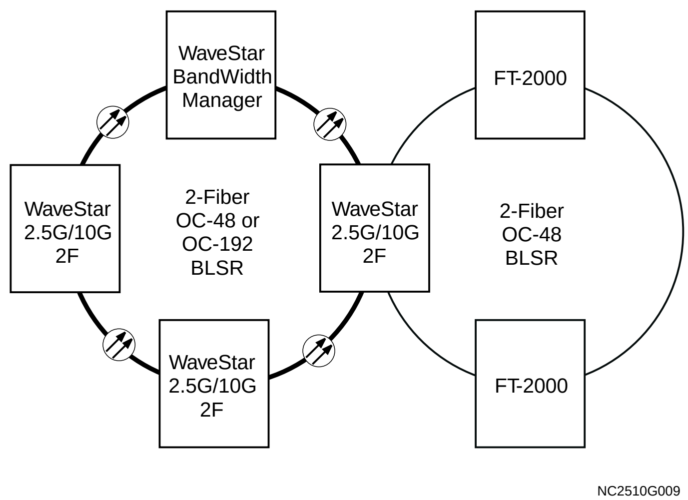
WaveStar TDM 2.5G/10G (2-Fiber) can participate in the same 2-fiber OC-48 BLSR with WaveStar Bandwidth Manager (Release 2.0 or later) and FT-2000 OC-48 Lightwave System (Release 9.1 or later).

WaveStar TDM 2.5G/10G (2-Fiber) can participate in the same 2-fiber OC-192 BLSR with WaveStar Bandwidth Manager Release 3.0 or later.

Interworking with BandWidth Manager and FT-2000

WaveStar BandWidth Manager, WaveStar TDM 2.5G/10G (2-Fiber), and FT-2000 interworking is a good solution for central offices and hub sites that terminate many BLSRs. Traffic can be transported over OC-48 and OC-192 2-fiber BLSRs from smaller central offices and hub sites to larger ones as shown in the following figure.

Figure 3-17 WaveStar 2-Fiber OC-48 and OC-192 BLSR Compatibility

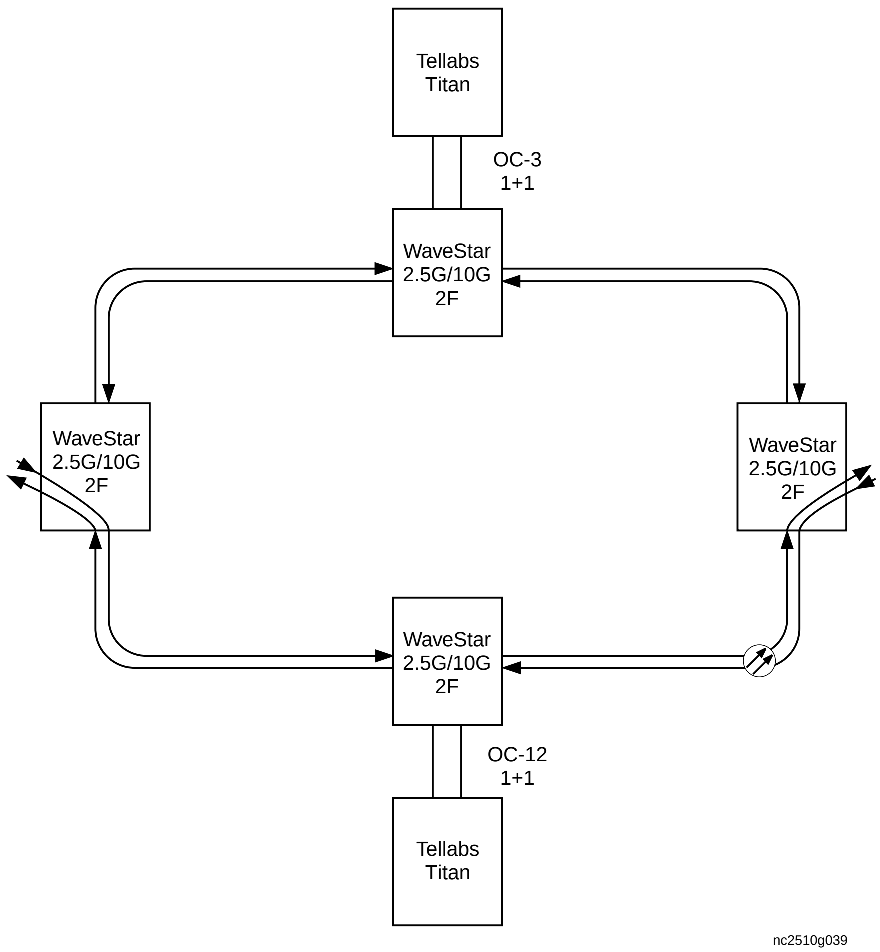


Interworking with Tellabs® Titan

The WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with the Tellabs® Titan over OC-3 and OC-12 lines (0x1 and 1+1 protected) as shown in the figure below.

The Titan can serve as the TL1/X.25 GNE (Gateway Network Element) for WaveStar TL1- RNEs. The SNMS and the WaveStar CIT can be connected to the Titan via an OSI LAN and provide full support of remote WaveStar products. The WaveStar CIT supports TL1 cut-through access through Titan to remote DDM 2000s. TARP and Level 2 routing capabilities are required in the DDM 2000s.

Figure 3-18 Interworking with Tellabs Titan over OC-3 and OC-12 1+1 Interfaces Example

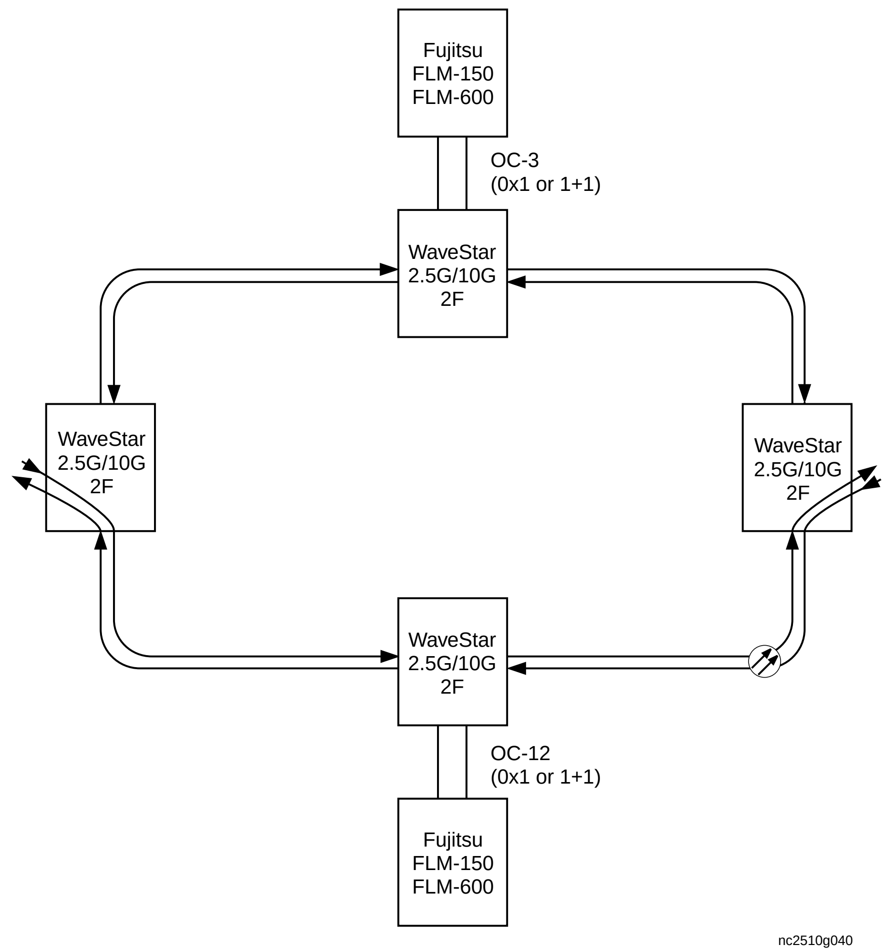


Interworking with Fujitsu FLM-150 and FLM-600

As shown in the figure below, the WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with the Fujitsu® FLM-150 R14.2 and FLM-600 R14.2 over OC-3 and OC-12 lines (0x1 and 1+1 protected).

The WaveStar CIT supports TL1 cut-through access to remote Fujitsu FLMs. TARP and OSI Level 2 routing capabilities are required in all FLMs. The use of WaveStar products as intermediate nodes has no adverse affects on FLM interworking capabilities currently supported by Lucent applications (FLM to FLM, FLM to DDM-2000, or OS to FLM to DDM-2000).

Figure 3-19 Interworking with Fujitsu FLM-150/FLM-600 over OC-3 and OC-12 (0x1 and 1+1 protected) Interfaces Example



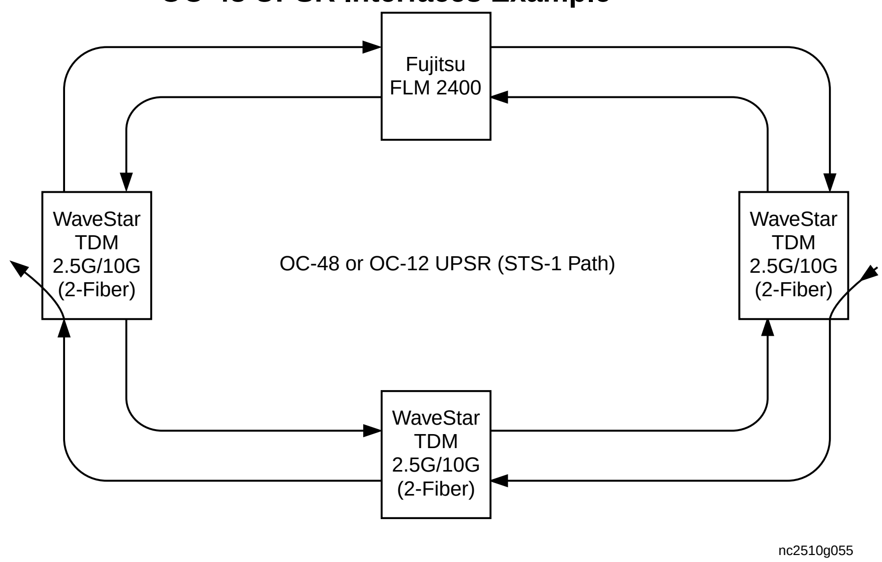
Interworking with Fujitsu® FLM-2400

The figure below shows how the WaveStar TDM 2.5G/10G (2-Fiber) and the Fujitsu FLM-2400 Release 15 can interwork together in an OC-48 or OC-12 UPSR (STS-1 path switching) application.

The WaveStar CIT supports TL1 cut-through access to remote Fujitsu FLMs. TARP and OSI Level 2 routing capabilities are required in all FLMs. The use of WaveStar products as intermediate nodes has no adverse affects on FLM interworking capabilities currently supported by Lucent applications (FLM to FLM, FLM to DDM-2000, or OS to FLM

to DDM-2000).

Figure 3-20 Interworking with Fujitsu FLM-2400 over OC-12 or OC-48 UPSR Interfaces Example

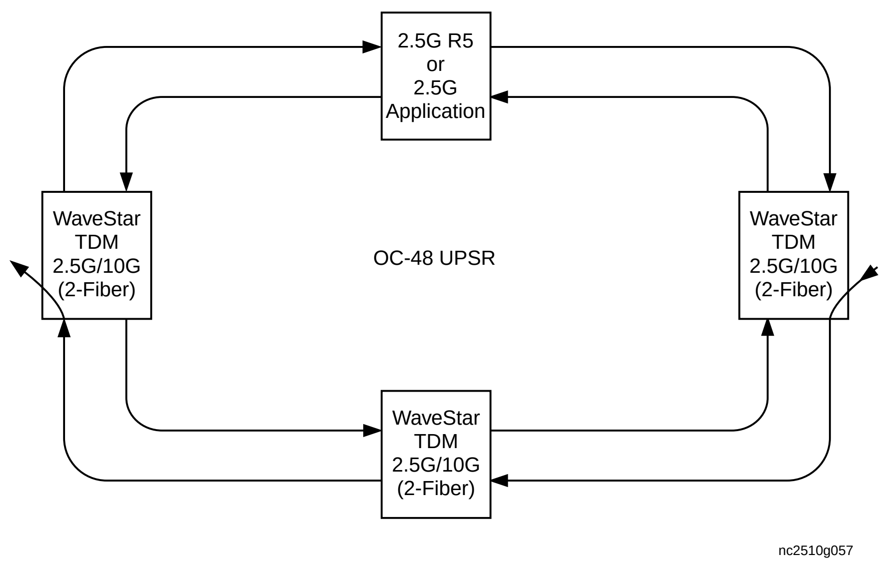


Interworking with the 2.5G Application of the WaveStar TDM 2.5G/10G (2-Fiber)

As shown in the figure below, the WaveStar TDM 2.5G/10G (2-Fiber) supports interworking with the 2.5G application of the WaveStar TDM 2.5G/10G, Release 6 over OC-48 UPSRs (STS-1 path)

> **Important!** When the 2.5G (low-speed or tributary) shelf of the WaveStar TDM 2.5G/10G (2-Fiber) system is used by itself, it is referred to as the 2.5G Application of the WaveStar TDM 2.5G/10G (2-Fiber).

Figure 3-21 Interworking with the 2.5G Application of the WaveStar TDM 2.5G/10G (2-Fiber) Example



DDM-2000 Pseudo Linear Interfaces

Overview

This configuration supports applications that multiplex low-speed DS1 traffic onto an OC-3 or OC-12 interface with WaveStar DCC compatibility.

In this application, shown in the figure on the following page, DDM-2000 supports an OC-3 (or OC-12) unidirectional path switched ring (UPSR) interface. The DDM-2000 high-speed OC-3 (or OC-12) UPSR fiber pairs are connected to WaveStar TDM 2.5G/10G (2-Fiber), but those ports (on a tributary I/O shelf) are provisioned as a linear (1+1) transmission protection group. Transmission protection is based on incoming line failures and not on individual path failures (as is done for UPSRs). The paths on such linear (1+1) interfaces can be cross-connected to any other port on the WaveStar TDM 2.5G/10G (2-Fiber).

You can connect and provision multiple DDM-2000s to a WaveStar TDM 2.5G/10G (2-Fiber) for this application, but each DDM-2000 must be in its own separate “single-node” UPSR. The DDM-2000 can be either collocated with or remote from the WaveStar TDM 2.5G/10G (2-Fiber).

Refer to the table below for a summary of WaveStar TDM 2.5G/10G (2-Fiber)'s pseudo-linear compatibility with DDM-2000.

Table 3-2 DDM-2000 Pseudo-Linear Compatibility

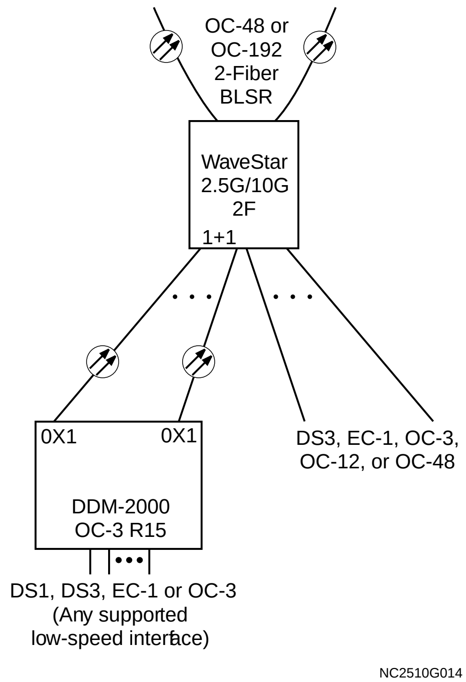
		DDM-2000 TARP Releases		**DDM-2000 OC-3 R15.0 and later, FiberReach R4.0 and later**
		UPSR (VT1.5 XCONs) with distinct DCCs	**UPSR (STS-N(c) XCONs) with distinct DCCs**	**UPSR (VT1.5/STS-N(c) XCONs) with linear (1+1) identical DCC**
2.5G/10G (2F)	Linear (1+1) transmission with distinct 0x1 DCCs	yes	yes	-
2.5G/10G (2F) R4 and later	Linear (1+1) transmission and DCC	-	-	yes

DCC provisioning

DDM-2000 supports DCC on both high-speed UPSR interfaces by default. The DDM-2000 DCCs default to User-Side and Network-Side, respectively. Both DDM-2000 DCCs should be provisioned to Network-Side. WaveStar TDM 2.5G/10G (2-Fiber) Release 4 and later requires DDM-2000 OC-3 R15s “identical DCC” feature on the DDM-2000 high-speed UPSR interface. DDM-2000's “identical DCC” feature supports linear (1+1) DCC and is compatible with WaveStar's default DCC assignment for a linear (1+1) protection group. The WaveStar linear (1+1) DCC defaults to User-Side.

Example The figure below shows a diagram of the WaveStar TDM 2.5G/10G (2-Fiber) interfacing with the DDM-2000, which is operating as a UPSR with low-speed interfaces.

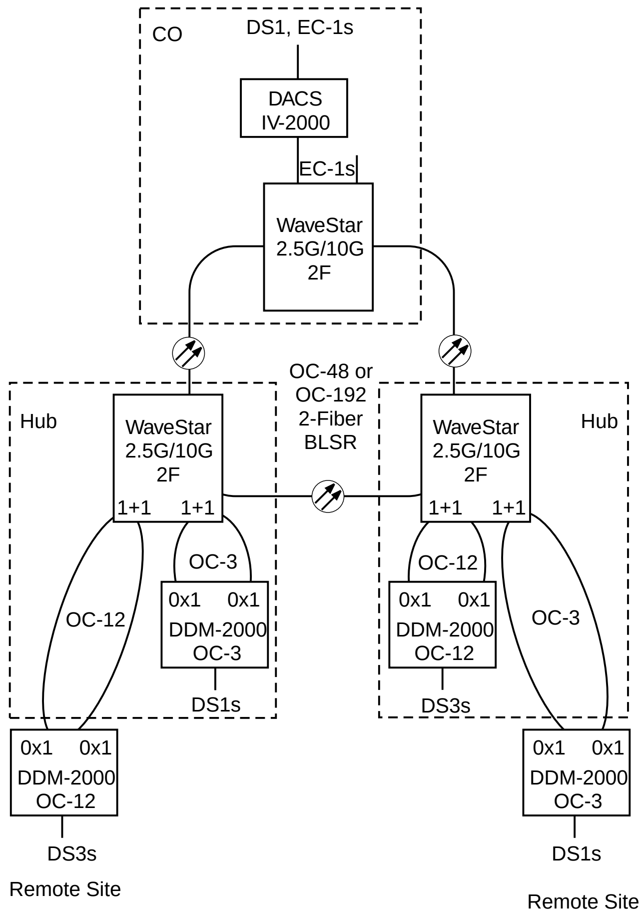
Figure 3-22 Linear Interface to a DDM-2000 OC-3 or OC-12 UPSR



Example with DACS IV-2000

The following figure shows a configuration that can be used in conjunction with DACS IV-2000 in a larger CO. The DACS IV-2000 is used to groom DS1 traffic. One or more STS-1s on the BLSR are dedicated to the DS1 add/drop traffic at each hub site. The DACS IV-2000, which supports VT1.5 granularity, rearranges the DS1 traffic, as necessary, on EC-1 interfaces (for example, for efficient use of EC-1 interfaces to a collocated 5ESS Switch).

Figure 3-23 DS1 Grooming with DACS IV-2000



Transporting DDM-2000 Rings Over a WaveStar TDM 2.5G/10G (2-Fiber) Ring

Overview

If a linear chain is geographically close enough to a backbone system, then the linear chain can be deployed as a ring by connecting both ends to the backbone. Traffic from the newly-formed ring can be transported by the backbone system. This is referred to as ring transport.

DDM-2000 OC-3/OC-12 ring transport

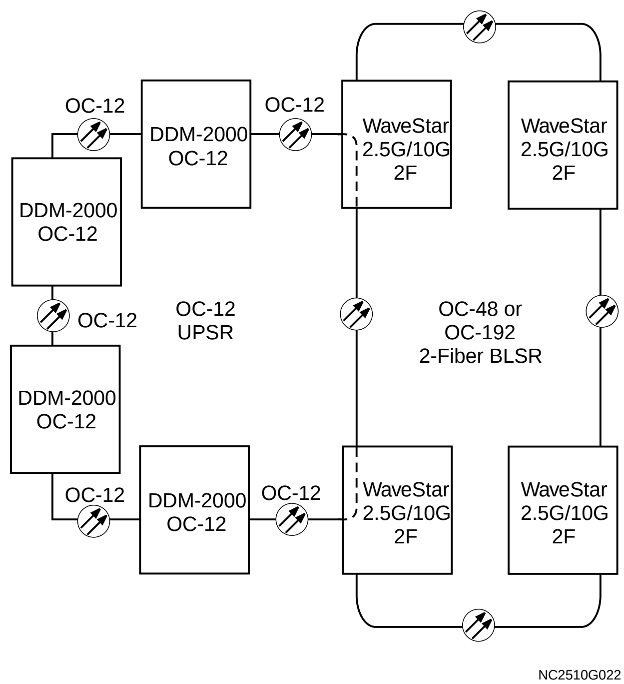
A DDM-2000 OC-3 or OC-12 ring is an end-to-end, self-healing ring providing path-switched protection of DS1 or other services.

A WaveStar TDM 2.5G/10G (2-Fiber) ring carrying backbone traffic can be used to transport a span of a DDM-2000 OC-3 or OC-12 ring. The figure below shows how WaveStar TDM 2.5G/10G (2-Fiber) OC-12 low-speed interfaces can provide transport for a DDM-2000 OC-12 ring. The WaveStar TDM 2.5G/10G (2-Fiber) ring provides 12 STS-1 equivalents of bandwidth to transport the DDM-2000 ring.

DDM-2000 OC-12 ring transport example

In the figure below, a WaveStar TDM 2.5G/10G (2-Fiber) ring is used to transport a span of a DDM-2000 OC-12 ring.

Figure 3-24 DDM-2000 OC-12 Ring Transport



Path-in-Line

Overview

Path-in-line is a configuration in which path-switched, ring traffic is carried within the bandwidth of line-switched rings. The path for a signal is the connection between the point where its SONET frame is assembled and the point where it is disassembled. Figure 3-25 illustrates a configuration in which traffic is protected by both the loopback protection switching capabilities of a WaveStar TDM 2.5G/10G (2-Fiber) BLSR and the path switching protection capabilities of DDM-2000 UPSRs (unidirectional path-switched rings). This example shows the following types of OC-3 interface connections between a WaveStar TDM 2.5G/10G (2-Fiber) ring and DDM-2000 OC-3 rings:

- Dual-homed ring (0x1) interface connections to a WaveStar TDM 2.5G/10G (2-Fiber) ring at Nodes A and E
- Single-homed ring (0x1) interface connections to a WaveStar TDM 2.5G/10G (2-Fiber) ring at Nodes B and C

The subtending DDM-2000 can be collocated with or remote from the WaveStar TDM 2.5G/10G (2-Fiber) nodes.

Dual-homed vs. single-homed

In a dual-homed ring 0x1 interface configuration, one ring connects to the other by means of a 0x1 OC-3 or OC-12 interface connection at each of two WaveStar TDM 2.5G/10G (2-Fiber) nodes. In a single-homed ring 0x1 interface configuration, one ring connects to the other by means of two 0x1 OC-3 or OC-12 interface connections to a single WaveStar TDM 2.5G/10G (2-Fiber) node.

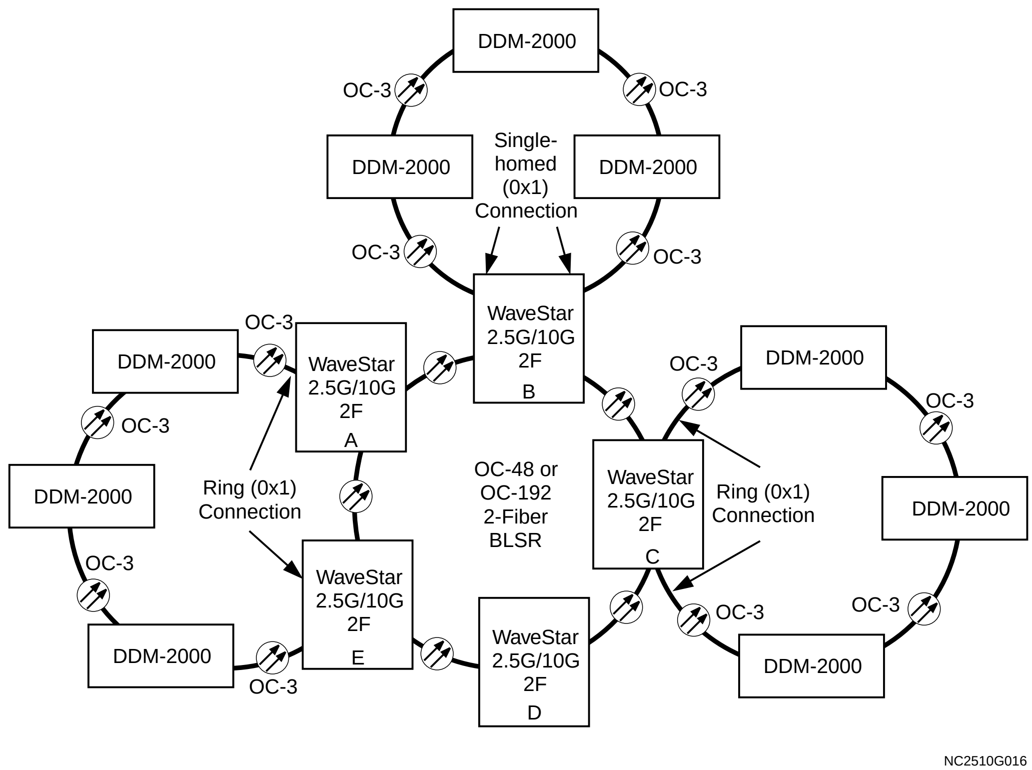
Although the WaveStar TDM 2.5G/10G (2-Fiber) OC-3 or OC-12 interface is unprotected in each of these cases, the DDM-2000 automatically performs a nonrevertive path protection switch if one of the interfaces fails.

Path-in-line example 1

The figure below shows single-homed and dual-homed configurations.

WaveStar TDM 2.5G/10G (2-Fiber) transports path-in-line traffic and can terminate the path-in-line traffic on OC-12 or OC-48 UPSRs (STS-1 path) itself. Yet, in the figure below all path-in-line traffic originates and terminates at the DDM-2000 nodes only. The typical application of this topology is used for VT-level path switching for DS1 traffic.

Figure 3-25 Dual-homed and Single-homed Path-in-line Connections



Bandwidth management

In the example in Figure 3-25, the DDM-2000 UPSR provides STS-1 and VT1.5 bandwidth management. This capability enables you to designate one or more bandwidth rails (for example, an STS-1, STS-3, or STS-12 bandwidth) on the WaveStar TDM 2.5G/10G (2-Fiber) ring for different types of service on the DDM-2000 OC-3/OC-12 rings. Because bandwidth management is at the STS-1 and VT1.5 level, you can choose to completely fill a particular bandwidth rail (for example, one STS-3 rail can hold up to 3 STS-1 or 84 DS1 equivalent signals). You can also add, drop, or pass through service at any node. This bandwidth management capability, in essence, allows you to transport virtual OC-3 or OC-12 UPSRs within the OC-48 or OC-192 BLSR bandwidth.

It is generally recommended that the same STS-1s be assigned at every node in a BLSR to support each virtual path-in-line UPSR, for example, STS-1s 1-3 add/dropped or passed through at each BLSR node. The path-in-line approach allows you to add and drop DS1s on the same STS-1s at different sites, thus facilitating efficient bandwidth utilization, for example, to groom all DS1 switched voice traffic onto a minimum number of STS-1s to be terminated as EC1s on a 5ESS switch.

Alternatively, if there is sufficient DS1 traffic demand from each site on a BLSR and/or adequate STS-1 capacity on the BLSR, an STS-1 (or multiple STS-1s) can be dedicated for the DS1 traffic to be added and dropped at each BLSR node. In that case, the path-in-line approach is not necessary.

Non-preemptible Unprotected Traffic (NUT)

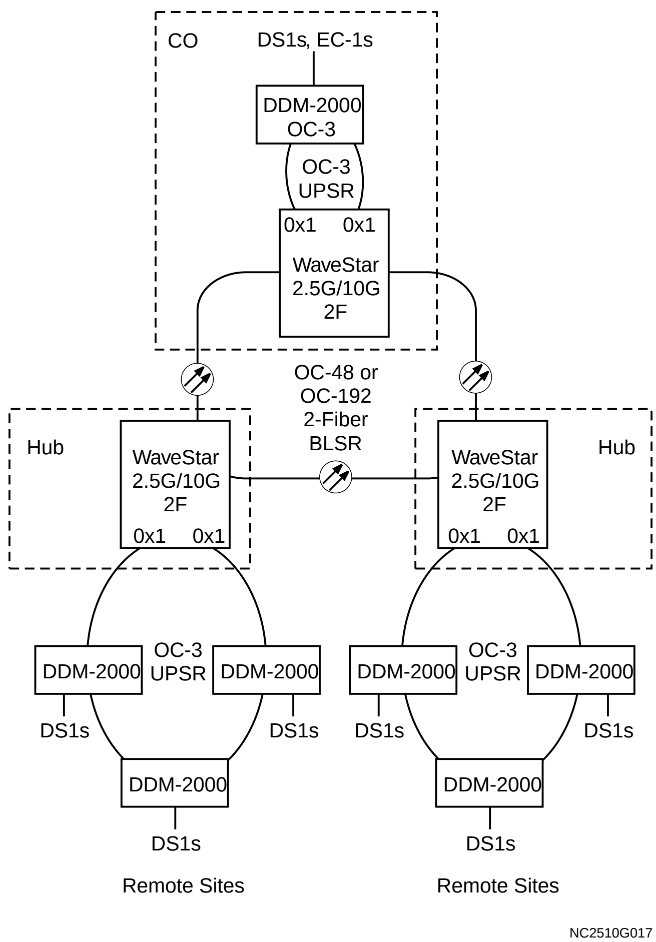
Preemptible protection access capacity in a BLSR (STS-1s 97-192 in an OC-192 BLSR, STS-1s 25-48 in an OC-48 BLSR) must not be used for path-in-line traffic because the traffic would be vulnerable to even a single failure. Path-in-line traffic must be carried either by the working (service) capacity (STS-1s 1-96 in an OC-192 BLSR, STS-1s 1-24 in an OC-48 BLSR) or by capacity provisioned for Non-preemptible Unprotected Traffic (NUT, also known as Non-Preemptible Protection Access, NPPA). NUT effectively doubles the capacity available for path-in-line traffic or other traffic that does not need to be protected by the BLSR but that must not be preempted by BLSR protection switching.

As an example, two STS-1 circuits of path-in-line traffic could be carried by two working tributaries; or instead, they could be carried by one STS-1 working tributary provisioned as an NUT tributary and its corresponding STS-1 protection tributary which also becomes an NUT tributary. Using the two NUT tributaries saves the capacity of one working tributary for traffic that does require BLSR protection. With additional STS-1 tributaries provisioned as NUT to carry more path-in-line traffic, the savings increases. Also, more path-in-line traffic can be carried in one BLSR than by using the working tributaries alone.

Path-in-line example 2

The figure below shows how a DDM-2000 OC-3 shelf with OC-12 optics in a small central office (CO) can be used to terminate and groom DS1 traffic from remote DDM-2000s (e.g., for efficient utilization of the EC1 interfaces to a collocated 5ESS Switch). The DDM-2000 OC-3 shelf in the CO terminates multiple OC-3 path-in-line rings with VT1.5 granularity.

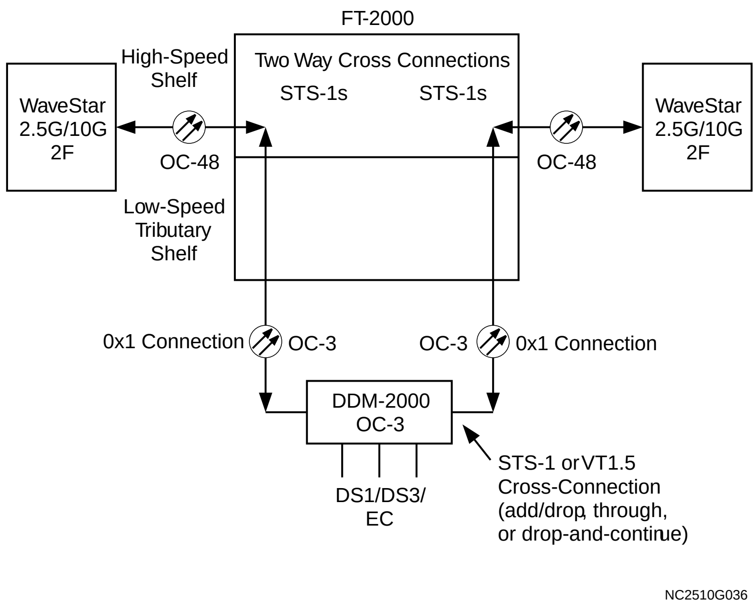
Figure 3-26 Terminating and Grooming DS1 Traffic from Remote DDM-2000s



Path-in-line example 3

The figure below illustrates a single-homed (0x1) interface connection between an FT-2000 and a DDM-2000. It also shows two-way cross-connections on an FT-2000 OC-48 Add/Drop-Rings Terminal and an STS-1 or VT1.5 cross-connection on a DDM-2000 Multiplexer. DDM-2000 low-speed interfaces to WaveStar TDM 2.5G/10G (2-Fiber). The FT-2000 and the WaveStar TDM 2.5G/10G (2-Fiber) nodes shown in the figure are interworking within the same BLSR.

Figure 3-27 Path-In-Line Example with FT-2000



□

SDH Transport

Overview Although WaveStar TDM 2.5G/10G (2-Fiber) is a SONET system, supporting only SONET interfaces, SONET Performance Monitoring (PM), and so on, the system can transport SDH signals over SONET ports and can use the same cross-connections for SONET or SDH signals. An STS-3 cross-connection can be used for either three VC-3 signals or for a VC-4 signal (STM-1) transported over OC-3, OC-12, OC-48, or OC-192 ports. An STS-48 cross-connection can be used either for VC-3, VC-4, and VC-4-4c or for a VC-4-16c signal (STM-16) transported over OC-48 or OC-192 ports.

Note With older embedded-base SDH equipment, provisioning of SS-bits may be required for interworking, refer to the provisionable SS-bits feature information in Chapter 5.

☐

Dual Node Ring Interworking

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 rings. Protection for the route between the two rings is provided by interconnecting the rings at two places (see Figure 3-28).

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 rings 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 WaveStar TDM 2.5G/10G (2-Fiber) tributary (linear) interfaces (DS3, EC-1, OC-3, OC-12, and OC-48) support DRI. The WaveStar TDM 2.5G/10G (2-Fiber) high-speed ring can be an OC-48 or OC-192 2-Fiber BLSR. A WaveStar TDM 2.5G/10G, Release 6 ring supports DRI with 2-fiber BLSRs, UPSRs, and rings using the following products:

- 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.

BLSR-to-BLSR interworking

In the BLSR, a bidirectional DRI-protected circuit to and from the terminating node is added and dropped at both a primary node and a secondary node, both of which interconnect with the other ring. The primary and secondary nodes are defined and provisioned on a per-circuit basis.

BLSR drop and continue

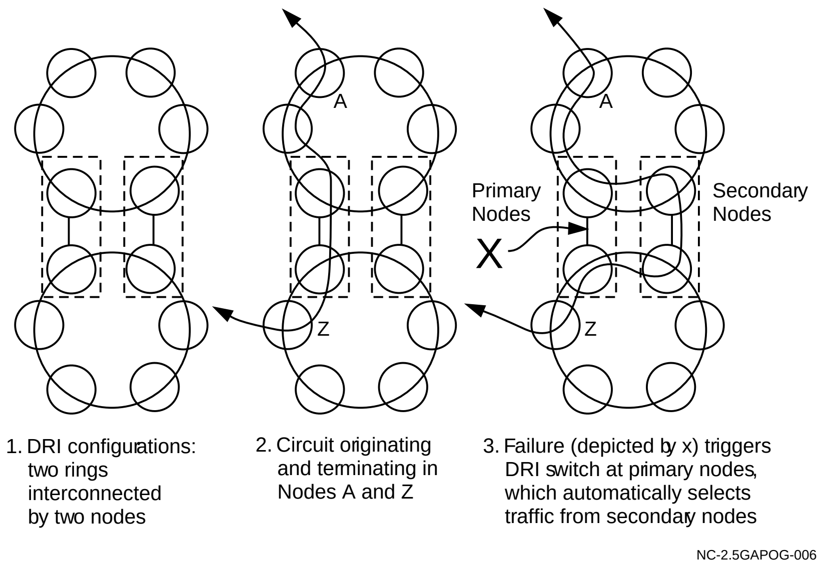
WaveStar TDM 2.5G/10G (2-Fiber) supports the drop and continue method of DRI, in which the primary node is between the terminating node and the secondary node and is the node that performs the drop-and-continue and path-selection functions. The primary node drops the circuit in the direction of the other ring and also continues (bridges) the circuit to the secondary node. The secondary node drops the circuit in the direction of the other ring and adds the circuit from the other ring in the direction of the terminating node. The primary node either adds the circuit received on its tributary interface from the other ring or passes through the duplicate signal received on the line from the secondary node, depending on standards-compliant path selection criteria.

BLSR to BLSR protection switching example

The figure below illustrates a failure of the interconnection to a primary 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 primary node in the lower ring. A failure in the route from Node Z to Node A results in a DRI switch at the corresponding primary node in the top ring.

A DRI protection switch in a WaveStar TDM 2.5G/10G (2-Fiber) occurs in $\leq$50 milliseconds (not counting the detection time) plus a provisionable hold-off time nominally of 100 milliseconds.

Figure 3-28 Dual Ring Interworking Protection



Types of connections

The two types of connections shown in Figure 3-29 are the following:

- A direct intraoffice connection between the primary nodes, Node 1 and Node 2, 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

WaveStar TDM 2.5G/10G (2-Fiber) 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

DS3 electrical interface

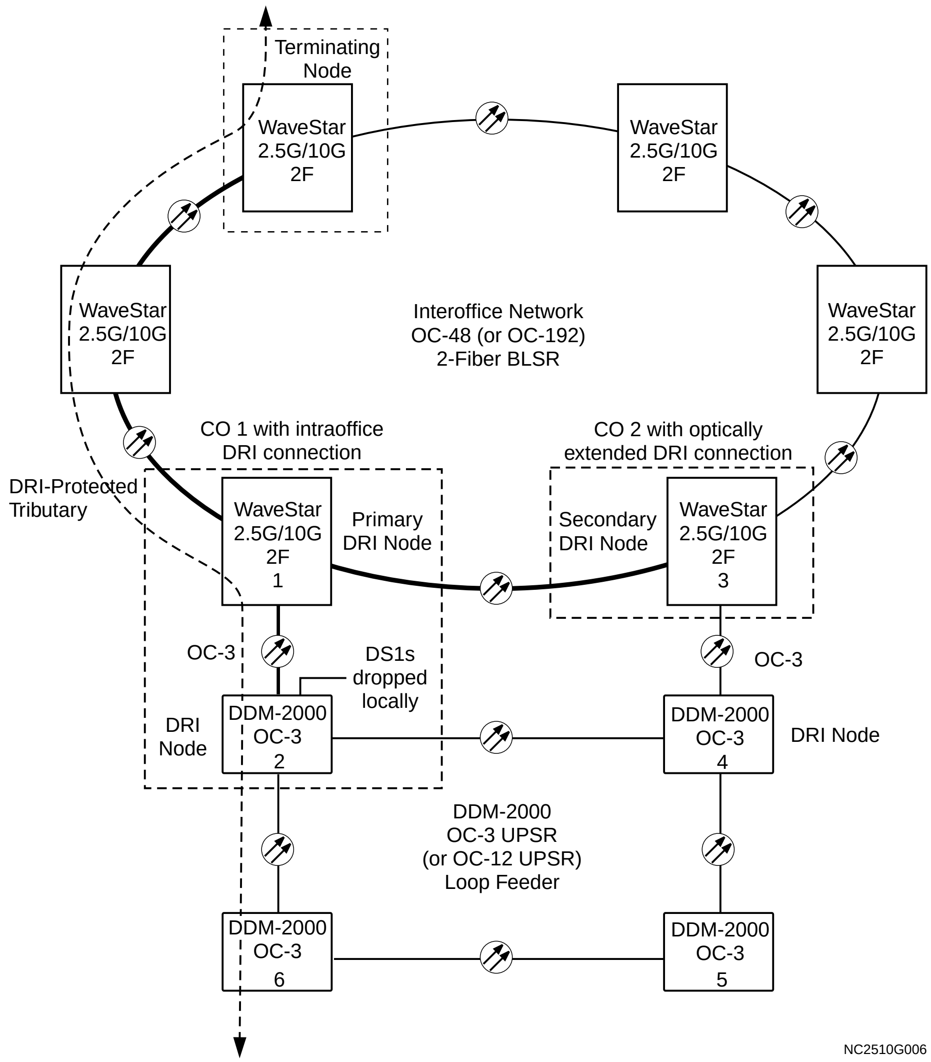
For DS3 interfaces, protection switching results from the following failure conditions (grouped by priority, from highest to lowest):

- LOS or OOF
- AIS

BLSR to UPSR interworking

The following figure illustrates a DRI configuration that uses OC-3 interfaces between a WaveStar TDM 2.5G/10G (2-Fiber) BLSR and a DDM-2000 OC-3 (or OC-12) UPSR.

Figure 3-29 DRI Between WaveStar TDM 2.5G/10G (2-Fiber) BLSR and DDM-2000 UPSR



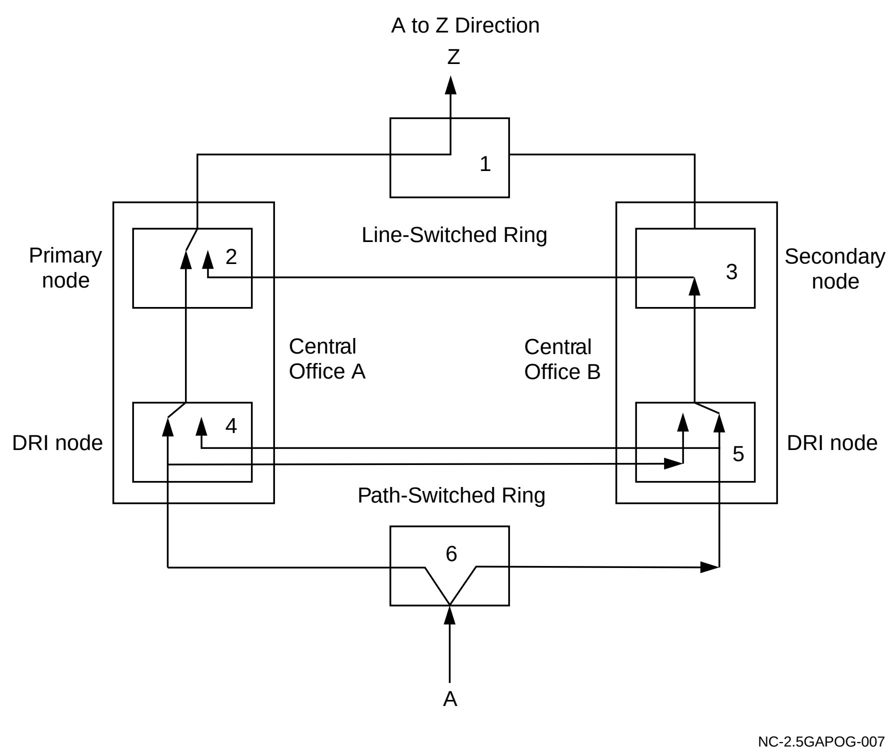
BLSR to UPSR DRI circuit examples

Figure 3-30 and Figure 3-31 show examples of a DRI configuration between a WaveStar TDM 2.5G/10G (2-Fiber) BLSR and a DDM-2000 unidirectional path-switched ring (UPSR). Figure 3-30 illustrates the 1-way circuit labeled A to Z Direction, in which the line-switched ring accepts two identical traffic inputs: one to the primary node (Node 2) and one to the secondary node (Node 3). In this case, there is no failure, so the primary node (Node 2) selects the traffic received by its own tributary interface. However, if a failure were to occur on the incoming signal, the primary node would automatically perform a DRI protection switch and select the signal received from the secondary node (Node3).

BLSR to UPSR DRI traffic flow example: A-Z

The figure below illustrates the A-to-Z direction of traffic in a DRI configuration between a WaveStar TDM 2.5G/10G (2-Fiber) BLSR and a DDM-2000 UPSR.

Figure 3-30 1-Way Circuit in Dual Interworked Rings: A to Z Direction



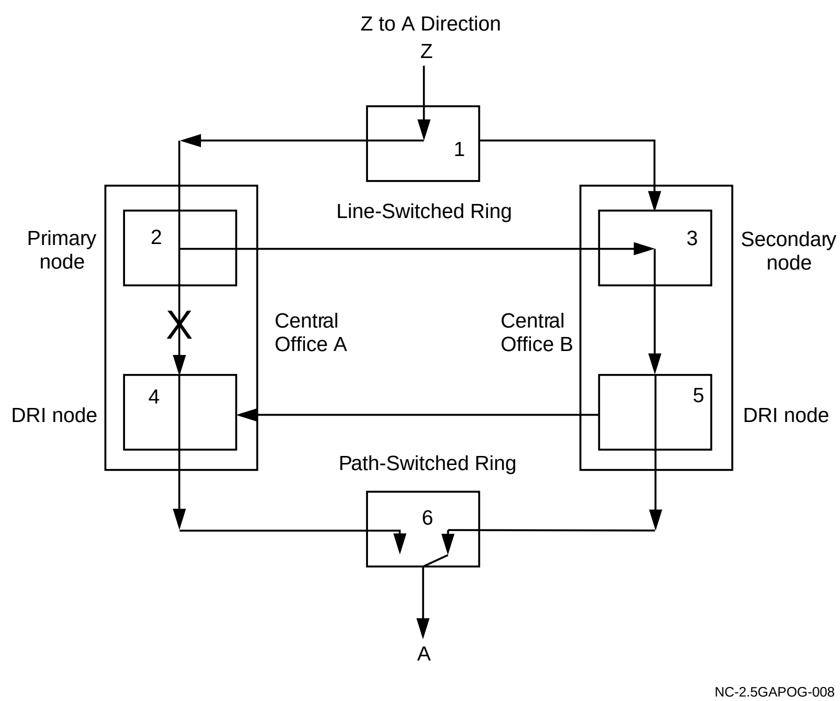
BLSR to UPSR protection-switched DRI traffic flow

For the 1-way circuit labeled Z to A Direction (see Figure 3-31), the line-switched ring provides two identical traffic outputs: one from the primary node (Node 2) and one from the secondary node (Node 3). The primary node (Node 2) bridges (duplicates) the traffic by using its drop-and-continue capability. A failure at the connection between the primary nodes (Node 2 and Node 4) causes the path-switched ring to initiate a protection switch at Node 6. Node 6 automatically selects the traffic received from the secondary node (Node 5).

BLSR to UPSR DRI traffic flow example: Z-A

The figure below illustrates the Z-to-A direction of traffic in a DRI configuration between a WaveStar TDM 2.5G/10G (2-Fiber) BLSR and a DDM-2000 UPSR.

Figure 3-31 1-Way Circuit in Dual Interworked Rings: Z to A Direction



Folded Rings

Overview

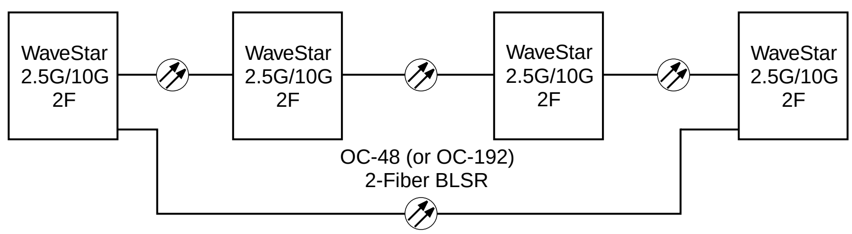
A folded ring is a ring that uses a linear cable route between its end nodes. All traffic passes through the same geographical locations, perhaps even in the same cable sheaths between nodes, instead of through diverse locations. This configuration is useful for networks in which not all locations are ready to be connected. In many cases, the initial network traffic demand suggests a linear add/drop chain because of short-term service needs between some of the nodes.

Later, the network traffic demand can evolve into a ring when there is a need for service and fiber facilities to other nodes in the network. It is easier to evolve the linear add/drop chain into a full ring configuration if a folded ring is used in the nodes that have this short-term service need. Folded rings have upgrade, operational, and self-healing advantages over other topologies for this type of evolution.

Folded ring example

The figure below shows a ring deployed geographically to act as a linear add/drop chain.

Figure 3-32 Simple Folded Ring



Reliability

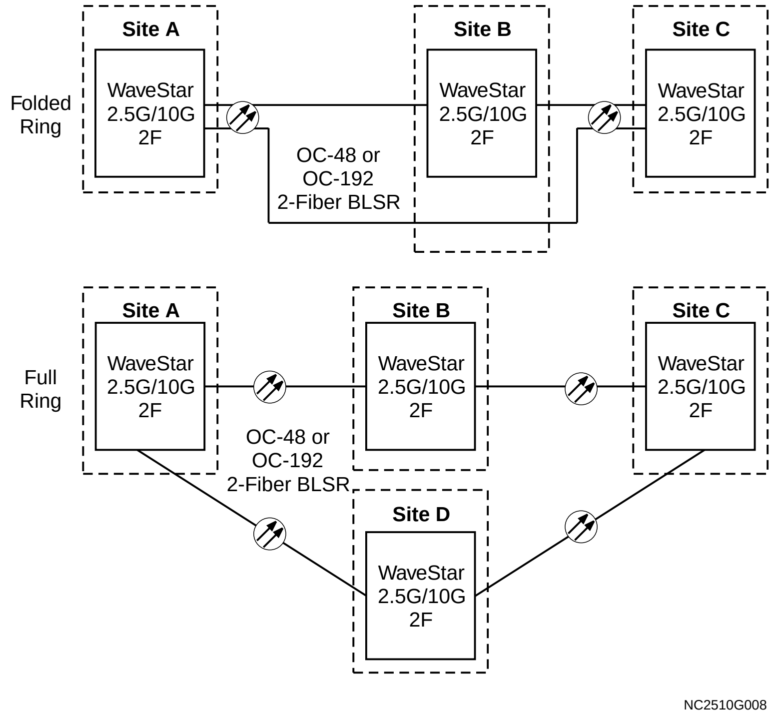
A folded ring configuration protects traffic from node failures. It cannot protect against a fiber cut if all the fibers are in the same cable. However, it does enhance the reliability of a linear route until there is enough traffic to warrant expanding to full rings.

Growth example

The top part of the figure below shows a network deployed as a folded ring for Sites A, B, and C. If the distance between Site A and Site C in the folded ring is too great for the OC-48 or OC-192 span, a second system (not shown) could be placed at Site B to serve as a 0% add/drop repeater.

The bottom part of the figure below shows the ring expanded at a later time into a full ring by adding Site D. Note that Site D is a separate system, and cannot be located in the Site B system.

Figure 3-33 Folded Ring Evolution



□

Multiple Rings

Overview

A single node can support multiple rings[1]. For instance, to increase network capacity and reliability, you can add an OC-192 BLSR into configurations of existing OC-48 BLSRs. WaveStar TDM 2.5G/10G (2-Fiber) has the capability to terminate and cross-connect circuits between multiple BLSRs (OC-192 or OC-48) and UPSRs (OC-48 or OC-12), significantly reducing the need for low-speed circuit packs and interfaces. In multiple ring applications, the WaveStar TDM 2.5G/10G (2-Fiber) cross-connects circuits between OC-48 and OC-192 ring interfaces internally by means of its STS-1 granularity TSI capability.

The OC-192 lines of the WaveStar TDM 2.5G/10G (2-Fiber) are associated with a node in an OC-192 BLSR ring, and the OC-48 lines of the WaveStar TDM 2.5G/10G (2-Fiber) are associated with one or more nodes in one or more OC-48 BLSR rings. The circuit is protected by the BLSR protection switching within each BLSR ring independently.

The OC-48 lines of the WaveStar TDM 2.5G/10G (2-Fiber) are associated with a node in one or more OC-48 UPSR rings, and the OC-12 lines of the WaveStar TDM 2.5G/10G (2-Fiber) are associated with one or more nodes in one or more OC-12 UPSR rings. The circuit is protected by the path protection switching within each node independently.

OC-192 BLSR as a backbone or “super-trunk”

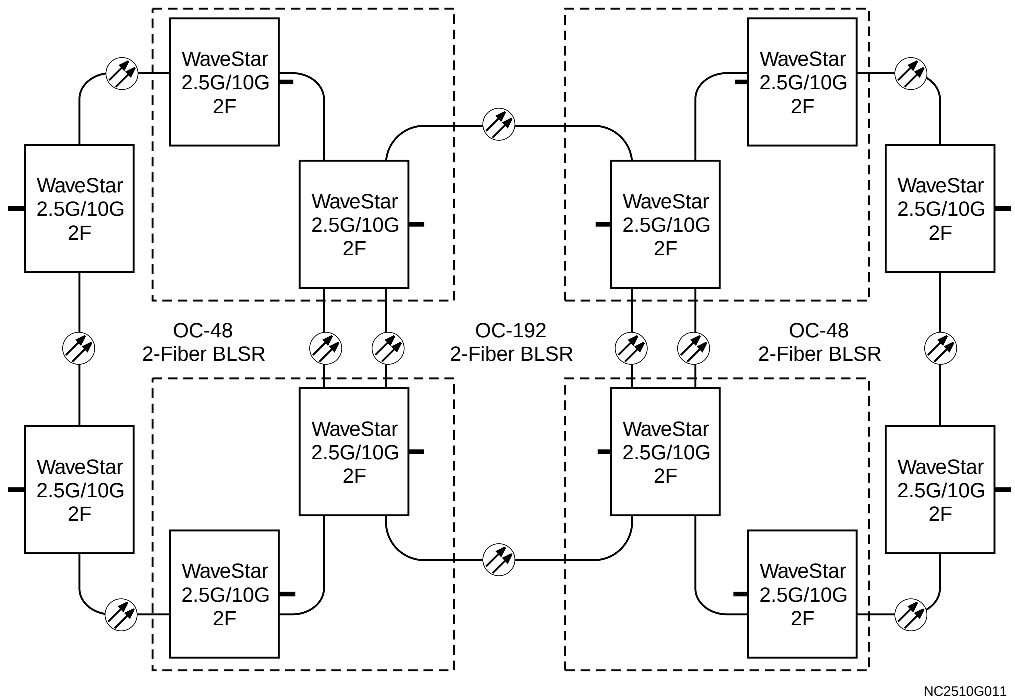
In a backbone or “super-trunk” topology, the OC-192 ring serves as the central core of the network. You can use an OC-192 BLSR as a backbone interworked with OC-48 BLSRs. As more capacity is needed and as more fibers are available, you can add up to 16 nodes (the maximum according to the SONET standard) to an OC-192 BLSR.

Backbone example

The following figure shows an OC-192 BLSR used as a backbone for two OC-48 BLSRs.

Figure 3-34 OC-192 Backbone BLSR with 2.5G/10G Subtending OC-48 BLSRs

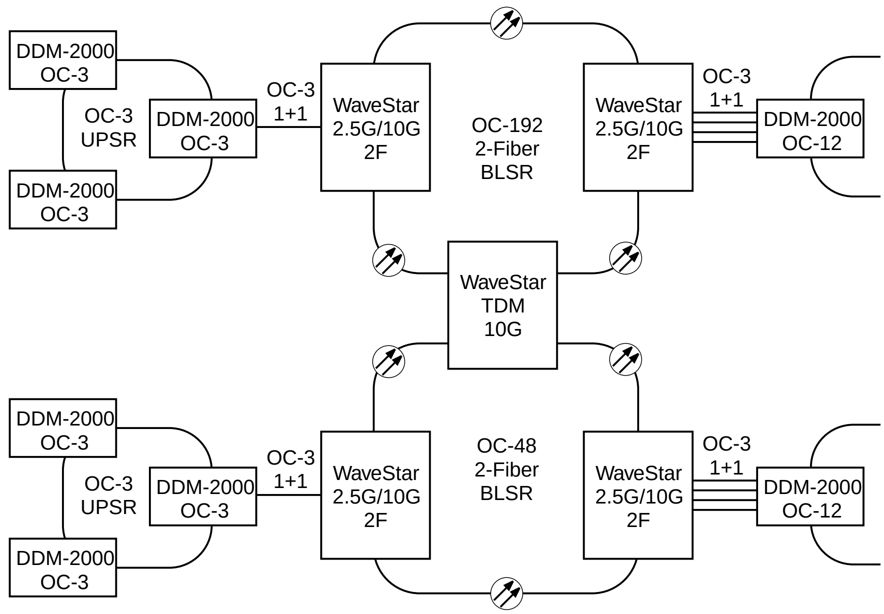
1 This feature is available in Release 5.1.x and later releases in which the numbering scheme is x.1.x, where x is a number between 0 and 9. This feature is unavailable in Release 5.0.x and later releases in which the numbering scheme is x.0.x.


WaveStar 2.5G/10G 2F
OC-48 2-Fiber BLSR
OC-192 2-Fiber BLSR
OC-48 2-Fiber BLSR
NC2510G011

Backbone example with subtending DDM-2000

The figure below shows an OC-192 BLSR used as a backbone for an OC-48 BLSR and subtending DDM-2000 rings connected by means of OC-3 linear (1+1) and OC-12 UPSR interfaces.

Figure 3-35 OC-192 BLSR as Backbone for an OC-48 BLSR with Subtending DDM-2000 Rings



Mesh Networks

Overview

A mesh network is a common topology (especially in data networks) that allows multiple routes between hosts in a network. Mesh topologies are relatively immune to bottleneck and component failure. Due to the variety of paths, traffic can be routed around failed or busy components.

Creating a mesh network

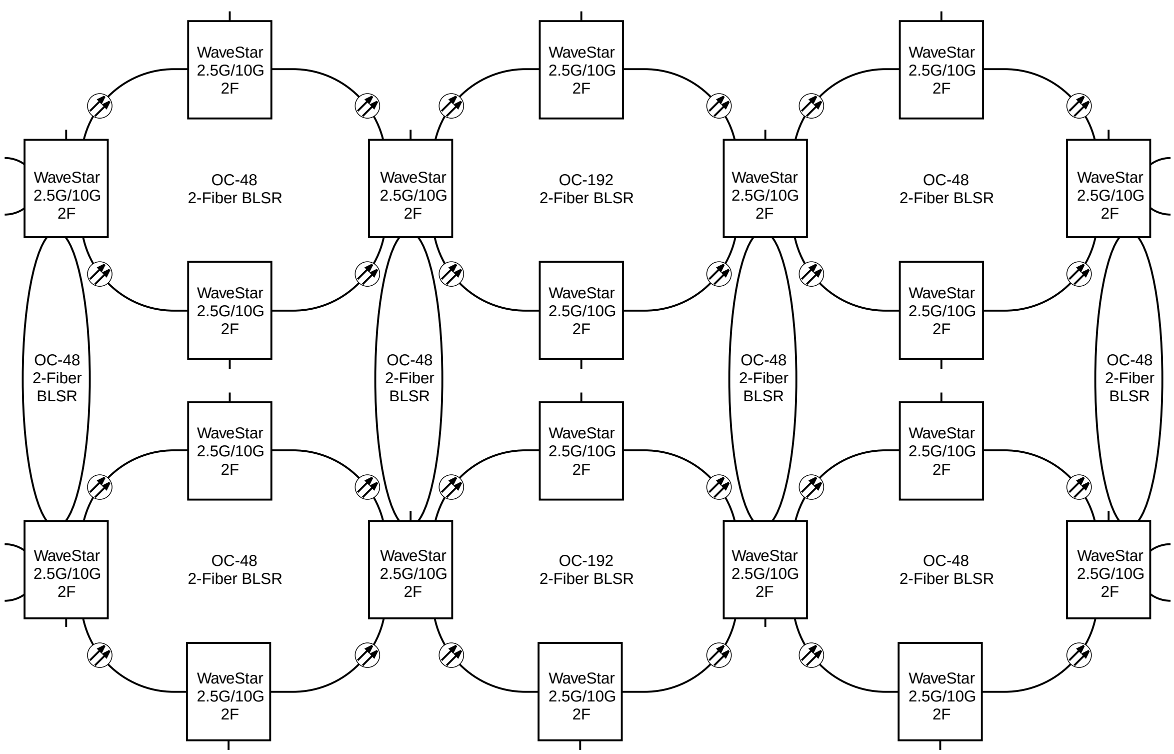
With the WaveStar TDM 2.5G/10G (2-Fiber), you can interconnect adjoining pairs of rings to create mesh networks with BLSR protection in a cost-effective manner. For additional protection, you can use dual node ring interworking (DRI) to support two interconnections between each pair of rings.

By using WaveStar TDM 2.5G/10G (2-Fiber) add/drop multiplexers at the points of interconnection of multiple rings, a single network element can route traffic from a node in one ring to a node in the other ring. The mesh can include linear interfaces, for example, optical 1+1 or electrical 1xN linear systems, as well as BLSRs and UPSRs.

Multiple interconnected rings

The figure below shows multiple, interconnected rings creating a mesh network.

Figure 3-36 Multiple, Interconnected Rings



Restoration Through Protection Access

Overview

Protection access is the capability or practice of accessing the protection capacity of a ring in order to carry extra traffic. If a failure occurs, preemptible protection access capacity is taken back for normal protection use by the ring.

WaveStar TDM 2.5G/10G (2-Fiber) offers both Preemptible Protection Access and Non-preemptible Unprotected Traffic (also known as Non-Preemptible Protection Access) as an economical way to obtain more capacity for traffic that does not need to be protected. Typically, a customer would temporarily provision the capacity as non-preemptible when it is more important for the restored traffic to remain uninterrupted in case of a subsequent failure than it is for the working traffic on the corresponding tributary to remain protected during the restoration. Figure 3-37 and Figure 3-38 show examples of DCS-based configurations for restoration through protection access.

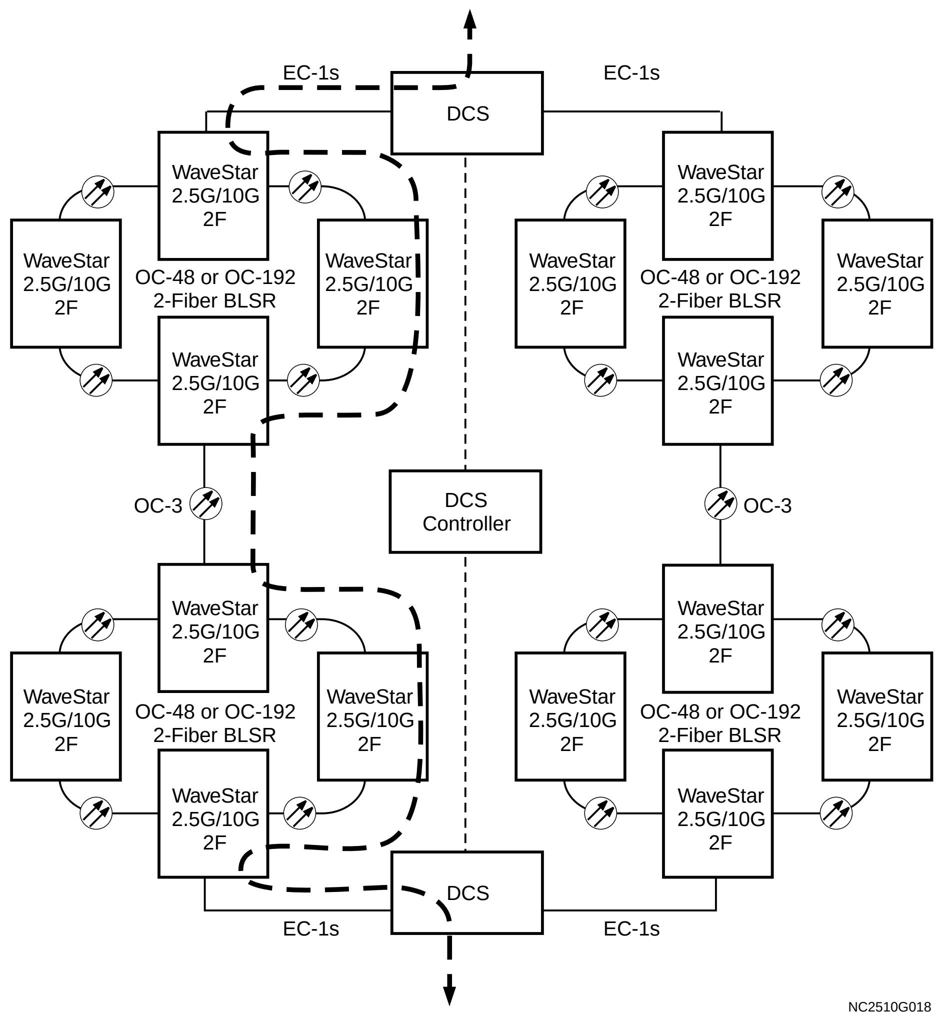
DCS-based restoration

In the figure below, WaveStar TDM 2.5G/10G (2-Fiber) is used with a DCS and a DCS controller to restore network traffic by accessing protection capacity. If a failure occurs between central offices, the DCS controller receives alarms and sends cross-connect commands to the DCSs in the network to reroute traffic around the failure. The protection channels are used to carry rerouted traffic until the failure is fixed and the regular route is restored.

Protection access example

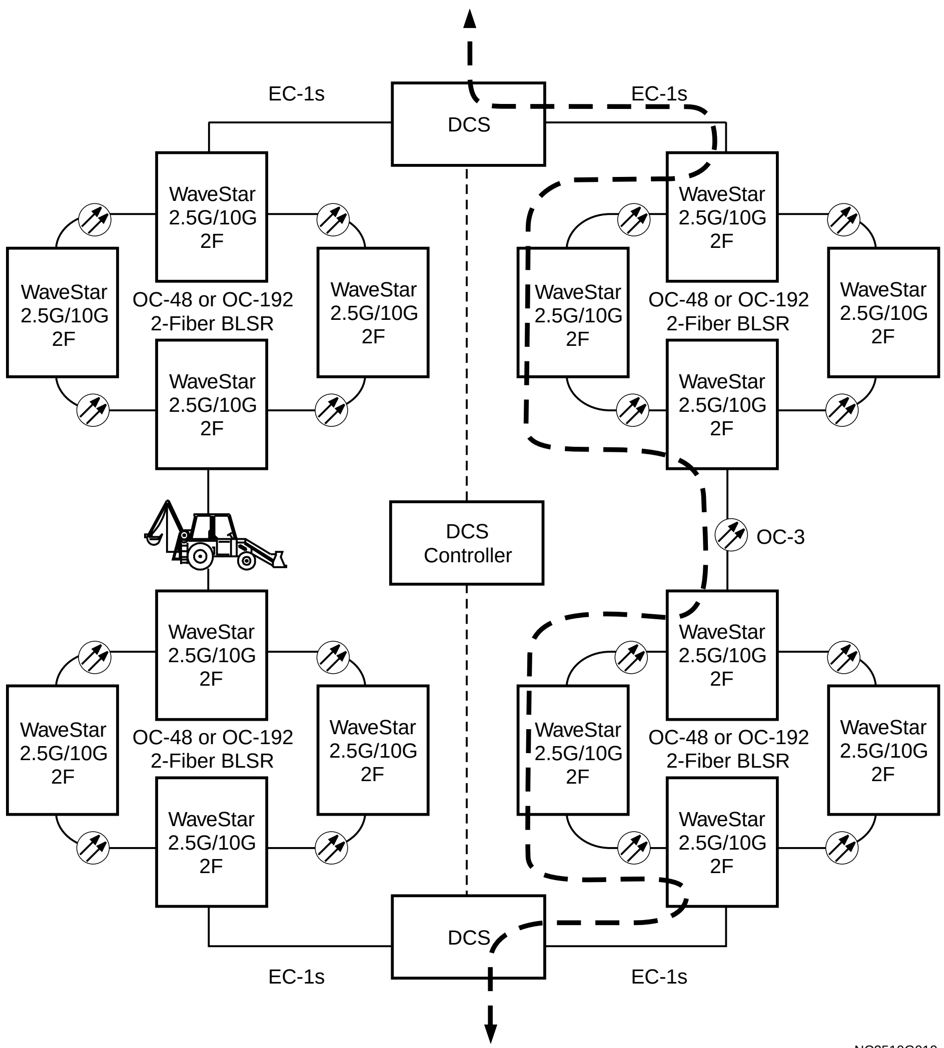
The figure below shows the path of DCS-protected traffic using the working capacity of two WaveStar TDM 2.5G/10G (2-Fiber) BLSRs.

Figure 3-37 DCS-Based Network Restoration Using Protection Access



Restoration The figure below shows an example of DCS-protected traffic being restored over the protection capacity of two WaveStar TDM 2.5G/10G (2-Fiber) BLSRs.

Figure 3-38 Restoration Over Protection Capacity



Loop Feeder

Overview

The "loop" is typically the wiring and associated equipment that connect the devices of the subscribers or users to the central office (CO). The equipment in the CO or in outside buildings that moves the signals into and out of the CO is loop feeder equipment. The WaveStar TDM 2.5G/10G (2-Fiber) supports the loop feeder equipment from within the CO building or from within a controlled environment vault (CEV) outside the CO. Figure 3-39 shows a loop feeder configuration being used to support the following:

- Intrasite hubbing connection to a local DDM-2000 OC-3 or OC-12 (CEV 1 and office building)
- Intersite remote hubbing connection to a remote DDM-2000 OC-3 (CEV 2) (Although not shown, you could also use a remote DDM-2000 OC-12 connection.)

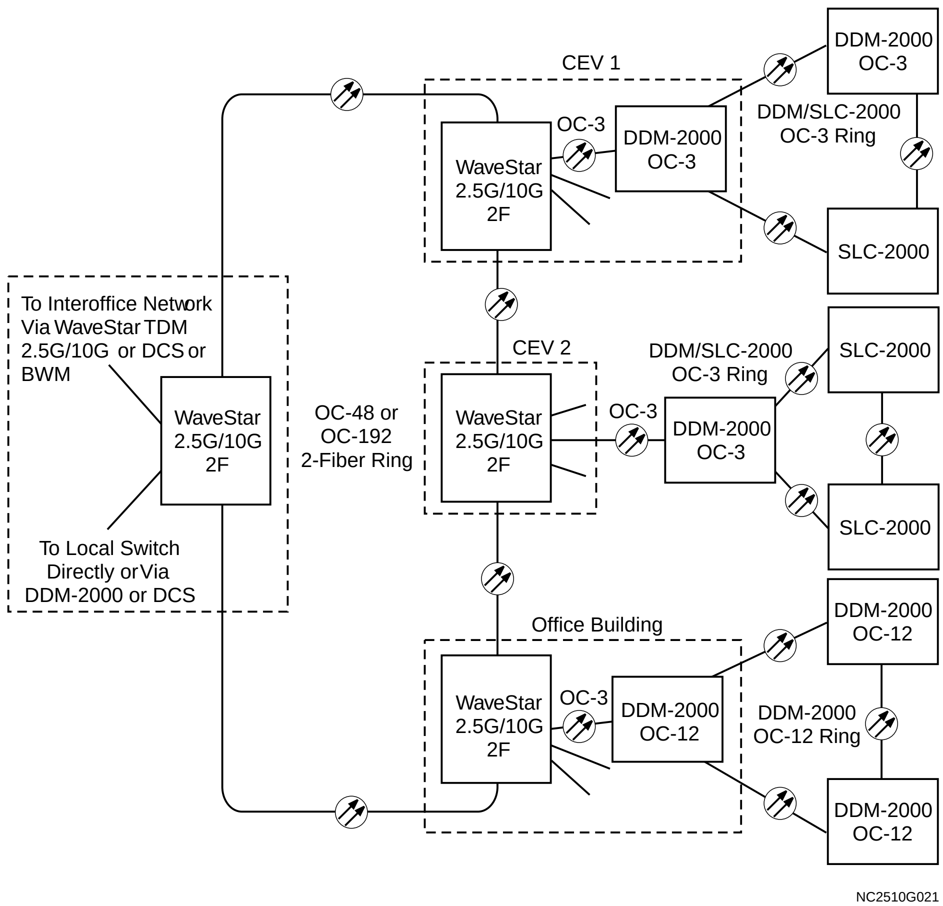
Intrasite hubbing connections

Through its OC-3 low-speed interface, WaveStar TDM 2.5G/10G (2-Fiber) can have an intrasite connection to a local DDM-2000 OC-3 or OC-12. In the CEV 1 section of Figure 3-39, the DDM-2000 OC-3 is a node in an OC-3 ring that supports VT and STS-1 path switching. All VT-switching takes place in the DDM-2000. In this example, the WaveStar TDM 2.5G/10G (2-Fiber) OC-3 interface connects to the OC-3 interface of a DDM-2000 OC-3 ring terminal. However, the remote nodes in the DDM-2000 OC-3 ring beyond the local DDM-2000 could be a combination of DDM-2000 OC-3 and SLC-2000 nodes.

In the office building section of Figure 3-39, the local DDM-2000 OC-12 is a node in an OC-12 ring. In this example, the WaveStar TDM 2.5G/10G (2-Fiber) OC-3 low-speed interface connects to the OC-3 low-speed interface of a DDM-2000 OC-12 ring terminal.

Loop feeder network The figure below illustrates a WaveStar TDM 2.5G/10G (2-Fiber) ring supporting loop feeder equipment.

Figure 3-39 Loop Feeder Support



Intersite remote hubbing connections

Through the WaveStar TDM 2.5G/10G (2-Fiber) OC-3 or OC-12 low-speed interface, WaveStar TDM 2.5G/10G (2-Fiber) can have an intersite connection to a DDM-2000 OC-3 or OC-12, or to an SLC-2000. In the example shown in Figure 3-39, the WaveStar TDM 2.5G/10G (2-Fiber) OC-3 interface connects to the OC-3 interface of a DDM-2000 OC-3 ring terminal in CEV 2. The nodes in the DDM-2000 OC-3 ring beyond this remote DDM-2000 can be a combination of DDM-2000 OC-3 and SLC-2000 nodes.

CO connections

At a CO, direct EC-1, OC-3, or OC-12 terminations on the WaveStar TDM 2.5G/10G (2-Fiber) are desirable for STS-12c, STS-3c, DS3, and DS1 services that require intraoffice transport to a DCS in the same CO or that require interoffice transport and are not terminated in this CO. At a CEV or hut, direct OC-3 or OC-12 terminations on the WaveStar TDM 2.5G/10G (2-Fiber) are desirable for all services to avoid the need to deploy additional equipment.

□

Broadband Transport

Overview

Broadband transport is transmitting and receiving voice, data, and/or video communications at greater than 2 Mb/s rates. Broadband services include:

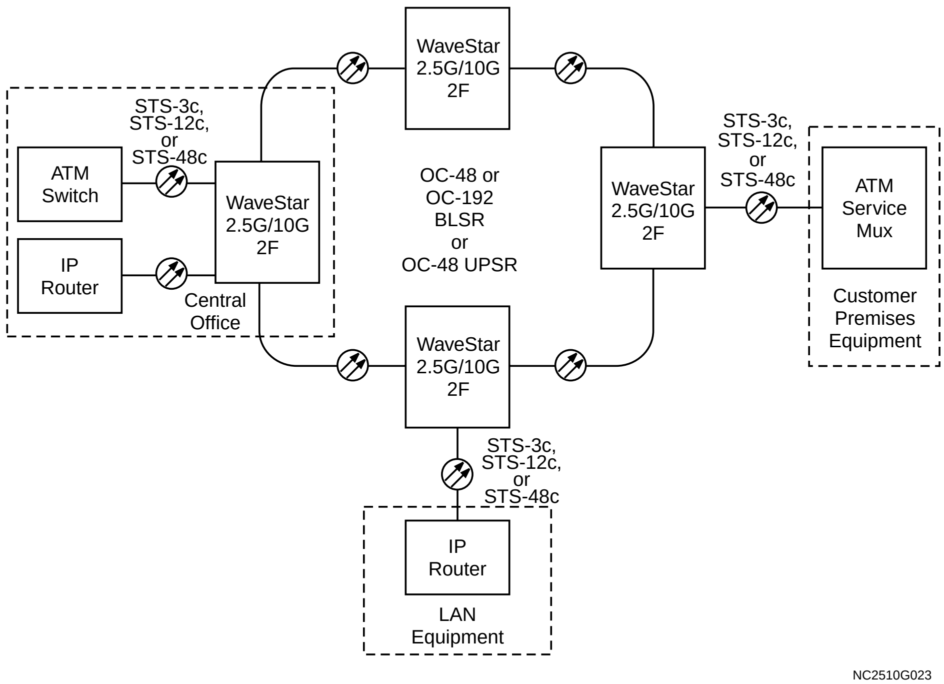
- LAN interconnection
- Video distribution from a video server
- Medical imaging

WaveStar TDM 2.5G/10G (2-Fiber) can transport STS-3c, STS-12c, and STS-48c payloads, including asynchronous transport mode (ATM) and internet protocol (IP) traffic, over OC-3, OC-12, OC-48, or OC-192 lines. Although some data services do not rely on SONET transmission protection, WaveStar TDM 2.5G/10G (2-Fiber) transmission protection switching is typically much quicker than data service-based restoration.

ATM and IP transport

The figure below shows WaveStar TDM 2.5G/10G (2-Fiber) transporting ATM and IP traffic between a central office and customer premises.

Figure 3-40 Broadband Service Transport



Interface Mixing

Overview

Interface mixing is using more than one type of port unit on the tributary shelves. This interface mixing provides the flexibility to make more efficient use of shelf capacities and to upgrade nodes independently of one another.

Shelf fill

In today's central offices many shelves are only partially filled. This is because some earlier systems required any particular shelf to contain only electrical interfaces or only optical interfaces, or only interfaces of the same rate. Therefore, the odd numbers of low-speed interface circuit packs often ended up in shelves by themselves, leaving unused slots.

WaveStar TDM 2.5G/10G (2-Fiber) supports a mix of EC-1, DS3, OC-3, OC-12, and OC-48 interface circuit packs both within the same tributary shelf and between source and destination shelves. By accommodating any combination of GE1/SX2, GE1/LX2, DS3, EC-1, OC-3, OC-12, and OC-48 circuit packs in one shelf, WaveStar TDM 2.5G/10G (2-Fiber) can reduce the number of shelves by increasing circuit pack slot usage (shelf fill).

End-to-end interface mixing

WaveStar TDM 2.5G/10G (2-Fiber) supports several combinations of transmission interfaces concurrently with a mix of port units (transmission interface circuit packs) within and between the terminals in a ring. A circuit can enter a WaveStar TDM 2.5G/10G (2-Fiber) network through one type of interface and exit through another type. The only requirement is for compatible payloads. For example, an STS-1 that is carrying DS3 traffic must terminate on an NE that is provisioned for an STS-1 that is carrying DS3 traffic and not on an NE that is provisioned for an STS-1 carrying VT1.5 circuits.

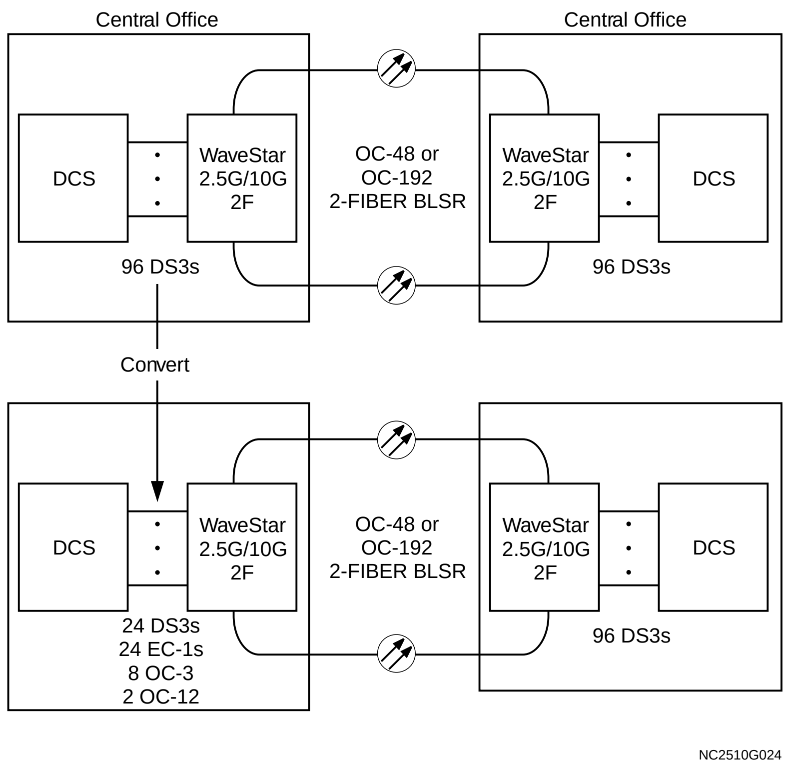
Network evolution

WaveStar TDM 2.5G/10G (2-Fiber) interface mixing capabilities offer more efficient network evolution and let planners deploy equipment based on the needs of the particular application. For example, network needs (sudden demand) may require SONET deployment in one area before others. See Figure 3-41.

Interface mixing example

The figure below shows how asynchronous DS3 interfaces at one end of a circuit within a WaveStar TDM 2.5G/10G (2-Fiber) network can be converted in-service to SONET interfaces (EC-1, OC-3, OC-12, or OC-48) without any changes at the other end of the line.

Figure 3-41 End-to-End Interface Mixing



0% Add/Drop Node

Overview

A 0% add/drop configuration is one in which a network element is used as if it were a repeater. This creates a BLSR node at which none of the ring capacity is added or dropped. All traffic is through traffic. In a 2.5G application, the tributary shelf is equipped as a 0% add/drop node on the OC-48 BLSR. In a 10G application using an OC-192 BLSR, a minimum complement of circuit packs is required in the high-speed shelf. For information about the minimum complement of circuit packs, see Chapter 4, "Product Description."

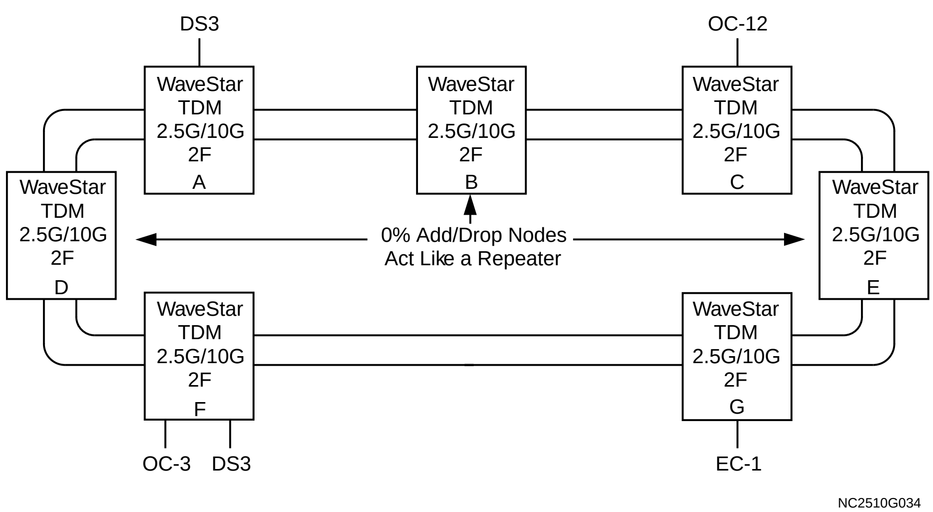
Uses for 0% add/drop

A 0% add/drop node provides access to the OC-192 DCC to perform remote operations, administration, maintenance, and provisioning for other nodes in the ring. Additionally, 0% add/drop node provides a convenient growth path for in-service upgrades when add/drop capability is needed in the future.

0% add/drop example

The figure below shows a network in which several nodes currently use 0% add/drop. As the demand for services increases, you can add low speed interface circuit packs as necessary to support add/drop traffic at nodes that do not currently require such connections.

Figure 3-42 0% Add/Drop Application



□

4 Product Description

Overview

Purpose

This chapter describes physical characteristics of the WaveStar TDM 2.5G/10G (2-Fiber) including the following:

- Shelf and bay configurations
- Circuit packs/ port units
- Basic architecture
- Transmission
- Control
- Power
- Cooling

Shelf and Bay Configurations

Overview

WaveStar TDM 2.5G/10G (2-Fiber) supports two basic system options:

- **2.5G system option –** A stand-alone tributary shelf that supports OC-48, Gigabit Ethernet (GE1), OC-12, and OC-3 port units and accommodates electrical connector panels and DS3EC1/8 port units for DS3/EC1 connections. A tributary shelf can have up to eight OC-48 port units, up to eight GE1 port units, up to sixteen OC-12 port units, up to sixteen OC-3 port units, up to 12 DS3 port units, or a mixture of port units.

  The interface capacity varies according to the number and type of port units you equip the shelf with. Up to three tributary shelves can fit in a 7-foot bay.

  When internally mounted DS3 connector panels are used, up to two tributary shelves can fit in a 7-foot bay.

- **10G system option –** A 7-foot bay with a high-speed (OC-192) shelf and one or two low-speed, tributary shelves, plus an optional second bay with one or two more low-speed, tributary shelves.

  An in-service upgrade is available for migrating one WaveStar TDM 2.5G (2-Fiber) BLSR to a WaveStar TDM 10G (2-Fiber) BLSR.

  The first tributary shelf (the Main 2.5G shelf) is common to both options. It contains the control and timing for the entire 2.5G/10G system and has an interface capacity of up to 384 STS-1s.

  The three optional tributary shelves (the Expansion 2.5G shelves) can be added while the system is in service, and each provides an interface capacity of up to 384 STS-1s.

  The high-speed shelf supports up to two OC-192 port units.

  Each shelf has a switch fabric. The high-speed shelf can be equipped either with a 576x576 STS-1 switch fabric or a 768x768 STS-1 switch fabric. The larger switch fabric is needed to support more than two tributary shelves, and it provides a larger cross-connection capacity between the high-speed shelf and the tributary shelves.

The high-speed shelf has 18 usable circuit pack slots, and each tributary shelf has 25 circuit pack slots (16 universal slots for port units).

To see detailed engineering drawings of typical bay and floor plan arrangements, order the engineering drawing ED 8C789-10, listed in “About This Information Product” at the beginning of this document.

DS3/EC1 mounting options

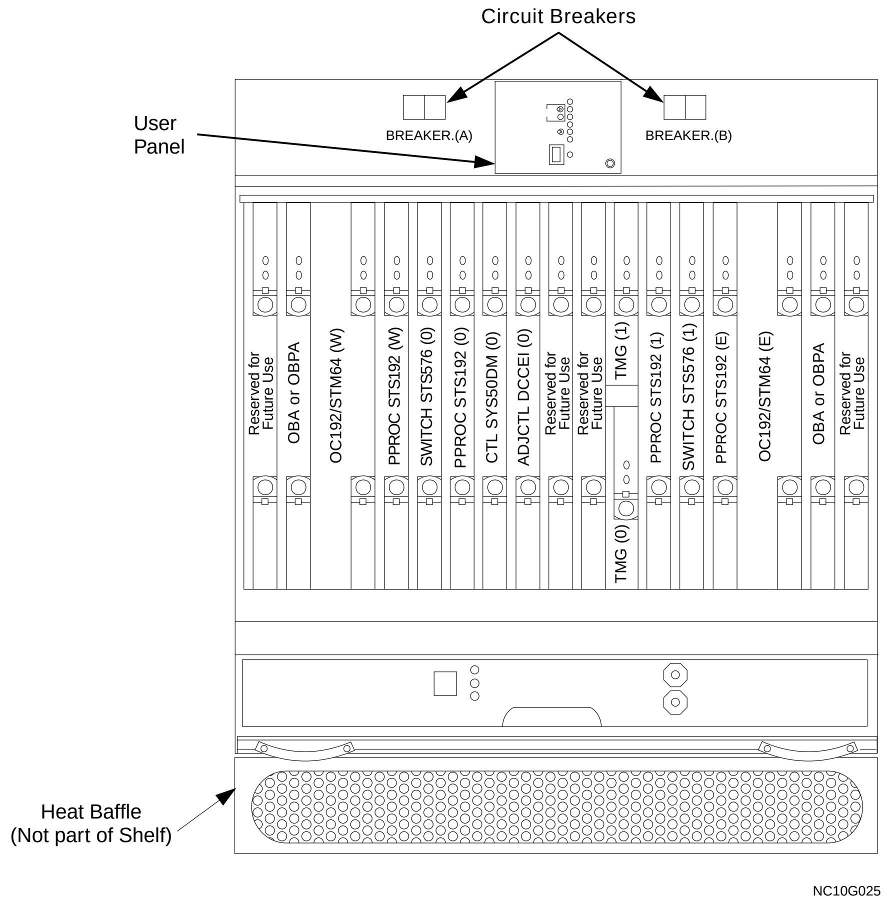
The optional DS3/EC1 connector panels can be installed in any of three ways:

- As external “wings” attached to the outside of the bay. This configuration requires equipping the bays with spacers to ensure adequate space between bays for cabling and for connector panel mounting.
- As internal in-bay modules. This configuration allows one seven-foot bay to contain up to two low-speed shelves or one low-speed shelf and one high-speed shelf.
- As rear-mounted panels. This configuration allows one seven-foot bay to contain either three 2.5G (OC-48) tributary shelves or one high-speed (OC-192) shelf and two tributary shelves. This option adds to the depth (3.45") of the bay.

High-speed shelf layout

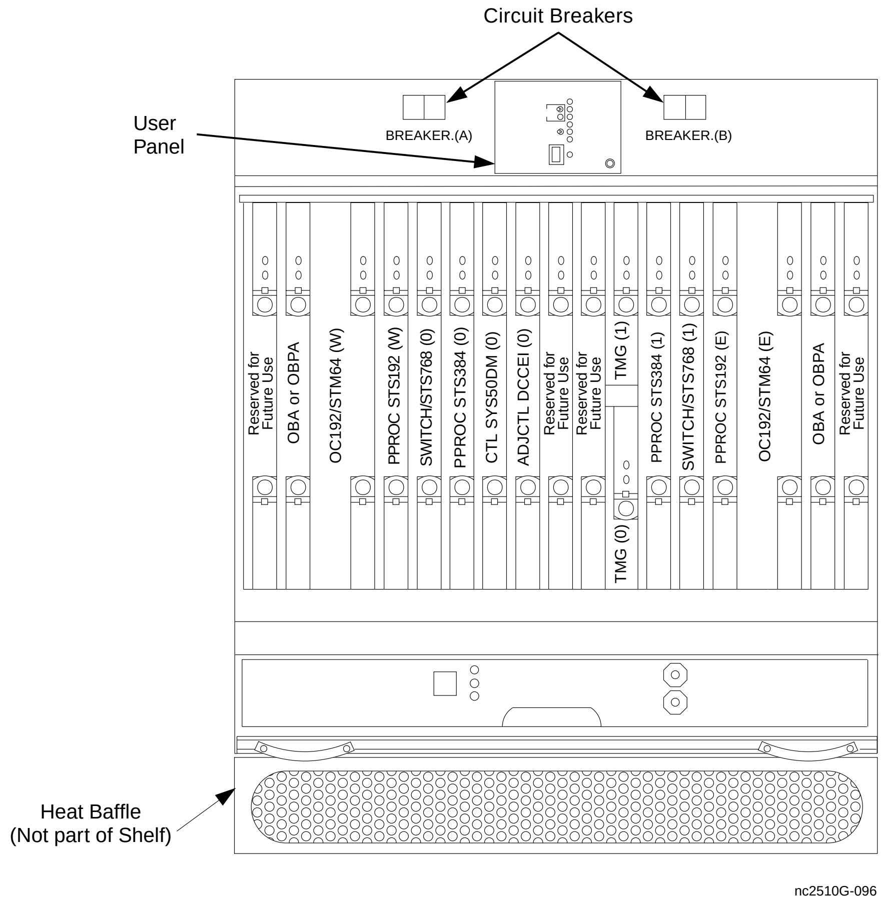
The following figure shows the layout for the WaveStar TDM 2.5G/10G (2-Fiber) high-speed shelf when the 576x576 STS-1 switch fabric is used. Table 4-1 provides a list of the slot labels and their location on the shelf. Table 4-2 discusses how the slots can be equipped.

Figure 4-1 WaveStar TDM 2.5G/10G (2-Fiber) High-Speed Shelf, 576x576 STS-1 Switch Fabric



The following figure shows the layout for the WaveStar TDM 2.5G/10G (2-Fiber) high-speed shelf when the 768x768 STS-1 switch fabric is used. Table 4-1 provides a list of the slot labels and their location on the shelf. Table 4-2 discusses how the slots can be equipped.

Figure 4-2 WaveStar TDM 2.5G/10G (2-Fiber) High-Speed Shelf, 768x768 STS-1 Switch Fabric



In the figure above, slots SWITCH 0 and SWITCH 1 contain the SWITCH/STS768 circuit pack. Note that when SWITCH/STS768 circuit pack is used, the shelf must also be equipped with PPROC/STS384 circuit packs in the PPROC 0 and PPROC 1 slots. The other common circuit packs for this shelf are the same as when it is equipped with the SWITCH/STS576 circuit packs.

Labels for the high-speed shelf

The table below shows the labels for the high-speed shelf plug-in units and circuit pack slots.

Table 4-1 Labels for the High-Speed Shelf Circuit Pack Slots

Slot (left to right)	Label
1st	- blank-
2nd	OBA or OBPA
3rd	OC192 STM64 W
4th	PPROC W
5th	SWITCH 0
6th	PPROC 0
7th	CTL SYSDM 0
8th	DCCEI
9th	-blank-
10th	-blank-
11th, a and b	TMG 1/TMG 0
12th	PPROC 1
13th	SWITCH 1
14th	PPROC E
15th	OC192 STM64 E
16th	OBA or OBPA
17th	- blank-

Circuit pack slots for high-speed shelf

The table below lists the circuit pack slots for the high-speed shelf.

Table 4-2 High-Speed Shelf Circuit Pack Slot Equipage

Slot Designation	Slot Equipage
(blank)	Reserved for future use.
OBA or OBPA	Either the OBA (Optical Booster Amplifier) or OBPA (Optical Booster Pre-Amplifier) port units occupy these slots. These port units are responsible for amplifying optical signals from the OC-192 port units in order to achieve long-reach transmission distances for a span.
OC192 STM64 W OC192 STM64 E	Each of the two OC-192 port units occupies two slots. The two port units can be any of: • OC192/STM64/SR1 (intermediate range) 1.5µ port units • OC192/STM64/IR1 (extended/intermediate range) 1.5µ port units • 32 OC192/STM64/POU passive port units • 40 OC192/STM64/WDM port units
PPROC W	The PPROC/STS192 circuit pack in this slot supports the OC192 port unit function assigned to the western aggregate port. The CP is responsible for pointer processing and synchronization to the system clock and for POH monitoring.
SWITCH 0	Fabric Switch 0. The SWITCH/STS576 or SWITCH/STS768 circuit pack in this slot can make cross-connections between the STS-1 equivalent tributaries in the port units within the shelf, or between shelves. This switch is paired with Fabric Switch 1 in a 1+1 non-revertive protection mode configuration.

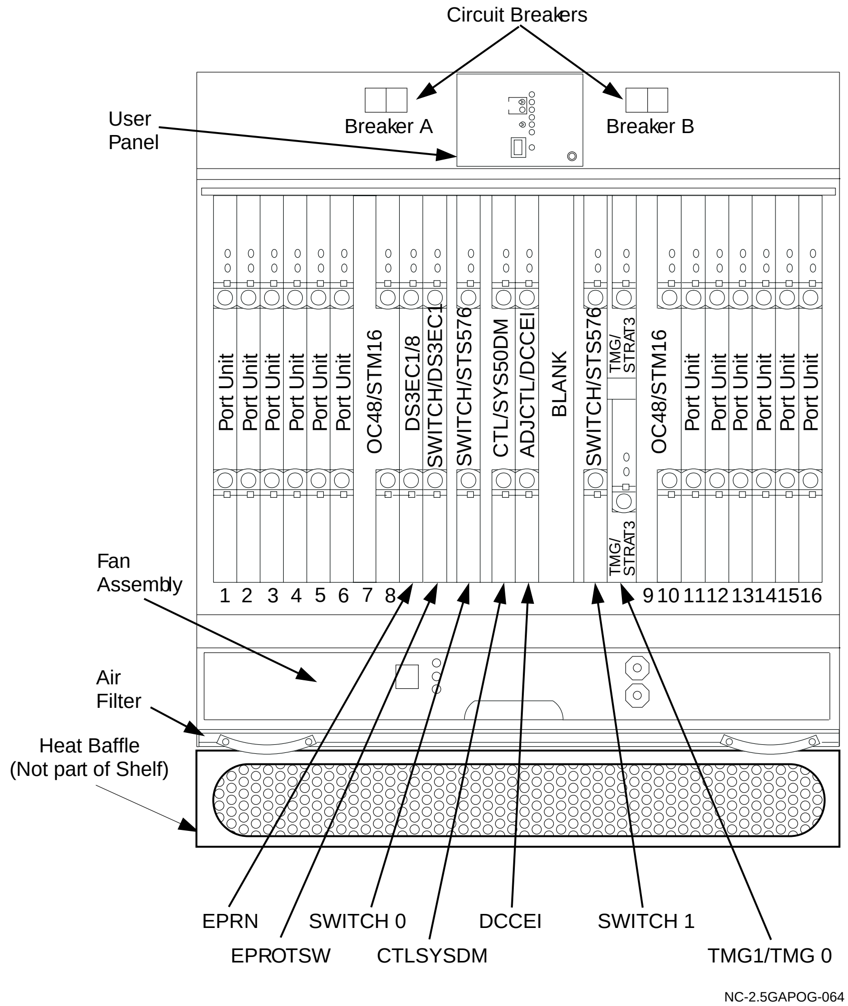
Slot Designation	Slot Equipage
PPROC 0	The PPROC/STS192 or PPROC/STS384 circuit pack in this slot provides frame delay management between the switch functions of each tributary shelf and the high-speed shelf, which ensures that all the tributaries to the switches are aligned. It works in conjunction with Fabric Switch 0. The PPROC you use depends on the switch fabric used. Equip this slot with PPROC/STS192 when SWITCH 0 and SWITCH 1 are equipped with SWITCH/STS576. Equip this slot with PPROC/STS384 when SWITCH 0 and SWITCH 1 are equipped with SWITCH/STS768.
CTL SYSDM 0	Controller for the system and nonvolatile memory. The CTL/SYS50DM circuit pack in this slot is the working controller for the high-speed shelf.
DCCEI	Adjunct controller, DCC, and external interface. The ADJCTL/DCCEI circuit pack terminates up to 32 data communications channels and interfaces them to the shelf 10Base-T LAN.
DCC	This slot is left empty for the current release of WaveStar TDM 2.5G/10G (2-Fiber).
CTL SYSDM 1	This slot is left empty for the current release.
TMG 1 TMG 0	Two half-height Stratum 3 timing generator circuit packs are located one above the other in this slot. When WaveStar TDM 2.5G/10G (2-Fiber) is initially powered on after shipment from the factory, the lower TMG/STRAT3 is the active circuit pack and the upper TMG/STRAT3 is the standby circuit pack. However, both circuit packs are of equal level and protection switching is nonrevertive, so there is no default configuration.

Slot Designation	Slot Equipage
PPROC 1	The PPROC/STS192 or PPROC/STS384 circuit pack in this slot provides frame delay management between the switch functions of each tributary shelf and the high-speed shelf, which ensures that all the tributaries to the switches are aligned. It works in conjunction with Fabric Switch 1. The PPROC you use depends on the switch fabric used. Equip this slot with PPROC/STS192 when SWITCH 0 and SWITCH 1 are equipped with SWITCH/STS576. Equip this slot with PPROC/STS384 when SWITCH 0 and SWITCH 1 are equipped with SWITCH/STS768.
SWITCH 1	Fabric Switch 1. The SWITCH/STS576 or SWITCH/STS768 circuit pack in this slot can make cross-connections between the STS-1 equivalent tributaries in the port units within the shelf, or between shelves. This switch is paired with Fabric Switch 0 in a 1+1 non-revertive protection mode configuration.
PPROC E	The PPROC/STS192 circuit pack in this slot supports the OC192 port unit function assigned to the eastern aggregate port. The CP is responsible for pointer processing and synchronization to the system clock and for POH monitoring.

Tributary shelf layout

The following figure shows the WaveStar TDM 2.5G/10G (2-Fiber) tributary shelf plug-in units and circuit pack slots, including the slots used for GE1, DS3/EC1, OC-3, OC-12, and OC-48 tributary port units.

Figure 4-3 WaveStar TDM 2.5G/10G (2-Fiber) Tributary Shelf



Circuit pack slots for tributary shelf

The table below identifies the circuit packs used in the WaveStar TDM 2.5G/10G (2-Fiber) tributary shelf.

Table 4-3 Tributary Shelf Circuit Pack Slot Equipage

Slot Designation	Slot Equipage
1 - 16	Any mix of transmission interface circuit packs: • DS3EC1/8 (DS3 port unit) • OC3/STM1/1.3LR4 (OC-3 port unit, long reach 1.3µ fiber) • OC3/STM1/1.3I/SR8 (OC-3 port unit, intermediate/short reach 1.3µ fiber) • OC12/STM4/1.3LR2 (OC-12 port unit, long reach 1.3µ fiber) • OC12/STM4/1.3I/SR2 (OC-12 port unit, intermediate/short reach 1.3µ fiber) • OC48/STM16/1.3VSR1 (OC-48 port unit, very short reach 1.3µ fiber) • OC48/STM16/1.3LR1 (OC-48 port unit, long reach 1.3µ fiber) • OC48/STM16/1.5LR1 (OC-48 port unit, long reach 1.5µ fiber) • Any of 16 Metropolis™ EON-compatible DWDM port units • Any of 80 WaveStar® OLS 1.6T compatible WDM port units • Any of 16 Lucent Passive optics port units • Gigabit Ethernet (GE1) interface port unit Slots 7 -10 do not support DS3EC1/8 port units. In addition, if you are using 1xN DS3 or EC-1 protection, slot 16 cannot contain an optical port unit. Therefore, it is recommended that, when using DS3EC1/8 port units, you install the first one in slot 16. Each OC-48 and GE1 port unit occupies two slots, which must be an odd (left) even (right) pair. For any OC-48 2-fiber BLSR, the two ports must be in slot numbers located either as adjacent pairs (2 and 4, 6 and 8, 10 and 12, or 14 and 16) or symmetric pairs (8 and 10, 6 and 12, 4 and 14, or 2 and 16).
EPRN	Electrical protection. This slot can be equipped with a DS3EC1/8 port unit to protect DS3EC1/8 port units or it can be left empty.
EPROTSW	Electrical protection switch. This slot can be equipped with a SWITCH/DS3EC1 protection switching circuit pack to provide the 1xN switching function for protected DS3EC1/8 port units. This slot can also be left empty.

Slot Designation	Slot Equipage
SWITCH 0	Fabric Switch 0. The SWITCH/STS576 circuit pack in this slot can make cross-connections for 576 STS-1 equivalent circuits. This switch is paired with Fabric Switch 1 in a 1+1 nonrevertive protection mode configuration.
CTLSYSDM 0	Controller for the system and nonvolatile memory. The CTL/SYS50DM circuit pack in this slot is the working controller for the shelf. In the first tributary shelf, this is the main controller for the entire WaveStar TDM 2.5G/10G (2-Fiber) system. Use this controller for CIT and EMS connections and to collect all alarms and signal them on the User Panel and the office alarm interface.
DCCEI	Adjunct controller, DCC, and external interface. The ADJCTL/DCCEI circuit pack in this slot terminates up to 32 data communications channels and interfaces them to the shelf 10Base-T LAN.
CTLSYSDM 1	The slot is left empty for the current release.
SWITCH 1	Fabric Switch 1. The SWITCH/STS576 circuit pack in this slot can make cross-connections for 576 STS-1 equivalent circuits. This switch is paired with Fabric Switch 0 in a 1+1 nonrevertive protection mode configuration.
TMG 1 TMG 0	Two half-height Stratum 3 timing generator circuit packs are located one above the other in this slot. When WaveStar TDM 2.5G/10G (2-Fiber) is initially powered on after shipment from the factory, the lower TMG/STRAT3 is the active circuit pack and the upper TMG/STRAT3 is the standby circuit pack. However, both circuit packs are of equal level: protection switching is nonrevertive, and there is no default configuration.

Minimum complement of circuit packs

The minimum complement of circuit packs required for an operational WaveStar TDM 2.5G/10G (2-Fiber) system is the following circuit packs in the tributary control (2.5G I/O MAIN) shelf:

- SWITCH/STS576 (two)
- CTL/SYS50DM (one)
- ADJCTL/DCCEI (one)
- TMG/STRAT3 (two)
- port units as required for the application

No specific minimum of port units is required for the system to operate.

> **Important!** Although the WaveStar TDM 2.5G/10G (2-Fiber) requires only one SWITCH/STS576 and one TMG/STRAT 3 circuit pack to operate, it is not recommended that you use only one of either pack. It is recommended that you always use two of each of these circuit packs in order to ensure that the WaveStar TDM 2.5G/10G (2-Fiber) system's switching and synchronization functions are properly protected at all times.

The minimum complement of circuit packs that uses the OC-192 2-fiber BLSR consists of the following:

- SWITCH/STS576 (two in high-speed shelf and two in tributary shelf)
- CTL/SYS50DM (one in high-speed shelf and one in tributary shelf)
- ADJCTL/DCCEI (one in high-speed shelf and one in tributary shelf)
- TMG/STRAT3 (two in high-speed shelf and two in tributary shelf)
- OC192/STM64 (two in high-speed shelf)

DS3/EC1 connector panels

To terminate DS3/EC1s, the tributary shelves require DS3/EC1 connector panels. Each DS3/EC1 connector panel has 48 pairs of BNC cable connectors. Each pair includes a transmit and a receive connection. These are connected electrically to the shelf backplane through shielded ribbon cables.

Three options exist for attaching the connector panels:

- External, vertical “wings” attached to the bay frame
- Internal, horizontal modules inserted inside the bay frame
- Panels mounted at the back of the shelf

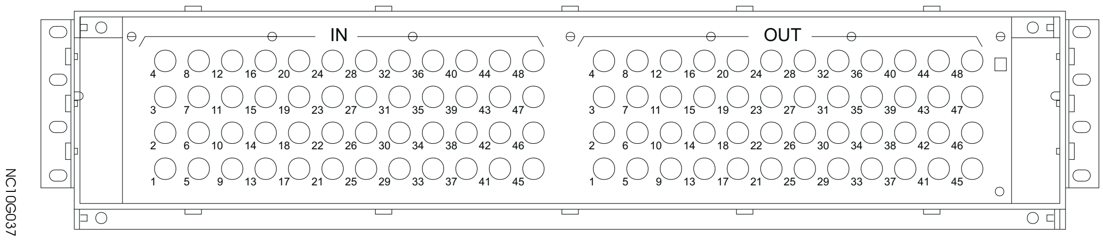
The external connector panels attach to the two sides of the shelf like wings and require additional space between bay frames. The rear-mounted connector panels attach to the back of the bay frame and require approximately 4 additional inches of space to the rear of the bayframe. Each side panel connects to a maximum of six of the port unit slots on the that same side (1-6 or 11-16). With the external connectors, the DS3/EC1 cables that connect to the front of the panels are run through the cabling areas between bays.

The internal, “in-bay” DS3/EC1 connector panels fit into a bay above and below the tributary shelf. The panel that mounts on the top of a shelf connects to a maximum of six of the port unit slots on the left side (11-16). The panel that mounts under a shelf connects to a maximum of six of the port unit slots on the right side (1-6). With the internal connectors, the DS3/EC1 cables attach to the backplane from the back of the connector panels.

Figure of DS3/EC1 connector panel

The following figure shows an example of a connector panel. In this case, the panel is a front, horizontal view of an in-bay DS3/EC1 connector panel module with the front door removed.

Figure 4-4 In-Bay DS3/EC1 Connector Panel



DS3/EC1 connector dimensions

The dimensions of the vertically and externally attached DS3/EC1 connector panels are as follows:

Height	546.1 mm (21.5 in. nominal)
Width	101.6 mm (4 in. nominal)
Depth	57.2 mm (2.25 in. nominal)

The dimensions of the horizontally and internally equipped DS3/EC1 connector panels are as follows:

Height	115 mm (4.5 in. nominal)
Width	543 mm (21 in. nominal)
Depth	347.5 mm (13.7 in. nominal)

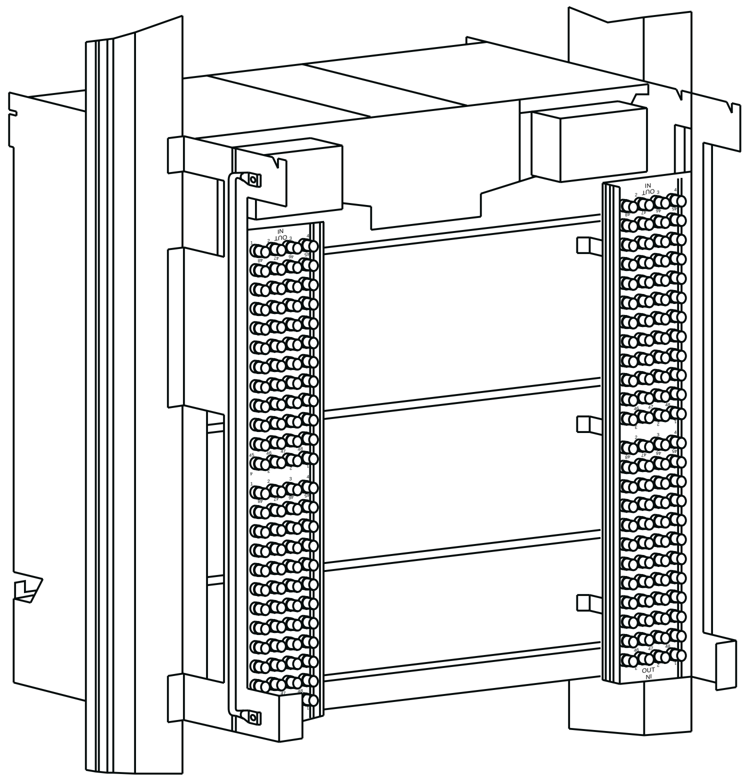
The dimensions of the rear-mounted DS3/EC1 connector panels are as follows:

Height	546.1 mm (21.5 in. nominal)
Width	101.6 mm (4 in. nominal)
Depth	170 mm (6.7 in.), 87 mm (3.45 in.) beyond the standard depth of the shelf.

Figure of rear-mounted DS3/EC1 connector panels

The figure below shows a rear view of a shelf with rear-mounted DS3/EC1 connector panels with the rear door removed.

Figure 4-5 Rear-Mounted DS3/EC1 Connector Panels

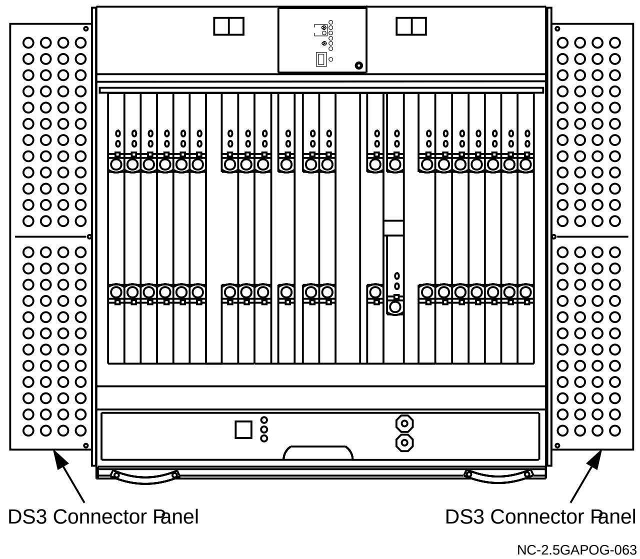


nc2510g001

DS3/EC1 connector panel mounting

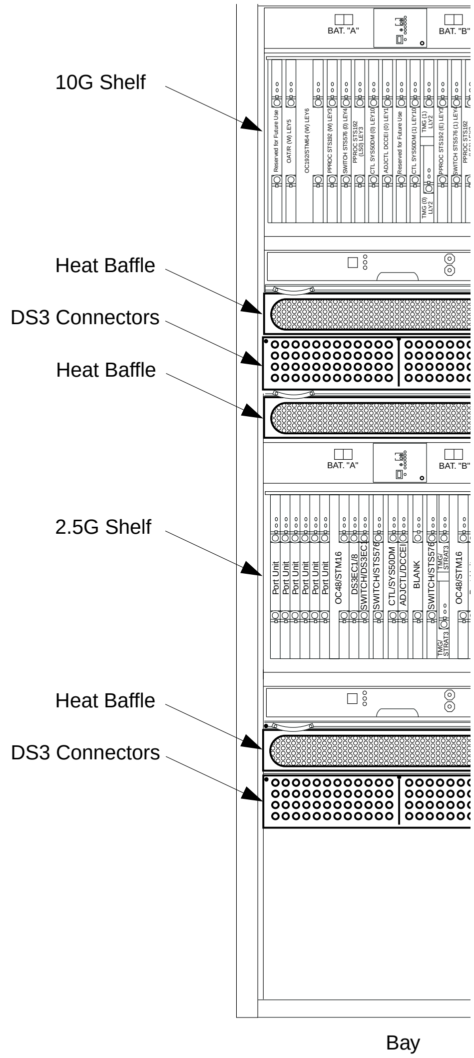
The following figure shows DS3/EC1 connector panels mounted vertically and externally on the sides of a tributary shelf.

Figure 4-6 DS3/EC1 Connector Panels Mounted Externally



The figure below shows DS3/EC1 connector panels mounted internally in a bay.

Figure 4-7 DS3/EC1 Connector Panels Mounted Internally



Important! When DS3/EC1 connector panels are mounted on the interior of the WaveStar TDM 2.5G/10G (2-Fiber) shelf, a bay can support only two shelves.

Shelf dimensions

The WaveStar TDM 2.5G/10G (2-Fiber) shelf dimensions without DS3/EC1 connector panels are as follows:

Height	575 mm (23 in. nominal)
Width	543 mm (21 in. nominal)
Depth	400 mm (15 in. nominal)

With the external, vertical DS3/EC1 connector panels, the tributary shelf is 755 mm wide (30 in. nominal).

Shelf mounting

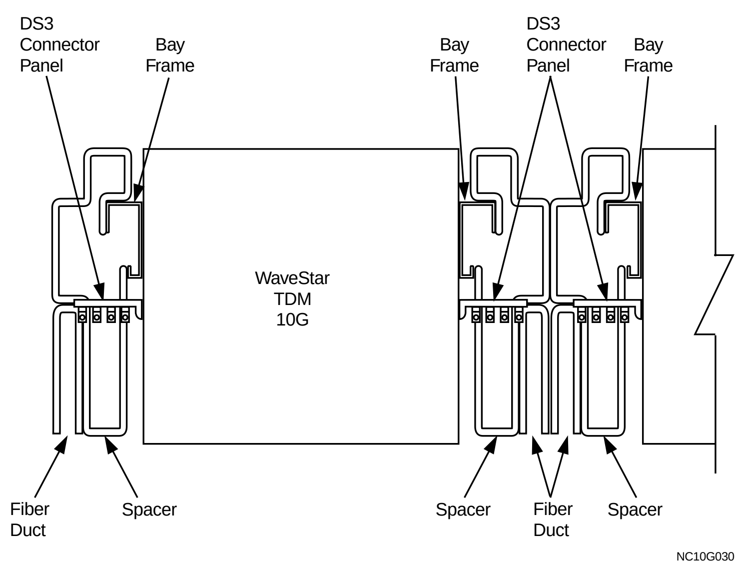
WaveStar TDM 2.5G/10G (2-Fiber) shelves mount into standard seismic network bay frames. The bay frames must be mounted on the floor such that the narrower shelf mounting flanges are facing the maintenance aisle.

Shelves equipped with external, vertical DS3/EC1 connector panels must be mounted in bays that are separated by spacers. The bay spacers provide structural integrity and the correct amount of space between bays. (See Figure 4-7.)

Bay spacers

The following figure shows a top view of bays using spacers to accommodate externally attached DS3/EC1 connector panels.

Figure 4-8 Top View of Bay Spacers



Multiple shelves

With the configuration of one high-speed shelf and one tributary shelf, the shelves should be mounted in the upper two positions. This allows for future growth to a second tributary shelf in the bottom position.

A WaveStar TDM 2.5G/10G (2-Fiber) shelf in the top position of a bay requires a heat baffle immediately below it. WaveStar TDM 2.5G/10G (2-Fiber) shelves in the other two bay positions require heat baffles directly between them. There must be no gaps above or below the heat baffles and the shelves.

Up to three tributary shelves fit into a bay, provided that all DS3/EC1 connector panels are mounted externally or at the back of the shelf. If DS3/EC1 connector panels are mounted internally, only two WaveStar TDM 2.5G/10G (2-Fiber) shelves can fit in a bay. In bays with only two tributary shelves with external DS3/EC1 connector panels, it is recommended that the shelves be mounted in the lower two positions. It is preferable to reserve the upper mounting position for future expansion or for interworking with other equipment.

The heat baffle mounted below the lowest shelf in the bay is required to ensure adequate air flow between the lowest shelf and the bottom of the bay.

Installation of tributary shelf in an FT-2000 OC-48 Lightwave System Dual Bay Frame

Up to two tributary shelves can be inserted into an FT-2000 OC-48 Lightwave System Dual Bay as shown in the figure (Figure 4-8) on the following page.

Configuration A

When you replace one HSS/LSS FT-2000 OC-48 Lightwave System shelf, the upper shelf must be removed first. The FT-2000 System is removed as one complete shelf. It is then replaced by a WaveStar TDM 2.5G/10G (2-Fiber) Shelf assembly and one heat baffle (as shown in Configuration A below). The two DS3/EC1 connector panels pictured below are optional.

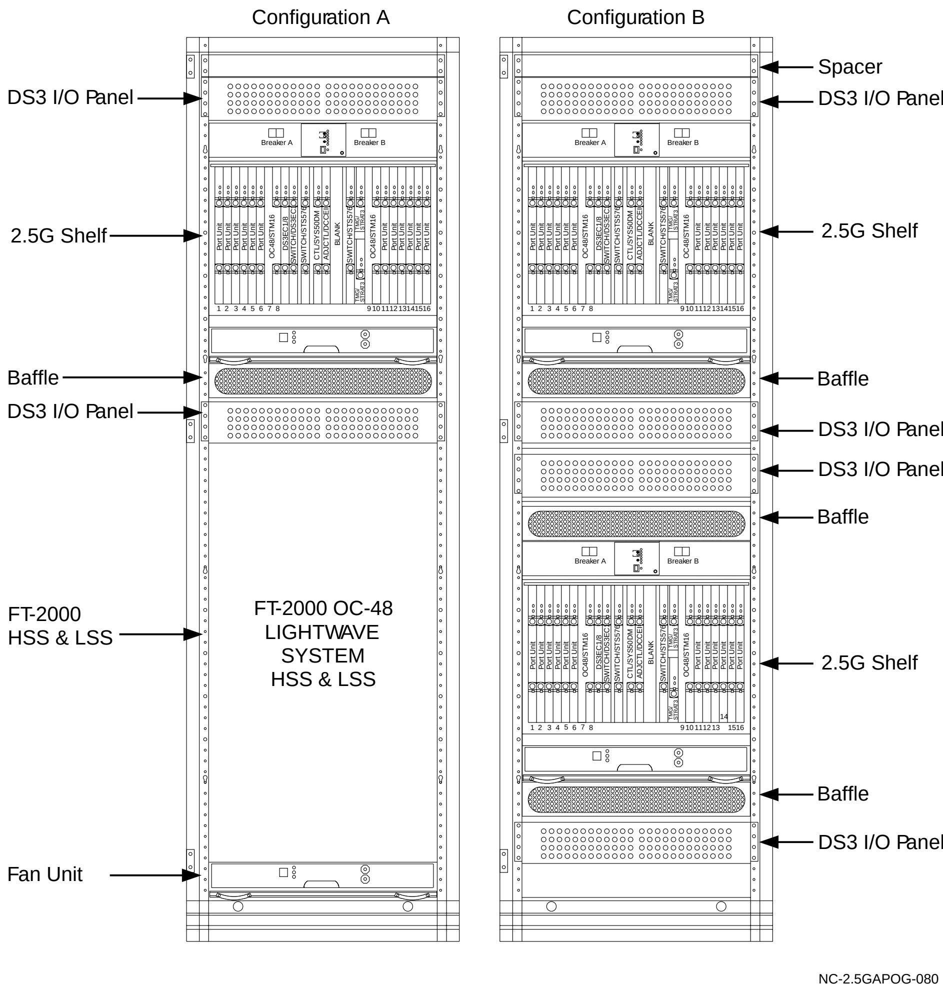
Configuration B

When you replace two HSS/LSS FT-2000 OC-48 Lightwave System shelves or add a second WaveStar TDM 2.5G/10G (2-Fiber) system, the final configuration is represented by Configuration B in the figure below. The lower HSS/LSS Shelf assembly, Fan Unit, and Power Distribution Filter are removed. They are then replaced by a WaveStar TDM 2.5G/10G (2-Fiber) Shelf assembly, two heat baffles, two DS3/EC1 connector panels, and one Space/Filler Plate (located at top of bay where the PDP was positioned). The two DS3/EC1 connector panels pictured below are optional. When both FT Shelves are replaced, the Fan Unit is not required because WaveStar TDM 2.5G/10G (2-Fiber) shelves contain shelf-based fan cooling systems.

Illustration

The figure below shows how a WaveStar TDM 2.5G/10G (2-Fiber) Shelf mounts in an FT-2000 OC-48 Lightwave System Dual Bay.

Figure 4-9 Installation of Tributary Shelf in an FT-2000 Dual Bay



Dispersion Compensation Module (DCM) holder tray

For applications requiring the use of Dispersion Compensation Modules (DCMs), a DCM holder tray can be miscellaneously mounted into a WaveStar TDM 2.5G/10G (2-Fiber) bay. The tray holds 4 DCMs. A bay with a DCM holder tray, can support up to two WaveStar TDM 2.5G/10G (2-Fiber) shelves.

Passive Optics Units (Passive DWDM Filter Units)

Lucent Passive Optics Units (POUs) are a family of Passive WDM and DWDM filter units that complement Lucent's overall product offerings, to provide the most cost-effective transport of signals over a fiber, to maximize fiber and network utilization, and to relieve fiber exhaust conditions.

The current 4 POUs are:

- 16CH-MUX
- 16CH-DMUX
- 16CH-MUXINT
- 16CH-DMUXINT

These 4 units combine multiple signals, of different wavelengths, onto a single fiber. Each MUX/DMUX pair supports the optical combining of 16 signals of different wavelengths onto one fiber in one direction (16 wavelength unidirectional application), or the optical combining of 8 wavelengths from 2 directions (8 east to west and 8 west to east) onto one fiber (8 wavelength bidirectional application).

The 4 POUs can be combined to support 32 wavelength unidirectional or 16 wavelength bidirectional applications. In these applications, the wavelengths for the 16CH-MUX and 16CH-DMUX pair are interleaved with the other 16 wavelengths from the 16CH-MUXINT and 16CH-DMUXINT pair. The "INT" denotes interleaver.

The Figures 4-10 through 4-14 outline the wavelengths and frequencies supported for each of the POUs. The corresponding channel number is also provided. The inputs and outputs are shown for each 16 wavelength unidirectional, and each 8 wavelength bidirectional application. The last figure outlines how the POUs are connected together to support the 32 wavelength unidirectional application (for west to east traffic).

The COMMON port is the output or input port for the mutliwavelength (DWDM) signal. The UPGRADE ports located on the 16CH-MUXINT and 16CH-DMUXINT units are used for applications requiring wavelength interleaving. The UPGRADE ports are connected with the appropriate COMMON ports on the 16CH-MUX and 16CH-DMUX units for applications where wavelength interleaving is required.

Figure 4-10 16CH-MUX and 16CH-DMUX Unidirectional Application(s)

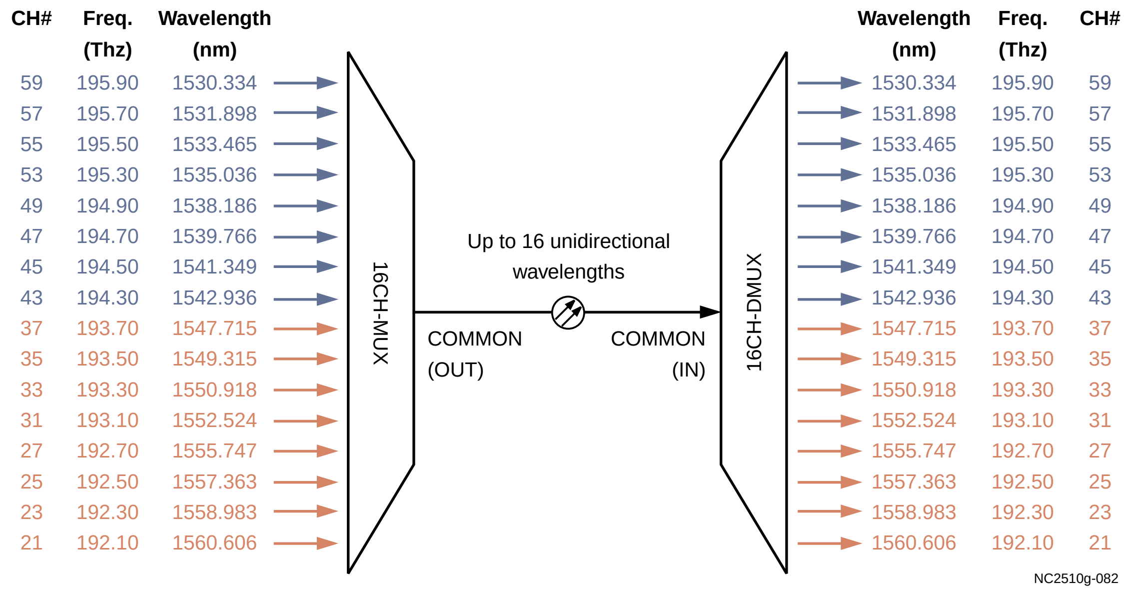


Figure 4-11 16CH-MUX and 16CH-DMUX Bidirectional Application(s)

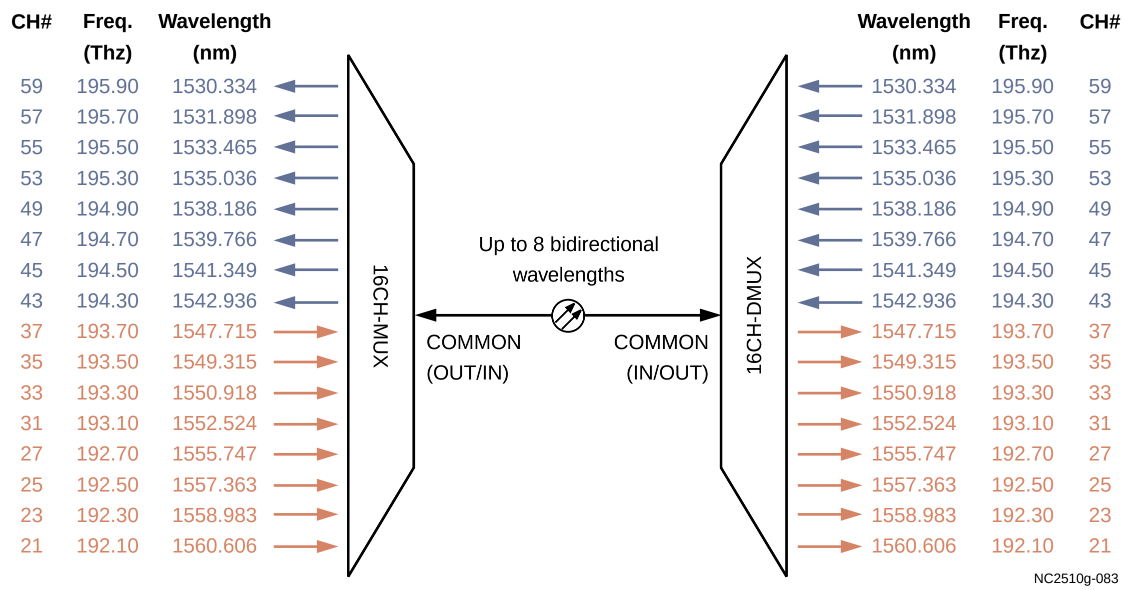


Figure 4-12 16CH-MUXINT and 16CH-DMUXINT Unidirectional Application(s)

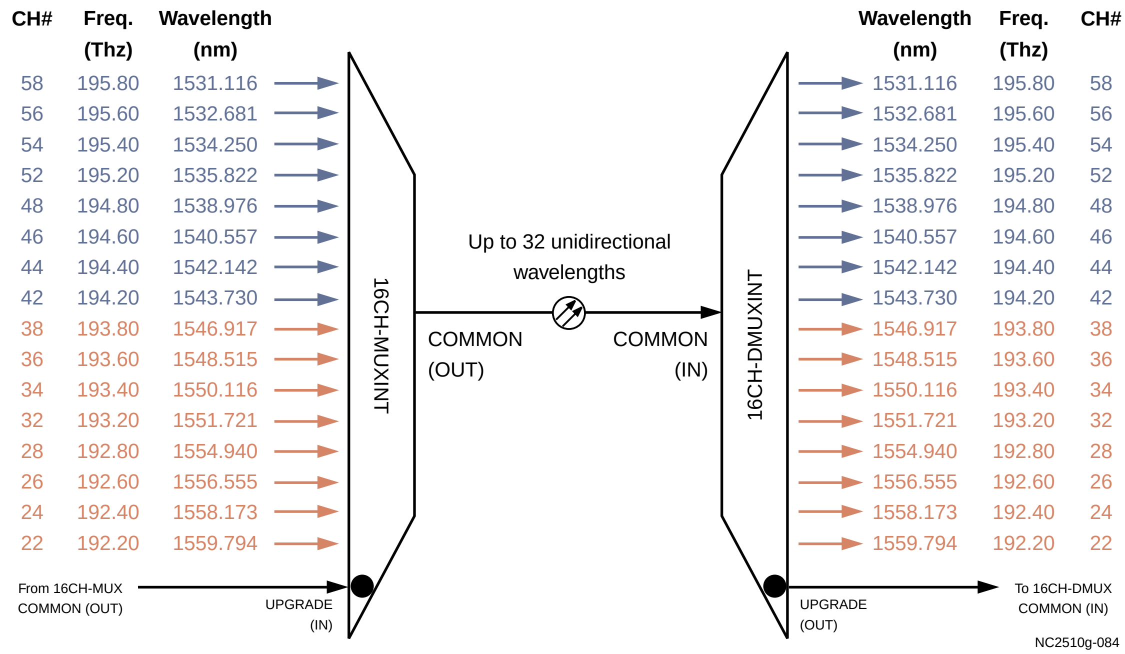


Figure 4-13 16CH-MUXINT and 16CH-DMUXINT Bidirectional Application(s)

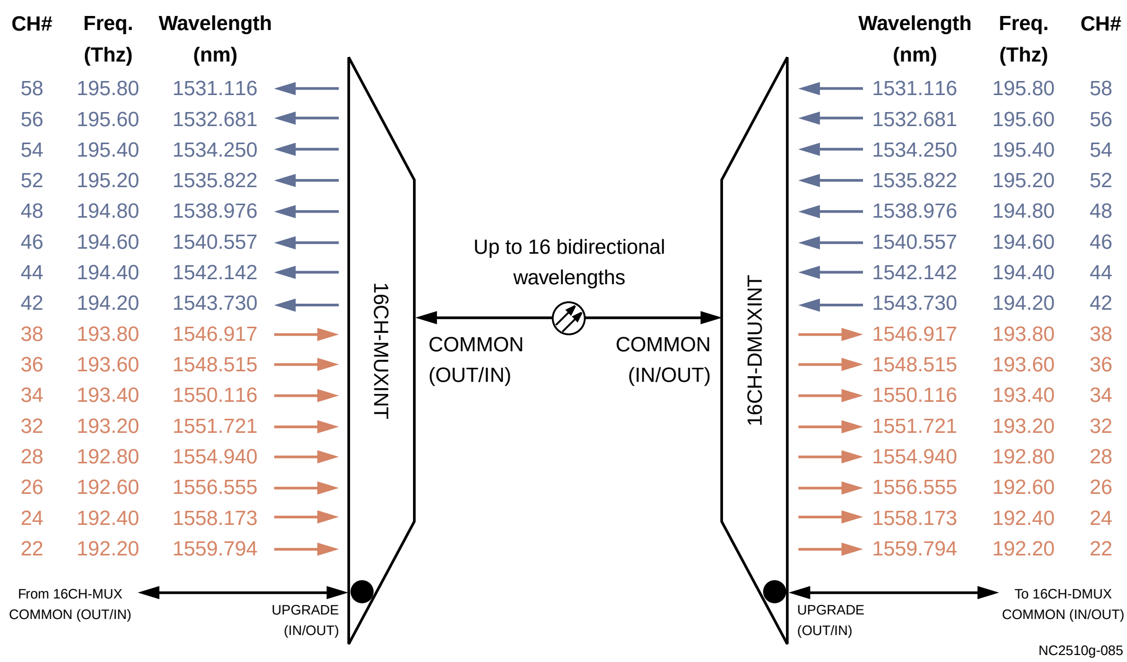
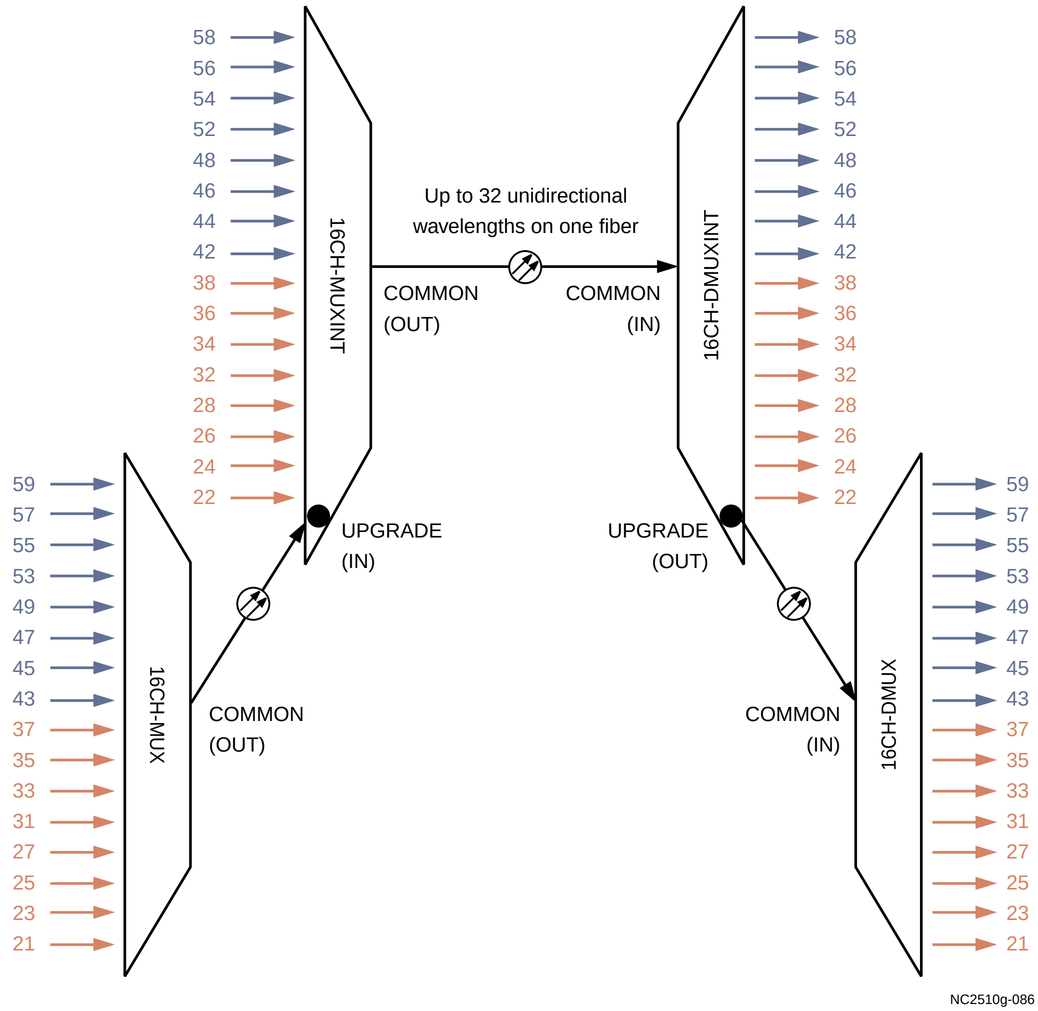


Figure 4-14 Example of 32 Wavelength Unidirectional Application West to East Traffic Flow



Each POU, the 16CH-MUX, 16CH-DMUX, 16CH-MUXINT, and 16CH-DMUXINT have Universal Optical Connectors, equipped from the factory with 0 dB LBO optical attenuators. Other types of optical attenuators, ST and FC, can be order separately, if desired.

The wavelength, frequency, and channel number are provided above the optical connector on each POU.

The POUs can be used in controlled environment applications.

Each POU has a small footprint (less than 3 inches in height). The POUs can be used in 23-inch Lucent Technologies NEBS and NEBS 2000 bays.

When one POU is used in a 7-foot bay with a WaveStar TDM 2.5G/10G (2-Fiber) system or systems, the bay can hold up to 2

WaveStar TDM 2.5G/10G shelves (one 10G high speed with a tributary shelf, or two 2.5G/tributary shelves).

The following applications are supported with the POUs and the WaveStar TDM 2.5G/10G (2-Fiber) R6 system equipped with Passive DWDM compatible optics:

- Unidirectional transport of up to 16, OC-192 and/or OC-48, wavelengths on one fiber using the 16CH-MUX and the 16CH-DMUX
- Bidirectional transport of up to 8, OC-192 and/or OC-48, wavelengths on one fiber using the 16CH-MUX and the 16CH-DMUX
- Unidirectional transport of up to 16 OC-192 wavelengths on one fiber using the 16CH-MUXINT and the 16CH-DMUXINT
- Unidirectional transport of up to 32 OC-192 wavelengths on one fiber using the 16CH-MUX, 16CH-DMUX, 16CH-MUXINT, and 16CH-DMUXINT.
- Bidirectional transport of up to 16 OC-192 wavelengths on one fiber using the 16CH-MUX, 16CH-DMUX, 16CH-MUXINT, and 16CH-DMUXINT.

The appropriate optical connection should be made between each POU and the appropriate Passive DWDM compatible optics circuit pack on the WaveStar TDM 2.5G/10G (2-Fiber).

The POUs do not require power, software, or operations support. Protection schemes and alarming functions can be performed by the multiplexers or DCS systems connected to the POUs.

The Passive Optics Units can be used to combine signals from different products, and at different rates (OC-48 and OC-192) onto a single fiber. The signals being combined must have different frequencies/wavelengths, and those frequencies/wavelengths must be supported on appropriate POUs.

The worst case conditions should be considered when designing a Passive DWDM route. The worse case optical transmitter/receiver specifications for all products transmitting/receiving information to/from a POU should be used to calculate the span distance for the Passive DWDM route. Optical specifications vary by product, and by optical rate. Typically, using OC-48 optics allows longer distances than OC-192 optics (distance versus capacity tradeoff).

The loss, for the combination of the 16CH-MUX and 16CH-DMUX units, is 6.4 dB. The loss anytime the 16CH-MUXINT and 16CH-DMUXINT units are used is 10.2 dB

Information for the WaveStar TDM 2.5G/10G (2-Fiber) Passive DWDM compatible optics port units, such as wavelengths and loss budgets in applications with the POUs, can found in Appendix B. Ordering information can be found in Section 7 “Ordering”.

Each WaveStar TDM 2.5G/10G (2-Fiber) Passive DWDM compatible optics port unit has a 4-digit numeric suffix, after the “POU” in its description. This suffix directly corresponds to the frequency of each optical signal. For example, the OC-192 port unit designated OC192/STM64/POU9210, operates at a frequency of 192.10 Thz (192.10 Thz). This frequency, 192.10 Thz, a wavelength 1560.606 nm, is supported on the 16CH-MUX and 16CH-DMUX units.

Hint: It is easier to upgrade an existing 16 wavelength unidirectional (8 bidirectional) architecture, to a 32 wavelength unidirectional (16 bidirectional) architecture, if the 16CH-MUXINT and 16CH-DMUXINT units are deployed initially. Then the upgrade simply requires that the 16CH-MUX and 16CH-DMUX units, be added to the network by connecting their COMMON ports with the UPGRADE ports on the 16CH-MUXINT and 16CH-DMUXINT units. Service can then be added on the 16CH-MUX and 16CH-DMUX.

If the 16CH-MUX and 16CH-DMUX are deployed first, at some point in the upgrade, the signal carrying multiple wavelengths (COMMON ports on the 16CH-MUX and 16CH-DMUX) will need to be disconnected, and then connected to the UPGRADE ports on the 16CH-MUXINT and 16CH-DMUXINT. This could require the rolling of traffic or be service affecting. Of course, the choice of which POUs to deploy, depends on the specific application.

The appropriate selection of wavelengths for network deployments helps to keep sparing costs for optical port units to a minimum.

□

Basic Architecture

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) system with the high-speed shelf option, and at least one tributary shelf, is a flexible high-capacity multiplexer that supports OC-192 2-fiber BLSR or 2-fiber UPSR applications. The system can multiplex DS3/EC1, OC-3, OC-12, GE1, and OC-48 signals on the OC-192 ring. The low-speed interfaces can be protected in a variety of ways (see information later in this section). The OC-192 system supports up to four tributary shelves when equipped with the 768x768 STS-1 switch fabric in the high-speed shelf (up to two tributary shelves when equipped with the 576x576 STS-1 switch fabric). Each tributary shelf can terminate up to 4 OC-48 BLSRs, 4 OC-48 UPSRs, or up to 16 OC-12 UPSRs. Each tributary shelf allows the flexible mixing of interfaces and protection schemes for those interfaces.

For stand-alone OC-48 applications, the WaveStar TDM 2.5G/10G (2-Fiber) stand-alone tributary shelf (also referred to as the 2.5G Application) supports all of the following stand-alone OC-48 applications, 2-fiber BLSR, UPSR, 1+1, 0x1 applications. Just as in the case for each tributary shelf in an OC-192 application, the stand-alone system can terminate up to 4 OC-48 BLSRs and 4 OC-48 UPSRs (up to 16 OC-12 UPSRs are supported). In addition to the OC-48 interfaces, DS3/EC1, OC-3, OC-12, and GE1 interfaces are also supported. The system supports flexible mixing of interfaces and protection schemes for those interfaces. Full hairpinning is supported to ensure that interfaces can be utilized in the most efficient way.

Diagram of basic architecture for system with high-speed shelf

The figure below outlines the overall architecture of a WaveStar TDM 2.5G/10G (2-Fiber) system that includes both the high-speed and tributary shelves. This diagram does not show the physical distribution of functions on different shelves.

NOTE:

> For information about which OC-192/STM64 port units to use with SEN3AE (OBA) and SEN4AE (OBPA) and whether or not the application requires Dispersion Compensation Modules (DCMs), see Chapter 3, “Network Topologies.”

Figure 4-15 System with High-Speed Shelf -- Basic Architecture

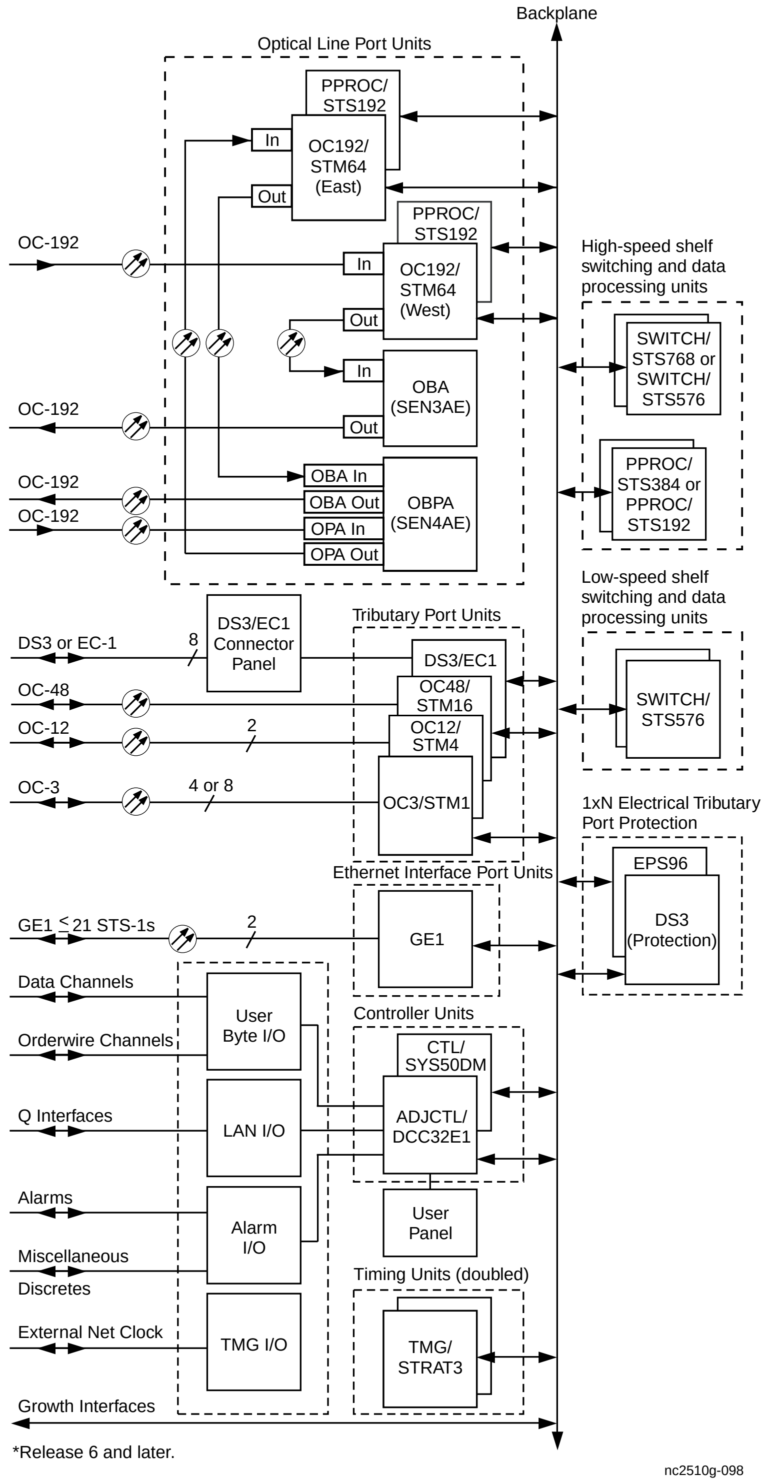
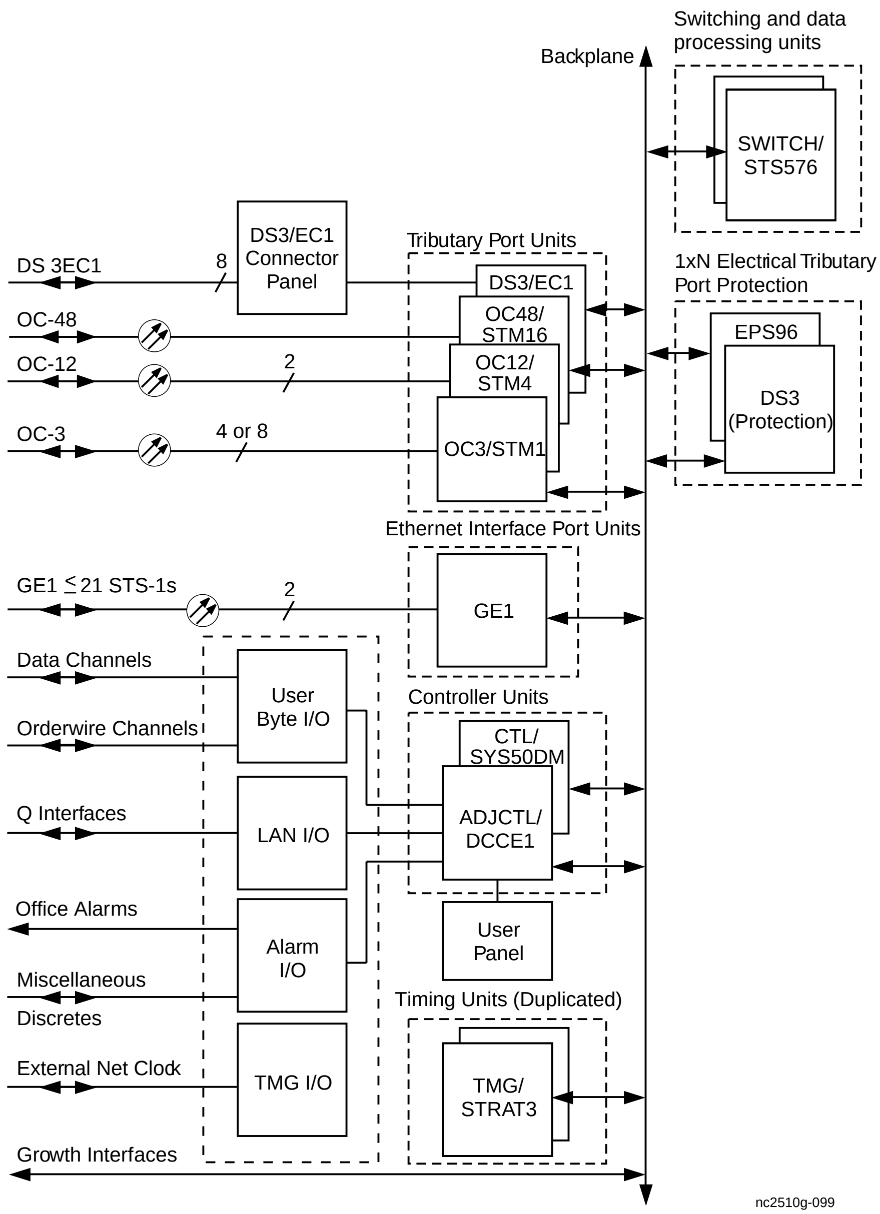


Diagram of basic architecture for stand-alone tributary shelf

The figure below outlines the overall architecture of the tributary shelf.

Figure 4-16 Stand-alone Tributary Shelf Basic Architecture



□

Transmission

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) add/drop multiplexer uses two port units (transmission interface circuit packs) in the high-speed shelf to connect as a node in an OC-192 2-fiber BLSR or UPSR, or as a node on or between two OC-192 unprotected ports. It uses up to 16 tributary port unit circuit packs on each tributary shelf to connect as nodes in a mix of supported network configurations, including interfacing with up to 4 OC-48 2-fiber BLSRs, 4 OC-48 UPSRs, 16 OC-12 UPSRs or a mix of these ring types and other interfaces on the tributary shelf. Traffic can be connected between any of the ports. For information about the port units, refer to Appendix B, Port Unit Data Sheets. For information about capacity planning, refer to Chapter 6, System Planning and Engineering.

Optical transmission

In order to provide the most cost effective solutions for short and long distance applications and to maximize the utilization of fiber base the specific applications need, the WaveStar TDM 2.5G/10G (2-Fiber) system supports a wide range of optical transmission capabilities for OC-192 and OC-48 applications. A summary of these capabilities is provided below. Information on other transmission interfaces is provided in the remainder of this section. Detailed specifications for port units are provided in Appendix B.

For OC-48 applications:

- Standard 1.3µ
- Standard 1.5µ
- DWDM applications
  - 16 OC-48 wavelengths in the 1.5µ range for use with Metropolis™ EON
  - 16 OC-48 wavelengths in the 1.5µ range for use with POU shelves (DWDM Filter Units).
  - 80 OC-48 wavelengths in the 1.5µ range for use with WaveStar® OLS 1.6T.

For OC-192 applications:

- Standard 1.5µ
- DWDM applications
  - 32 OC-192 (DWDM) wavelengths in the 1.5µ range for use with POU Shelves (DWDM Filter Units).
  - 40 OC-192 (DWDM) wavelengths in the 1.5µ range for use with WaveStar® OLS 1.6T.
- Internal optical amplifiers (OBA and OBPA used with the appropriate OC192 port unit)
- Compatible with External Optical Amplifier

Add/drop optical transmission

WaveStar TDM 2.5G/10G (2-Fiber) supports OC-12 and OC-3 1.3µ interfaces over standard fiber and OC-48 1.3µ or 1.5µ interfaces over standard fiber. OC-12 and OC-3 transmission can be provisioned for 0x1 or 1+1 protection. OC-12 UPSRs are also supported. OC-48 transmission can be provisioned for 0x1, 1+1, UPSR, or BLSR protection.

DS3/EC1 transmission

WaveStar TDM 2.5G/10G (2-Fiber) supports DS3/EC1 transmission over coaxial cables. A DS3/EC1 connector panel is required either on the left side of, above, or on the right rear of (as you face the back of the shelf) the appropriate tributary shelf for any DS3/EC1 port unit circuit packs in slots 1 through 6. A panel is required either on the right side of, below, or on the left rear of (as you face the back of the shelf) the appropriate tributary shelf for any DS3/EC1 port units in slots 11 through 16. Therefore, it is practical to keep all DS3/EC1 circuit packs in the same side of the shelf until you need to terminate more than 48 DS3/EC1s.

Gigabit Ethernet Transmission

The Gigabit Ethernet (GE1) interfaces supported by the WaveStar TDM 2.5G/10G (2-Fiber) allows you to transport Gigabit Ethernet signals over SONET networks by encapsulating ethernet packets in virtually concatenated STS1s. The GE1 interfaces support point-to-point connectivity. They provide two fully independent bidirectional ports on each port unit. The GE1 interfaces are:

GE1/SX2:

- 770 to 860 nm, Short Reach (according to IEEE802.3, clause 38.3), 2 interfaces per circuit pack.

GE1/LX2:

- 1270 to 1335 nm, Long Reach (according to IEEE802.3, clause 38.4), 2 interfaces per circuit pack.

All connections to the 1000BASE-SX ethernet interface on the GE1/SX2 and GE1/LX2 port units require Dual SC Connectors.

Transmission provisioning

Provisioning of the transmission circuit packs is controlled by the system controller circuit pack in response to commands received over the SONET DCC circuits or from a WaveStar Craft Interface Terminal (CIT) connected to the port on the user panel.

Transmission architecture

WaveStar TDM 2.5G/10G (2-Fiber) transmission port units interconnect with a 576x576 STS-1 switch fabric in each low-speed tributary shelf and with either a 576x576 STS-1 switch fabric or a 768x768 STS-1 switch fabric in the high-speed shelf. The switch provides cross-connections between input and outputs at the STS-1 level or higher. It also provides both line protection switching and path protection switching. For 1xN equipment protection of DS3/EC-1 port units, the switch also interfaces to an electrical protection switch unit (the SWITCH/DS3/EC1 circuit pack) that selects between the working and protection DS3/EC1 circuit packs.

□

Control

Overview

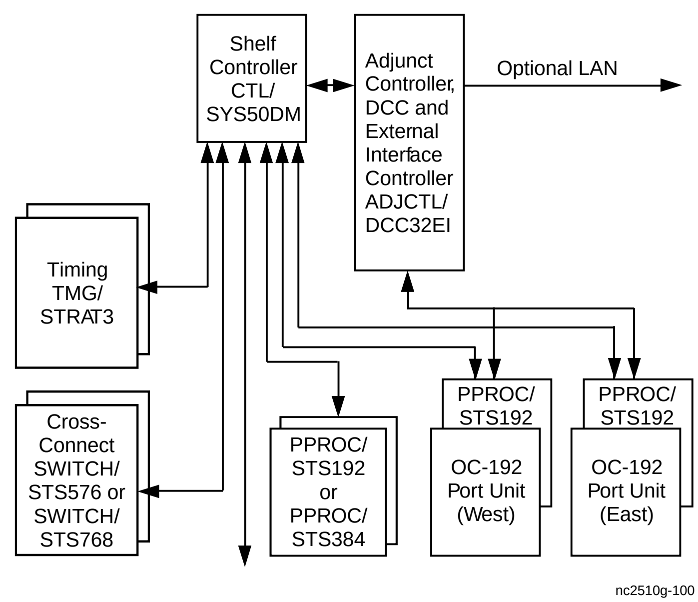
The WaveStar TDM 2.5G/10G (2-Fiber) shelf functions are controlled by shelf controller circuit packs and by function microcontrollers on the port units (transmission circuit packs). The shelf controllers control the port units and also the timing and switching circuit packs, which have no internal function controllers. Overall system operation is controlled by signals received over the SONET DCC channels or from the user interface (WaveStar CIT or OS system).

The controller in the first tributary shelf additionally serves as a system controller for the complete network element (including the high-speed shelf, if used, and the tributary shelf or shelves).

Control architecture

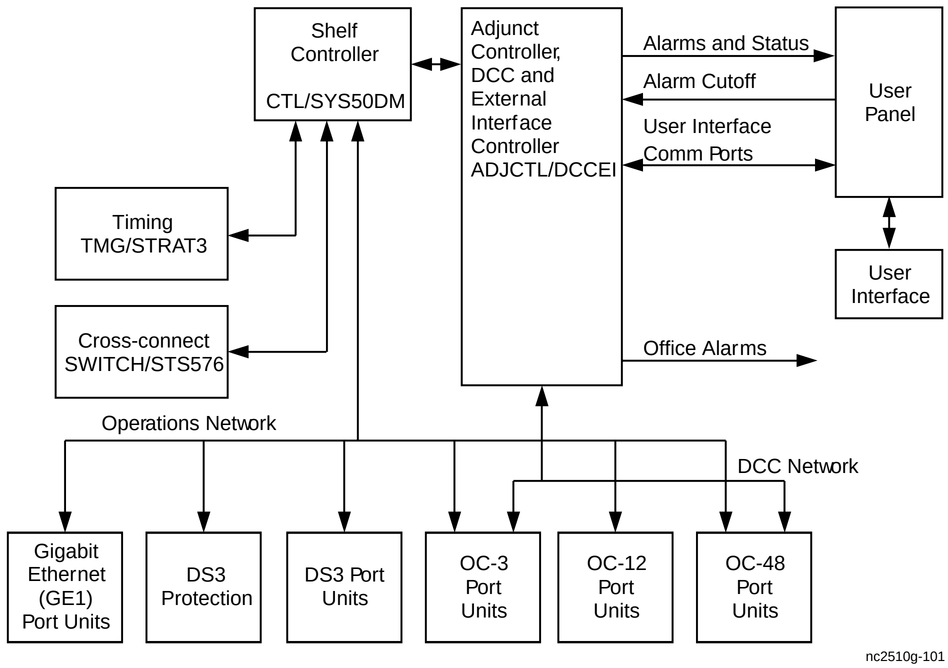
The high-speed shelf interfaces with the tributary shelf or shelves by means of backplane wiring. The following figure shows the major paths of control and status information among the circuit packs in the WaveStar TDM 2.5G/10G (2-Fiber) high-speed shelf.

Figure 4-17 WaveStar TDM 2.5G/10G (2-Fiber) High-Speed Shelf Control Architecture



The figure below shows the control architecture for the tributary (low-speed) shelf. The minimum configuration includes one tributary shelf and the maximum includes two tributary shelves.

Figure 4-18 WaveStar TDM 2.5G/10G (2-Fiber) Tributary Shelf Control Architecture



Control circuit packs

WaveStar TDM 2.5G/10G (2-Fiber) uses one shelf controller and one adjunct controller:

- CTL/SYS50DM – shelf controller
- ADJCTL/DCCEI – adjunct controller that handles DCC signals and external interfaces

CTL/SYS50DM circuit pack

The CTL/SYS50DM shelf controller circuit pack contains the main processor and memory controlling the WaveStar TDM 2.5G/10G (2-Fiber) shelves. The primary functions this circuit pack performs include:

- Communicates with the function controllers in the port units to monitor performance and to perform provisioning and maintenance
- Directly controls the timing and switching circuit packs
- Detects the presence of circuit packs in the shelf
- Communicates with the user interface by way of the ADJCTL/DCCEI circuit pack
- Resets circuit packs as necessary
- Monitors shelf power

ADJCTL/DCCEI circuit pack

Serving as an interface to the shelf controllers, the ADJCTL/DCCEI adjunct controller obtains, processes and stores information for transfer to and from the shelf controller. Additionally, the ADJCTL/DCCEI controller supports

- DCE (data communications equipment) configurations for user interface ports
- Status indicators on the user panel

□

Power

Overview The WaveStar TDM 2.5G/10G (2-Fiber) system uses a distributed powering system, rather than bulk power supplies. It distributes –48 V power throughout each shelf, and each circuit pack uses onboard power converters to derive the necessary operating voltages.

Dual power feeds On each shelf, office power feeders BREAKER (A) and BREAKER (B) are filtered and protected by circuit breakers at the input to the shelf. The two –48 V supplies are then distributed separately to each circuit pack and the fan unit, where they are filtered and fused before being converted to the working voltages.

Circuit breakers The –48 V circuit breakers have self-indicating rocker switches. The normally hidden portion of the rocker switch is red. When the breaker is tripped, the red portion is exposed, providing a visual indication. You can trip a breaker manually by inserting a small screwdriver blade (or equivalent) into the slot on the rocker switch. This feature reduces the risk of a shelf being switched off accidentally.

The fan unit also has two circuit breakers, but they cannot be manually tripped. When these breakers trip, a white cylinder protrudes from the breaker. These breakers can be reset by pressing the white cylinder so that it is flush with the black body of the breaker.

Power indicator The green PWR ON indicators on the user panel and fan units remain lighted as long as either –48 V supply is received from the circuit breakers.

□

Cooling

Overview

Cooling is provided by a plug-in fan unit. Fans draw air in through a filter beneath the fan unit and force it through the shelf from bottom to top. Heat baffles are required beneath each shelf to prevent the fan unit from drawing in the exhaust air from the shelf beneath it. The fan filter must be replaced when a filter alarm occurs. Alternatively, the filter should be replaced every 6 months to ensure the proper cooling. For specific dimensions of the cooling equipment, see Chapter 10, "Technical Specifications."

Fan controller

The fan unit includes six fans and a microcontroller that senses air flow, air temperature, and fan faults. The microcontroller adjusts the speed of the fans to compensate for the failure of a fan or to conserve power when full air flow is not needed. It also reports the status of the fan unit to the shelf controller.

Controls and indicators

The front panel of the fan unit includes the following controls and indicators:

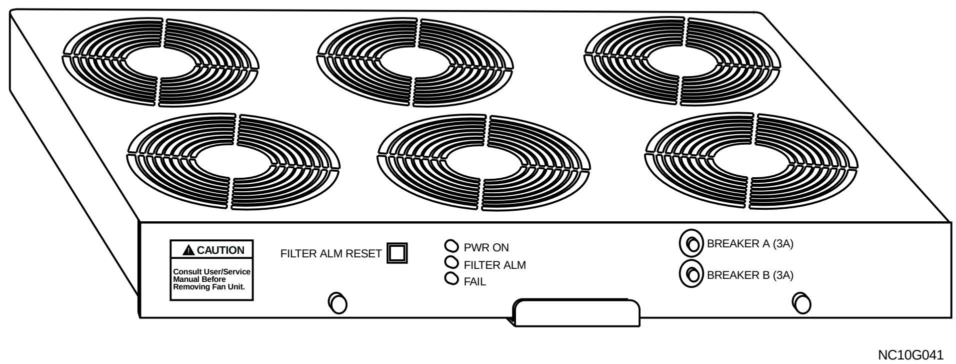
- Status indicators
  - PWR ON (power on)
  - FILTER ALM (filter alarm)
  - FAIL
- Filter alarm reset button
- Circuit breakers
  - BREAKER (A) (25A)
  - BREAKER (B) (25A)

Important! The fan unit must be installed and operating in a shelf before any circuit packs are installed.

Fan unit

The following figure illustrates the fan unit that mounts in each WaveStar TDM 2.5G/10G (2-Fiber) shelf.

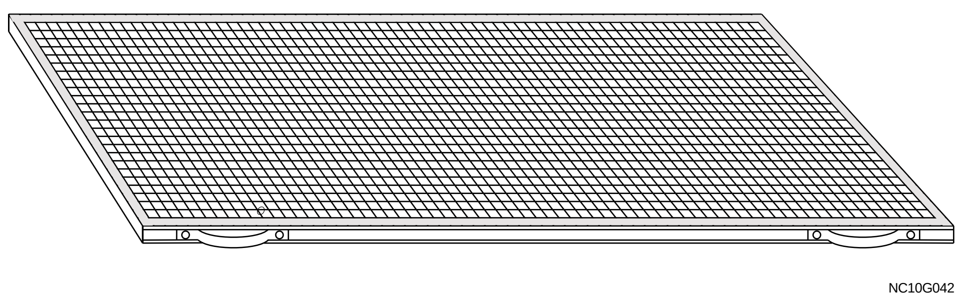
Figure 4-19 Fan Unit



Filter assembly

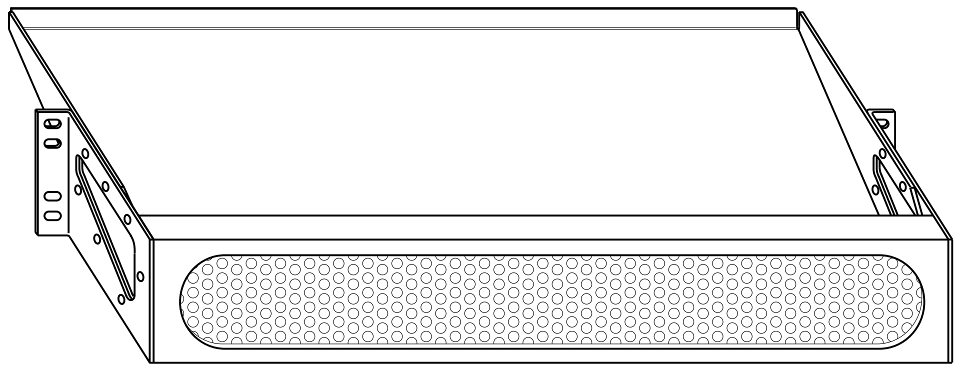
The figure below shows the filter that is installed beneath the fan assembly.

Figure 4-20 Fan Filter



Heat baffle The figure below shows the heat baffle that must be mounted between and beneath shelves to ensure proper cooling.

Figure 4-21 Heat Baffle



Blank faceplates Any slot that is not equipped with a circuit pack must be covered with a blank faceplate to preserve the cooling of the shelf.

□

5 Operations, Administration, Maintenance, and Provisioning

Overview

Purpose This chapter provides information on the operations, administration, maintenance, and provisioning functions of the WaveStar TDM 2.5G/10G (2-Fiber).

☐

Operations

Overview

Purpose

This section describes hardware and software interfaces used for administration, maintenance, and provisioning activities. These include

- Visible and audible indicators
- Graphical User Interface (GUI) on the WaveStar™ CIT (Craft Interface Terminal)
- Operations interfaces
- SubNetwork Management System (SNMS) – the Lucent Technologies network element management system

Visible and audible indicators

Visible and audible indicators notify you of maintenance conditions such as faults and alarms.

Graphical user interface

The GUI on the WaveStar CIT retrieves detailed information about local and remote network elements. The GUI is also used to provision local and remote WaveStar TDM 2.5G/10G (2-Fiber) circuit packs and the cross-connect switch fabric.

Operations system interfaces

Operations interfaces include the DCC interfaces on the OC-3, OC-12, OC-48, and OC-192 port units and the IAO LAN (intraoffice LAN) interface. Both the DCC interface and the IAO LAN interface can receive commands from operations systems (network element management systems) or from a remote WaveStar CIT. The LAN interface provides both TCP/IP and OSI protocols.

Visible Alarm Indicators

Overview

This section describes the visible indicators in WaveStar TDM 2.5G/10G (2-Fiber) that are located on the

- User panel
- Circuit pack faceplates
- Fan unit
- Circuit breakers

User panel

The user panel contains indicators, controls, and connectors.

Indicators

The user panel is the primary source of shelf-level visible alarm indicators. (See Figure 5-1, User Panel Controls and Indicators.) It provides the following indicators:

- Red LED that indicates Critical (CR) alarms – indicating severe, service-affecting conditions
- Red LED that indicates Major (MJ) alarms – indicating service-affecting failures, main or unit controller failures, or power supply failures
- Yellow LED that indicates Minor (MN) alarms – indicating non-service-affecting failures of equipment or facility
- Yellow LED that indicates Abnormal (ABN) conditions – temporary conditions that may potentially affect transmission, such as a WaveStar CIT-initiated protection switch or a loopback
- Yellow LED that indicates Near-end Activity (NE ACTY) status condition at the local shelf, such as wait-to-restore-switch periods
- Yellow LED that indicates Far-end Activity (FE ACTY) – status condition indicating that a condition exists on another network element.
- Green Power On (PWR ON) LED that indicates that power is applied to the shelf
- Green Alarm Cut-off (ACO) LED that indicates that the ACO button was pressed to silence audible office alarms

Controls and Connectors

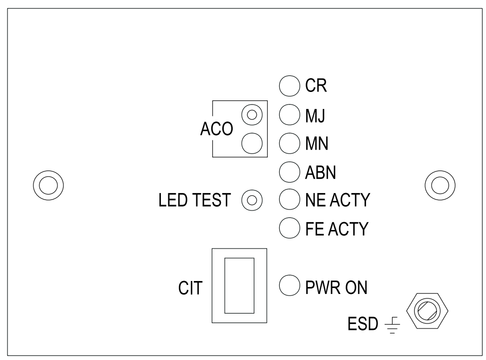
The user panel contains the following controls and connectors:

- LED test (LED TEST) button for testing all shelf LEDs (except PWR ON on the user panel and the fan unit LEDs)
- ACO button to silence audible office alarms (lights green when pressed)
- ESD (electrostatic discharge) wrist strap ground
- CIT port to connect a WaveStar CIT to the shelf

Controls and indicators

Figure 5-1, User Panel Controls and Indicators illustrates the user panel.

Figure 5-1 User Panel Controls and Indicators



Circuit pack faceplate

All circuit pack faceplates are equipped with a fault indicator (FLT) and an active indicator (ACT).

FLT LED

A continuously lighted red FLT LED on a circuit pack means that WaveStar TDM 2.5G/10G (2-Fiber) has isolated an equipment failure to or involving that circuit pack. On a multiple port circuit pack, for example, OC3/STM1 or OC12/STM4, any port on the circuit pack that is experiencing an incoming facility failure causes the red LED to blink. A flashing FLT LED indicates a facility failure of an input signal, as listed in Table 5-1.

Table 5-1 Failures Indicated by a Flashing Fault LED

A flashing FLT LED on...	INDICATES that...
a port unit	an incoming signal to that port unit has failed.
a synchronization circuit pack	an externally timed reference signal has failed.

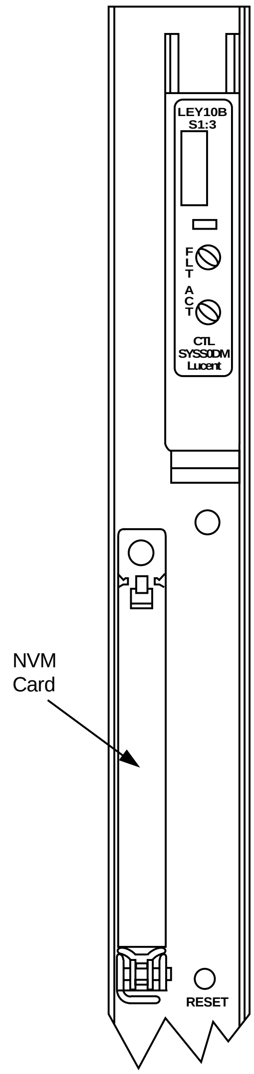
ACT LED

All circuit packs have a green ACT LED to indicate that the circuit pack is either in the active (ON) or standby (OFF) mode. When a circuit pack is inserted in a shelf, the green ACT LED flashes as software is downloaded and self-tests are performed. The LED stops flashing and remains lighted after the circuit pack has downloaded software and initialized.

When any port on a multi-port pack is either currently active in its protection group (for example, 1+1, BLSR, or 1xN) or provisioned 0x1, the circuit pack ACT LED is lighted. The green ACT LED is only turned off when no ports on the circuit pack are currently selected by the protection group and no port is provisioned 0x1.

Circuit pack indicators The figure below illustrates the placement of the LEDs on a circuit pack faceplate.

Figure 5-2 Circuit Pack Faceplate Indicators



Fan unit The fan unit has the following controls and indicators:

LEDs

- Green power on (PWR ON) LED lights when the fan receives -48V power
- Red fail (FAIL) LED lights when there is an alarm of any type associated with the fan unit (for example, a fan in the unit fails)

NOTE: The FAIL LED indicates both Severity 1 (service-affecting) and Severity 2 (non-service-affecting) alarms. The FILTER ALM LED indicates only Severity 2 alarms. (Severity 1 alarms are either service-affecting or potentially service-affecting. For example, total loss of the fan unit. Severity 2 alarms are non-service-affecting. For example, a dirty filter or the loss of one of the six fans in the fan unit.)

- Red filter alarm (FILTER ALM) LED lights when the fan filter needs attention (for example, the filter is dirty and must be replaced)

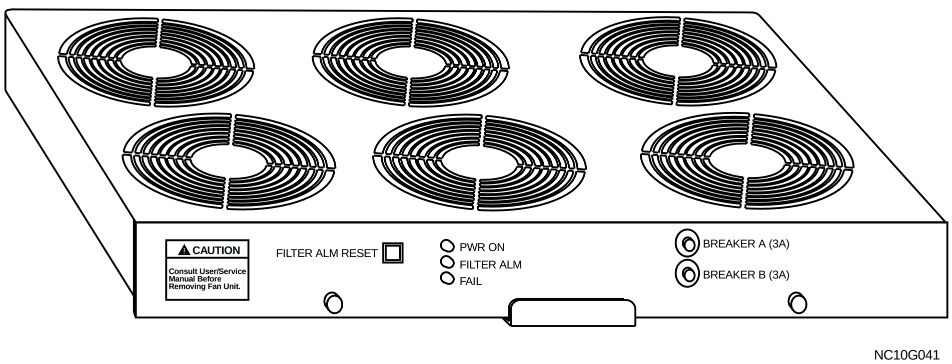
Important! When replacing a fan unit, ensure that the spare fan unit is at hand.

Buttons

- Filter alarm reset button to reset the FILTER ALM LED after the condition is resolved
- Two flush-mounted -48V circuit breakers (BREAKER A and BREAKER B) to protect against current overload

The figure below shows the fan unit included with each shelf in WaveStar TDM 2.5G/10G (2-Fiber).

Figure 5-3 Fan Unit and Faceplate



Circuit breakers

Each shelf is equipped with two -48V circuit breakers, one for each power feed (BREAKER A and BREAKER B). Circuit breakers provide a visual indication of their status via their rocker switches.

> **Important!** The normally hidden portion of each rocker switch is red. Should a circuit breaker operate, the hidden red portion of the rocker switch rotates out and becomes visible, indicating that -48V power has been lost or normal currents have been exceeded.

□

WaveStar CIT

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) interface terminal (CIT) provides

- Microsoft Windows 2000™ or Microsoft Windows NT™ -based graphical user interface (GUI)
- Convenient CIT access connections
- Security features to prevent unauthorized access
- Easily accessible Transaction Language 1 (TL1) interface
- Easily accessible via IAO LAN with TCP/IP protocol interface
- Information and control of maintenance and administrative activities

Definition

The WaveStar CIT is a desktop or laptop computer that is loaded with the WaveStar TDM 2.5G/10G (2-Fiber) CIT software. The WaveStar CIT provides a graphical user interface (GUI) with pull-down menus and extensive, context-sensitive, on-line help. The WaveStar CIT gives you a unified set of features for provisioning, testing, and reporting. The WaveStar CIT is necessary to install and accept the system.

Minimum requirements

Chapter 10, “Technical Specifications” lists the minimum and recommended requirements for the WaveStar CIT.

TL1 interface

You can use the GUI to manage all provisioning, testing, and report generation easily and intuitively, with the GUI handling the TL1 interface behind the scenes.

Many customers develop standardized scripts for use in the field for standard operations. The GUI supports the capability to write, save, and execute standardized TL1 scripts.

WaveStar CIT access

WaveStar TDM 2.5G/10G (2-Fiber) supports local and remote access by a WaveStar CIT. Remote access uses the data communications channel (DCC) or an external OSI WAN connected to a WaveStar TDM 2.5G/10G (2-Fiber) LAN port. The LAN interface provides both TCP/IP and OSI protocols. At any given time, only one WaveStar CIT can be connected to a CIT port on the user panel.

Security function

WaveStar TDM 2.5G/10G (2-Fiber) provides a security function to protect against unauthorized access to the WaveStar CIT system functions (such as provisioning). Security is controlled through logins, passwords, WaveStar CIT port disabling/enabling, and authorization levels for the system capabilities.

Maintenance and administrative activities

The WaveStar CIT provides detailed information and system control of the following specialized local/remote maintenance and administrative activities:

- Provisioning
- Loopback operation and testing
- Reporting
- Cross-connect (or time slot) assignments
- Protection switching
- Initialization of performance monitoring (PM) storage registers
- Software download
- Backup and restore of provisioned data

Operations Interfaces

Overview

WaveStar TDM 2.5G/10G, Release 6 system supports the following operations interfaces

- Office alarms: relay closures to control visual and audible alarms (for each shelf) and user settable miscellaneous discretes
- Message-based operations system (OS) interface, access via TCP/IP or OSI communication protocols, support for SNMS, Telcordia and other systems
- Data communications channels (DCC)

Office alarms interface

The office alarms interface is a set of discrete relays (for each shelf) that control audible and visible office alarms. Separate relays handle critical, major, and minor alarms. If desired, critical and major alarm outputs can be wired so that either, neither, or both of the outputs control the major office alarm. An alarm cut-off (ACO) button on the interface allows you to silence audible alarms.

User Settable Miscelaneous Discretes

The user-definable miscellaneous discrete interface transports alarm and status information from co-located equipment at remote sites. At each remote site, a total of 8 alarm/status inputs (in each WaveStar TDM 2.5G/10G (2-Fiber) are available to monitor environmental conditions like open doors or high temperature. A change in the monitored condition generates an autonomous alarm/status message.

Each user-assignable input is provisionable with a name and a status condition or a MN, MJ, or CR alarm.

Eight control outputs are also provided at each remote site to control auxiliary equipment like generators and pumps.

The 8 miscellaneous discrete inputs and outputs, MDIs/MDOs, are supported on a system node basis, for stand-alone 2.5G applications and 10G applications. For example, a 10G node with 4 tributary shelves supports 8 MDIs and 8 MDOs.

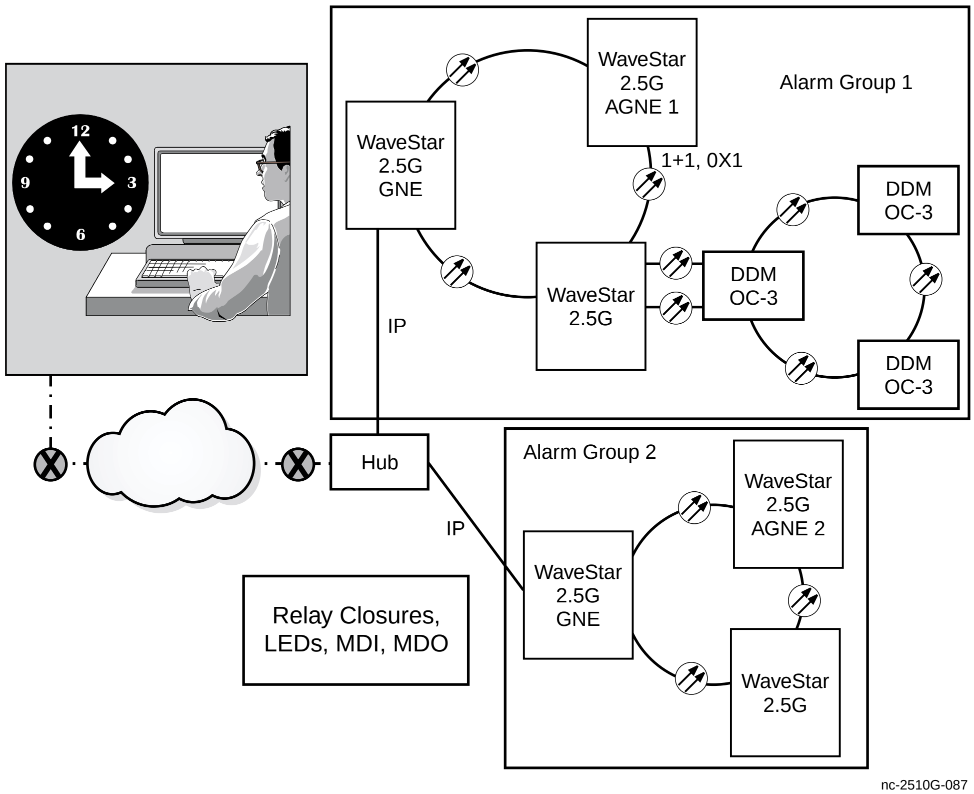
Software download, backup and restore

WaveStar TDM 2.5G/10G (2-Fiber) provides the capability, via the OSI network using the OSI or TCP/IP or FTTD-FTP/FTAM protocol, to download software from the WaveStar CIT to the NE or from the element/network management system to the NE and support backup and restore of the NE database. WaveStar TDM 2.5G/10G (2-Fiber) also provides the capability to install a full-featured software release from the management system.

Remote NE Status (RNES)/Alarm Gateway Network Element (AGNE)

The WaveStar TDM 2.5G/10G (2-Fiber) supports the ability to detect the existence of any alarm, condition, or miscellaneous discrete activation at remote Network Elements (see Remote Network Element Status (RNES) Application Example: WaveStar TDM 2.5G/10G (2-Fiber) and DDM-2000 OC-3 Application (5-14)). The RNES/AGNE feature requires that at least one network element is provisioned as the AGNE and that the remaining network elements are members of an Alarm Group. The members of the Alarm Groups communicate over the DCC to the AGNE. The AGNE then broadcasts this information to all of the other members of the Alarm Group, including activating the user panel LEDs. Once an LED is lit, a user can login to the network element to determine the cause and location of the activity. In addition to lighting the LEDs, the Network Element will generate Audible and Visual Office Alarms.

Figure 5-4 Remote Network Element Status (RNES) Application Example: WaveStar TDM 2.5G/10G (2-Fiber) and DDM-2000 OC-3 Application



The RNES/AGNE feature is supported on other Lucent Technologies products, such as DDM-2000 Release 15. Products that support the RNES/AGNE feature can share remote alarm information, provided they are provisioned to be in the same alarm group

Alarm Gateway Network Element (AGNE)

The Alarm Gateway Network Element or AGNE exchanges information to and from the members of its Alarm Group. At least one member of 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 broadcasts 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.

Remote NE Status (RNES)

Provisioning the Remote NE Status or RNES feature enables the NE to become a member of an Alarm Group, thus providing the NE the ability to report alarm/conditions to a alarm gateway NE which in turn shares the status information to all members of an alarm group

An alarm group is a set of NEs that share status information between themselves, such as alarms, and LED status. The set of remote NEs that an NE can exchange status information with 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 Technologies NEs in the same SONET subnetwork. In the WaveStar 2.5G/10G, 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. All members of the same alarm group share NE status information but do not share information with other alarm groups.

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.

Alarm group functions

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

- Notify the AGNE of any alarm/status changes
- Notify the Alarm Gateway Network Element (AGNE) of any miscellaneous discrete changes
- Know the alarm/status of all members of the same alarm group
- Know the status of miscellaneous discrete information for all members of the same 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

Message-based OS interface

The WaveStar TDM 2.5G/10G, Release 6 provides Transaction Language 1 (TL1) for commands/messages that complies with applicable standards. The OS interface is accessed through one of the 10BaseT Ethernet IAO LAN rear-panel connectors. The IAO LAN interface can be configured for TCP/IP and OSI protocols. The system supports software downloads, provisionable data backup, and restore using FTP or FTAM for the TCP/IP and OSI protocols, respectively.

TL1 Interface

The TL1 (or OS) interface is compatible with Telcordia's Network Monitoring and Analysis (NMA), Telcordia's Transport Element Management System (T-EMS), and the WaveStar Subnetwork Management System (SNMS). The WaveStar TDM 2.5G/10G, Release 5 OS interfaces supported include:

- IAO LAN with TCP/IP or OSI protocol (to SNMS or another compatible OS)
- TCP/IP (RFC1006) (via NCC to SNMS)
- TL1 X.25 (via NCC to NMA, T-EMS, or other compatible OS)
- TL1 TCP/IP (via NCC to NMA, FEMS, or other compatible OS)

Important! As stated above, the WaveStar TDM 2.5G/10G, Release 6 system OS interface supports TCP/IP directly (without the need for an external mediation/conversion device). The WaveStar TDM 2.5G/10G (2-Fiber) system also supports the use of Lucent Technologies Network Communication Control (NCC) R3.2 for those who plan to, or want to continue to, use the NCC as part of their operations environment. The NCC can perform conversion (gateway function) of OSI (TL1 based) to TL1 TCP/IP, TCP/IP (RFC 1006), and TL1/x.25. These functions may be useful when connecting a mix of deployed mutlivendor network elements to various OS systems. Lucent Technologies NCC Applications and Ordering and other useful information provide available in the *Network Communications Controller Release 3.2 User's Guide Issue 2*. The other document that may be useful the NCC is the *Network Communications Controller Release 3.2 Operations Systems Engineering Guide*, *Issue 2*.

Interface security function

WaveStar TDM 2.5G/10G (2-Fiber) also provides a security function to protect against unauthorized access to OS functions, such as provisioning. Security is controlled through logins, passwords, and authorization levels for the system capabilities.

Data Communications Channel (DCC)

The WaveStar CIT and operations interface features extend beyond the local WaveStar TDM 2.5G/10G (2-Fiber) to access remote sites. Those remote network operations capabilities use the SONET section DCC bytes in the OC-192, OC-48, OC-12, and OC-3 SONET overhead. WaveStar CIT dialogues and operations interface messages are transmitted in these DCC bytes.

Operations via a bridge TCP/IP and OSI

A transport service bridge (TSB) that reaches the NE via the embedded OSI network (such as the DCC channel) allows TCP/IP to OSI message conversion. Using a TSB, an element/network management system can control an NE by means of a TCP/IP access network, handling functions such as software download or backup/restore.

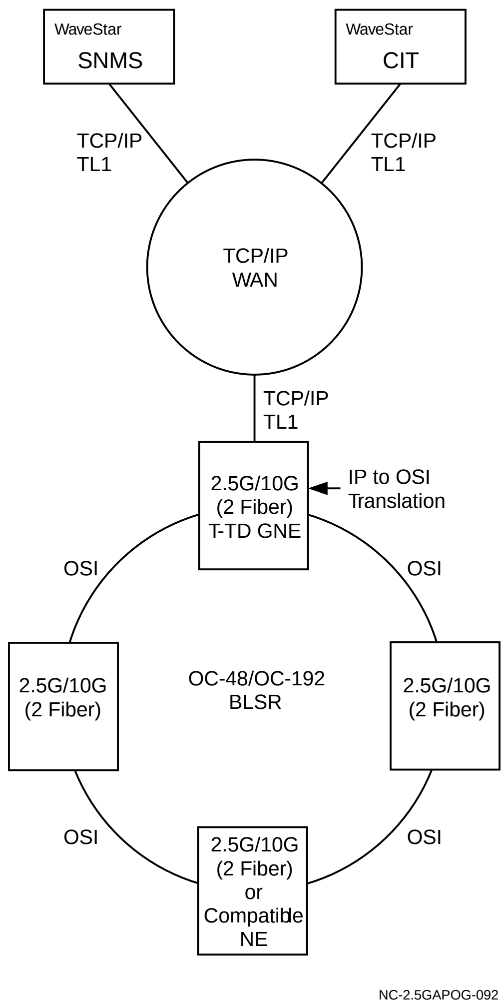
IP Access

The WaveStar TDM 2.5G/10G (2-Fiber) supports two types of IP Access. In one case, the WaveStar TDM 2.5G/10G (2-Fiber) can serve as a **TL1 Translation Device** (T-TD) by acting as a gateway network element that allows an SNMS and/or 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 CIT located on a TCP/IP based network to various NEs on a connected OSI network. In the second instance, the WaveStar TDM 2.5G/10G (2-Fiber) can functionally encapsulate IP packets within OSI packets to be transmitted through the OSI network to the proper NE. Thus the WaveStar TDM 2.5G/10G (2-Fiber) 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 WaveStar TDM 2.5G/10G (2-Fiber) 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 WaveStar TDM 2.5G/10G (2-Fiber) 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 WaveStar TDM 2.5G/10G (2-Fiber) 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.

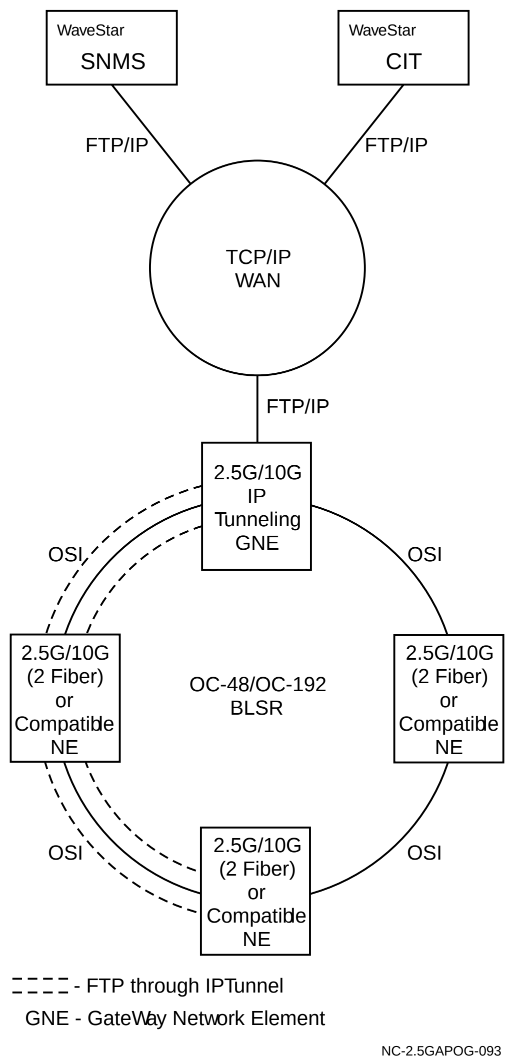
Figure 5-5 TL1 Translation Device



IP Tunneling

IP tunneling allows for file transfer (FTP) through an IP access network. IP tunneling is used to perform end-to-end FTP through the IP and OSI portion of the network. In this instance the WaveStar TDM 2.5G/10G (2-Fiber) 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 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 product.

Figure 5-6 IP Tunneling



Administration

Overview

Purpose The system management function for the administration of WaveStar TDM 2.5G/10G (2-Fiber) supports secure control and monitoring of the system.

Security WaveStar TDM 2.5G/10G (2-Fiber) provides for secure system access by means of a three-tier mechanism.

Security

Overview

This section describes the various security features WaveStar TDM 2.5G/10G (2-Fiber) provides to monitor and control access to the system.

Three-tier security

The three tiers of security that protect against unauthorized access to the WaveStar CIT and the network element functions are

- Port security
- Network element login security
- User login security

Port security

Port security controls access to the system through a per-optical-port enable/disable mechanism and inactivity time-outs.

Network element login security

NE login security controls access to the system through a lockout mechanism to disable all but administrative logins.

User login security

User login security controls access to the system on an individual user basis by means of

- Login ID and password assignment
- Autonomous indications and history records
- User privilege codes

Login and password assignment

To access the system, the user must enter a valid login ID and password. WaveStar TDM 2.5G/10G (2-Fiber) allows up to 500 login IDs and passwords. Two of these login IDs are for the two pre-installed logins that have superuser authorization level and the balance are for users with less than superuser authorization level.

Autonomous messages and history records

The system provides autonomous messages (resulting from a system event, not a user command) and history log records of successful and unsuccessful logins, as well as intrusion attempts for security audits.

User privilege codes

When a user is added to the NE, a set of User Privilege Codes is assigned to that user based on the type of work the user is doing. The User Privilege Codes restrict the commands and functions that the user is allowed to perform.

The set of User Privilege Codes consists of an authorization level in each of five functional categories. The authorization level is represented by a number in the range of 0 to 5, with 5 being the highest authorization level indicating full privileges and 0 indicating that the user has no authorization to perform any command in that functional category (the range of authorization levels for the Security functional category is 1 to 5). The two pre-installed superusers are assigned an authorization level of 5, that is, full privileges, in every functional category. For other users, it is permissible to grant the user full privileges in any combination of 4 of the 5 functional categories, but not in all functional categories.

Functional Categories

The functional categories for the user privilege codes can include

- Security (S)
- Maintenance (M)
- Performance monitoring (PM)
- Testing (T)
- Provisioning (P)

Command Access

Every command requires a specific authorization level in each of one or more of the functional categories. Users can execute any commands at their functional categories authorization level, as well as commands at lower levels. For example, a user with the authorization level of 4 in the maintenance category can also execute commands in levels 3, 2, and 1 in the maintenance category.

Login and Password Aging

The following aging processes provide additional means of monitoring and controlling access to the system

- Login aging deletes individual logins if unused for a pre-set number of days or on a particular date (for example, for a visitor or for temporary access during installation).
- Password aging requires that users change passwords periodically.

Equipment inventory

The system provides an inventory of all circuit packs that includes equipment type, version, and serial number. Inventory information is available by user request.

Maintenance

Overview

Purpose This section introduces the maintenance features available in WaveStar TDM 2.5G/10G (2-Fiber).

Definition Maintenance refers to the system's capability to continuously monitor its equipment and the signals that it carries in order to notify the user of any current or potential problems. This enables the user to take appropriate proactive (preventive) or reactive (corrective) action.

Types of maintenance Maintenance information and control are provided by

- Maintenance signals
- Facility fault detection, isolation, and reporting
- Provisioning consistency audits
- Loopbacks and tests
- Protection switching
- Performance monitoring
- Reports

☐

Facility Fault Processing

Overview

This section describes fault processing in WaveStar TDM 2.5G/10G (2-Fiber).

Definition

The WaveStar TDM 2.5G/10G (2-Fiber) detects signal faults (section, line, path, DS3) and maintenance signals. The system also generates maintenance signals according to equipment, signal, and facility failures. WaveStar TDM 2.5G/10G (2-Fiber) maintenance signals notify downstream equipment that a failure has been detected and alarmed by some upstream equipment (Alarm Indication Signal) or the WaveStar TDM 2.5G/10G (2-Fiber), and they notify upstream equipment that a downstream failure has been detected (Remote Defect Indication).

Standards compliant

The fault monitoring and maintenance signals supported in WaveStar TDM 2.5G/10G (2-Fiber) are SONET, ANSI and Telcordia compliant.

Monitoring failures

WaveStar TDM 2.5G/10G (2-Fiber) continuously monitors its internal conditions and its incoming signals as listed in the table below. Read access to the path trace information is provided for all signals.The system can generate and monitor an STS-N section trace message on the SONET port J0 using read\write access.

Table 5-2 Signal Monitoring

<table>
<tr><th>If you have...</th><th colspan="2">Then the signals are monitored for...</th></tr>
<tr><td rowspan="2">incoming SONET signals</td><td>Line</td><td>Path</td></tr>
<tr><td>Loss of Signal (LOS)
Alarm Indication Signal (AIS)
Loss of Frame (LOF)
Equivalent Bit Error Rate (EBER)
High Bit Error Rate (BER)
Remote Failure Indication (RFI)</td><td>Alarm Indication Signal (AIS)
Unequipped (UNEQ)
Loss of Pointer (LOP)
Signal Rate Mismatch (SRM)
Payload Defect Indication (PDI)
Equivalent Bit Error Rate (EBER)
High Bit Error Rate (BER)</td></tr>
<tr><td>incoming DS3 signals</td><td colspan="2">Loss of Signal (LOS)
Loss of Frame (LOF)
DS3 Alarm Indication Signal (AIS)
High Bit Error Rate (BER)
DS3 Idle Signal</td></tr>
<tr><td>SONET STS-1 signals that terminate in DS3 interfaces</td><td colspan="2">Alarm Indication Signal (AIS)
Path Unequipped (UNEQ)
Payload Mismatches (PLM)
Remote Failure Indication (RFI)</td></tr>
</table>

Signal maintenance

When defects are detected, WaveStar TDM 2.5G/10G (2-Fiber) inserts an appropriate maintenance signal to downstream and/or upstream equipment. The SONET maintenance signals include line Remote Defect Indications (RDI), STS Path AIS, line AIS, Path Unequipped, path RDI, and Payload Defect Indications (PDI). Path Unequipped is a special maintenance signal that is sourced only when no cross-connect exists for the outgoing tributary. The DS3 maintenance signals include DS3 AIS and DS3 Idle Signal.

Facility failures are sent out as communication alarm notifications.

Fault detection and reporting

When a fault is detected, WaveStar TDM 2.5G/10G (2-Fiber) employs automatic diagnostics to isolate any failed circuit pack or signal. Failures are reported to local maintenance personnel and to the OS so that repair decisions can be made. If desired, OS personnel and local personnel can use the WaveStar CIT to gain more detailed information about a specific fault condition.

Fault history

All alarmed fault conditions detected and isolated by WaveStar TDM 2.5G/10G (2-Fiber) are stored and made available to be reported, on demand, through the WaveStar CIT. In addition, a history of the past 500 alarm and status conditions and WaveStar CIT- or OS-initiated events is maintained and available for on-demand reporting. Each event is date and time stamped.

Reports

WaveStar TDM 2.5G/10G (2-Fiber) automatically and autonomously reports all detected alarm and status conditions through the

- Office alarm relays
- User panel
- Circuit pack Fault LEDs
- Message-based OS

Provisioning Consistency Audits

Overview

This section describes the provisioning consistency audits available in WaveStar TDM 2.5G/10G (2-Fiber).

Definition

WaveStar TDM 2.5G/10G (2-Fiber) monitors the consistency of the provisioning information for ring administration and cross-connections and alerts you to situations that may result in lost traffic or protection switching problems.

Audit types

WaveStar TDM 2.5G/10G (2-Fiber) audits the following information to ensure consistent operation of the BLSR/UPSR

- Target Identifier (TID)
- Ring Squelch Map

Target identifier (TID)

The TID must be unique within a given subnetwork for proper operation of the OS interface. WaveStar TDM 2.5G/10G (2-Fiber) uses a protocol called SONET Directory Services to ensure the uniqueness of TIDs for all network elements in a subnetwork. You can make changes to a TID at anytime. However, if a change results in a duplication, the WaveStar TDM 2.5G/10G (2-Fiber) sends an alarm and does not put the changes into effect until you make another change that removes the duplication.

Ring squelch map

The ring squelch map consists of the provisioned source and destination TIDs for each cross-connection at each node in the ring. Incorrect information in this map could result in misconnected or unnecessarily dropped traffic during failure conditions. This part of the audit function flags all instances of unknown TID values in the squelch map. It also propagates changes to the TID in any node in the ring and to all other nodes so that they can automatically update their squelch maps. Thus, you do not have to change the ring squelch maps manually.

Loopbacks and Tests

Overview

This section describes the automatic and manual loopbacks and tests that WaveStar TDM 2.5G/10G (2-Fiber) performs.

Loopback definition

A loopback is a troubleshooting test in which a signal is transmitted through a port unit to a set destination and then returned to the originating port unit. The transmitted and received signals are measured and evaluated by the user to ensure that the received signal is accurate and complete when compared to the originating signal.

User-initiated loopbacks

WaveStar TDM 2.5G/10G (2-Fiber) can perform user-initiated loopbacks within the port units. Active loopbacks are indicated by the abnormal (ABN) LED on the user panel.

Facility Loopbacks

The WaveStar TDM 2.5G/10G (2-Fiber) system supports facility loopbacks on a port or a set of ports for both electrical and optical signals. Loopbacks allow for testing of cabling and system operation as well as troubleshooting during factory system tests, and channel growth. Near-side facility loopbacks are used during system installation and channel growth activities to test the integrity of cabling and connections to the new NE. Far-side facility loopbacks are employed during system installation and channel growth activities to test the integrity of paths through the WaveStar TDM 2.5G/10G (2-Fiber) system itself.

□

Protection Switching

Overview

WaveStar TDM 2.5G/10G (2-Fiber) provides the following types of protection:

Optical and electrical interface protection switching includes

- OC-192: 2-Fiber BLSR, UPSR (STS-1 level path switching on the UPSR), and 0x1
- OC-48: 2-Fiber BLSR, UPSR (STS-1 level path switching on the UPSR), 0x1, and 1+1
- OC-12: UPSR (STS-1 level path switching on the UPSR), 0x1, and 1+1
- OC-3: 0x1 and 1+1
- DS3 and EC-1: 0x1 and 1xN (N≤12)
- GE1: 0x1

The switch fabric complex is protected in a 1+1 equipment protection architecture.

Timing synchronization is protected with 1+1 non-revertive protection switching for the Stratum 3 Timing Generator and with DS1 external timing reference signal protection.

OC192 protection

OC-192 2-fiber BLSR/UPSR protection switching (high-speed shelf only) occurs in response to automatically detected faults in the optical line (BLSR)/ path (UPSR), equipment failures in the OC192 port unit, and external commands from a local or remote CIT or operations system. Protection switching in WaveStar TDM 2.5G/10G (2-Fiber) complies with GR-253.

OC48 protection

The protection mode for the OC48 port units can be provisioned as a BLSR, UPSR, 1+1 (protected), or 0x1 (unprotected). The WaveStar TDM 2.5G/10G (2-Fiber) supports both revertive and non revertive protection switching for the OC-48 port units. The default value is 0x1. The OC-48 2-fiber provides protection switching in response to automatically detected faults in the optical line (BLSR)/path (UPSR), equipment failures in the OC48 port unit, and external commands from a local or remote CIT or operations system. Bidirectional 1+1 protection switching may be provisioned as either revertive or non revertive. Unidirectional 1+1 protection switching is always non revertive.

OC12 protection

The protection mode for the OC12 port units can be provisioned as

- Unidirectional and bidirectional 1+1 (two port units providing 1+1 revertive or non-revertive protection) or 0x1 unprotected. Unidirectional protection is always non revertive. Bidirectional protection may be provisioned as either revertive or non revertive.
- 0x1 unprotected

Important! If the 1+1 protection mode is used, it is recommended to place the port units in adjacent slots. The possible adjacent slots are slots 1/2, 3/4, 5/6, 7/8, 9/10, 11/12, 13/14, 15/16; however, you can only use slot 16 for OC-3 or OC-12 if DS3 protection packs are not used or installed. The adjacent slots must have an odd number on the left. For example, two optical port units that are 1+1 protected should not be installed in slots 2/3.

OC3 protection

The protection mode for the OC-3 port units can be provisioned as

- Unidirectional and bidirectional 1+1 (two port units providing 1+1 revertive or non-revertive protection). Unidirectional protection is always non revertive. Bidirectional protection may be provisioned as either revertive or non revertive.
- 0x1 (unprotected)

Important! If the 1+1 protection mode is used, it is recommended to place the port units in adjacent slots. The possible adjacent slots are slots 1/2, 3/4, 5/6, 7/8, 9/10, 11/12, 13/14, 15/16; however, you can only use slot 16 for OC-3 or OC-12 if DS3 protection packs are not used or installed. The adjacent slots must have an odd number on the left. For example, two optical port units that are 1+1 protected can not be installed in slots 2/3.

DS3EC1/8 protection

WaveStar TDM 2.5G/10G (2-Fiber) provides protection for all DS3EC1/8 circuit packs. Electrical circuit packs are 1xN ($N \leq 12$) protected and use bidirectional revertive switching. One dedicated protection DS3EC1/8 circuit pack (in slot EPRN, the electrical protection slot) provides protection for N ($N \leq 12$) working DS3EC1/8 circuit packs. All eight DS3EC1 ports on a DS3EC1/8 circuit pack are protected by a single protection switching operation.

GE1 protection

The GE1 can be used only in the 0x1 configuration.

To protect Gigabit Ethernet traffic:

- Use standard SONET protection schemes (for example, BLSR) on the STS1s that carry the encapsulated EtherNET frames. This scheme covers failures in the SONET network, not GE1 interface failures.
- Use protection offered by the external router equipment. For example, two 0x1 GE1 interfaces can be connected in parallel between external routers. This scheme covers failures in the SONET network and the GE1 interfaces.

Synchronization protection

WaveStar TDM 2.5G/10G (2-Fiber) provides protection for the Stratum 3 Timing Generator (TMG/STRAT3) circuit packs and the timing reference signals. Two Stratum 3 circuit packs provide 1+1 non-revertive protection switching. In addition, two DS1 timing ports are provided to each TMG/STRAT3 pack for external timing reference signal protection. For line timing on the OC-3 and OC-12 port units, the packs being referenced must be in the even numbered slots on the tributary shelf.

Switch fabric protection

On each shelf, the switch fabric is protected in a 1+1 non-revertive protection switching. At initial start-up, Switch 0 is the active line. If the circuit pack for Switch 0 fails, Switch 1 becomes the active line.

Automatic Laser Shutdown

WaveStar TDM 2.5G/10G (2-Fiber) supports Automatic Laser Shutdown (ALS) on certain long-reach and very long-reach OC-192 interfaces. ALS is activated whenever (due to a cable break or otherwise) the signal no longer arrives at the receiver. When an LOS defect is present at the receive end of a section, the adjacent transmitter sending signals in the opposite direction is automatically shut down. The deactivation time from the moment the LOS defect is first detected is between 500 and 800 milliseconds. When the cable break is repaired, a restart procedure will make sure the transmitters are turned back on again.

This feature is designed to be used when the

- OBA is paired with the LEY69AE or LEY97AE
- OBPA is paired with the LEY228AE

Refer to Table 7-11 for other possible pairings of port units with the OBA and OBPA for applications where ALS is not required.

Restart Modes

The following three restart modes are offered as part of the ALS feature:

- Automatic
- Manual
- Manual for Test

In the automatic restart mode, 100 seconds after ALS is activated the transmitter is switched on again for two seconds to test the integrity of the bi-directional section. If the bi-directional section is found to be O.K., the LOS defect will be cleared and the transmitters at both ends will remain in operation. If the integrity of the bi-directional section is found to be flawed, the laser remains shut-down and new restart attempts are made continually at 100 second intervals.

In the manual restart mode, 2 second restart pulses are generated at the user's request. As in the automatic restart mode, the minimum interval between restart attempts is 100 seconds.

In the manual restart for test mode, the restart pulse lasts a total of 90 seconds. As in the automatic and manual restart modes, the minimum interval between restart pulses is 100 seconds.

□

SONET Performance Monitoring

Overview

This section describes performance monitoring applicable to OC-3, OC-12, OC-48, and OC-192 signals.

Description

WaveStar TDM 2.5G/10G (2-Fiber) provides performance monitoring to support proactive maintenance of a network, such as the optic power receive (OPR) parameters. WaveStar TDM 2.5G/10G (2-Fiber) also provides fault-locating parameters, such as the coding violations (CV) and severely errored seconds (SES) parameters.

Types of performance monitoring

WaveStar TDM 2.5G/10G (2-Fiber) accumulates SONET PM parameters and reports Threshold Crossing Alerts when parameters exceed their thresholds. The Near End (NE) and Far End (FE) parameters are Telcordia SONET GR-253 parameters. In addition, Far End (FE) parameters are supported to provide single point monitoring of what is being detected by the terminating point of the line travelling in the opposite direction. For information about specific parameters, see the WaveStar TDM 2.5G/10G (2-Fiber) *User Operations Guide*.

The following types of parameters are reported:

- physical (receive and transmit)
- section (near end)
- line (incoming for both NE and Far End [FE])
- path intermediate (incoming NE and FE)
- terminated path (incoming NE and FE)

Performance thresholds

Thresholds can be assigned to performance parameters. These are indicative of degraded (in 24 hour measurements) or unacceptable (in 15 minute measurements) performance levels. When a performance-monitoring threshold is crossed, a report is sent to the OS. All threshold crossings that are associated with a particular line can be correlated by the OS and the source of the degradation identified.

Parameter processing

WaveStar TDM 2.5G/10G (2-Fiber) processes the basic performance indicators (Code Violations and Defects) into derived performance parameters. The derived parameters are based on the condition of the incoming optical signal during a given second.

□

DS3 Performance Monitoring

Overview

This section describes the performance monitoring for DS3 signals.

Definition

Thresholds can be assigned to DS3 performance parameters. These are indicative of degraded (in 24 hour measurements) or unacceptable (in 15 minute measurements) performance levels. When a performance-monitoring threshold is crossed, it is reported to the operations system where all threshold crossings associated with a particular path can be correlated, and the likely source of the degradation can be identified.

Performance monitoring occurs for NE incoming DS3 line and path parameters as described in the GR-820 standard. In addition, WaveStar TDM 2.5G/10G (2-Fiber) monitors NE outgoing DS3 path parameters and FE DS3 parameters.

For details on specific performance parameters, see the WaveStar TDM 2.5G/10G (2-Fiber) *User Operations Guide*.

□

Reports

Overview

This topic contains information about the

- Active alarms and status report
- Performance monitoring report
- History report
- Report on circuit pack, slot, port and switch states
- Version/equipment list
- Synchronization report

Active alarms and status reports

WaveStar TDM 2.5G/10G (2-Fiber) provides an on-demand report that shows all the active alarm and status conditions. WaveStar TDM 2.5G/10G (2-Fiber) automatically displays the local alarm and status report on the local or remote WaveStar CIT. The report shows the following alarm levels and alarm conditions:

- Critical (CR)
- Major (MJ)
- Minor (MN)
- Not Alarmed (status) (NA)

The source address and description of each alarm condition (for example, controller failure and incoming signal failure) are included in the report along with the date and time detected. The report also indicates whether or not the alarm is service-affecting. Multiple options are available to sort alarm data (for example, in order of severity).

Performance monitoring report

WaveStar TDM 2.5G/10G (2-Fiber) provides reports that contain the values of all performance monitoring registers requested at the time of the report. The start time of each register’s recording period is also included. The reports provide all DS3 and SONET parameters and performance monitoring data that was recorded in a series of 15-minute and 24-hour storage registers.

Performance Parameters Report

WaveStar TDM 2.5G/10G (2-Fiber) provides another report that contains a summary of all DS3 and SONET performance parameters that have crossed their provisioned 15-minute or 24-hour thresholds within the history of the 15-minute and 24-hour registers.

> **Important!** A series of 32 previous and one current 15-minute registers is provided for each parameter, allowing for up to 8 hours and 15 minutes (495 minutes) of history in 15-minute registers. Also, one current register and one previous 24-hour register are provided, allowing for up to 2 days (48 hours) of history in 24-hour registers.

Fault Management History Report

A history report displays the past 500 events. An event is any change in WaveStar TDM 2.5G/10G (2-Fiber) that may affect its performance (for example, a failure) or change its operation status (for example, loopback setup). This summary contains time stamps showing when each condition was detected and when it cleared. The WaveStar CIT events contain a time stamp showing when the command was entered.

Time Stamp

The day bin time stamp at the top of the reports reflects the last time the 24-hour performance monitoring counts were initialized, even if the resulting “day” is longer or shorter than 24 hours. The report shows corrupted data as a question mark (?) for all non-24-hour day bin collection intervals, including those exceeding 24 hours.

Report on pack, slot, port and switch states

This on-demand report displays

- Circuit pack, transmission port, and timing port state information
- Protection group switch states

Version/equipment list

The version/equipment list report is an on-demand report that lists all

- Provisioned and pre-provisioned circuit packs
- Circuit packs that are present

Synchronization report

The synchronization report is an on-demand report that lists

- System synchronization status
- Clock parameters that can be interrogated from a WaveStar CIT or from remote telemetry

Additional Items

The other items of information that can be retrieved include:

- Cross-connection information
- Shelf-level information
- System-level information
- Node-level information

□

Provisioning

Overview

Purpose

This section contains information about the following features:

- Local or remote provisioning
- Preprovisioning circuit packs
- Circuit pack replacement provisioning
- Original value provisioning

Definition

Provisioning refers to assigning values to parameters used for specific functions by network elements. The values of the provisioned parameters determine many operating characteristics of a network element.

Local or remote provisioning

WaveStar TDM 2.5G/10G (2-Fiber) software allows local and remote provisioning of all user-provisionable parameters. The provisionable parameters and values (current and original) are maintained in the nonvolatile memory of the controller circuit pack.

Preprovisioning circuit packs

To simplify circuit pack installation, parameters can be provisioned before inserting the corresponding circuit pack. The appropriate parameters are automatically downloaded when the corresponding circuit pack is installed. All system parameters and values (current and original) are retrievable on demand regardless of the means used for provisioning.

Circuit pack replacement provisioning

Replacement of a failed circuit pack is simplified by the automatic provisioning of the original circuit pack values. The controller circuit packs maintain a provisioning map of the current provisioning values. When a transmission and/or a timing circuit pack is replaced, the controller automatically downloads the previous provisioning parameters to the new circuit pack.

Original value provisioning

Installation provisioning is minimized with factory-preset values. Each provisionable parameter is assigned an original value at the factory. The provisionable parameters are automatically set to their original values during installation.

There are two complete sets of data (parameters and their values) located in the nonvolatile memory of the controller circuit pack under normal conditions:

- The first set contains the system parameters and their original values (values assigned to a parameter at the factory).
- The second set contains the system parameters and their current values (values currently being used by the system).

Important! The original values assigned at the factory cannot be changed. However, the current values can be overridden through local or remote provisioning.

Provisionable SS bits

The WaveStar TDM 2.5G/10G (2-Fiber) provisionable SS bits feature allows users to the provision the value of SS bits 5 and 6. These are the SS bits that are transmitted in the first H1 pointer byte of an STS- Nc signal. Present SONET (Telcordia) and SDH (ITU-T) standards require that these bits be ignored by the receiving equipment. However, some older, embedded SONET and SDH equipment may not ignore these bits.

Provisioning the SS bits to 00 (overwrite enabled) can allow interworking with older embedded SONET equipment. Provisioning the SS bits to 10 (overwrite disabled) can allow interworking with older embedded SDH equipment.

Note:

The SS bits are provisionable on a per shelf basis.

References

For more information about provisioning parameters and original values using the WaveStar CIT, refer to, *WaveStar TDM 2.5G/10G (2-Fiber) User Operations Guide*

□

Port Monitoring Modes

Overview This section describes the different port monitoring modes in WaveStar TDM 2.5G/10G (2-Fiber).

Definition Port monitoring modes represent the monitoring state for each port in the system at any given time. Each port monitoring mode has its own characteristics for signal failure alarms and PM (performance monitoring) data collection. Transitions between modes occur due to events such as applying a good signal and WaveStar CIT commands. The detection of a fault does not affect the state of the port monitoring mode.

Port modes The port modes in WaveStar TDM 2.5G/10G (2-Fiber) are

- Automatic (AUTO): AUTO refers to a port that is available for automatic provisioning. A port transitions from the AUTO mode to the MON mode if a good signal is detected. The original port monitoring mode value is AUTO. When the port monitoring mode is AUTO, the port is not alarmed.
- Monitored (MON): MON refers to a port that is fully monitored and alarmed.
- Not monitored (NMON): NMON refers to a port that is not monitored and does not transition to the MON state even if a good signal is detected. Any port modes can be user-provisioned independently to the NMON state at anytime, regardless of the auto-provisioned mode of the terminating interface slot. This port mode is used to suppress facility (communications) alarms and performance monitoring processing.

6 System Planning and Engineering

Overview

Purpose This chapter provides information about planning capacity, power, synchronization, floor plan layout, and equipment interconnection.

General Planning Information

Overview

This section provides general planning information for WaveStar TDM 2.5G/10G (2-Fiber).

Planning considerations

When planning your network, you should consider the eventual system size, including

- Capacity
- Power
- Synchronization
- Floor plan layout
- Equipment interconnection

Worldwide Services

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. For more information about Lucent Technologies Engineering Services, Installation Services, and Technical Support, contact your Account Executive or refer to Chapter 8, “Product Support.”

Operations Interface

The WaveStar TDM 2.5G/10G, Release 6 provides Transaction Language 1 (TL1) for commands/messages that complies with applicable standards. The OS interface is accessed through one of the 10BaseT Ethernet IAO LAN rear panel connectors. The IAO LAN interface can be configured for TCP/IP and OSI protocols.

The WaveStar TDM 2.5G/10G, Release 6 system does provide front local access, typically used by craft personnel to access the system with the WaveStar CIT. The requirements for the PC that runs the WaveStar CIT are listed in Chapter 5.

The TL1 (or OS) interface is compatible with Telcordia's Network Monitoring and Analysis (NMA), Telcordia's Transport Element Management System (T-EMS), and the WaveStar Subnetwork Management System (SNMS).

> **Important!** As stated above, the WaveStar TDM 2.5G/10G, Release 6 system OS interface supports TCP/IP directly (without the need for an external mediation/conversion device). The WaveStar TDM 2.5G/10G (2-Fiber) system also supports the use of Lucent's Network Communication Control (NCC) R3.2 for those who plan to, or want to continue to, use the NCC as part of their operations environment. The NCC can perform conversion (gateway function) of OSI (TL1 based) to TL1 TCP/IP, TCP/IP (RFC 1006), and TL1/x.25. These functions may be useful when connecting a mix of deployed multivendor network elements to various OS systems. Lucent NCC Applications and Ordering and other useful information provide available in the *Network Communications Controller Release 3.2 User's Guide Issue 2*. The other document that may be useful the NCC is the *Network Communications Controller Release 3.2 Operations Systems Engineering Guide*, *Issue 2*.

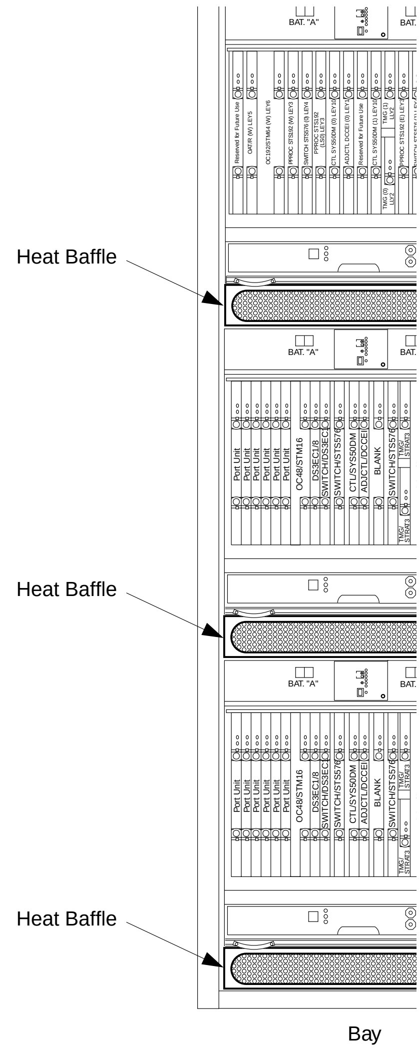
Power planning Two –48V power feeders [BREAKER (A) and BREAKER (B)] power each WaveStar TDM 2.5G/10G (2-Fiber) shelf. Redundant power feeders are used to ensure maximum system reliability. All power feeders should be sized to carry the maximum shelf power consumption. Each feeder is equipped with a filter to reduce any switching noise that may be present at the input. For more information about power, refer to Chapter 4, Product Description and Chapter 10, Technical Specifications.

Cooling If you mount a WaveStar TDM 2.5G/10G (2-Fiber) shelf at the top of a bay, install a heat baffle directly below it. If you mount a WaveStar TDM 2.5G/10G (2-Fiber) shelf at the center or bottom of a bay, install a heat baffle directly above it and directly below it. Allow no gaps between the baffle mounted below the WaveStar TDM 2.5G/10G (2-Fiber) shelf and any equipment mounted directly below the baffle. Observing this rule prevents hot air, exhausted from a lower shelf, from being used to cool the upper shelf. See Figure 6-1. Any slot that does not contain a circuit pack must have a blank cover to ensure both proper EMC (Electro-Magnetic Compatibility) containment and air flow.

Heat baffle locations

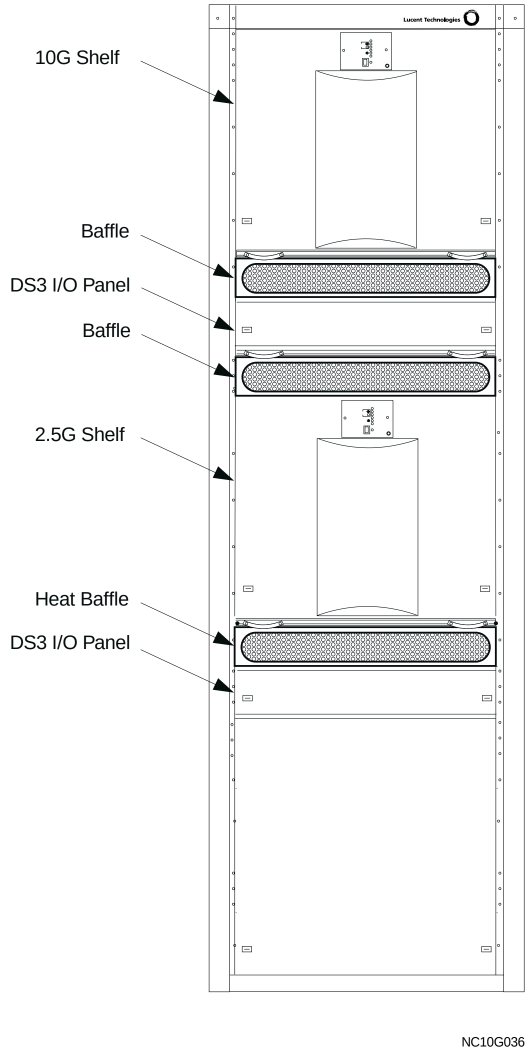
The figure below shows the locations of the heat baffles in a bay housing a WaveStar TDM 2.5G/10G (2-Fiber) system with no internally mounted DS3 connectors.

Figure 6-1 Heat Baffle Locations



The figure below shows the heat baffle locations for a WaveStar TDM 2.5G/10G (2-Fiber) system with internally mounted DS3 connector panels. This figure shows the system from the front with the shelf doors closed.

Figure 6-2 Heat Baffle Locations with Internal DS3 Connector Panels



Dispersion Compensation Module (DCM) holder tray

For applications requiring the use of Dispersion Compensation Modules (DCMs), a DCM holder tray can be miscellaneously mounted into a WaveStar TDM 2.5G/10G (2-Fiber) bay. The tray holds 4 DCMs. A bay with a DCM holder tray, can support up to two WaveStar TDM 2.5G/10G (2-Fiber) shelves.

Transmission Capacity

Overview

Each low-speed, tributary shelf supports up to 384 STS-1 equivalents of interface capacity which can be used to support a mix of OC-48 BLSR, OC-48 UPSR, OC-48 1+1, OC-48 0x1, OC-12 UPSR, OC-12 1+1, OC-12 0x1, OC-3 1+1, OC-3 0x1, DS3, EC-1, and/or Gigabit Ethernet ports. (The 1xN equipment protection for DS3/EC-1 port units is separate, not a part of this interface capacity.) Except as noted in the section “Port Location Rules” in this chapter, you can equip each low-speed shelf with any mixture of OC-48, OC-12, OC-3, DS3/EC-1, and GE1 port units

The high-speed shelf supports up to 384 STS-1 equivalents of interface capacity which can be used to support one OC-192 2-Fiber BLSR, or one OC-192 UPSR, or two 0x1 (unprotected) OC-192 ports.

The STS-1 or STS-Nc tributaries, which carry traffic at the path level within the ports, are interconnected with a 576 x 576 STS-1 switch fabric in each low-speed shelf and with either a 576 x 576 STS-1 switch fabric or a 768 x 768 STS-1 switch fabric in the high-speed shelf. The switch provides the user-provisioned cross-connections between input and outputs at the STS-1 or STS-N level. It also provides both line protection switching and path protection switching. For 1xN equipment protection of DS3/EC-1 port units, the switch also interfaces to an electrical protection switch unit (the SWITCH/DS3/EC1 circuit pack) that selects between the working and protection DS3/EC1 circuit packs.

With the 576 x 576 STS-1 switch fabric in the high-speed shelf, the system supports one or two low-speed, tributary shelves

With the 768 x 768 STS-1 switch fabric in the high-speed shelf, the system supports one to four low-speed, tributary shelves. The larger switch fabric provides a larger cross-connection capacity between the high-speed shelf and the low-speed shelves.

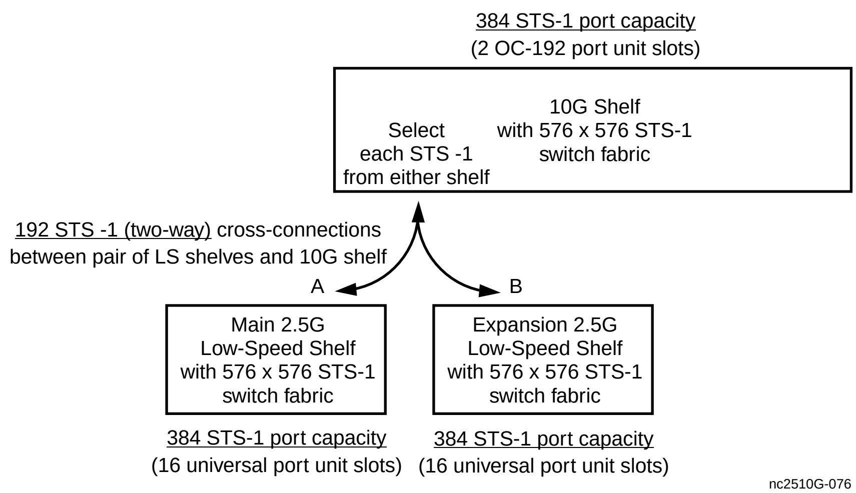
The user provisions cross-connections only for the working (protected) traffic and any additional unprotected traffic carried by 0x1 ports or by BLSR protection access. Since the additional connections between working and protection tributaries for BLSR, UPSR, and 1+1 port protection are made automatically by the system within each shelf, they are not counted in the utilization of the cross-connection capacity between the high-speed and low-speed shelves.

The next subsections of this chapter provide information to help you plan how to use the transmission capacity of the system in various applications.

Switch Fabrics in Each Shelf and the Inter-Shelf Cross-Connection Capacity

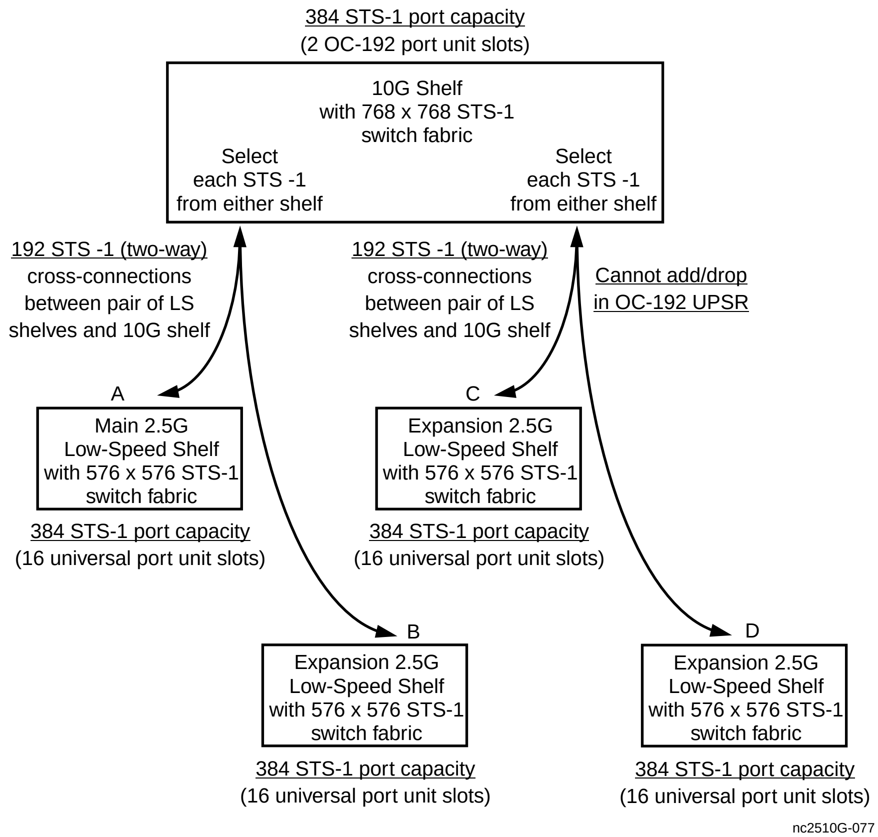
When equipped with the 576 x 576 STS-1 switch fabric in the high-speed shelf, the TDM 2.5G/10G (OC-192) system supports up to 3 shelves: 2 low-speed, tributary shelves and a high-speed shelf. This switch fabric consists of SWITCH/STS576 switch units and PPROC/STS192 switch unit pointer processors, each with working and protection circuit packs. With a total of 576 STS-1 inputs and 576 STS-1 outputs, it supports 384 STS-1 equivalents of interface capacity and cross-connection capacity within the high-speed shelf, plus 192 STS-1 equivalents of inter-shelf cross-connection capacity that can be used for connections to other shelves. (See the next figure.)

Figure 6-3 Configuration with 576x576 Switch in the 10G Shelf



When equipped with the 768 x 768 STS-1 switch fabric in the high-speed shelf, the TDM 2.5G/10G (OC-192) system supports up to 5 shelves: 4 low-speed, tributary shelves and a high-speed shelf. This switch fabric consists of SWITCH/STS768 switch units and PPROC/STS384 switch unit pointer processors, each with working and protection circuit packs. With a total of 768 STS-1 inputs and 768 STS-1 outputs, it supports 384 STS-1 equivalents of interface capacity and cross-connection capacity within the high-speed shelf, plus 384 STS-1 equivalents of intershelf cross-connection capacity that can be used for connections to other shelves. (See Figure 6-4, Configuration with the 768x768 Switch in a 10G Shelf (page 6-10).)

Figure 6-4 Configuration with the 768x768 Switch in a 10G Shelf



Each low-speed, tributary shelf is equipped with a 576 x 576 STS-1 switch fabric. Similarly, this supports 384 STS-1 equivalents of interface and cross-connection capacity within the low-speed shelf, plus 192 STS-1 equivalents of inter-shelf cross-connection capacity for connections to the high-speed shelf.

For each shelf, either low-speed or high-speed, the switch fabric in that shelf supports 384 STS-1 equivalent one-way cross-connections between inputs and outputs within the same shelf. This capacity within each shelf is sufficient so that, regardless of how any shelf is provisioned (meaning, with any combination of port units and any supported mix of protection configurations), the user can provision a cross-connection to each and every output logical tributary of each port in each slot of the shelf from any input logical tributary in the same shelf.

The inter-shelf cross-connection capacity which is additionally supported by each shelf can be used to provision cross-connections between inputs and outputs in different shelves. The interface capacity of a shelf is greater than the inter-shelf cross-connection capacity. (This allows a larger number of shelves to be supported, rather than providing more inter-shelf connection capacity than would be useful for most applications.) Therefore, the number of cross-connections between inputs and outputs in different shelves is limited by the inter-shelf connection capacity in some applications.

Using Switch Fabrics and Inter-Shelf Cross-Connection Capacity for Various Applications

In applications using the 2 ports in the high-speed shelf for a ring -- which can be either an OC-192 2-Fiber BLSR or an OC-192 UPSR -- the inter-shelf cross-connection capacity of 192 STS-1 equivalents with the 576 STS-1 switch fabric is sufficient to add/drop all the working traffic in this ring from/to port units in the low-speed, tributary shelf(ves). For a BLSR using protection access to carry extra traffic, the capacity of 384 STS-1 equivalents with the 768 STS-1 switch fabric is sufficient to add/drop all of both the working and protection access traffic. (See Figure 6-5, Adding a Second Low Speed Shelf in a High Speed Shelf Equipped with a 768x768 Switch (page 6-11) and Figure 6-6, Adding Second, Third, and Fourth Low-Speed Shelves (page 6-12).)

Figure 6-5 Adding a Second Low Speed Shelf in a High Speed Shelf Equipped with a 768x768 Switch

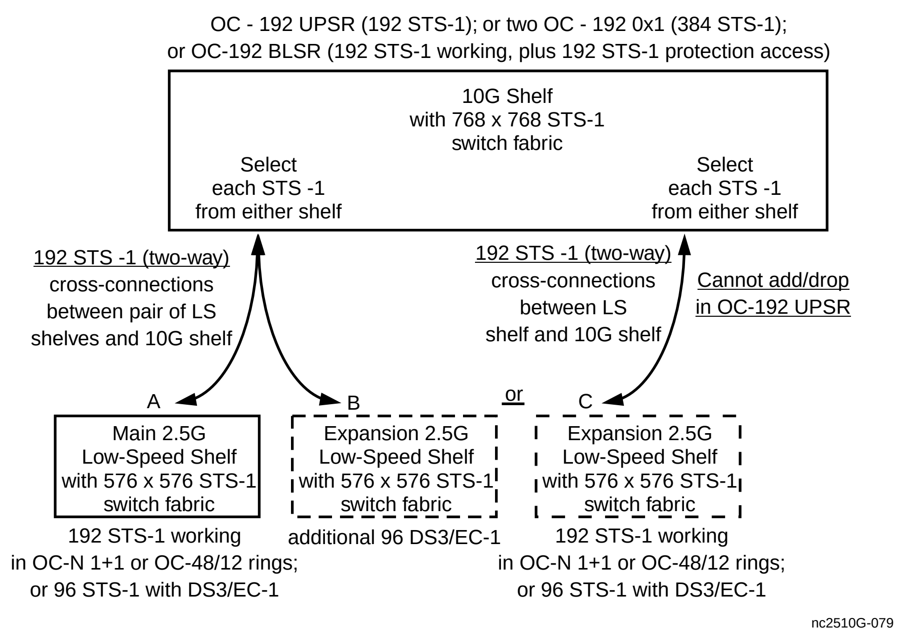
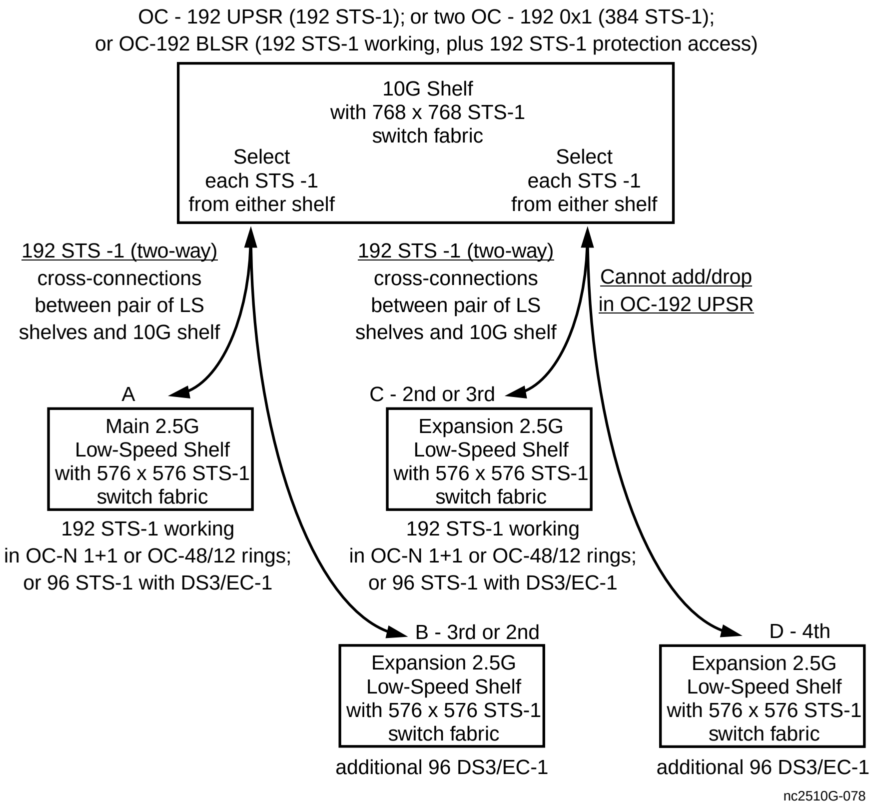


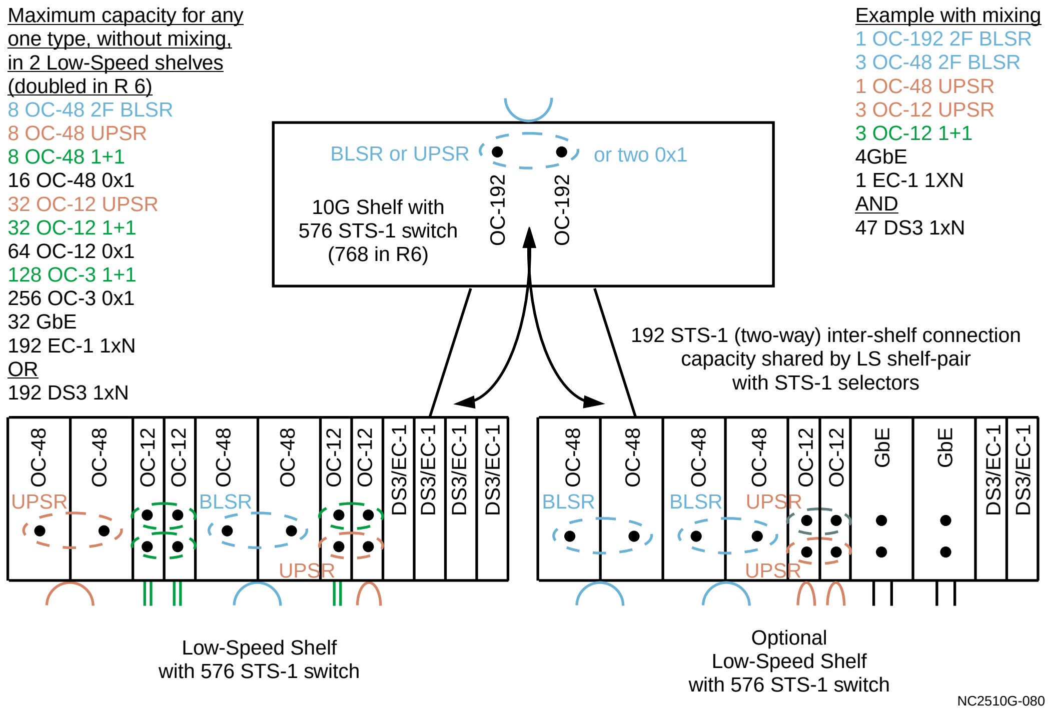
Figure 6-6 Adding Second, Third, and Fourth Low-Speed Shelves



Similarly, with one 0x1 (unprotected) OC-192 port, the capacity of the 576 STS-1 switch fabric is sufficient for all the traffic. With two 0x1 OC-192 ports, the capacity of the 768 STS-1 switch fabric is sufficient for all the traffic.

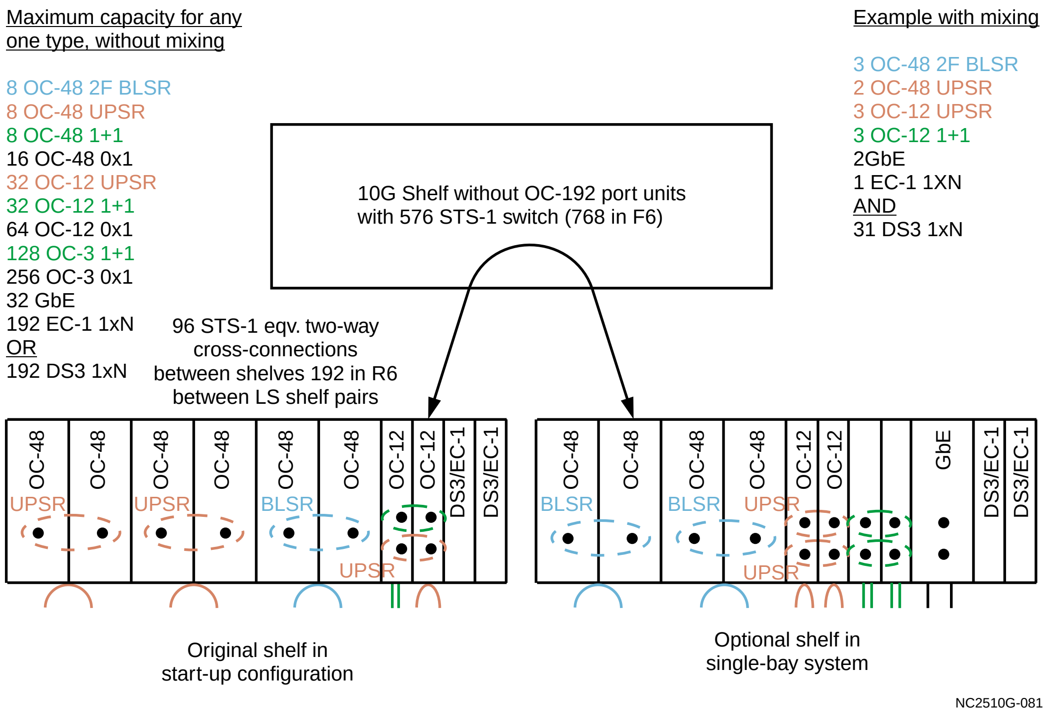
OC-48 and OC-12 rings can be mixed and matched by using the flexible provisioning of port units in the low-speed, tributary shelves. Traffic can be directly connected between any rings without using the add/drop ports and cabling that would be needed to connect rings in separate network elements. Any add/drop ports used for the rings in the low-speed shelves should typically be located in the same shelves as the rings, to avoid unnecessary use of the inter-shelf cross-connection capacity. Rings (or any ports) in different low-speed shelves may also be interconnected, but only to the extent that the inter-shelf connection capacity would not be needed for add/drop of the OC-192 ring since this ring has no other ports in its own shelf. For applications such as these, some planning is recommended to optimize which ports should be placed in which low-speed shelves. (See Figure 6-7, WaveStar TDM 10G (OC-192) (2-Fiber) Power and Flexible Growth for Optical Hubs (page 6-13).)

Figure 6-7 WaveStar TDM 10G (OC-192) (2-Fiber) Power and Flexible Growth for Optical Hubs



If little of the OC-192 ring traffic needs to be added/dropped at this site, or if the system is equipped without any OC-192 ports at all, then most or all of the inter-shelf cross-connection capacity can be freely used for cross-connections between low-speed, tributary shelves. With the 768 STS-1 switch fabric in the high-speed shelf, up to 192 STS-1 equivalent two-way cross-connections can be interconnected between two low-speed shelves (A and C). For two low-speed shelves equipped with OC-48 and OC-12 rings, as well as 1+1 protected optical ports and electrical ports, this cross-connection capacity is sufficient to connect all the working traffic from each shelf to the other. This way, the system can be used as an OC-48/OC-12 Broadband DCS. (See Figure 6-8, Wavestar TDM 10G OC-48/12 Broadband Cross-Connect Application (page 6-14).)

Figure 6-8 Wavestar TDM 10G OC-48/12 Broadband Cross-Connect Application



For a hypothetical application in which all cross-connections can be made between inputs and outputs within the same shelf (meaning, no inter-shelf cross-connections needed), the total cross-connection capacity for a system with 2 low-speed shelves is 1152 STS-1 equivalents. For a system with 4 low-speed shelves, it is 1920 STS-1 equivalents.

Bandwidth sharing between low-speed (tributary) shelf pairs

The intershelf cross-connection capacity between any directly interconnected shelves (meaning, between the high-speed shelf and each one of the low-speed, tributary shelves) supports up to 192 STS-1 equivalent one-way cross-connections in each direction between input and output tributaries that are not in the same shelf. However, this maximum capacity is shared by a pair of low-speed shelves.

More specifically, in the direction from the low-speed shelves to the high-speed shelf, the inter-shelf connection capacity of 192 STS-1 equivalents is shared by two low-speed shelves. This shared capacity is allocated to either shelf (on a first-come first-served basis, as cross-connections are set up and taken down) by 2-to-1 bandwidth concentration with STS-1 granularity. The amount of inter-shelf connection bandwidth allocated in this direction from each of the two low-speed shelves to the high-speed shelf, in terms of STS-1 equivalents, can be any two integers whose sum does not exceed 192. For example, 101 STS-1 equivalents can be added to an OC-192 BLSR (or UPSR) from tributaries in one shelf and 91 STS-1 equivalents from tributaries in the other shelf. Cross-connection commands are denied by the network element when the necessary bandwidth is not available.

In the other direction, from the high-speed to the low-speed shelves, each of the 192 STS-1 equivalent units of capacity can be cross-connected to either or both of these low-speed shelves. (The same signal can go to both shelves without its bandwidth being counted twice.)

The pairing of shelves that share the inter-shelf cross-connection capacity applies only when more than one low-speed shelf is equipped. In a configuration supporting only two low-speed shelves (meaning, with the 576 STS-1 switch fabric), it is obviously these two shelves which are paired. In a configuration supporting up to four low-speed shelves (meaning, with the 768 STS-1 switch fabric), the method of pairing is determined by the physical cable connections from the low-speed shelves to the high-speed shelf's SWITCH/PPROC Ports A, B, C, and D. (The first low-speed shelf, which is always part of the system, uses SWITCH/PPROC Port A.) Low-speed shelves connected to SWITCH/ PPROC Ports A and B are one pair, and shelves connected to C and D are another pair.

Using Low-Speed (Tributary) Shelf Pairs for Various Applications

OC-192 add/drop applications in which the capability of bandwidth sharing between low-speed shelf pairs is typically most beneficial are those using DS3/EC-1 electrical port units, or 1+1 protected OC-3 ports (with 4 ports per port unit). The number of logical tributaries which can be used for cross-connections in a shelf that is completely filled with these port units is only 96 STS-1 equivalents. Therefore, a second shelf can double this capacity while sharing the same 192 STS-1 equivalents of inter-shelf cross-connection capacity. (See Figure 6-5, Adding a Second Low Speed Shelf in a High Speed Shelf Equipped with a 768x768 Switch (page 6-11) and Figure 6-6, Adding Second, Third, and Fourth Low-Speed Shelves (page 6-12).)

On the other hand, bandwidth sharing is not typically as beneficial in OC-192 add/drop applications using unprotected OC-3 ports, 1+1 protected OC-12 ports, or 1+1 protected OC-48 ports. The number of logical tributaries in a shelf that is completely filled with these ports is 192 STS-1 equivalents. Therefore, a second shelf sharing the same 192 STS-1 equivalents of inter-shelf cross-connection capacity would be useful only if some tributaries in each shelf were unused.

In applications using OC-12 or OC-48 ports that are either unprotected or in rings (BLSR or UPSR), the number of logical tributaries in a shelf completely filled with these ports is 384 STS-1 equivalents. A second shelf would be useful only if some tributaries were either unused, or used for through traffic within a ring instead of add/drop traffic, or used for add/drop traffic with the add/drop ports located in the same shelf.

Applications with mixing of the above cases in the same shelves would generally need to be considered individually, but if there is even a small proportion of the applications which do fill a shelf before filling the inter-shelf connection capacity, a second shelf sharing the inter-shelf cross-connection capacity would often be useful.

The intershelf cross-connection capacity between the high-speed shelf and each pair of low-speed shelves can be used for cross-connections between ports in different low-speed shelves, themselves, when this capacity is not needed for connections to/from OC-192 ports in the high-speed shelf. Up to 192 STS-1 equivalent two-way cross-connections can be interconnected between low-speed shelves in different shelf-pairs (A and C); or up to 96 STS-1 equivalent two-way cross connections (or 192 one-way) between low-speed shelves in the same shelf-pair (A and B).

Planning to Upgrade the Switch Fabric

The cross-connection capacity can be upgraded, while the system is in-service, by replacing the 576 STS-1 switch fabric in the high-speed shelf with the 768 STS-1 switch fabric. The 1+1 protected circuit packs of the switch fabric, including the switch units and the switch unit pointer processors, are sequentially replaced while the system remains in-service. None of the existing cabling is moved.

The normal impact on transmission is 2 hits (each less than 50 milliseconds) for each circuit. These hits are expected due to the difference in delay through the different switch units, even though manual protection switching of the switch units is normally hitless.

For a system with only one low-speed shelf before the upgrade (or a system installed initially with the 768 STS-1 switch fabric), the additional 192 STS-1 equivalents of inter-shelf connection capacity provided by the larger switch fabric can be used for connections between the high-speed shelf and a second low-speed shelf. This is useful to terminate all 384 STS-1 equivalents of traffic that can be carried in 2 unprotected (0x1) OC-192 ports, or all of both the working and protection access traffic in an OC-192 2-Fiber BLSR. It is also useful for interconnecting more traffic between different low-speed shelves via the high-speed shelf.

For any system, whether upgraded or installed initially with the 768 STS-1 switch fabric in the high-speed shelf, the additional 192 STS-1 equivalents of inter-shelf connection capacity increases the number of low-speed shelves supported from 2 to 4. The original 192 STS-1 equivalents of inter-shelf connection capacity can be either dedicated to one low-speed shelf or shared by a pair of low-speed shelves; and the additional inter-shelf capacity can also be either dedicated to another low-speed shelf or shared by a second pair. Only the first pair of low-speed shelves can be used to add/drop all traffic from an OC-192 UPSR, but otherwise the transmission capabilities of each low-speed shelf are the same. The pairing of shelves is determined by the cabling to the SWITCH/PPROC Port (A and B; C and D), not by the order in which the shelves are added.

Users planning an in-service upgrade from the 576 switch fabric to the 768 switch fabric are advised to complete the upgrade of the switch fabric, if possible, before adding the second low-speed shelf. This allows the option to connect the second low-speed shelf to SWITCH/PPROC Port C, instead of B. SWITCH/PPROC Port C provides an additional 192 STS-1 equivalents of intershelf cross-connection capacity to/from the high-speed shelf.

It is also possible to add a second low-speed shelf in a system with the 576 STS-1 switch fabric, and to upgrade to the 768 STS-1 switch fabric afterward. But then the second low-speed shelf must be connected to SWITCH/PPROC Port B, and remain there (unless it will be taken out of service). Low-speed shelves connected to SWITCH/PPROC Ports A and B share the existing 192 STS-1 equivalents of intershelf cross-connection capacity to/from the high-speed shelf.

Planning to Add Low-Speed (Tributary) Shelves

Low-speed, tributary shelves can be added on an in-service basis, without any impact on the transmission performance of existing circuits.

When the 576 x 576 STS-1 switch fabric is used in the high-speed shelf, the cabling from the additional (second) low-speed shelf must be connected to the high-speed shelf using SWITCH/PPROC Port B. The existing 192 STS-1 equivalents of intershelf cross-connection capacity to/from the high-speed shelf that has been used for the first low-speed shelf (connected to SWITCH/PPROC Port A) will now be shared between the pair of shelves connected to SWITCH/PPROC Ports A and B. (see Figure 6-3, Configuration with 576x576 Switch in the 10G Shelf (page 6-9))

When the 768 x 768 STS-1 switch fabric is used in the high-speed shelf (whether the system was installed initially or upgraded with the 768 switch), the user can choose whether to connect the cabling of the second low-speed shelf to either SWITCH/PPROC Port B or C (see Figure 6-4, Configuration with the 768x768 Switch in a 10G Shelf (page 6-10), Figure 6-5, Adding a Second Low Speed Shelf in a High Speed Shelf Equipped with a 768x768 Switch (page 6-11), and Figure 6-6, Adding Second, Third, and Fourth Low-Speed Shelves (page 6-12)).

Connect the 2nd low-speed shelf to SWITCH/PPROC Port C when the additional ports in this shelf may need to use the additional 192 STS-1 equivalents of cross-connection capacity from the high-speed shelf. Applications include: add/drop of protection access for OC-192 BLSR; add/drop of two OC-192 0x1 ports; or to interconnect more traffic between different low-speed shelves via the high-speed shelf (e.g., when using the system as an OC-48/12 Broadband DCS without OC-192 ports).

Connect the 2nd low-speed shelf to SWITCH/PPROC Port B when the additional ports may be used for add/drop in an OC-192 UPSR. The main application is: DS3/EC-1 or 1+1 OC-3 (4-port) add/drop ports (only 96 working STS-1 per shelf) for an OC-192 UPSR.

Connect the 3rd low-speed shelf to SWITCH/PPROC Port C if the 2nd low-speed shelf is already connected to SWITCH/PPROC Port B. Otherwise, connect it to SWITCH/PPROC Port B.

Connect the 4th LS shelf to SWITCH/PPROC Port D. The existing 192 STS-1 equivalents of intershelf cross-connection capacity to/from the high-speed shelf that has been used for the low-speed shelf connected to SWITCH/PPROC Port C will now be shared between the pair of shelves connected to SWITCH/PPROC Ports C and D.

Port unit capacities

The table below lists the transmission capacity required for each port unit.

Table 6-1 Interface Capacity per Port Unit

Port Unit	STS-1 Equivalents
DS3EC1/8	8
OC3/STM1/1.3LR4	12
OC3/STM1/1.3SR4	12
OC3/STM1/1.3IR/SR8	24
OC12/STM4/1.3LR2	24
OC12/STM4/1.3SR2	24
GE1/SX2	≤ 42
GE1/LX2	≤ 42
OC48/STM16/1.3VSR1	48
OC48/STM16/1.3LR1	48
OC48/STM16/1.5LR1	48
OC48/STM16/DWDM01 through OC48/STM16/DWDM16 (16 colors)	48
OC48/STM16/WDM 9190 through OC48/STM16/WDM9585 (80 colors)	48
OC48/STM16/POU9590 through POU9210 (16 colors)	48
OC192/STM64/1.5SR1	192
OC192/STM64/1.5VLR1	192
OC192/STM64/1.5LR1	192
OC192/STM64/1.5IR1	192
OC192/STM64/WDM9580 through WDM9190 (40 colors)	192
OC192/STM64/POU9590 through POU9210 (32 colors)	192

The same number of STS-1 equivalents apply for all NEBS Level 3 compliant versions of the circuit packs listed in the table above.

Growth considerations

If you anticipate connecting to the WaveStar 10G shelf in the future, you should equip the WaveStar TDM 2.5G/10G (2-Fiber) low-speed shelf so that the total of all traffic routed in each direction to and from the 10G shelf does not exceed 192 STS-1 equivalents. For example, 101 STS-1 equivalents can be added to the OC-192 2-fiber BLSR (or UPSR) from tributaries in one 2.5G shelf and 91 STS-1 equivalents from tributaries in the other 2.5G shelf. Similarly, the same numbers (or different numbers totaling 192) can be dropped from the OC-192 2-fiber BLSR (in the high-speed shelf) to tributaries in each low-speed (2.5G) shelf. Refer to Table 6-1, "STS-1 Equivalents per Port Unit" (page 6-19).

□

Port Location Rules

Purpose

This section provides rules and recommendations for locating port unit circuit packs in a shelf and for locating the optical ports in a port protection group.

Table 6-1, Interface Capacity per Port Unit (page 6-19) shows the interface capacity used by each type of port unit: the port rate times the number of ports per port unit. (The name of each port unit generally indicates both the rate and the number of ports.) For example, an OC-3 port unit with 4 ports provides 12 STS-1 equivalents of interface capacity. The interface capacity of each shelf, 384 STS-1 equivalents, is achieved when the shelf is equipped with port units that use the maximum capacity supported in all port unit slots. Each OC-48 or GE1 port unit occupies two of the sixteen port unit slots in a low-speed shelf.

Protection considerations

The 1xN equipment protection for DS3/EC-1 port units is provided by a separate circuit pack (plus a separate switch pack) which is not counted as part of the interface capacity.

Protection of optical ports is provided by provisioning a port protection group (either 1+1 or BLSR) for individual ports on different port units. All optical ports are counted as part of the interface capacity. For example, if you equip a low-speed shelf with OC-12 port units in all of the 16 port unit slots, then all of the 384 STS-1 equivalents of interface capacity are used (12 STS-1 equivalents per port, times 2 ports, times 16 slots.) If all of these OC-12 ports are unprotected (0x1), then they can carry 384 STS-1 equivalents of traffic. (Not all of this traffic can be connected to ports in other shelves, since the intershelf cross-connection capacity is 192 STS-1 equivalents, but it can all be connected within the same shelf.) On the other hand, if you provision 1+1 port protection for all of these OC-12 ports, then there are 192 STS-1 equivalents of working tributaries for which you can provision cross-connections to ports in any shelf.

On optical port units that have multiple ports, the protection for each port is provisioned and operated independently. Facility failures (incoming signal failures) are protected by the affected port protection group. Equipment failures (port unit failures) are protected by all affected port protection groups.

DS3/EC-1 port units

Because the electrical DS3/EC-1 ports require DS3 connector panels, it is practical to fill one side of the low-speed shelf with DS3/EC-1 port units before placing any in the other side. One connector panel is used for slots 1-6, and an additional connector panel is needed for slots 11-16.

Slots 7-10 cannot be used for electrical port units because they are not wired to a connector panel. To maximize the potential for DS3/EC1 port unit utilization, you may want to place your initial set of optical port units in slots 7-10.

1xN Equipment Protection for DS3/EC-1 Port Units

When you use 1xN equipment protection for DS3/EC-1 port units, slot 16 must either contain a DS3/EC1 port unit or else be empty.

OC-48 and GE1 Port Units

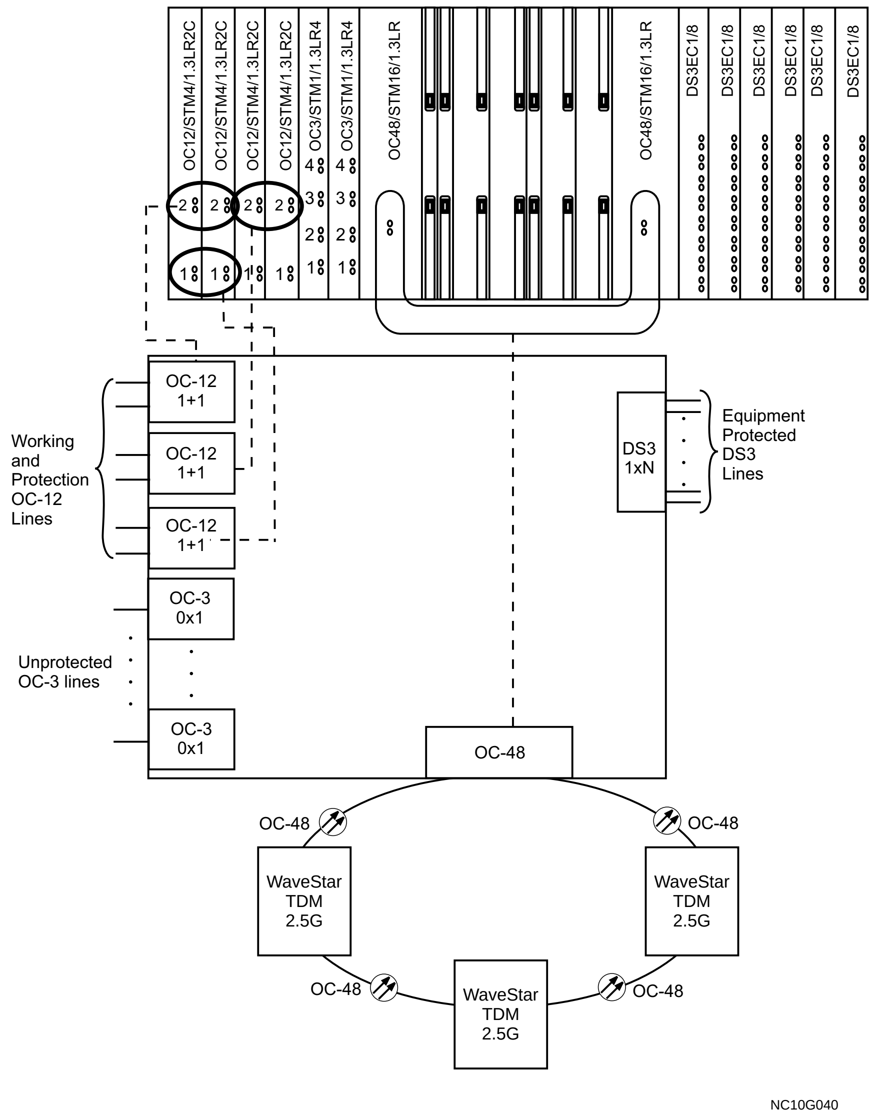
OC48/STM16 port units and Gigabit Ethernet port units each occupy two port unit slots of a low-speed shelf. These slots must be an odd (left) and even (right) pair.

Port Protection Groups for Optical Ports

To utilize your equipment fully, you can mix the types of protection for ports on the same port unit. You can also create a protection group by matching any ports within the same shelf. (They must be on different port units, but you can use any ports in any slots except as noted.) However, for ease of maintenance and for support by certain operations systems, users are advised to locate the working port in an odd-numbered slot and the protection port in the adjacent higher-numbered port unit slot.

Figure 6-9, Port Protection Groups (page 6-23) shows an example of port protection groups in a low-speed, tributary shelf. The shelf is provisioned with: 2 OC-48 ports in a BLSR port protection group; 4 OC-12 port units with 3 1+1 port protection groups and 2 unprotected ports; 2 OC-3 port units with 8 unprotected ports; and 6 DS3/EC-1 port units with 48 ports and 1xN equipment protection.

Figure 6-9 Port Protection Groups



OC-48 2-Fiber BLSR

For any OC-48 2-fiber BLSR, the two ports must be in slot numbers located either as adjacent pairs (2 and 4, 6 and 8, 10 and 12, or 14 and 16) or symmetric pairs (8 and 10, 6 and 12, 4 and 14, or 2 and 16).

Synchronization Protection

To protect synchronization in line-timed applications, the OC-3 or OC-12 port units that are connected to the lines being referenced must occupy even-numbered slots in the low-speed, tributary shelf.

□

Synchronization

Overview

The WaveStar TDM 2.5G/10G (2-Fiber) system synchronizes add, drop, and through signals by using one timing source for all transmission. The timing source is normally locked to an external reference signal, such as one from the building integrated timing source (BITS) or an internal line reference signal derived from an incoming OC-192 line on a 10G application or an incoming OC-48 line on a 2.5G application.

Two TMG/STRAT3 circuit packs are located in each WaveStar TDM 2.5G/10G (2-Fiber) shelf. The master timing circuit packs are on the first tributary shelf (also called the MAIN 2.5G/10G I/O shelf) and control the timing for the entire system. These timing signals are used for clock, frame, and multiframe synchronization. The output clock signals of the slave timing generators in the other shelves, if any exist, are locked to the active master.

Synchronization modes

The WaveStar TDM 2.5G/10G (2-Fiber) system operates in any of three synchronization modes:

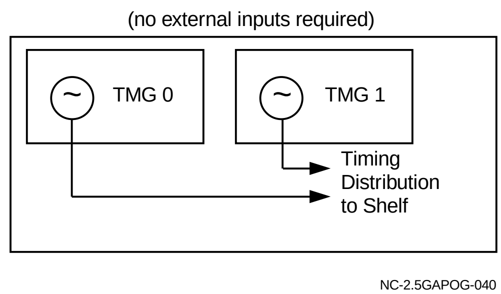
- Free-running
- Locked
- Holdover State

Free running mode

In the free-running mode, the Stratum 3 clock in the active master TMG/STRAT3 circuit pack in the first tributary (MAIN) shelf is not locked to a reference signal. However, the standby master TMG/STRAT3 circuit pack remains locked to the active timing generator, and the subordinate TMG/STRAT3 circuit packs in the other shelves, if any exist, are locked to the active master. The free-running mode is provisionable.

The figure below illustrates the free-running mode, in which the WaveStar TDM 2.5G/10G (2-Fiber) system is synchronized by timing signals generated in the TMG/STRAT3 circuit pack.

Figure 6-10 Free-Running Mode



Locked timing

In the locked timing mode, each of two master TMG/STRAT3 timing generator circuit packs in the first tributary (MAIN) shelf can be provisioned to receive DS1 reference signals from the BITS or from another network element and also can be provisioned to receive 8-kHz synchronization OC-192 line reference signals from the OC-192/STM64 port units in 10G applications and OC-48, OC-12, or OC-3 line reference signals in 2.5G applications. Reference signals enter the system through connectors on the rear of the tributary (MAIN) shelf. The active master TMG/STRAT3 timing generator circuit pack selects each reference signal in turn and derive the timing signals used to synchronize the transmission port units. The standby master is locked to the active master.

The reference signals typically are based on a Stratum 1 clock. The active master TMG/STRAT3 timing generator circuit pack synchronizes its internal Stratum 3 clock to the reference signal. The standby master TMG/STRAT3 circuit pack as well as any TMG/STRAT3 circuit packs in the other shelves synchronize their internal Stratum 3 clocks to the active master TMG/STRAT3 circuit pack. Then all the timing generator circuit packs distribute clock signals to all the other circuit packs in the system. The locked mode is provisionable.

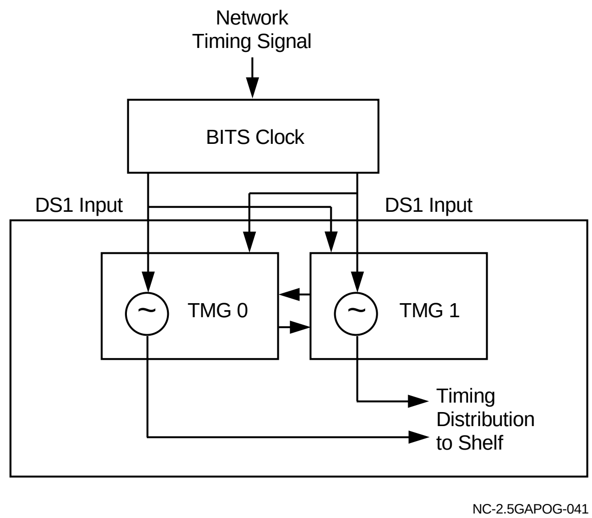
The 8-kHz synchronization reference signal is continuously monitored for error-free operation. If the reference signal becomes corrupted or unavailable, the TMG/STRAT3 circuit packs can select an alternate reference signal. If all provisioned DS1 synchronization reference signals are corrupted or unavailable, the active master TMG/STRAT3 circuit pack enters the holdover mode.

Reference signals

DS1 reference signals

The figure below shows the locked timing mode with DS1 reference signals, which enter the WaveStar TDM 2.5G/10G (2-Fiber) system through connectors on the rear of the shelf.

Figure 6-11 Locked Timing Mode with DS1 Reference Signals

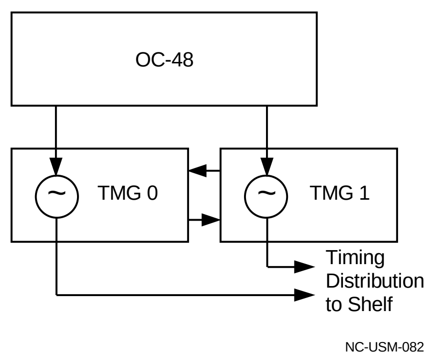


Optical line reference signals

The figure below shows the locked timing mode with OC-48 reference signals. Similarly, OC-192, OC-12, and OC-3 reference signals can be used. The TMG/STRAT3 timing generator circuit packs accept a 8-kHz synchronization reference signal from one OC-3, OC-12, OC-48, or OC-192 port unit and derive the timing signals used to synchronize the transmission port units.

The integrity of the 8-kHz synchronization reference signal is continuously monitored for error-free operation using synchronization status messages (SSMs). If the reference signal becomes corrupted or unavailable, the TMG/STRAT3 circuit packs select an alternate reference signal. If both DS1 synchronization reference signals are corrupted or unavailable, the TMG/STRAT3 circuit packs enter the holdover mode.

Figure 6-12 Locked Timing Mode with OC-48 Reference Signals



Holdover State

The active timing generator enters a holdover state if all reference signals fail. In a holdover state, the active timing generator keeps its internal Stratum 3 clock at the point at which it was synchronized to the last known good reference signal. The standby timing generator remains locked to the active timing generator. When the reference signal is restored, the active timing generator resumes the normal locked timing mode.

A Holdover state is automatically available when the shelf is in the locked timing mode. The TMG/STRAT3 timing generator circuit packs monitor the quality of the reference signals they receive. If one of the reference signals fails, the WaveStar TDM 2.5G/10G (2-Fiber) system uses another. If all reference signals fail, the WaveStar TDM 2.5G/10G (2-Fiber) system enters a holdover state. The holdover state is not provisionable; however, holdover can be selected by the clock mode protection switch command.

TMG/STRAT 3 circuit packs

WaveStar TDM 2.5G/10G (2-Fiber) is timed from duplex TMG/STRAT3 circuit packs. These are synchronized to the office BITS clock by means of duplicated DS1 inputs. The TMG/STRAT3 packs on the first low-speed (10G/2.5G I/O MAIN) shelf distribute timing to all circuit packs in that shelf and to all TMG packs in the other shelves, which in turn distribute timing to all circuit packs in their shelves.

OC-192, OC-48, OC-12, OC-3 line timing

The WaveStar TDM 2.5G/10G (2-Fiber) accepts timing references from up to eight OC-3, OC-12, OC-48, or OC-192 lines in 10G application (up to six OC-3, OC-12, or OC-48 in the 2.5G application). The WaveStar TDM 2.5G/10G (2-Fiber) monitors SSMs (Synchronization Status Messages) that notify the system if a reference signal is acceptable or unacceptable. If a reference signal is unacceptable the system reconfigures itself to use the next assigned reference source. If no other sources are available, the system goes into a holdover state. A signal is deemed unacceptable when the incoming SSM is below Stratum 3. The WaveStar TDM 2.5G/10G (2-Fiber) system supports the reconfiguration of up to two DS1/E1 inputs and two line references. The system is restricted to two line references.

Timing provisioning

The WaveStar TDM 2.5G/10G (2-Fiber) system synchronization mode can be provisioned to locked or free-running. Additionally, either timing generator circuit pack in each shelf can be switched to be the active timing generator. However, when the WaveStar TDM 2.5G/10G (2-Fiber) system is provisioned for the locked mode, the holdover state is entered automatically upon loss of reference signals. The holdover state is not provisionable.

Incoming/Outgoing SSMs

Standard synchronization status messages (SSMs) are transported on the S1 Byte. The transmission of SSMs on the S1 Byte is required on all OC-192, OC-48, OC-12, and OC-3 lines. Incoming SSMs are used to monitor the acceptability of timing references. If an SSM reads below Stratum 3, the line reference is deemed to be unacceptable. SSMs are determined according to SONET (ANSI, Tellcordia) standards.

Automatic reconfiguration of synchronization mode

The WaveStar TDM 2.5G/10G (2-Fiber) supports the automatic reconfiguration of the synchronization mode based on incoming SSMs. When an incoming SSM is deemed to be unacceptable, the system reconfigures itself to use the next assigned reference signal source. If no other sources are available, or of a high enough quality, the system goes into a holdover state. The WaveStar TDM 2.5G/10G (2-Fiber) supports the automatic reconfiguration of up to two DS1/E1 inputs and two line references.

Synchronization protection switching

The TMG/STRAT3 circuit packs and reference signals are protected against failures. Synchronization protection switching includes the following:

- TMG/STRAT3 circuit pack switching
- Synchronization reference switching
- Synchronization mode switching

Timing protection

The WaveStar TDM 2.5G/10G, Release 6 system uses nonrevertive 1+1 protection switching to protect its timing circuit packs. Initially the master TMG/STRAT3 timing generator circuit pack in the lower (0) position of the TMG slot on the tributary (MAIN) shelf is the active circuit pack, and the master TMG/STRAT3 circuit pack in the upper (1) position of the TMG slot on the tributary (MAIN) shelf is the standby circuit pack. If the active circuit pack fails and causes a switch to the standby circuit pack, the standby circuit pack becomes the active circuit pack. It remains the active circuit pack, even when the failed circuit pack is replaced. The replacement circuit pack becomes the standby circuit pack. There is no automatic revertive switching.

If the active timing generator fails while in a holdover state, the standby timing generator becomes the active timing generator and switches to holdover until the reference signal is restored to acceptable quality.

Control and status

The behavior of the master TMG/STRAT3 circuit packs is controlled by switching them among several defined states. As commands are issued or as failures occur and are cleared, the timing system switches from one state to another. The status of the timing is retrievable for user observation. You can issue commands to obtain status reports or to change the synchronization state manually.

□

Floor Plan Layout

Overview

This section illustrates the space needed to mount a WaveStar TDM 2.5G/10G (2-Fiber) system.

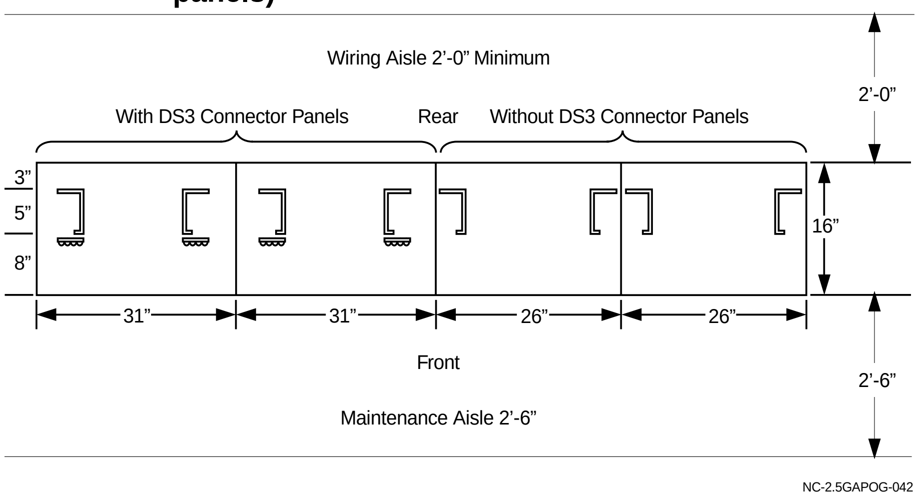
System footprint

WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia's Network Equipment Building System (NEBS) and AT&T's Network Equipment Design System (NEDS) standard bay areas, floor loading, and support requirements.

Front and rear access

The following figure illustrates the space required for front and rear access to the system. Front access is required for maintenance and operations activities. Rear access is required for shelf additions and for upgrades that require cable rearrangements.

Figure 6-13 Front and Rear Access (externally mounted DS3 panels)



NOTE

The figure above shows front and rear access with externally mounted DS3 panels. Just as the externally mounted panels require additional space between bays, rear mounted panels require more space at the rear of the shelf. Internally mounted DS3 panels do not affect front or rear access, but they limit a standard 7-foot bay to 2 tributary (low-speed) shelves.

References For more detailed information about the layout, refer to the floor plan data sheet (ED8C789-10).

Equipment Interconnection

Introduction

This section describes equipment interconnection in WaveStar TDM 2.5G/10G (2-Fiber).

Interbay cabling

The cabling between bays for WaveStar TDM 2.5G/10G (2-Fiber) is through a raised floor or overhead racking.

DS3EC1/8 cabling

DS3 cables can be ordered in two lengths. The 734D cables are 450 feet. The 735D cables are 250 feet.

Optical connectors

The port units provide optical connections through faceplate-mounted connectors.

LBOs

If required, WaveStar TDM 2.5G/10G (2-Fiber) provides optical attenuation using lightguide build-outs (LBOs) on the optical port units.

LC™-type optical attenuators are required for these port units:

- LEY23AE (OC3/STM1/1.3IR-SR8)
- LEY101AE - LEY180AE (OC48/STM16/WDM)
- LEY201AE - LEY240AE (OC192/STM64/POU)

All other port units are capable of operating with the following three connector types:

- ST-type
- FC-type
- SC-type

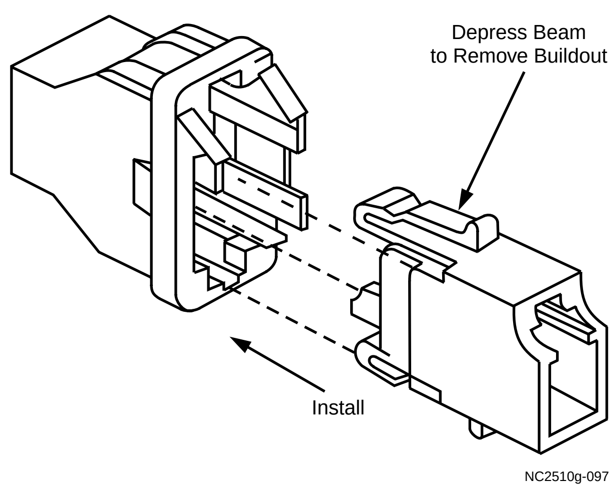
Important! The LEY23A, LEY101AE-180AE, and LEY 201AE-240AE port units are factory equipped with 0 dB LC-type connectors. You must use a special fiber jumper if you want to convert the LEY101 - LEY180AE port units to the other connector types.

All optical other interfaces are factory equipped with 0 dB SC-type connectors. The optical attenuation and connector type for other port units can be changed by replacing the LBO.

LC-Type LBO

The figure below illustrates the universal build-out block with one of the two kinds of LC-type LBOs.

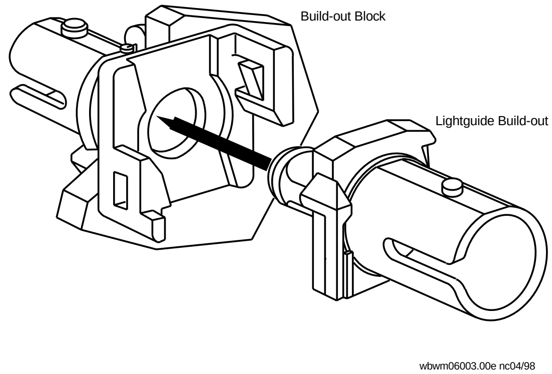
Figure 6-14 LC-Type LBO



ST-Type LBO

The figure below illustrates the universal build-out block with an ST-type LBO.

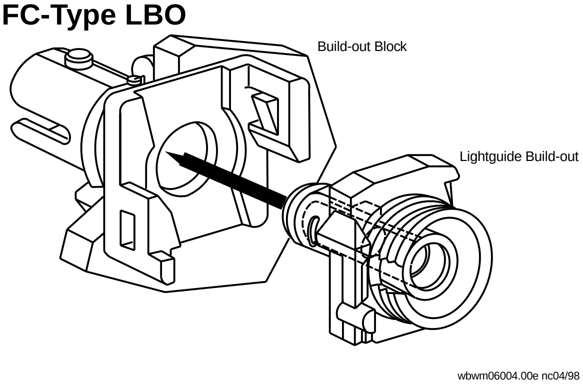
Figure 6-15 ST-Type LBO



FC-Type LBO

The figure below illustrates the universal build-out block with an FC-type LBO.

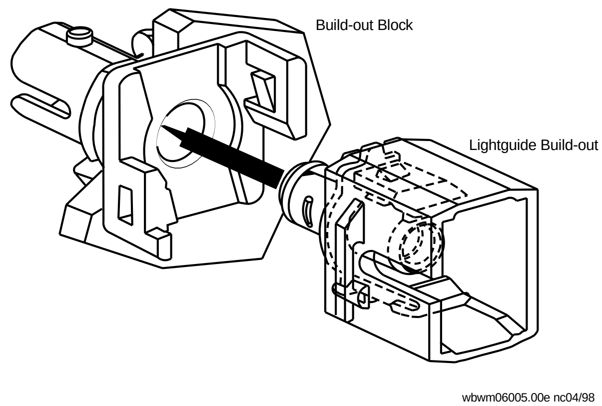
Figure 6-16 FC-Type LBO



SC-Type LBO

The figure below illustrates the universal build-out block with an SC-type LBO.

Figure 6-17 SC-Type LBO



Line build-out

Because the DS3EC1/8 port units on the low-speed shelves are designed to accept the entire DSX signal range, the high-speed (10G) SHELF does not require external line build-outs.

Electrical connectors

The DS3EC1/8 port units are cabled to the DS3 connector panels by means of backplane-mounted shielded ribbon cables. Coaxial cable connections to the DS3 connector panels use BNC-type connectors. All coaxial cables must be terminated in 75-ohm terminations.

More information

For more detailed information about equipment interconnection, refer to the *Installer's Cabling Plan for 2.5G Shelves* (ED8C789-15) and *Installer's Cabling Plan for 10G Bays* (ED8C789-16).

For ordering information on LBOs and various optical jumpers, see Chapter 7.

□

7 Ordering

Overview

Purpose

The WaveStar TDM 2.5G/10G (2-Fiber) has been carefully engineered. All equipment can be ordered individually. Common unit circuit packs can also be ordered via kits. The tables in this chapter list the drawings necessary to engineer and then order your application.

For detailed information about assembling a bay, see the engineering drawing ED8C789-10, “Typical Bay Arrangements.”

If you need the *Installation Manual and System Turn-up Services (IMSTS)* this document can be ordered. Please refer to the section entitled “Documentation Ordering Information” in the *About This Information Product* chapter of this book.

Important!

Tables 7-1 through 7-21 provide information necessary in ordering the WaveStar TDM 2.5G/10G (2-Fiber) system. These tables allow you to order the system with any combination of equipment, including the low-speed tributary shelves.

For your convenience, Tables 7-22 through 7-29 have been included to allow you to order the 2.5G application more easily. Use these tables if you are interested in the 2.5G application alone.

□

Ordering WaveStar TDM 2.5G/10G (2-Fiber) Equipment

10G bay The table below lists the bay options for WaveStar TDM 2.5G/10G (2-Fiber) NEBS Level 3.

Table 7-1 WaveStar TDM 2.5G/10G (2-Fiber) Bay Options

Drawing/Comcode	Group Code	Description
ED8C789-35	G1E	Bay with one OC-192 HS Shelf and one 2.5G (Tributary) Shelf
ED8C789-35	G2E	Bay with one OC-192 HS Shelf and two 2.5G (Tributary) Shelves
ED8C789-35	G3E	Growth Bay with one 2.5G (Tributary) Shelf
ED8C789-35	G4E	Growth Bay with two 2.5G (Tributary) Shelves
ED8C789-35	G5E	Bay with one 2.5G (Tributary) Shelf and space for addition of 10G Shelf
ED8C789-35	G6E	Bay with two 2.5G (Tributary) Shelves and space for addition of one 10G Shelf
ED8C789-35	G8E	Bay equipped with one 2.5G (Tributary) Shelf, two Internal (front access) DS3 Connector Panels, and one 10G Shelf
ED8C789-35	G9E	Bay equipped with one 2.5G (Tributary) Shelf mounted at the bottom of a bay.

Related Documents

The following table lists the documents included in the WaveStar TDM 2.5G/10G (2-Fiber) documentation set.

Table 7-2 The WaveStar TDM 2.5G/10G (2-Fiber) Documentation Set

Document Number	Title	Comcode
365-371-527	*WaveStar TDM 2.5G/10G (2-Fiber) Applications and Planning Guide (APG)*	109205054
365-371-528	WaveStar TDM 2.5G/10G (2-Fiber) User Operation Guide (UOG)	109205062
365-371-529	*WaveStar TDM 2.5G/10G (2-Fiber) Alarm Messages and Trouble Clearing Guide (AMTCG)*	109205070
365-371-206	*WaveStar TDM 2.5G/10G (2-Fiber) Installation Manual and System Turnup Services (IMSTS)*	109151738
365-371-530	*WaveStar TDM 2.5G/10G (2-Fiber) Operations Systems Engineering Guide (OSEG)*	109205088
365-371-202	*WaveStar TDM 2.5G/10G (2-Fiber) Software Ordering Guide (SOG)*	
*Use Comcode for Ordering	*WaveStar TDM 2.5G/10G, Release 6.0.5/6.1.5 Software Release Description (SRD)*	109166835
*Use Comcode for Ordering	WaveStar TDM 2.5G/10G, Release 6*.0.5/6.1.5* Documentation CD-ROM (contains the User Operations Guide and the Alarm Messages and Trouble Clearing Guide)	109205096

Notes

***** These items are shipped initially with the software. If you need to order these items anytime after initial shipment of the product and software, contact Software Manufacturing.

WaveStar TDM 2.5G/10G (2-Fiber) Equipment Components

This section provides ordering information for the components of the 10G shelf.

High-speed shelf and common units

The table below lists the high-speed shelf and common units.

Table 7-3 High-Speed Shelf, Cables, and Common Units

Drawing/Comcode	Group/Apparatus Code/Table	Description	Notes
ED8C789-31	G1E	10G OC-192 High Speed Shelf (NEBS Level 3)	
ED8C789-32	Table AB	Individual Blank faceplates listed by slot (NEBS Level 3)	Go to the tables and pick only the faceplates you need
ED8C789-32	G101E	Common Circuit Packs (NEBS Level 3)	
ED8C789-28	G2	Cables for 10G Shelf	
108765645	LEY97AE	OC192/STM64/1.5IRS1 (NEBS Level 3)	replaces LEY67AE
108734849	LEY69AE	OC192/STM64/1.5IR1 (NEBS Level 3)	
SEN3AE: 1008940149 plus LEY69AE:108734849 (OC192/STM64 comcodes are in Table 7-10, *NEBS Level 3 Port Units*.)	SEN3AE (OBA) and LEY69/LEY69AE (or one of various other OC192/STM64 port units. See Table 7-11 for details)	OC192/STM64/1.5LR1 (long reach)	See Table 7-11, *NEBS Level 3 SEN3AE (OBA) and SEN4AE (OBPA) Port Units* for details.
SEN4AE: 108929936 plus LEY228AE: 108733908 or LEY295AE: 108734559	SEN4AE (OBPA) plus LEY228/LEY228AE or LEY295/LEY295AE	OC192/STM64/1.5VLR1 (very-long reach)	See Table 7-11, *NEBS Level 3 SEN3AE (OBA) and SEN4AE (OBPA) Port Units*.
T-8C500-31		Installer Interconnect	
ED8C789-16		Installer's Cabling Plan for WaveStar TDM 10G Bays	
ED8C789-10/ 848825329		DCM holder tray, miscellaneously mounted	Holds four DCMs

NEBS Level 3 common packs for high-speed shelf equipped with the 576x576 STS-1 switch fabric

The table below lists the high-speed shelf common circuit packs when the shelf is equipped with the 576x576 STS-1 switch fabric.The entire set of circuit packs listed in the table below can be ordered as a group using the following codes: ED8C789-32, G101E.

Table 7-4 NEBS Level 3 Common Packs for High-Speed (10G OC-192) Shelf with the 576x576 STS-1 Switch Fabric

Comcodes	Apparatus Codes	Quantity	Description
108730102	LEY1AE	1	ADJCTL/DCCEI
108734617	LEY4AE	2	SWITCH/STS576
108730227	LEY10BE	1	CTL/SYS50DM
108734609	LEY3AE	4	PPROC/STS192
108865882	LLY2BE	2	TMG/STRAT3

NEBS Level 3 packs required to upgrade a high-speed shelf to the 768x768 STS-1 switch fabric

Order the circuit packs listed in the following table if you want to upgrade a high-speed shelf from the 576x576 STS-1 switch fabric to the 768x768 STS-1 switch fabric.

Table 7-5 NEBS Level 3 Common Packs Required to Upgrade a High-Speed Shelf to the 768x768 STS-1 STS-1 Switch Fabric

Comcodes	Apparatus Codes	Quantity	Description
108734898	LEY73AE	2	SWITCH/STS768
108927609	LEY47AE	2	PPROC/STS384

NEBS Level 3 Common packs for high-speed shelf equipped with the 768x768 STS-1 switch fabric

The table below lists the high-speed shelf common circuit packs when the shelf is equipped with the 768x768 STS-1 switch fabric.The entire set of circuit packs listed in the table below can be ordered as a group using the following codes: ED8C789-32, G102E.

Table 7-6 NEBS Level 3 Common Packs for High-Speed (10G OC-192) Shelf with the 768x768 STS-1 Switch Fabric

Comcodes	Apparatus Codes	Quantity	Description
108730102	LEY1AE	1	ADJCTL/DCCEI
108734898	LEY73AE	2	SWITCH/STS768
108730227	LEY10BE	1	CTL/SYS50DM
108927609	LEY47AE	2	PPROC/STS384
108734609	LEY3AE	2	PPROC/STS192
108865882	LLY2BE	2	TMG/STRAT3

Software and software-documentation kits

The table below lists the document needed to order software and kits containing software, the Software Release Description, and the UOG and AMTCG CD-ROM for the WaveStar TDM 2.5G/10G (2-Fiber).

Table 7-7 WaveStar TDM 2.5G/10G (2-Fiber) Basic Software

Document Number	**Description**
365-371-202	*WaveStar TDM 2.5G/10G (2-Fiber) Software Ordering Guide*

Tributary (low-speed) shelf, cables, and common units

Table 7-8 Tributary (Low-Speed) Shelf, Cables, and Common Units

Drawing/ Comcode	Group or Tables	Description	Notes
ED8C789-30	G2E	2.5G I/O Shelf (NEBS Level 3)	
ED9C280-31	G160	BNC Panel for DS3 Service and Cables	Max. 2 per 2.5G Shelf
ED8C789-32	G2E or G3E	Circuit Pack Kit for 2.5G Shelf (NEBS Level 3)	See Table 7-9, *Tributary (Low-Speed) Shelf Common Packs NEBS Level 3*
ED8C789-32	Table AA and AB	Individual Blank Faceplates listed by slot (NEBS Level 3)	Go to the tables and pick only the faceplates you need
ED8C789-33	G1	Baffle	
ED8C789-33	G10	Closing Details for Bay with DS3 Kit	
ED8C789-33	G20	Closing Details for Bay without DS3 Kit	
ED8C789-33	G30	Closing Details for Bay with one external DS3 connector panel on the right side of the bay	
ED8C789-33	G40	Closing Details for Bay with 2 DS3 panels mounted in the rear of the shelf	
ED8C789-33	G41	Conversion Kit to change from a 16 inch to a 19- inch deep bay	
ED8C789-34	G1	Upper DS3 Panel (for in-bay DS3 connectors)	
ED8C789-34	G2	Lower DS3 Panel (for in-bay DS3 connectors)	
ED8C789-34	G10	Left, rear-mounted DS3 Panel	
ED8C789-34	G11	Right, rear-mounted DS3 Panel	
ED8C789-34	G12	Rear-mounted bracket (cover). Must be ordered when G10, but not G11 is installed.	

Drawing/ Comcode	**Group or Tables**	**Description**	**Notes**
ED8C789-15		Installer's Cabling Plan for WaveStar TDM 2.5G Shelves	
ED8C789-28	G1 (for MAIN shelf) G2 (for 2nd shelf)	Cables for WaveStar TDM 2.5G Shelf	
ED8C789-28	Table B	-48VA and -48VB Power Cables	
ED8C900-20	Tables 6A and 6B	DS3 Cables	
ED8C789-10/ 848825329		DCM holder tray, miscellaneously mounted	Holds four DCMs

NEBS Level 3 Common packs for tributary (low-speed) shelf

The table below lists the tributary (low-speed) shelf common circuit packs (ED8C789-32; G2E-- G3E omits the Memory Card) when the shelf is equipped with the 576x576 STS-1 switch fabric.

Table 7-9 Tributary (Low-Speed) Shelf Common Packs NEBS Level 3

Comcode	Apparatus Code	Quantity	Description
108730227	LEY10BE	1	CTL/SYS50DM
108730102	LEY1AE	1	ADJCTL/DCCEI
108734617	LEY4AE	2	SWITCH/STS576
108865882	LLY2BE	2	TMG/STRAT3
109126409		1 per shelf	Memory Card

NEBS Level 3 Port Units

Table 7-10 NEBS Level 3 Port Units

Comcodes	Apparatus Codes	Description
108733163	LEY182AE	OC48/STM16/1.3VSR1
108735184	LEY7AE	OC48/STM16/1.3LR1
108735192	LEY8AE	OC48/STM16/1.5LR1
108730441	LEY13AE	OC12/STM4/1.3LR2
108730557	LEY14AE	OC12/STM4/1.3SR2
108730813	LEY15AE	OC3/STM1/1.3LR4
108730821	LEY16AE	OC3/STM1/1.3SR4
108825118	LEY23AE	OC3/STM4/1.3IR-SR8
108733445	LEY17AE	DS3EC1/8
108733452	LEY18AE	SWITCH/DS3EC1
108765645	LEY97AE	OC192/STM64/1.5IRS1 (intermediate range, new version of LEY67AE)
108734849	LEY69AE	OC192/STM64/1.5IR1 (intermediate range)
108940149 plus 108734849	SEN3AE (OBA) plus LEY69/LEY69AE (or one of various other OC192/STM64 port units. See Table 7-11, *NEBS Level 3 SEN3AE (OBA) and SEN4AE (OBPA) Port Units* for details.)	OC192/STM64/1.5LR1) (long reach)
108929936 plus 108734559 (or 108733908)	SEN4AE (OBPA) plus LEY228/LEY228AE (or LEY295/LEY295AE)	OC192/STM64/1.5VLR1 (very long reach) (See Table 7-11, *NEBS Level 3 SEN3AE (OBA) and SEN4AE (OBPA) Port Units*)
108925637	LEY309AE	GE1/SX2 port (Gigabit Ethernet Interface, 2 port, short reach)
109149120	LEY310AE	GE1/LX2 (Gigabit Ethernet Interface, 2 port, long reach)

Optical Booster Amplifier (OBA) and Optical Booster/Pre-amplifier (OBPA)

The table below lists the comcodes and apparatus codes for the SEN3AE (OBA) and SEN4AE (OBPA) port units which can be installed in slots 2 and/or 15 of the high-speed shelf for optical amplification of the OC-192 signal.

Table 7-11 NEBS Level 3 SEN3AE (OBA) and SEN4AE (OBPA) Port Units

Comcodes	Apparatus Codes	Description
108940149	SEN3AE	OBA is typically paired with LEY69AE, but it can be paired with one of various other OC192/STM64 port units, except those specified in the Note below
108929936	SEN4AE	OBPA must be paired with LEY228AE or LEY295AE

Note:

The SEN3AE (OBA) should not be paired with LEY67/LEY67AE. The SEN3AE can be paired with LEY97/LEY97AE, but it will not meet standards dispersion requirements for an OC192 long-reach interface.

The automatic laser shutdown (ALS) feature can only be used if the paired OC192/STM64 port unit is an LEY69AE, LEY97AE, or LEY228AE.

NEBS Level 3 passive DWDM compatible optics, OC-48 port units (OC48/STM16/POU), for use in applications With Passive Optics Units (DWDM Filter Units)

The table below lists the NEBS Level 3 compliant OC48/STM16/POU passive port units (16 wavelengths).

Table 7-12 NEBS Level 3 Passive DWDM Compatible Optics, OC-48 Port Units (OC48/STM16/POU), 16 Wavelengths

Comcodes	Apparatus Codes	Description
108734955	LEY80AE	OC48/STM16/POU9590
108734963	LEY81AE	OC48/STM16/POU9570
108734971	LEY82AE	OC48/STM16/POU9550
108734989	LEY83AE	OC48/STM16/POU9530
108735002	LEY84AE	OC48/STM16/POU9490
108735010	LEY85AE	OC48/STM16/POU9470
108735028	LEY86AE	OC48/STM16/POU9450
108735036	LEY87AE	OC48/STM16/POU9430
108735044	LEY88AE	OC48/STM16/POU9370
108735051	LEY89AE	OC48/STM16/POU9350
108735069	LEY90AE	OC48/STM16/POU9330
108735077	LEY91AE	OC48/STM16/POU9310
108735085	LEY92AE	OC48/STM16/POU9270
108735093	LEY93AE	OC48/STM16/POU9250
108735101	LEY94AE	OC48/STM16/POU9230
108735119	LEY95AE	OC48/STM16/POU9210

NEBS Level 3 passive port units, OC-192 port units (OC192/STM64/POU), for use in applications with Passive Optics Units (DWDM Filter Units)

The table below lists the NEBS Level 3 compliant OC192/STM64/POU passive port units (32 wavelengths).

Table 7-13 NEBS Level 3 Passive DWDM Compatible Optics, OC-192 Port Units (OC192/STM64/POU), 32 Wavelengths

Comcodes	Apparatus Codes	Description
108734443	LEY284AE	OC192/STM64/POU9590
108734450	LEY285AE	OC192/STM64/POU9570
108734468	LEY286AE	OC192/STM64/POU9550
108734476	LEY287AE	OC192/STM64/POU9530
108734484	LEY288AE	OC192/STM64/POU9490
108734492	LEY289AE	OC192/STM64/POU9470
108734500	LEY290AE	OC192/STM64/POU9450
108734518	LEY291AE	OC192/STM64/POU9430
108734526	LEY292AE	OC192/STM64/POU9370
108734534	LEY293AE	OC192/STM64/POU9350
108734542	LEY294AE	OC192/STM64/POU9330
108734559	LEY295AE	OC192/STM64/POU9310
108734567	LEY296AE	OC192/STM64/POU9270
108734575	LEY297AE	OC192/STM64/POU9250
108734583	LEY298AE	OC192/STM64/POU9230
108734591	LEY299AE	OC192/STM64/POU9210
109010686	LEY384AE	OC192/STM64/POU9580
109010710	LEY385AE	OC192/STM64/POU9560
109010728	LEY386AE	OC192/STM64/POU9540
109010736	LEY387AE	OC192/STM64/POU9520
109010744	LEY388AE	OC192/STM64/POU9480
109010751	LEY389AE	OC192/STM64/POU9460
109010769	LEY390AE	OC192/STM64/POU9440
109010777	LEY391AE	OC192/STM64/POU9420

Comcodes	Apparatus Codes	Description
109010785	LEY392AE	OC192/STM64/POU9380
109010793	LEY393AE	OC192/STM64/POU9360
109010801	LEY394AE	OC192/STM64/POU9340
109010819	LEY395AE	OC192/STM64/POU9320
109010827	LEY396AE	OC192/STM64/POU9280
109010835	LEY397AE	OC192/STM64/POU9260
109010850	LEY398AE	OC192/STM64/POU9240
109010876	LEY399AE	OC192/STM64/POU9220

Passive Optics Units, (DWDM Filter Units)

The table below outlines the ordering information for the Passive Optics Units (POUs), the 16CH-MUX, the 16CH-DMUX, the 16CH-MUXINT, and the 16CH-DMUXINT.

Name	Descriptive Name	Comcode
16CH-MUX	16 Channel MUX	109164665
16CH-DMUX	16 Channel DMUX	109164673
16CH-MUXINT	16 Channel MUX + Interleaver	109164129
16CH-DMUXINT	16 Channel DMUX + Interleaver	109164111

NEBS Level 3 OC48/STM16/DWDM port units

The table below lists the NEBS Level 3 compliant OC48/STM16/DWDM port units (16 wavelengths), for use in applications with the Metropolis^{TM} EON.

Table 7-14 NEBS Level 3 OC48/STM16/DWDM Port Units (16 Wavelengths)

Comcodes	Apparatus Codes	Description
108734666	LEY50AE	OC48/STM16/DWDM01
108734674	LEY51AE	OC48/STM16/DWDM02
108734682	LEY52AE	OC48/STM16/DWDM03
108734690	LEY53AE	OC48/STM16/DWDM04
108734708	LEY54AE	OC48/STM16/DWDM05
108734716	LEY55AE	OC48/STM16/DWDM06
108734724	LEY56AE	OC48/STM16/DWDM07
108734732	LEY57AE	OC48/STM16/DWDM08
108734740	LEY58AE	OC48/STM16/DWDM09
108734757	LEY59AE	OC48/STM16/DWDM10
108734765	LEY60AE	OC48/STM16/DWDM11
108734773	LEY61AE	OC48/STM16/DWDM12
108734781	LEY62AE	OC48/STM16/DWDM13
108734799	LEY63AE	OC48/STM16/DWDM14
108734807	LEY64AE	OC48/STM16/DWDM15
108734815	LEY65AE	OC48/STM16/DWDM16

Nebs Level 3 OC48/STM16/WDM port units

The table below lists the NEBS Level 3 compliant OC48/STM16/WDM9585 through OC/48/STM16/WDM9190, 80 wavelengths, for use in applications with WaveStar OLS 1.6T.

Table 7-15 NEBS Level 3 OC48/STM16/WDM Units (80 Wavelengths)

Comcodes	Apparatus Codes	Description
108730110	LEY101AE	OC48/STM16/WDM9585
108730128	LEY102AE	OC48/STM16/WDM9580
108730136	LEY103AE	OC48/STM16/WDM9575
108730144	LEY104AE	OC48/STM16/WDM9570
108730151	LEY105AE	OC48/STM16/WDM9565
108730169	LEY106AE	OC48/STM16/WDM9560
108730185	LEY107AE	OC48/STM16/WDM9555
108730193	LEY108AE	OC48/STM16/WDM9550
108730219	LEY109AE	OC48/STM16/WDM9545
108730235	LEY110AE	OC48/STM16/WDM9540
108730243	LEY111AE	OC48/STM16/WDM9535
108730250	LEY112AE	OC48/STM16/WDM9530
108730268	LEY113AE	OC48/STM16/WDM9525
108730284	LEY114AE	OC48/STM16/WDM9520
108730292	LEY115AE	OC48/STM16/WDM9515
108730300	LEY116AE	OC48/STM16/WDM9510
108730318	LEY117AE	OC48/STM16/WDM9505
108730326	LEY118AE	OC48/STM16/WDM9500
108730334	LEY119AE	OC48/STM16/WDM9495
108730342	LEY120AE	OC48/STM16/WDM9490
108730359	LEY121AE	OC48/STM16/WDM9485
108730367	LEY122AE	OC48/STM16/WDM9480
108730375	LEY123AE	OC48/STM16/WDM9475
108730383	LEY124AE	OC48/STM16/WDM9470
108730391	LEY125AE	OC48/STM16/WDM9465

Comcodes	Apparatus Codes	Description
108730409	LEY126AE	OC48/STM16/WDM9460
108730417	LEY127AE	OC48/STM16/WDM9455
108730425	LEY128AE	OC48/STM16/WDM9450
108730433	LEY129AE	OC48/STM16/WDM9445
108730458	LEY130AE	OC48/STM16/WDM9440
108730466	LEY131AE	OC48/STM16/WDM9435
108730474	LEY132AE	OC48/STM16/WDM9430
108730482	LEY133AE	OC48/STM16/WDM9425
108730490	LEY134AE	OC48/STM16/WDM9420
108730508	LEY135AE	OC48/STM16/WDM9415
108730516	LEY136AE	OC48/STM16/WDM9410
108730524	LEY137AE	OC48/STM16/WDM9405
108730532	LEY138AE	OC48/STM16/WDM9400
108730540	LEY139AE	OC48/STM16/WDM9395
108730565	LEY140AE	OC48/STM16/WDM9390
108730573	LEY141AE	OC48/STM16/WDM9385
108730581	LEY142AE	OC48/STM16/WDM9380
108730599	LEY143AE	OC48/STM16/WDM9375
108730607	LEY144AE	OC48/STM16/WDM9370
108730615	LEY145AE	OC48/STM16/WDM9365
108730623	LEY146AE	OC48/STM16/WDM9360
108730631	LEY147AE	OC48/STM16/WDM9355
108730649	LEY148AE	OC48/STM16/WDM9350
108730656	LEY149AE	OC48/STM16/WDM9345
108730664	LEY150AE	OC48/STM16/WDM9340
108730672	LEY151AE	OC48/STM16/WDM9335
108730680	LEY152AE	OC48/STM16/WDM9330
108730698	LEY153AE	OC48/STM16/WDM9325
108730706	LEY154AE	OC48/STM16/WDM9320
108730714	LEY155AE	OC48/STM16/WDM9315
108730722	LEY156AE	OC48/STM16/WDM9310

Comcodes	Apparatus Codes	Description
108730730	LEY157AE	OC48/STM16/WDM9305
108730748	LEY158AE	OC48/STM16/WDM9300
108730755	LEY159AE	OC48/STM16/WDM9295
108730763	LEY160AE	OC48/STM16/WDM9290
108730771	LEY161AE	OC48/STM16/WDM9285
108730789	LEY162AE	OC48/STM16/WDM9280
108730797	LEY163AE	OC48/STM16/WDM9275
108730805	LEY164AE	OC48/STM16/WDM9270
108732991	LEY165AE	OC48/STM16/WDM9265
108733007	LEY166AE	OC48/STM16/WDM9260
108733015	LEY167AE	OC48/STM16/WDM9255
108733023	LEY168AE	OC48/STM16/WDM9250
108733031	LEY169AE	OC48/STM16/WDM9245
108733049	LEY170AE	OC48/STM16/WDM9240
108733056	LEY171AE	OC48/STM16/WDM9235
108733064	LEY172AE	OC48/STM16/WDM9230
108733072	LEY173AE	OC48/STM16/WDM9225
108733080	LEY174AE	OC48/STM16/WDM9220
108733098	LEY175AE	OC48/STM16/WDM9215
108733106	LEY176AE	OC48/STM16/WDM9210
108733122	LEY177AE	OC48/STM16/WDM9205
108733130	LEY178AE	OC48/STM16/WDM9200
108733148	LEY179AE	OC48/STM16/WDM9195
108733155	LEY180AE	OC48/STM16/WDM9190

NEBS Level 3 OC192/STM64/WDM port units for use in applications with WaveStar OLS 1.6T

The following table lists the comcodes for the OC192/STM64/WDM port units that are available for use in applications with WaveStar OLS 1.6T.

Table 7-16 NEBS Level 3 OC192/STM64/WDM Port Units (40 Wavelengths)

Comcodes	Apparatus Codes	Description
108733221	LEY201AE	OC192/STM64/WDM9580
108733254	LEY202AE	OC192/STM64/WDM9570
108733262	LEY203AE	OC192/STM64/WDM9560
108733270	LEY204AE	OC192/STM64/WDM9550
108733288	LEY205AE	OC192/STM64/WDM9540
108733304	LEY206AE	OC192/STM64/WDM9530
108733312	LEY207AE	OC192/STM64/WDM9520
108733320	LEY208AE	OC192/STM64/WDM9510
108733338	LEY209AE	OC192/STM64/WDM9500
108733346	LEY210AE	OC192/STM64/WDM9490
108733361	LEY211AE	OC192/STM64/WDM9480
108733379	LEY212AE	OC192/STM64/WDM9470
108733387	LEY213AE	OC192/STM64/WDM9460
108733395	LEY214AE	OC192/STM64/WDM9450
108733411	LEY215AE	OC192/STM64/WDM9440
108733429	LEY216AE	OC192/STM64/WDM9430
108733775	LEY217AE	OC192/STM64/WDM9420
108733783	LEY218AE	OC192/STM64/WDM9410
108733791	LEY219AE	OC192/STM64/WDM9400
108733825	LEY220AE	OC192/STM64/WDM9390
108733833	LEY221AE	OC192/STM64/WDM9380
108733841	LEY222AE	OC192/STM64/WDM9370
108733858	LEY223AE	OC192/STM64/WDM9360
108733866	LEY224AE	OC192/STM64/WDM9350
108733874	LEY225AE	OC192/STM64/WDM9340

Comcodes	Apparatus Codes	Description
108733882	LEY226AE	OC192/STM64/WDM9330
108733890	LEY227AE	OC192/STM64/WDM9320
108733908	LEY228AE	OC192/STM64/WDM9310
108733916	LEY229AE	OC192/STM64/WDM9300
108733924	LEY230AE	OC192/STM64/WDM9290
108733932	LEY231AE	OC192/STM64/WDM9280
108733940	LEY232AE	OC192/STM64/WDM9270
108733957	LEY233AE	OC192/STM64/WDM9260
108733973	LEY234AE	OC192/STM64/WDM9250
108733981	LEY235AE	OC192/STM64/WDM9240
108733999	LEY236AE	OC192/STM64/WDM9230
108734005	LEY237AE	OC192/STM64/WDM9220
108734013	LEY238AE	OC192/STM64/WDM9210
108734021	LEY239AE	OC192/STM64/WDM9200
108734039	LEY240AE	OC192/STM64/WDM9190

Lightguide jumpers

WaveStar TDM 2.5G/10G (2-Fiber) uses Lucent Technologies *AllWave ADVANTAGE*™ Lightguide Jumpers, part of Lucent Technologies AllWave ADVANTAGE Optical Connectivity Solution (OCS). Table 7-17, *Recommended Lightguide Jumpers* lists the lightguide jumpers recommended for customer use. These jumpers contain a boot angled at 40 degrees, allowing the jumpers to dress appropriately into the fiber tray. The angled boot eliminates projection outside the front of the shelf assembly.

Table 7-17 Recommended Lightguide Jumpers

Cable Type	Length (in feet)	Comcode
MS1A40LC-A40LC-2	2	108918269
MS1A40LC-A40LC-4	4	108918707
MS1A40LC-A40LC-E/W	Customer Specified	108918715
MS1A40LC-LC-2	2	108918830
MS1A40LC-LC-4	4	108918855
MS1A40LC-LC-6	6	108918863
MS1A40LC-LC-8	8	108918871
MS1A40LC-LC-10	10	108918889
MS1A40LC-LC-15	15	108918897
MS1A40LC-LC-20	20	108918913
MS1A40LC-LC-25	25	108918921
MS1A40LC-LC-30	30	108918939
MS1A40LC-LC-35	35	108918947
MS1A40LC-LC-40	40	108918962
MS1A40LC-LC-50	50	108918970
MS1A40LC-LC-E/W	Customer Designated	108918988
MS1A40LC-SC-2	2	108919002
MS1A40LC-SC-4	4	108919010
MS1A40LC-SC-6	6	108919028
MS1A40LC-SC-8	8	108919036
MS1A40LC-SC-10	10	108919044
MS1A40LC-SC-15	15	108919051
MS1A40LC-SC-20	20	108919069
MS1A40LC-SC-25	25	108919077
MS1A40LC-SC-30	30	108919085
MS1A40LC-SC-35	35	108919093
MS1A40LC-SC-40	40	108919101
MS1A40LC-SC-50	50	108919119
MS1A40LC-SC-E/W	Customer Designated	108919996

Cable Type	Length (in feet)	Comcode
MS1A40LC-FC-2	2	108918723
MS1A40LC-FC-4	4	108918731
MS1A40LC-FC-6	6	108918749
MS1A40LC-FC-8	8	108918756
MS1A40LC-FC-10	10	108918764
MS1A40LC-FC-15	15	108918772
MS1A40LC-FC-20	20	108918780
MS1A40LC-FC-25	25	108918798
MS1A40LC-FC-30	30	108918806
MS1A40LC-FC-35	35	108918814
MS1A40LC-FC-40	40	108918822
MS1A40LC-FC-50	50	108918848
MS1A40LC-FC-E/W	Customer Designated	108918905
MS1A40LC-EP-2	2	108919713
MS1A40LC-EP-4	4	108919721
MS1A40LC-EP-6	6	108919739
MS1A40LC-EP-8	8	108919747
MS1A40LC-EP-10	10	108919754
MS1A40LC-EP-15	15	108919770
MS1A40LC-EP-20	20	108919788
MS1A40LC-EP-25	25	108919796
MS1A40LC-EP-30	30	108919804
MS1A40LC-EP-35	35	108919812
MS1A40LC-EP-40	40	108919820
MS1A40LC-EP-50	50	108919838
MS1A40LC-EP-E/W	Customer Designated	108919846

Optical Attenuators [Lightguide build-outs (LBOs) – SM-SM]

The tables in this section list the single-mode to single-mode (SM-SM) optical attenuators that are available for the port units.

These port units use *LC*™-type optical attenuators are required for these port units:

- LEY23AE (OC3/STM1/1.3IR-SR8)
- LEY101AE - LEY180AE (OC48/STM16/WDM)
- LEY201AE - LEY240AE (OC192/STM64/WDM)

ST, SC, and FC single-mode to single-mode optical attenuators can be used for the remaining WaveStar TDM 2.5G/10G (2-Fiber) port units.

Important! The LEY23AE, LEY101AE-180AE, and LEY201AE-240AE port units are factory equipped with 0 dB LC-type connectors. You must use a special fiber jumper if you want to convert the LEY101 - LEY180AE port units to the other connector types. For information about converting the LEY101AE - LEY180AE port units to use other connector types, contact your Lucent Technologies Account Executive.

All optical other interfaces are factory equipped with 0 dB SC-type connectors. The optical attenuation and connector type for other port units can be changed by replacing the LBO.

LC-Type LBOs (for LEY23AE, LEY101AE - LEY180AE, and LEY201AE - 240AE)

The LEY23AE, LEY101AE - LEY180AE, LEY201AE - LEY240AE use Lucent Technologies state-of-the-art *AllWave ADVANTAGE*™ Fiber Optic Attenuators [lightguide build-outs (LBOs). 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*™ 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, DWDM networks, metropolitan or regional networks, applications supported by conventional single-mode optical fiber, and multiservice network protocols.

The next table lists the LC-type optical attenuators [lightguide build-outs (LBOs)] for the LEY23AE OC3 port unit.

Table 7-18 LC LBOs and Accessories for the LEY23AE OC3 Port Unit

Product Code	Comcode	Description		See note
		Power Level	Color	
		LC Build-Out Attenuators:	Yellow	1
ABLCS-05.0	108279381	5 dB		
ABLCS-10.0	108279431	10 dB		
ABLCS-15.0	108279480	15 dB		
ABLCS-20.0	108279530	20 dB		
	108622929	Allwave ADVANTAGE Fiber Optic Identification Kit		2

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 LEY23AE pack, the specified attenuation may not be achieved if a single-mode-multi-mode (SM-MM) 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 Technologies AllWave Fiber paths. An instruction sheet is included with recommendations on how to install and use the labels.

The next table lists the LC-type LBOs that are used with the LEY101AE - LEY180AE and LEY201AE - LEY240AE port units.

Table 7-19 LC LBOs and Accessories for LEY101AE - LEY180AE and LEY201AE - 240AE Port Units

Product Code	Comcode	Description		See note
		Power Level	Color	
		LC Build-Out Attenuators:	Yellow	1
AALCS-05.0	108288473	5 dB		
AALCS-10.0	108288457	10 dB		
AALCS-15.0	108358169	15 dB		
AALCS-20.0	108358219	20 dB		
	108622929	Allwave ADVANTAGE Fiber Optic Identification Kit		2

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 LEY101AE - LEY180AE and LEY201AE - LEY240AE port units, 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 Technologies AllWave Fiber paths. An instruction sheet is included with recommendations on how to install and use the labels.

ST®-, SC-, and FC-Type LBOs for Port Units that Do Not Require LC-Type LBOs

The next table lists the ST-, SC-, and FC-type LBOs and LBO kits that are available for the transmit connectors and receive connectors for the OC192/STM64 and OC48/STM16 port units that do not require LC-type LBOs. These single-mode to single-mode LBO kits are also are also for the transmit connectors on the OC12/STM4 and OC3/STM1 port units that do not require LC-type LBOs. Each kit includes a 0dB, 5dB, 10dB, 15 dB, and a 20 dB attenuator.

Table 7-20 Single-Mode to Single-Mode ST, FC, and SC LBOs

Product Code	Comcode	Description		Notes
		Power Level	Color	
ST-Type LBOs (SM-SM)				
NA	108 812 231	ST-Type SM-SM LBO Kit		
A3070	106 795 354	0 dB	White or Blue	
ASTS5	108 053 091	5 dB	Yellow or Green	
ASTS10	108 053 190	10 dB		
ASTS15	108 053 240	15 dB		
ASTS20	108 053 273	20 dB		
FC-Type LBOs (SM-SM)				
NA	108 812 249	FC-Type SM-SM LBO Kit		
A3080	106 795 404	0 dB	White or Blue	
AFCS5	108 107 095	5 dB	Yellow or Green	
AFCS10	108 107 194	10 dB		
AFCS15	108 107 244	15 dB		
AFCS20	108 107 277	20 dB		
SC-Type LBOs (SM-SM)				
NA	108 812 256	SC-Type SM-SM LBO Kit		
A3060	106 708 951	0 dB	White or Blue	
ASCS5	108 314 501	5 dB	Yellow or Green	
ASCS10	108 314 600	10 dB		
ASCS15	108 440 538	15 dB		
ASCS20	108 440 561	20 dB		

Optical Attenuators (LBOs), *continued*

Single-Mode to Multi-Mode (SM-MM)

The table below lists the SM-MM LBO kits as well as the individual SM-MM LBOs for the receive connectors on the OC12/STM4 and OC3/STM1 port units. Each kit includes a 0dB, 5dB, 10dB, 15dB, and a 20dB attenuator.

Table 7-21 Single-Mode to Multi-Mode LBOs

Product Code	Comcode	Description		Notes
		Power Level	Color	
ST-Type LBOs (SM-MM)				
NA	108 812 207	ST-Type SM-MM LBO Kit		
A3070	106 795 354	0 dB	White or Blue	
ASTM5	108 052 960	5 dB	Beige or Gray	
ASTM10	108 052 994	10 dB		
ASTM15	108 053 018	15 dB		
ASTM20	108 053 042	20 dB		
FC-Type LBOs (SM-MM)				
NA	108 812 215	FC-Type SM-MM LBO Kit		
A3080	106 795 404	0 dB	White or Blue	
AFCM5	108 107 285	5 dB	Beige or Gray	
AFCM10	108 107 301	10 dB		
AFCM15	108 107 327	15 dB		
AFCM20	108 107 343	20 dB		
SC-Type LBOs (SM-MM)				
NA	108 812 223	SC-Type SM-MM LBO Kit		
A3060	106 708 951	0 dB	White or Blue	
ASCM5	108 440 579	5 dB	Beige or Gray	
ASCM10	108 440 595	10 dB		
ASCM15	108 440 611	15 dB		
ASCM20	108 440 637	20 dB		

Closing Details

The table below provides information about ordering Closing Details for the WaveStar TDM 2.5G/10G (2-Fiber) system.

Table 7-22 WaveStar TDM 2.5G/10G (2-Fiber) Closing Details

Drawing/Comcode	Group Code	Description
ED8C789-33	G1	Baffle
ED8C789-33	G10	Bay with DS3 kit (closing details)
ED8C789-33	G20	Bay without DS3 kit (closing details)
ED8C789-33	G30	Bay with DS3 wing on the right only (closing details)
ED8C789-33	G40	Closing Details for Bay with 2 DS3 panels mounted in the rear of the shelf
ED8C789-33	G41	Conversion Kit to change from a 16 inch to a 19 inch deep bay
ED8C800-50	G10	Bay framework (closing details)
ED8C802-55	G3	End Guard Assembly (closing details)
ED8C806-50	G28	2 1/2 inch Base Filler Plate

□

Ordering WaveStar TDM 2.5G/10G (2-Fiber) 2.5G Application

Introduction

The WaveStar TDM 2.5G/10G (2-Fiber) has been carefully engineered. All equipment can be ordered individually. Common unit circuit packs may also be ordered via kits. The tables in this section list the drawings necessary to engineer and order your application.

Because the tributary (low-speed) shelf of the WaveStar TDM 2.5G/10G (2-Fiber) can be used by itself as a 2.5G application, the following tables have been included to facilitate the ordering of the 2.5G application by itself.

For detailed information about assembling a bay, see the engineering drawing ED8C789-10, “Typical Bay Arrangements.”

2.5G bay

The table below lists the bay options for the WaveStar TDM 2.5G/10G (2-Fiber) 2.5G Application.

Table 7-23 WaveStar TDM 2.5G/10G (2-Fiber) Bay Options

Drawing/Comcode	Group Code	Description
ED8C789-35	G3E	Bay with one 2.5G Shelf
ED8C789-35	G4E	Bay with two 2.5G Shelves
ED8C789-35	G5E	Bay with one 2.5G Shelf and space for addition of 10G Shelf
ED8C789-35	G6E	Bay with two 2.5G Shelves and space for addition of 10G Shelf
ED8C789-35	G7E	Bay with three 2.5G Shelves
ED8C789-35	G8E	Bay equipped with one 2.5G Shelf, two Internal (front access) DS3 Connector Panels, and one 10G Shelf
ED8C789-35	G9E	Bay equipped with one 2.5G Shelf mounted at the bottom of a bay.

Software for 2.5G shelf

The table below lists the document needed to order software and kits containing software, the Software Release Description, and the UOG and AMTCG CD-ROM for the WaveStar TDM 2.5G/10G (2-Fiber).

Table 7-24 WaveStar TDM 2.5G/10G (2-Fiber) Basic Software

Document Number	Description
365-371-202	*WaveStar TDM 2.5G/10G (2-Fiber) Software Ordering Guide*

2.5G shelf, cables, and common units

This section provides ordering information for the components of the 2.5G shelf

Table 7-25 2.5G Shelf, Cables, and Common Units

Drawing	Group or Tables	Description	Notes
ED8C789-30	G2E	2.5G Shelf (NEBS Level 3)	
ED8C789-32	G2E, G3E	Circuit Pack Kit for 2.5G Shelf (NEBS Level 3)	
ED8C789-32	Table AA	Individual Blank Faceplates listed by slot (NEBS Level 3)	Go to the tables and pick only the faceplates you need
ED8C789-33	G1	Baffle	
ED8C789-33	G10	Bay with DS3 Kit (closing details)	
ED8C789-33	G20	Bay without DS3 Kit (closing details)	
ED8C789-34	G1	Upper DS3 Panel (for in-bay DS3 connectors)	
ED8C789-34	G2	Lower DS3 Panel (for in-bay DS3 connectors)	
ED8C789-34	G10	Left, rear mounted DS3 Panel	
ED8C789-34	G11	Right, rear mounted DS3 Panel	
ED8C789-34	G12	Rear mounted bracket (cover). Must be ordered when G10, but not G11 is installed.	
ED8C789-15		Installer’s Cabling Drawing	
ED8C789-28	G1 (for MAIN shelf) G2 (for 2nd shelf)	Cables for 2.5G Shelf	
ED8C789-28	Table B	-48VA and -48VB Power Cables	
ED8C900-20	Tables 6A and 6B	DS3 Cables	
ED9C280-31	G160	BNC Panel for DS3 Service and Cables	Max. 2 per 2.5G Shelf
T-8C500-31		Installer Interconnect	
ED8C789-10/ 848825329		DCM holder tray, miscellaneously mounted	Holds four DCMs

Common packs for 2.5G Shelf

(ED8C789-32; G2E - G3E). G3E omits the Memory Card)

Table 7-26 Circuit Pack Kit for 2.5G Shelf

Comcode	Apparatus Code	Quantity	Description
108730227	LEY10BE	1	CTL/SYS50DM
108730102	LEY1AE	1	ADJCTL/DCCEI
108734617	LEY4AE	2	SWITCH/STS576
108865882	LLY2BE	2	TMG/STRAT3
109126409		1 per shelf	Memory Card

NEBS Level 3 Port units

The table below lists the comcodes for the NEBS Level 3 compliant port units.

Table 7-27 NEBS Level 3 Port Units

Comcodes	Apparatus Codes	Description
108733163	LEY182AE	OC48/STM16/1.3VSR1
108735184	LEY7AE	OC48/STM16/1.3LR1
108735192	LEY8AE	OC48/STM16/1.5LR1
108730441	LEY13AE	OC12/STM4/1.3LR2
108730557	LEY14AE	OC12/STM4/1.3SR2
108730813	LEY15AE	OC3/STM1/1.3LR4
108825118	LEY23AE	OC3/STM4/1.3IR-SR8
108730821	LEY16AE	OC3/STM1/1.3SR4
108733445	LEY17AE	DS3EC1/8
108733452	LEY18AE	SWITCH/DS3EC1
108925637	LEY309AE	GE1/SX2 port (Gigabit Ethernet Interface, 2 port, short reach)
109149120	LEY310AE	GE1/LX2 (Gigabit Ethernet Interface, 2 port, long reach

NEBS Level 3 OC48/STM16 passive port units

The table below lists the NEBS Level 3 compliant OC48/STM16/POU passive optics port units (16 wavelengths)

Table 7-28 NEBS Level 3 OC48/STM16 Passive POU Port Units (16 Wavelengths)

Comcodes	Apparatus Codes	Description
108734955	LEY80AE	OC48/STM16/POU9590
108734963	LEY81AE	OC48/STM16/POU9570
108734971	LEY82AE	OC48/STM16/POU9550
108734989	LEY83AE	OC48/STM16/POU9530
108735002	LEY84AE	OC48/STM16/POU9490
108735010	LEY85AE	OC48/STM16/POU9470
108735028	LEY86AE	OC48/STM16/POU9450
108735036	LEY87AE	OC48/STM16/POU9430
108735044	LEY88AE	OC48/STM16/POU9370
108735051	LEY89AE	OC48/STM16/POU9350
108735069	LEY90AE	OC48/STM16/POU9330
108735077	LEY91AE	OC48/STM16/POU9310
108735085	LEY92AE	OC48/STM16/POU9270
108735093	LEY93AE	OC48/STM16/POU9250
108735101	LEY94AE	OC48/STM16/POU9230
108735119	LEY95AE	OC48/STM16/POU9210

NEBS Level 3 OC48/STM16/DWDM port units

The table below lists the NEBS Level 3 compliant OC48/STM16/DWDM port units (16 wavelengths), for use in applications with the Metropolis EON.

Table 7-29 NEBS Level 3 OC48/STM16/DWDM Port Units (16 Wavelengths)

Comcodes	Apparatus Codes	Description
108734666	LEY50AE	OC48/STM16/DWDM01
108734674	LEY51AE	OC48/STM16/DWDM02
108734682	LEY52AE	OC48/STM16/DWDM03
108734690	LEY53AE	OC48/STM16/DWDM04
108734708	LEY54AE	OC48/STM16/DWDM05
108734716	LEY55AE	OC48/STM16/DWDM06
108734724	LEY56AE	OC48/STM16/DWDM07
108734732	LEY57AE	OC48/STM16/DWDM08
108734740	LEY58AE	OC48/STM16/DWDM09
108734757	LEY59AE	OC48/STM16/DWDM10
108734765	LEY60AE	OC48/STM16/DWDM11
108734773	LEY61AE	OC48/STM16/DWDM12
108734781	LEY62AE	OC48/STM16/DWDM13
108734799	LEY63AE	OC48/STM16/DWDM14
108734807	LEY64AE	OC48/STM16/DWDM15
108734815	LEY65AE	OC48/STM16/DWDM16

OC48/STM16/WDM port units

For ordering information concerning the OC48/STM16/WDM 9585AE-9190AE [for use in applications with WaveStar OLS 1.6T] port units, refer to Table 7-15, *NEBS Level 3 OC48/STM16/WDM Units (80 Wavelengths)*

Optical attenuators [lightguide build-outs (LBOs)]

For ordering information concerning optical attenuators, common lightguide build-outs (LBOs), refer to Table 7-18, *LC LBOs and Accessories for the LEY23AE OC3 Port Unit*, Table 7-20, *Single-Mode to Single-Mode ST, FC, and SC LBOs*, and Table 7-21, *Single-Mode to Multi-Mode LBOs*.

Closing Details

The table below provides information about ordering Closing Details for the WaveStar TDM 2.5G/10G (2-Fiber) system.

Table 7-30 WaveStar TDM 2.5G/10G (2-Fiber) Closing Details

Drawing/Comcode	Group Code	Description
ED8C789-33	G1	Baffle
ED8C789-33	G10	Bay with DS3 kit (closing details)
ED8C789-33	G20	Bay without DS3 kit (closing details)
ED8C789-33	G30	Bay with DS3 wing on the right only (closing details)
ED8C789-33	G40	Closing Details for Bay with 2 DS3 panels mounted in the rear of the shelf
ED8C789-33	G41	Conversion Kit to change from a 16 inch to a 19 inch deep bay
ED8C800-50	G10	Bay framework (closing details)
ED8C802-55	G3	End Guard Assembly (closing details)
ED8C806-50	G28	2 1/2 inch Base Filler Plate

Sparing Information for a WaveStar TDM 2.5G/10G (2-Fiber) System

Overview

This section provides circuit pack sparing information for WaveStar TDM 2.5G/10G (2-Fiber).

> **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.

Equipment

The table below lists the comcodes for equipment spares.

Table 7-31 Equipment Spares

Comcode	Description
847783859	Panel Assembly
408395051	Fan Unit
408280287	Fan Filter (Box of 25)
407862598	Power Filter

Circuit packs

Spare NEBS Level 3 Circuit Packs for high speed shelves equipped with the 576x576 STS-1 switch fabric

The table below lists the NEBS Level 3 compliant circuit packs that are available in WaveStar TDM 2.5G/10G (2-Fiber) for the high-speed shelf equipped with the 576x576 STS-1 switch fabric. The table below should only be used to order spare circuit packs.

Table 7-32 Spare NEBS Level 3 Circuit Packs for High Speed Shelves Equipped with the 576x576 STS-1 Switch Fabric

Comcodes	Apparatus Codes	Description	2.5G System	10G System
108730102	LEY1AE	ADJCTL/DCCEI	X	X
108734617	LEY4AE	SWITCH/STS576	X	X
108730227	LEY10BE	CTL/SYS50DM	X	X
108734609	LEY3AE	PPROC/STS192		X
108865882	LLY2BE	TMG/STRAT3	X	X

Spare NEBS Level 3 Circuit Packs for the high speed shelf equipped with the 768x768 STS-1 Switch Fabric

The table below lists the NEBS Level 3 compliant circuit packs that are available in WaveStar TDM 2.5G/10G (2-Fiber) for the high-speed shelf equipped with the 768x768 STS-1 switch fabric. The table below should only be used to order spare circuit packs.

Table 7-33 Spare NEBS Level 3 Circuit Packs for the High Speed Shelf Equipped with the 768x768 STS-1 Switch Fabric

Comcodes	Apparatus Codes	Description	10G System
108730102	LEY1AE	ADJCTL/DCCEI	X
108734609	LEY3AE	PPROC/STS192	X
108734898	LEY73AE	SWITCH/STS768	X
108730227	LEY10BE	CTL/SYS50DM	X
108734609	LEY47AE	PPROC/STS384	X
108865882	LLY2BE	TMG/STRAT3	X

Failure Rates

Circuit pack failure rates

The table below provides the steady-state circuit pack failure rates, specified as Failures in Time (FIT), for WaveStar TDM 2.5G/10G (2-Fiber).

Table 7-34 Circuit Pack Failure Rates

Circuit Pack	Failure Rate (FIT)	2.5G System	10G System
PPROC/STS192 (LEY3AE)	4800		X
PPROC/STS384 (LEY47AE)	3300		X
ADJCTL/DCCEI (LEY1AE)	7100	X	X
SWITCH/STS576 (LEY4AE)	4200	X	X
SWITCH/STS768 (LEY73AE)	3500		X
SWITCH/DS3EC1 (LEY18A)	2000	X	X
CTL/SYS50DM (LEY10BE)	5100	X	X
TMG/STRAT3 (LLY2BE)	3800	X	X

Port unit failure rates

The table below provides the steady-state port unit failure rates for WaveStar TDM 2.5G/10G (2-Fiber).

Table 7-35 Port Unit Failure Rates

Port Unit	Failure Rate (FIT) (see Note 1)	2.5G Application	10G Application
OC192/STM64/1.5IRS1 (LEY97AE)	8500		X
OC192/STM64/1.5IR1Extended/Intermediate (LEY69AE)	8500		X
OC192/STM64/WDM9580 through WDM9190 (LEY201AE-240AE)	8500		X
OC192/STM64/POU9590 through POU9210 (odd channels; see Note) (LEY284AE-299AE)	8500		X
OC192/STM64/POU9580 through POU9220 (even channels; see Note) (LEY384AE-399AE)	8500		X
OC48/STM16/1.3VSR1 (LEY182AE)	9900	X	X
OC48/STM16/1.3LR1 (LEY7AE)	7500	X	X
OC48/STM16/1.5LR1 (LEY8AE)	7500	X	X
OC48/STM16/WDM 9190-9585 (LEY 101AE-180AE)	7500	X	X
OC48/STM16/POU9590-9210 (odd channels; see Note) (LEY 80AE-95AE)	7500	X	X
OC48/STM16/DWDM01-16 (LEY 50AE-65AE)	7500	X	X
OC12/STM4/1.3LR2 (LEY13AE)	3900	X	X
OC12/STM4/1.3SR2 (LEY14AE)	3900	X	X
OC3/STM1/1.3LR4 (LEY15AE)	4900	X	X
OC3/STM4/1.3IR-SR8 (LEY23AE)	10500	X	X
OC3/STM1/1.3SR4 (LEY16AE)	4900	X	X
DS3EC1/8 (LEY17AE)	5200	X	X
Optical Booster Amplifier (SEN3AE)	6500		X
Optical Booster Pre-amplifier (SEN4AE)	6500		X
GE1/SX2 (LEY309AE)	5600	X	X
GE1/LX2 (LEY310AE)	5600	X	X

Notes

1. These fit rates are subject to change.

2. The frequency and channel plan for the passive optics units (DWDM filter units) are provided in Chapter 4.

Equipment failure rates

The table below provides the steady-state equipment failure rates for WaveStar TDM 2.5G/10G (2-Fiber).

Table 7-36 Equipment Failure Rates

Equipment	Failure Rate (FIT)
Circuit Breaker	10
Power Filter	40
User Panel	110
Fan Unit	1500
DS3 Connector Panel	110

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 7-34, *Circuit Pack Failure Rates*, Table 7-35, *Port Unit Failure Rates*, or Table 7-36, *Equipment Failure Rates*.

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 7-34, *Circuit Pack Failure Rates*, Table 7-35, *Port Unit Failure Rates*, or Table 7-36, *Equipment Failure Rates*.

ND OF STEPS

Example of using the graph

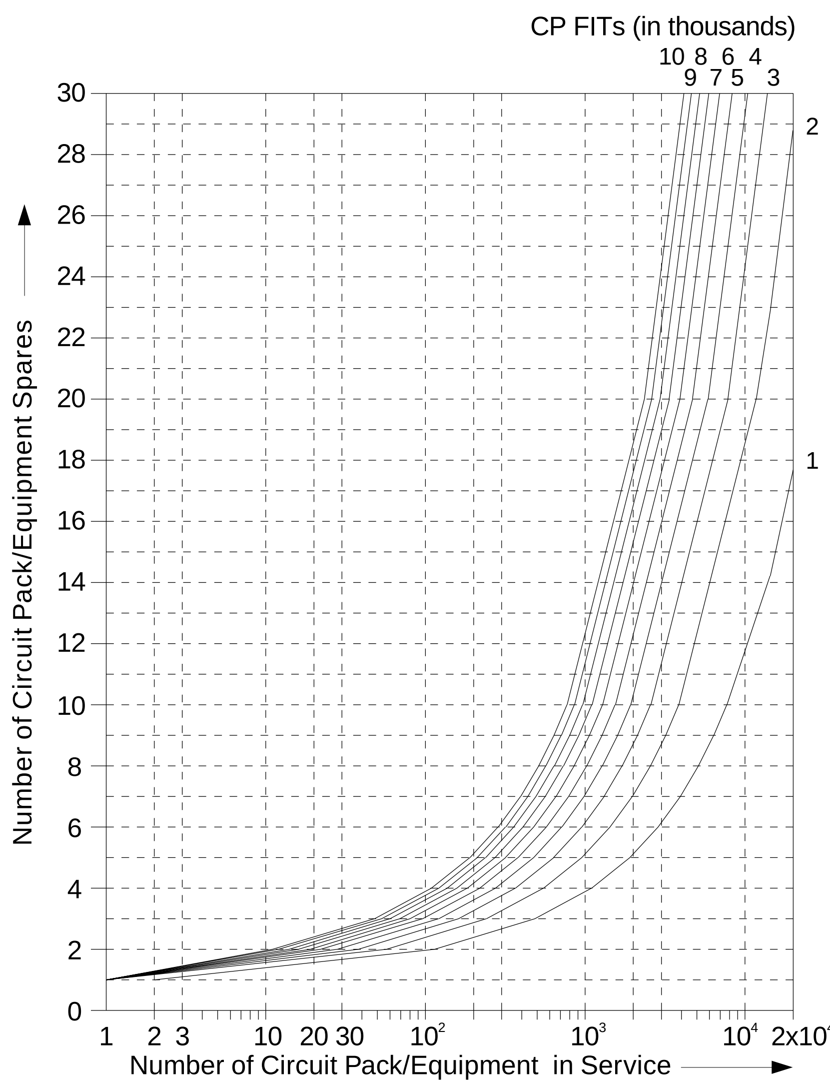
If there are 100 OC12/STM4/1.3LR2 port units (failure rate of 3900) in service at a given location and your lead time is 10 days, then you should order and stock 3 spare OC12/STM4/1.3LR2 port units for that location.

□

Sparing graph for 10-day lead time

Use Sparing Graph for a 10-Day Lead Time to plan the number of spares necessary for the circuit packs, port units and pieces of common equipment used in WaveStar TDM 2.5G/10G (2-Fiber).

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.

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 (for example, Network Realignment, System Capacity Planning, System Health Assessment

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 device 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.

Inside the United States and Canada

Technical Support Services can be reached at **1-866-LUCENT8** (866-582-3688): *Prompt 1*.

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 Quality and Reliability

Overview

Purpose This chapter contains information related to the quality and reliability of WaveStar TDM 2.5G/10G (2-Fiber).

Lucent Technologies' Commitment to Quality and Reliability

Overview

Lucent Technologies is extremely committed to providing our customers with products of the highest level of quality and reliability in the industry. WaveStar TDM 2.5G/10G (2-Fiber) is a prime example of this commitment.

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

Reliability in the Product's Life-Cycle

Each stage of the life cycle of WaveStar TDM 2.5G/10G (2-Fiber) relies on people and processes that contribute to the highest product quality and reliability possible. The reliability of a product begins at the earliest planning stage and continues into

- Product architecture
- Design and simulation
- Documentation
- Prototyping testing during development
- Design change control
- Manufacturing and product testing (including 100% screening)
- Product quality assurance
- Product field performance
- Product field return management

Ensuring Quality

Overview

This section describes the critical elements that ensure product quality and reliability within

- Product development
- Manufacturing

Critical Elements of Product Development

The product development group's strict adherence to the following critical elements ensures the product's reliability

- Design standards
- Design and test practices
- Comprehensive qualification programs
- System-level reliability integration
- Reliability audits and predictions
- Development of quality assurance standards for manufactured products

Critical Elements of Manufacturing

The manufacturing and field deployment groups' strict adherence to the following critical elements ensures the product's reliability

- Pre-manufacturing
- Qualification
- Accelerated product testing
- Product screening
- Production quality tracking
- Failure mode analysis
- Feedback and corrective actions

Important! Independent Quality Representatives are also present at manufacturing locations to ensure shipped product quality.

□

Failure Rates

Overview

This section provides failure rates for WaveStar TDM 2.5G/10G (2-Fiber). All data is based on Telcordia's Method I, *Reliability Prediction Procedure for Electronic Equipment*, Issue 6, December 1997.

Circuit Pack Failure Rates

The table below provides steady-state circuit pack failure rates, specified as Failures in Time (FIT), for WaveStar TDM 2.5G/10G (2-Fiber).

Table 9-1 Circuit Pack Failure Rates

Circuit Pack	Failure Rate (FIT)	2.5G System	10G System
SWITCH/DS3EC1	2000	X	X
SWITCH/STS576	4200	X	X
SWITCH/STS768	3500		X
PPROC/STS192	4800		X
PPROC/STS384	3300		X
CTL/SYS50DM	5100	X	X
ADJCTL/DCCEI	7100	X	X
TMG/STRAT3	3800	X	X

Port Unit Failure Rates

The table below provides steady-state port unit failure rates, specified as Failures in Time (FIT), for WaveStar TDM 2.5G/10G (2-Fiber).

Table 9-2 Port Unit Failure Rates

Port Unit	Failure Rate (FIT)	2.5G Application	10G Application
OC192/STM64/1.5IRS1 (LEY97AE)	8500		X
OC192/STM64/1.5IR1Extended/ Intermediate (LEY69AE)	8500		X
OC192/STM64/WDM9580 through WDM9190 (LEY201AE-240AE)	8500		X
OC192/STM64/POU9590 through POU9210 (LEY284AE-299AE)	8500		X
OC48/STM16/1.3VSR1 (LEY182AE)	9900	X	X
OC48/STM16/1.3LR1 (LEY7AE)	7500	X	X
OC48/STM16/1.5LR1 (LEY8AE)	7500	X	X
OC48/STM16/WDM 9190-9585 (LEY 101AE-180AE)	7500	X	X
OC48/STM16/POU9590 -9210 (LEY 80AE-95AE)	7500	X	X
OC48/STM16/DWDM01-16 (LEY50AE-65AE)	7500	X	X
OC12/STM4/1.3LR2 (LEY13AE)	3900	X	X
OC12/STM4/1.3SR2 (LEY14AE)	3900	X	X
OC3/STM1/1.3LR4 (LEY15AE)	4900	X	X
OC3/STM4/1.3IR-SR8 (LEY23AE)	10500	X	X
OC3/STM1/1.3SR4 (LEY16AE)	4900	X	X
DS3EC1/8 (LEY17AE)	5200	X	X
Optical Booster Amplifier (SEN3AE)	6500		X
Optical Booster Preamplifier (SEN4AE)	6500		X
GE1/SX2 (LEY309AE)	5600	X	X
GE1/LX2 (LEY310AE)	5600	X	X

Notes

* These FIT rates are subject to change.

Additional Failure Rates

The table below provides steady-state failure rates for WaveStar TDM 2.5G/10G (2-Fiber) equipment.

Table 9-3 Equipment Failure Rates

Equipment	Failure Rate (FIT)
Circuit Breaker	10
Power Filter	40
User Panel	110
Fan Unit	1500
DS3 Connector Panel	110

□

Unavailability Specifications

Overview

This section provides the port unit and system unavailability specifications for WaveStar TDM 2.5G/10G (2-Fiber). All data is based on the circuit pack failure rates that are calculated according to Telcordia's Method I, *Reliability Prediction Procedure for Electronic Equipment*, Issue 6, December 1997.

Port Unit Unavailability

The table below provides hardware unavailability estimates for the optical and electrical port units in WaveStar TDM 2.5G/10G (2-Fiber).

Table 9-4 Port Unit Unavailability (Hardware Only)

Port Unit	Unavailability (See the Notes)	2.5G System	10G System
OC192/STM64/1.5SR1	0.000502 min/year		X
OC192/STM64/1.5IR1	0.000502 min/year		X
OC192/STM64/1.5IRS1	0.000502 min/year		X
OC192/STM64/1.5LR1	0.000502 min/year		X
OC192/STM64/1.5VLR1	0.000502 min/year		X
OC192/STM64/WDM (all)	0.000502 min/year		X
OC192/STM64/POU (all)	0.000502 min/year		X
DS3EC1/8	0.00077 min/year	X	X
OC3/STM1/1.3SR4	0.00013 min/year	X	X
OC3/STM1/1.3LR4	0.00013 min/year	X	X
OC3/STM1/1.3IR/SR8	0.00013 min/year	X	X
OC12/STM4/1.3LR2	0.00011 min/year	X	X
OC12/STM4/1.3SR2	0.00011 min/year	X	X
OC48/STM16/1.3LR1	0.00020 min/year	X	X
OC48/STM16/1.5LR1	0.00020 min/year	X	X
OC48/STM16/1.3VSR1	0.00020 min/year	X	X
OC48/STM16/DWDM01 through OC48/STM16/DWDM16	0.00020 min/year	X	X
OC48/STM16/POU (all)	0.0009 min/year		X
SEN3AE	See Note		X

Port Unit	Unavailability (See the Notes)	2.5G System	10G System
SEN4AE	See Note		X
GE1/SX2	See Note	X	X
GE1/LX2	See Note	X	X

Note:

Contact your Lucent Technologies Account Executive for the latest information.

System Unavailability

The table below provides steady-state system unavailability estimates for the WaveStar TDM 2.5G/10G (2-Fiber) system due to hardware failures.

Table 9-5 System Unavailability

System	Unavailability
OC-192 to DS3/EC1 transmission	0.70 min/year
OC-192 to OC-3 transmission	0.72 min/year
OC-192 to OC-12 transmission	0.70 min/year
OC-192 to OC-48 transmission	0.76 min/year
OC-48 to DS3/EC1 transmission	0.31 min/year
OC-48 to OC-3 transmission	0.34 min/year
OC-48 to OC-12 transmission	0.32 min/year
DS3/EC1 interface transmission	0.20 min/year
OC-3 interface transmission	0.22 min/year
OC-12 interface transmission	0.20 min/year
OC-48 to OC-48 ring transmission	15.9 min/year
LAN interface to OS	12.6 min/year

Silent Failure Unavailability

The WaveStar TDM 2.5G/10G (2-Fiber) system is designed to minimize system unavailability due to silent failures. Equipment failures in the system that may result in a loss of service of protection trigger office alarms or generate autonomous messages.

General Specifications

Overview

This section provides general reliability specifications for WaveStar TDM 2.5G/10G (2-Fiber).

Mean Time Between Maintenance Activities

The Mean Time Between Maintenance Activities is 12.0 months for the tributary shelf and 17.6 months for the high-speed shelf.

Mean Time to Repair

The mean time to repair for WaveStar TDM 2.5G/10G (2-Fiber) is assumed to be 2 hours. This figure includes dispatch, diagnostic, and repair time.

Infant Mortality Factor

The number of failures that a product experiences during the first year of service after turn-up may be greater than the number of subsequent annual steady state failures.

The infant mortality factor (IMF) for WaveStar TDM 2.5G/10G (2-Fiber) is ≤1.3. Therefore, the first year failure rate (or infant mortality rate [IMR]) is 1.3 times the steady state failure rate.

> **Important!** The steady state failure rate is equal to the failure rate of the system.

Product Design Life

The product design life for WaveStar TDM 2.5G/10G (2-Fiber) is 25 years except for the fan unit. The fan unit design life is 12 years.

Maintainability Specifications

WaveStar TDM 2.5G/10G (2-Fiber) does not require periodic electronic equipment maintenance activities. Continuous performance monitoring enables the system to detect conditions before they become service-affecting.

> **Important!** The fan filter, located below the fan unit in the shelf, must be replaced once every 6 months to ensure the proper operation of the fan units.

Warranty

The terms and conditions of sale include a 1-year warranty on WaveStar TDM 2.5G/10G (2-Fiber) hardware and software.

10 Technical Specifications

Overview

Purpose

This chapter provides the technical specifications for WaveStar TDM 2.5G/10G (2-Fiber). This data is necessary for planning the use of a WaveStar TDM 2.5G/10G (2-Fiber) in an existing or new network.

References

For information about the following reliability specifications, refer to Chapter 9, “Quality and Reliability.”

- Port unit unavailability
- System unavailability
- Circuit pack FIT rates
- Mean time between maintenance activities

System Specifications

Overview

This section provides specifications for the transmission medium, cabling, and access to WaveStar TDM 2.5G/10G (2-Fiber).

Transmission fibers

WaveStar TDM 2.5G/10G (2-Fiber) uses the following transmission fibers:

- Standard single-mode non-dispersion shifted fiber
- *TrueWave*™ non-zero dispersion shifted fiber

Connectorized cabling

All connections are by means of connectorized cabling, except the DS1 external timing reference, which comes equipped with a wire-wrapped termination. This termination consists of a DSub9 Connector converted to a 5-pin wire-wrapped post.

Front access

Front access is provided for all circuit pack insertions and removals, all external connections and cabling to transmission interfaces, and the WaveStar® CIT port.

Rear access

Rear access is provided for cabling to shelf inputs and outputs.

□

Port Unit Specifications

Introduction

The optical specifications provided in this section apply to the optical port units in WaveStar TDM 2.5G/10G (2-Fiber), (OC192/STM64, OC48/STM16, OC12/STM4, and OC3/STM1).

Line rate

OC192/STM64

The optical line rate for the OC192/STM64 port units is 9.953 Gb/s.

OC48/STM16

The optical line rate for the OC48/STM16 port units is 2.488 Gb/s.

OC12/STM4

The optical line rate for the OC12/STM4 port units is 622.08 Mb/s.

OC3/STM1

The optical line rate for the OC3/STM1 port units is 155.52 Mb/s.

Line code

The optical line code for the optical port units is scrambled nonreturn to zero (NRZ).

Connector interfaces

LEY23/LEY23AE, LEY101/LEY101AE - LEY180/LEY180AE, and LEY201/LEY201AE - LEY240/LEY240AE use LC-type lightguide build-out (LBO) connectors optical attenuation. All other optical port units may be equipped with either ST-type, FC-type, or SC-type LBOs for optical attenuation.

Lightguide jumpers

Single-mode lightguide jumpers are used on all optical interfaces in WaveStar TDM 2.5G/10G (2-Fiber).

Optical source

OC192/STM64

The optical source for the OC192/STM64/1.5SR1, OC192/STM64/1.5LR1, and OC192/STM/IRS1 port units is the Electro-absorptive Modulated Laser (EML).

The optical source for the OC192/STM64/1.5IR1, OC192/STM64/POU, and the OC192/STM64/WDM port units is a Continuous Wave Laser with a Mach Zender Modulator (MZM).

The optical source for the OC192/STM64/1.5VLR1 port units is an EML if OC192/STM/IRS1 is used or MZM if the OC192/STM64/IR1 is used.

OC48/STM16

The optical source for the OC48/STM16/1.3VSR1, OC48/STM16/1.3LR1, OC48/STM16/1.5LR1, OC48/STM16/1.3LR1 (Transponder Module), and OC48/STM16/1.5LR1 (Transponder Module) port units is a distributed feedback (DFB) laser.

The optical source for the and OC48/STM16/DWDM01-16, OC48/STM16/WDM, OC48/STM16/POU port units is an Electro-absorptive Modulated Laser (EML).

OC12/STM4/1.3SR2

The optical source for the OC12/STM4/1.3SR2 port units is a DFB laser.

OC12/STM4/1.3LR2

The optical source for the OC12/STM4/1.3LR2 port units is a DFB laser.

OC3/STM1/1.3SR4

The optical source for the OC3/STM1/1.3SR4 port units can be either a DFB laser or a Fabre-Perot laser.

OC3/STM1/1.3LR4 and OC3/STM1/1.3IR-SR8

The optical source for the OC3/STM1/1.3LR4 and the OC3/STM1/1.3IR-SR8 port units is a DFB laser.

GE1

The optical source for GE1/SX2 port unit is a Vertical Cavity Surface Emitting Laser (VSCEL).

The optical source for the GE1/LX2 port unit is a Fabry-Perot (FP) laser.

Capacity

OC192/STM64

Each OC192/STM64 port unit supports either one OC-192 or one STM-64 (user-provisionable) bidirectional (one receive and one transmit) line.

OC48/STM16

Each OC48/STM16 port unit supports either one OC-48 or one STM-16 (user-provisionable) bidirectional (one receive and one transmit) line.

OC12/STM4

Each OC12/STM4 port unit supports either two OC-12 or two STM-4 (user-provisionable) bidirectional (one receive and one transmit) lines.

OC3/STM1

OC3/STM1 port units have either four or eight OC-3 or STM-1 ports, depending on the specific port unit selected. Therefore, either four or eight OC-3 or STM-1 (user-provisionable) bidirectional (one receive and one transmit) lines are supported.

GE1

Each GE1 port unit supports two Gigabit Ethernet bidirectional (one receive and one transmit) lines. The capacity per line is user provisionable (maximum of 21 STS1s).

Optical detector

The optical detector for the OC192/STM64/1.5LR1 and the OC192/STM64/1.5VLR1 is a Pin Diode.

The optical detector for all other optical port units is an avalanche photodiode (APD).

The optical detector for the GE1 port units is a Silicon PIN photodiode.

Optical safety

Optical safety data on laser-containing port units

- Class IIIB in the FDA/CDRH Classification System (applies to the 1.3 micron units)
- Class I in the FDA/CDRH Classification System (applies to the 1.5 micron units and GE1 units)

Protection

This section lists the protection schemes available for each optical port.

OC192

The protection mode for the OC192 ports in WaveStar TDM 2.5G/10G (2-Fiber) may be provisioned as

- 2-Fiber BLSR
  - Span capacity is 96 STS-1 equivalent working tributaries and 96 STS-1 equivalent protection tributaries.
  - Add/drop capacity at each node is up to 192 STS-1 equivalents of working traffic (west and east) plus 192 STS-1 equivalents of preemptible protection access traffic (west and east).
  - Non-preemptible Unprotected Traffic (NUT) can be provisioned for STS-1 timeslots around a 2-Fiber BLSR to exclude individual working tributaries and their corresponding protection tributaries from BLSR protection switching.
- UPSR (STS-1 path)
  - Ring capacity is 192 STS-1 equivalent tributaries
  - Add/drop capacity at each node is up to 192 STS-1 equivalents of working traffic
- 0x1 (unprotected) ports

OC48

The protection mode for the OC48 ports in WaveStar TDM 2.5G/10G (2-Fiber) may be provisioned as

- 2-Fiber BLSR

  - Span capacity is 24 STS-1 equivalent working tributaries and 24 STS-1 equivalent protection tributaries.
  - Add/drop capacity at each node is up to 48 STS-1 equivalents of working traffic (west and east) plus 48 STS-1 equivalents of preemptible protection access traffic (west and east).
- UPSR (STS-1 path)
  - Ring capacity is 48 STS-1 equivalent tributaries
  - Add/drop capacity at each node is up to 48 STS-1 equivalents of working traffic
- 1+1 line protection (unidirectional non-revertive, bidirectional non-revertive, or bidirectional revertive)
- 0x1 (unprotected) ports

OC12

The protection mode for the OC12/STM4 ports in WaveStar TDM 2.5G/10G (2-Fiber) may be provisioned as

- UPSR (STS-1 path)
  - Ring capacity is 12 STS-1 equivalent tributaries
  - Add/drop capacity at each node is up to 12 STS-1 equivalents of working traffic
- 1+1 line protection (unidirectional non-revertive, bidirectional non-revertive, or bidirectional revertive)
- 0x1 (unprotected) ports

OC3

The protection mode for the OC3 ports in WaveStar TDM 2.5G/10G (2-Fiber) may be provisioned as

- 1+1 line protection (unidirectional non-revertive, bidirectional non-revertive, or bidirectional revertive)
- 0x1 (unprotected) ports

GE1

The protection mode for the GE1 ports in WaveStar TDM 2.5G/10G (2-Fiber) is 0x1.

Dispersion

WaveStar TDM 2.5G/10G (2-Fiber) can accommodate the following types of dispersion:

Chromatic dispersion

See Table 10-1 for port unit chromatic dispersion information.

Group delay dispersion for PMD

The receiver can accommodate up to 75 ps/nm of group delay dispersion due to polarization mode dispersion (PMD) with an optical path penalty of no more than 2 dB when measured at 1x10-10 BER.

Table 10-1 Optical Port Unit Dispersion

Port Unit	Standard Apparatus Code	NEBS Level 3 Apparatus Code	Dispersion
OC192/STM64/1.5SR1 (This port unit has been discontinued.)	LEY67	LEY67AE	800 ps/nm
OC192/STM64/1.5IR1	LEY69	LEY69AE	1200 ps/nm
OC192/STM64/1.5IRS1	LEY97	LEY97AE	800 ps/nm
OC192/STM64/1.5LR1 (LEY69AE plus SEN3AE)		SEN3AE (OBA) plus LEY69AE (see Table 7-11 for information about using the SEN3AE with other OC192/STM64 port units)	1600 ps/nm (SEN3AE plus LEY69AE)
OC192/STM64/1.5VLR1 (LEY228AE + SEN4AE + DCM-40 as pre-compensation and DCM-50 as post compensation)		SEN4AE (OBPA) plus LEY228AE or LEY295AE	2400 ps/nm
OC192/STM64/1.5VLR1 [LEY228AE + SEN4AE (without DCMs]		SEN4AE (OBPA) plus LEY228AE or LEY295AE	1200 ps/nm
OC192/STM64/WDM (all)	LEY201-240	LEY201AE-240AE	See Note 2 below
OC192/STM64/POU (all)	LEY284-299	LEY284AE-299AE and LEY384AE-399AE	1200 ps/nm
OC192/STM64/			
OC48/STM16/1.3VSR1	LEY182	LEY182AE	300 ps/nm
OC48/STM16/1.3LR1	LEY7	LEY7AE	200 ps/nm
OC48/STM16/1.5LR1	LEY8	LEY8AE	1800 ps/nm
OC48/STM16/DWDM01-16	LEY50-65	LEY50AE-65AE	See Note 1 below

Port Unit	Standard Apparatus Code	NEBS Level 3 Apparatus Code	Dispersion
OC48/STM16/WDM (all)	LEY101-180	LEY101AE-180AE	See Note 2 below
OC48/STM16/POU (all)	LEY80-95	LEY80AE-95AE	1800 ps/nm
OC12/STM4/1.3SR2	LEY13	LEY13AE	200 ps/nm
OC12/STM4/1.3LR2	LEY14	LEY14AE	200 ps/nm
OC3/STM1/1.3SR4	LEY16	LEY16AE	300 ps/nm
OC3/STM1/1.3IR/SR8	LEY23	LEY23AE	300 ps/nm
OC3/STM1/1.3LR4	LEY15	LEY15AE	300 ps/nm
Gigabit Ethernet Interface port unit (GE1/SX2 2 port)	LEY309	LEY309AE	See Note 3 below
Gigabit Ethernet Interface port unit (GE1/LX2 2 port)		LEY310AE	See Note 3 below

Notes:

1. The optical dispersion for OC192 WDM port units is compatible with Metropolis EON. For additional information, refer to the Metropolis EON *Applications and Planning Guide* (APG).
2. The optical dispersion for OC192/STM64/WDM and OC48/STM16/WDM port units is compatible with WaveStar OLS 1.6T. For additional information, refer to the *WaveStar® Optical Line System (OLS) 1.6T Applications Planning Guide* (APG) and *WaveStar® Optical Line System (OLS) 1.6T Applications Ordering Guide* (AOG).
3. The fiber optic cable requirements for Gigabit Ethernet are described in IEEE 802.z, section 38.11.1.

□

Power Specifications

Overview

This section provides specifications about the power supply, heat dissipation, and current drain in WaveStar TDM 2.5G/10G (2-Fiber).

Power supply

The table below lists WaveStar TDM 2.5G/10G (2-Fiber) power requirements.

Table 10-2 Power Supply Requirements

Item	Description
Voltage range, all components	–40.0V to –72V
Power Feeders	two –48V power feeders [BREAKER (A) and BREAKER (B)]
Circuit Breakers (two per shelf)	25.0A

Power planning

The heat dissipation of a WaveStar TDM 2.5G/10G (2-Fiber) bay is approximately 1600 watts.

Current drain

The table below provides the **maximum** current drain requirements for a WaveStar TDM 2.5G/10G (2-Fiber) shelf. For a bay that will contain three WaveStar TDM 2.5G/10G (2-Fiber) shelves, the power feeders should provide at least 70A for the bay.

Table 10-3 WaveStar TDM 2.5G/10G (2-Fiber) Current Drains

Shelf	Current Drains per Feeder in Amperes		
	List 1	List 2	
	@ –48V	@ –42.75V	@ –39.5V
High-speed shelf (10G)	10.7	11.3	11.6
Low-speed shelf (2.5G application)	11.3	12.9	14.0
10G 2-Fiber Bay (bay with one high-speed and two low-speed shelves)	33.3	37.1	39.6

Equipment Dimensions

Overview This section provides the height, width, and depth of major WaveStar TDM 2.5G/10G (2-Fiber) components.

Circuit Pack Dimensions The table below lists the dimensions for all the circuit packs in WaveStar TDM 2.5G/10G (2-Fiber).

Table 10-4 Circuit Pack Dimensions

Circuit Pack	Dimensions (mm/inches)			2.5G Application	10G System
	Height	Width	Depth		
PPROC/STS192	336/13.1	25/.98	270/10.6		X
PPROC/STS384	336/13.1	25/.98	270/10.6		X
PPROC/FO (2.5G shelf)	336/13.1	25/.98	270/10.6	X	
CTL/SYS50DM	336/13.1	32/1.25	270/10.6	X	X
ADJCTL/DCCEI	336/13.1	20/.79	270/10.6	X	X
TMG/STRAT3	168/6.6	25/.98	270/10.6	X	X
SWITCH/STS576	336/13.1	30/1.2	270/10.6	X	X
SWITCH/STS768					X
SWITCH/DS3EC1	336/13.1	20/.79	270/10.6	X	X
DS3EC1/8	336/13.1	20/.79	270/10.6	X	X
OC192/STM64/1.5SR1	336/13.1	60/2.4	270/10.6		X
OC192/STM64/1.5IR1	336/13.1	60/2.4	270/10.6		X
OC192/STM64/1.5IRS1	336/13.1	60/2.4	270/10.6		X
OC192/STM64/1.5LR1	See Note Below				X
OC192/STM64/1.5VLR1					X
Optical Booster Amplifier (OBA)	336/13.1	41/1.6	270/10.6		X
Optical Booster Pre-Amplifier (OBPA)	336/13.1	41/1.6	270/10.6		X
OC192/STM64/POU9590 . . OC192/STM64/POU9210	336/13.1	60/2.4	270/10.6		X

Circuit Pack	Dimensions (mm/inches)			2.5G Application	10G System
	Height	Width	Depth		
OC192/STM64/WDM9580 . . OC192/STM64/WDM9190	336/13.1	60/2.4	270/10.6		X
OC48/STM16/1.3VSR1	336/13.1	38/1.5	270/10.6	X	X
OC48/STM16/1.3LR1	336/13.1	40/1.6	270/10.6	X	X
OC48/STM16/1.5LR1	336/13.1	40/1.6	270/10.6	X	X
OC48/STM16/DWDM01 . . OC48/STM16/DWDM16	336/13.1	40/1.6	270/10.6	X	X
OC48/STM16/POU9590 . . OC48/STM16/POU9210	336/13.1	40/1.6	270/10.6	X	X
OC48/STM16/WDM9585 . . OC48/STM16/WDM9190	336/13.1	40/1.6	270/10.6	X	X
OC12/STM4/1.3LR2	336/13.1	20/.79	270/10.6	X	X
OC12/STM4/1.3SR2	336/13.1	20/.79	270/10.6	X	X
OC3/STM1/1.3LR4	336/13.1	20/.79	270/10.6	X	X
OC3/STM1/1.3IR/SR8	336/13.1	20/.79	270/10.6	X	X
OC3/STM1/1.3SR4	336/13.1	20/.79	270/10.6	X	X
Gigabit Ethernet Interface port unit (GE1/SX2 2 port)	336/13.1	40/1.6	270/10.6	X	X
Gigabit Ethernet Interface port unit (GE1/LX2 2 port)	336/13.1	40/1.6	270/10.6	X	X

Note:

The OC192/STM64/1.5LR1 port unit is actually a combination of the SEN3AE (OBA) plus LEY69/LEY69AE (or one of various other OC192/STM64 port units). The SEN3AE should not be paried with LEY67/LEY67AE. SEN3AE can be paired with LEY97/LEY97AE, but it will not meet standards dispersion requirements for an OC192 long-reach interface.

The OC192/STM64/1.5VLR1 port unit is actually a combination of the SEN4AE (OBPA) and LEY228/LEY228AE (or LEY295/LEY295AE) port unit working together.

The automatic laser shutdown (ALS) feature can only be used if the paired OC192/STM64 port unit is an LEY69AE, LEY97AE, or LEY228AE.

Shelf Dimensions

The table below lists the dimensions of a WaveStar TDM 2.5G/10G (2-Fiber) shelf. These dimensions do not include the heat baffles (see Table 10-9 “Cooling Equipment Dimensions” and the section on “Heat baffle locations” in Chapter 6).

Table 10-5 Shelf Dimensions

	Dimensions (mm/inches)		
	Height	**Width**	**Depth**
Shelf only	575/22.6	543/21.4	400/15.7
With one DS3 externally attached connector panel (for tributary shelf only)	575/22.6	649/25.6	400/15.7
With two DS3 externally attached connector panels (for tributary shelf only)	575/22.6	755/29.7	400/15.7
With one DS3 internally attached connector panel (for tributary shelf only)	690/27.2	543/21.4	400/15.7
With two DS3 internally attached connector panels (for tributary shelf only)	805/31.7	543/21.4	400/15.7
With one or two rear mounted DS3 panel	575/22.6	543/21.4	570/19.15

DS3 connector panel dimensions

The table below lists the dimensions of an externally attached DS3 connector panel.

Table 10-6 External Connector Panel Dimensions

Dimensions (mm/inches)		
Height	**Width**	**Depth**
546.1/21.5	101.6/4	57.2/2.3

The table below lists the dimensions of an internally attached DS3 connector panel.

Table 10-7 Internal Connector Panel Dimensions

Dimensions (mm/inches)		
Height	**Width**	**Depth**
115/4.5	543/21.4	347.5/13.7

The table below lists the dimensions of an rear mounted DS3 connector panel.

Table 10-8 Rear Mounted Connector Panel Dimensions

Dimensions (mm/inches)		
Height	**Width**	**Depth**
546.1/21.5	101.6/4	57.2/2.3

Cooling equipment

The table below lists the dimensions of the cooling equipment.

Table 10-9 Cooling Equipment Dimensions

Equipment	Dimensions (mm/inches)		
	Height	**Width**	**Depth**
Fan Unit	48/1.9	543/21.4	380/14.9
Fan Filter	13.5/.5	543/21.4	380/14.9
Heat Baffle	70/2.75	543/21.4	380/14.9

☐

Environmental Specifications

Overview This section provides the specific environmental conditions that WaveStar TDM 2.5G/10G (2-Fiber) is designed to withstand without detrimentally affecting operation.

Conditions WaveStar TDM 2.5G/10G (2-Fiber) is designed to operate in a controlled environment that complies with the environmental requirements listed in the following table.

Table 10-10 Temperature and Humidity Requirements

Operating Condition	Normal		Short-term[a]	
	Celsius (C)	Fahrenheit (F)	Celsius (C)	Fahrenheit (F)
Ambient temperature[b]	5° to 40°	41° to 104°	–5° to 50°	23° to 122°
Maximum temperature rate of change	30°/hour	54°/hour	30°/hour	54°/hour
Ambient relative humidity	5% to 85%		5% to 90%[c]	
Altitude	(–61m to 1982m) (–200 ft to 6500 ft)		NA	

Notes

(a) Short-term refers to a period of time ≤ 90 consecutive hours and a total of ≤ 15 days in one year. The time may total 360 hours in any given year, but may not exceed 15 individual occurrences during that one year.
(b) Ambient refers to conditions at the specific location of 1.5 m (59 in) above the floor and 400 mm (15.8 in) in front of the equipment.
(c) Not to exceed 0.024 kg of water per kg of dry air.

Storage and transportation conditions

WaveStar TDM 2.5G/10G (2-Fiber) is designed to be fully operational after being subjected to the environmental conditions listed in the table below during storage and transportation.

Table 10-11 Storage and Transportation Requirements

Condition	Range
Temperature	–40°C to 70°C (–40°F to 158°F)
Maximum temperature rate of change	30°C/hour (54°F/hour)
Relative humidity	5% to 95%
Maximum absolute humidity	0.024 kg of water/ kg of dry air
Altitude	–61m to 12,195m (–200 ft to 40,000 ft)

□

WaveStar CIT Requirements

Overview

This section provides the table below and other information regarding the minimum and recommended WaveStar CIT requirements.

It is anticipated that most customers will dedicate a laptop personal computer (PC) to run the WaveStar CIT applications software. However, you can use a properly configured desktop PC. Recommended requirements are intended as a general guideline to optimize performance. As the CIT is used with multiple NE connections and multiple NE types, the processor type and speed and the memory size will all factor into CIT performance.

Description	**Minimum Requirement (see Note 1)**	**Recommended**
Processor	Pentium® 266 Mhz	Pentium III 500 Mhz
RAM	128 MB (see Note 1)	256 MB (see Note 2)
Virtual Memory	139 MB (see Note 1)	500 MB (see Note 2)
Disk space	1-GB hard drive with at least 250 MB free space (see Note 3)	6-GB hard drive with at least 500 MB free space (see Note 3)
CD-ROM Drive	CD-ROM drive compatible with the PC	CD-ROM drive compatible with the PC.
Floppy Disk Drive	3.5-inch, 1.44 MB	
Video (SVGA)	800 x 600	1024 x 768
Network Interface	10/100 Base T LAN NIC The pin designations/signals are: • 1 TD+ • 2 TD- • 3 RD+ • 6 RD-	10/100 Base T LAN NIC The pin designations/signals are: • 1 TD+ • 2 TD- • 3 RD+ • 6 RD-
Operating System (see Note 4)	Microsoft® Windows 2000 or Microsoft® Windows NT 4.0 with service pack 6A	Microsoft® Windows 2000 or Microsoft® Windows NT 4.0 with service pack 6A

Description	Minimum Requirement (see Note 1)	Recommended
PDF File Reader	Adobe *Acrobat Reader*™ for *Windows*™ (version 3.01 or later)	
Personal Computer Memory Card International Association (PCMCIA) slot	Type II slot with driver software that supports read/write of PCMCIA flash disk cards (see Note 5 and the “PCMCIA flash disk” section)	Type II slot with driver software that supports read/write of PCMCIA flash disk cards (see Note 5 and the “PCMCIA flash disk” section)
System Backup Drive (Optional)	Removable hard drive for system backups	Removable hard drive for system backups

Notes:

1. The minimum RAM and minimum virtual memory are sufficient for configuring only one system at a time.

2. The recommended RAM and virtual memory are sufficient to configure up to five sytems at a time.

3. The 250 MB of free disk space is required for installation of the WaveStar CIT application (130 MB) and NE software (64 MB). During installation 70 MB of free memory is needed.

The WaveStar CIT application supports multiple releases of the WaveStar 2.5G/10G. This capability may be necessary when using a single PC to connect to multiple rings that are using different releases of NE software. In this case, an additional 130 MB must be allotted for each copy of the NE software and NE database.

4. The customer is responsible for ensuring that the operating system remains virus-free

5. Regarding the user-supplied PCMCIA NVM card reader/writer, there are no vendor specific requirements. However, Lucent has tested the two products (a) Card Executive 2.0, from Softex Inc. and (b) Card Wizard from SystemSoft Corp, and found them to work properly for this application.

PCMCIA flash disk

Each WaveStar NE uses at least one PCMCIA flash disk as removable memory. The PC that functions as the WaveStar CIT must be able to read and write PCMCIA flash disk memory cards.

Laptop computers

Laptop computers contain 2 PCMCIA Type II card slots. One PCMCIA slot must be equipped with a 10/100 BaseT interface network card to support WaveStar CIT communications with the NE over the OSI LAN.

The other PCMCIA Type II slot is used to copy the NE installation generic from the laptop to the PCMCIA flash disk (NVM memory). The NVM is then installed (inserted into a controller circuit pack) in the NE.

Desktop computers

If a desktop computer is used for the NE installation process, the desktop computer must have one PCMCIA Type II card slot to copy the NE installation generic from the desktop to the PCMCIA flash disk (NVM memory). The NVM is then installed (inserted into a controller circuit pack) in the NE.

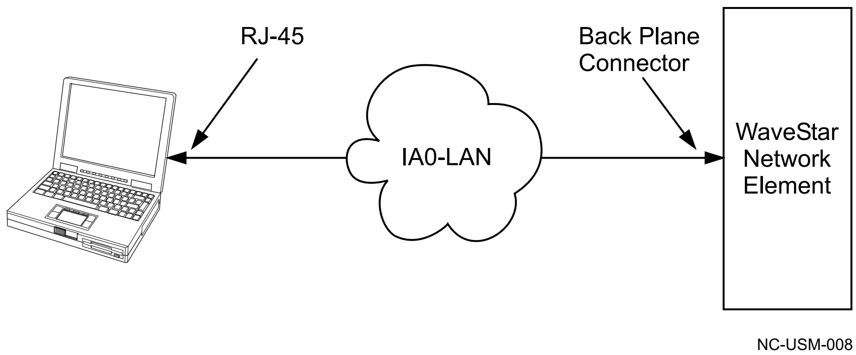
Physical “cable connections”

The PC connects to the WaveStar network via a 10/100 Base-T LAN cable. You can use a direct connection or an intraoffice (IAO) LAN connection.

Direct Connection:

The following figure depicts a direct connection using a short cable (straight cable and NOT a cross-over cable) to connect directly into the front of the user panel.

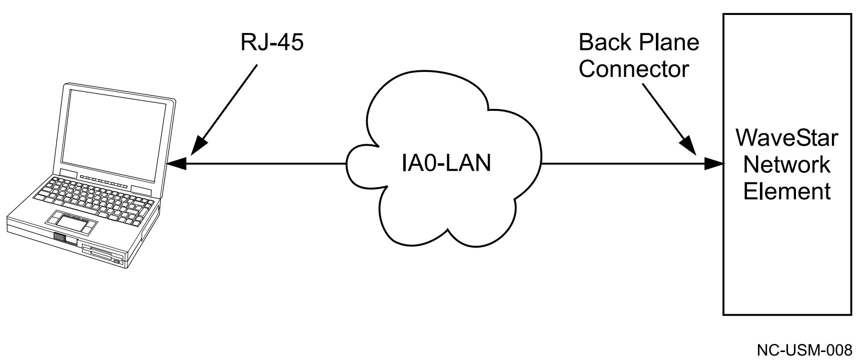
Figure A-1 WaveStar CIT with Direct Connection to the NE User Panel



Intraoffice LAN (IAO-LAN) Connection:

The following figure depicts a network connection using the Intraoffice LAN (IAO-LAN). The cable from the PC to the backplane connector is a straight cable and NOT a cross-over cable.

Figure A-2 WaveStar CIT with IAO-LAN Network Connection



Important! If the WaveStar NE consists of multiple shelves – then each shelf is physically connected via backplane cabling to a central hub. These cables (shelf-to-hub) are cross-over cables, installed by the installers, and should not be confused with that one cable going directly from the PC to the node's backplane "CIT" connector.

The communication protocol between the WaveStar CIT and the NE is mostly TL1 messages.

□

Appendix A: A SONET Overview

Overview

Purpose

This chapter briefly describes the Synchronous Optical Network (SONET).

History of the SONET name

The American National Standards Institute (ANSI) recognized the need for an optical signal standard for future broadband transmission, and a committee began working on optical signal and interface standards in 1984.

In 1985, Bellcore proposed a network approach to fiber system standardization to T1X1. In the proposal, Bellcore suggested the following:

- Hierarchical family of signals whose rates would be integer multiples of a basic modular signal
- Synchronous multiplexing technique, leading to the coining of the term *Synchronous Optical Network* (SONET)

CCITT interest in SONET

The International Telegraph and Telephone Consultative Committee (CCITT) was interested in SONET and held conferences in 1987 and 1988 which resulted in coordinated specifications and approval of both the American National Standard (SONET) and the CCITT-International Standard, Synchronous Digital Hierarchy (SDH) in 1988.

Important! The CCITT is now named International Telecommunication Union, Telecommunication Standardization Sector (ITU-T). For more information refer to the "Standards: Their Global Impact" in the *IEEE Communications Magazine*, Vol. 32, No. 1, January 1994.

Purpose

The basic purpose of SONET is to provide a standard synchronous optical hierarchy with sufficient flexibility to accommodate digital signals that currently exist in the networks of today, as well as those planned for the future.

SONET currently defines standard rates and formats and optical interfaces. Today, mid-span meet is possible at the optical transmission level. These and other related issues continue to evolve through the ANSI committees.

ANSI addressed issues

The set of American National Standards defines:

- Optical parameters
- Multiplexing schemes to map existing digital signals (that is, DS1 and DS3) into SONET payload signals
- Overhead channels to support standard operation, administration, maintenance, and provisioning (OAM&P) functions
- Criteria for optical line automatic protection switch (APS)

References

For more detailed information on SONET, refer to:

- ANSI T1.105 – 1995 American National Standard for Telecommunications, Synchronous Optical Network (SONET)
- ANSI T1.106-1988 American National Standard for Telecommunications – Digital Hierarchy Optical Interface Specifications, Single Mode
- ITU Recommendations G.707, G.708, G.709
- R. Ballart and Y. C. Ching, SONET: Now It's the Standard Optical Network, *IEEE Communications Magazine*, Vol. 27, No. 3 (March 1989): 8-15

SONET Signal Hierarchy

Introduction

This section describes the basics of the SONET hierarchy.

STS-1 frame

The SONET signal hierarchy is based on a basic “building block” frame called the synchronous transport signal-level 1 (STS-1), as shown in SONET STS-1 Frame Simplified Version.

The STS-1 frame has:

- A recurring rate of 8000 frames a second
- The frame rate of 125 microseconds

The STS-1 frame consists of:

- 90 columns
- 9 rows

Important! Each cell in the matrix represents an 8-bit byte.

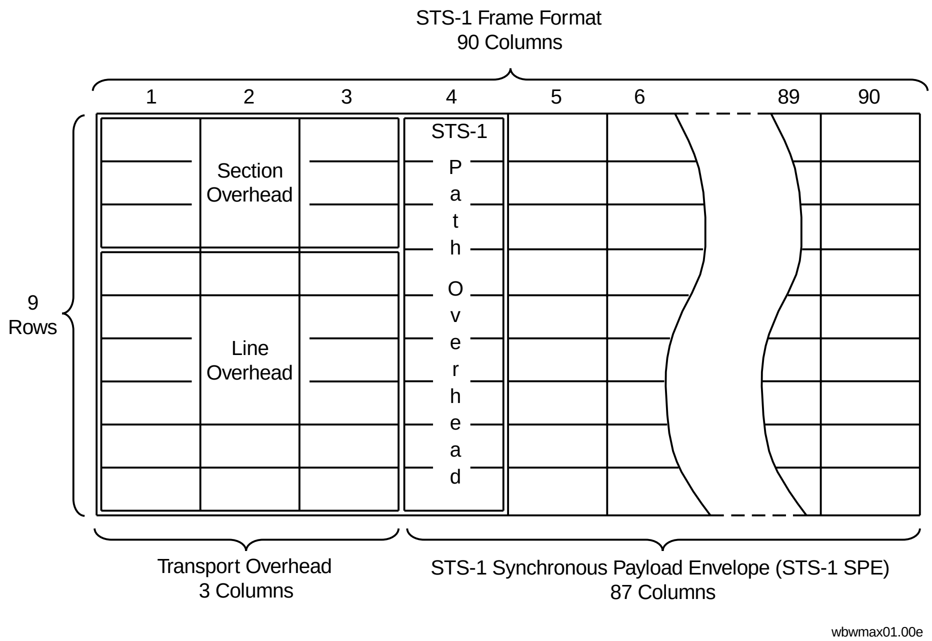
Transmitting signals

The STS-1 frame is transmitted serially starting from the left with row 1 column 1 through column 90, then row 2 column 1 through 90, continuing on, row-by-row, until all 810 bytes (9x90) of the STS-1 frame have been transmitted. Because each STS-1 frame consists of 810 bytes and each byte has 8 bits, the frame contains 6480 bits a frame. There are 8000 STS-1 frames a second, at the STS-1 signal rate of 51,840,000 (6480x8000) bits a second.

Figure of SONET STS-1 Frame

Figure A-1, “SONET STS-1 Frame Simplified Version” illustrates the SONET STS-1 frame.

Figure A-1 SONET STS-1 Frame Simplified Version



Transport overhead

The first three columns in each of the nine rows carry the section and line overhead bytes. Collectively, these 27 bytes are referred to as transport overhead.

Synchronous payload envelope

Columns 4 through 90 (the remainder of the frame), are reserved for payload signals (for example, DS1 and DS3) and is referred to as the STS-1 synchronous payload envelope (STS-1 SPE). The optical counterpart of the STS-1 is the optical carrier level 1 signal (OC-1), which is the result of a direct optical conversion after scrambling.

SONET Layers

SONET layers

SONET divides its processing functions into the following three layers:

- Section
- Line
- Path

These three layers are associated with:

- Equipment that reflects the natural divisions in network spans
- Bytes that carry information used by various network elements

Equipment layers

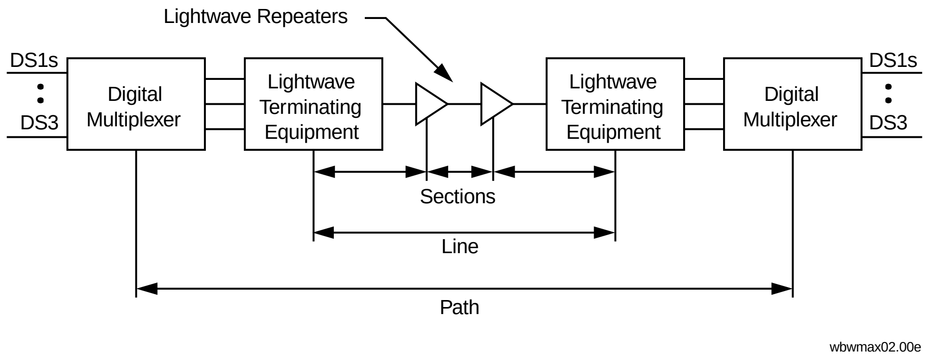
Table A-1, “SONET Equipment Layers” lists and defines each SONET equipment layer.

Table A-1 SONET Equipment Layers

Layer	Definition
Section and Section Terminating Equipment	The transmission spans (Spans between regenerators are also referred to as sections.) between lightwave terminating equipment and the regenerators. This equipment provides regenerator functions which terminate the section overhead to provide single-ended operations and section performance monitoring.
Line and Line Terminating Equipment	The transmission span between terminating equipment (STS-1 cross-connects) that provides line performance monitoring.
STS-1 and Virtual Tributary (VT) Path Terminating Equipment	The SONET portion of the transmission span for an end-to-end tributary (DS1 or DS3) signal that provides signal labeling and path performance monitoring for signals as they are transported through a SONET network. STS-1 path terminating equipment also provides cross-connections for lower-rate, (that is, DS1) signals. A VT is a sub-DS3 payload and is described later in more detail.

Figure A-2, “Section, Line, and Path Definitions” illustrates the equipment layers (section, line, and path) in a signal path.

Figure A-2 Section, Line, and Path Definitions



Overhead byte layers

Table A-2 “Overhead Byte Layers” lists and defines the overhead associated with each SONET layer.

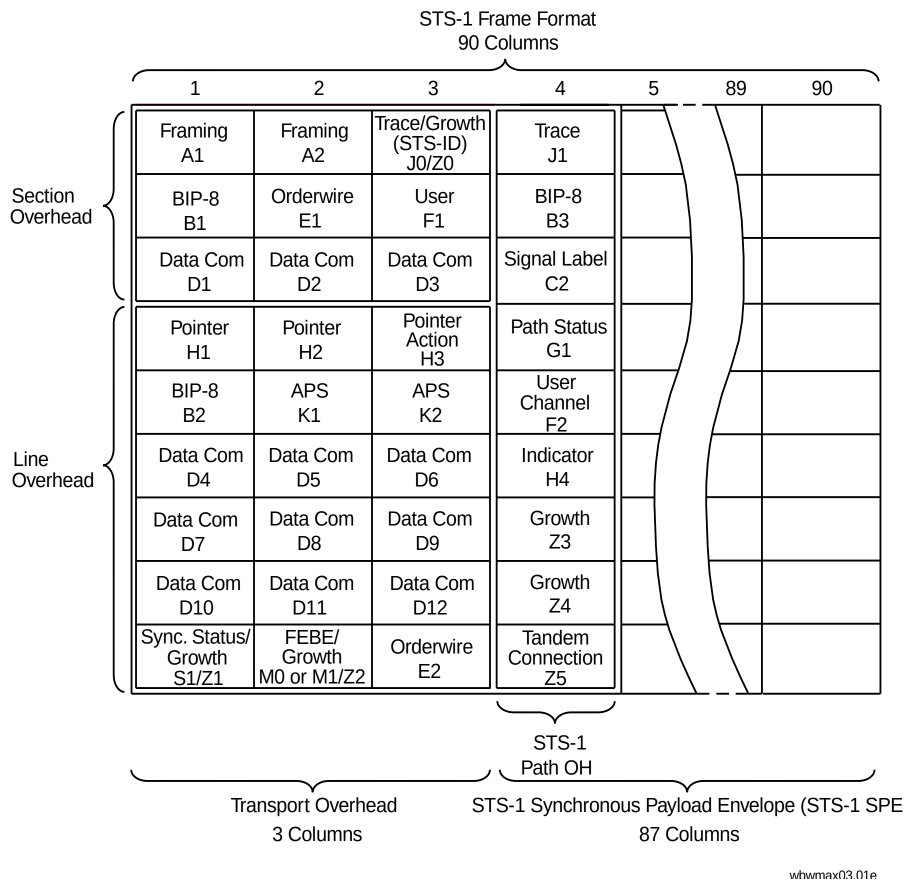
Table A-2 Overhead Byte Layers

Overhead Byte Layer	**Definition**
Section	Contains information that is used by all SONET equipment including repeaters.
Line	Used by all SONET equipment except repeaters.
Path	Carried within the payload envelope across the end-to-end path with: • STS-1 remaining with the STS-1 SPE until its payload is demultiplexed • VTN (N= 1.5, 2, 3, or 6) remaining with the VTN until it is demultiplexed to its asynchronous signal

Figure of SONET Frame Format

Figure A-3, “SONET Frame Format” illustrates each SONET layer and its set of overhead bytes.

Figure A-3 SONET Frame Format



SONET Frame Structure

Introduction

This section provides detailed information on the locations and functions of various overhead bytes for each of the following SONET layers:

- Section
- Line
- Path (STS-1 and VT)

Section overhead

Table A-3 “Section Overhead Bytes” identifies the location and function of each section overhead byte.

Table A-3 Section Overhead Bytes

Byte	Location and Function
Framing (A1 & A2)	Provides framing for each STS-1.
Trace/Growth (J0/Z0)	The Section Trace and Section Growth bytes replace STS-1 ID (C1). J0/Z0 are for future use and the locations are as follows: • J0 byte is in the first STS-1 of an STS-N. • Z0 byte is in the second through Nth STS-1 of the STS-N.
Section Bit Interleaved Parity (BIP-8) (B1)*	Provides section performance monitoring and is calculated over all bits of the previous STS-N frame.
Section Orderwire (E1)*	Provides a local orderwire for voice communication channel between regenerators.
Section User Channel (F1)*	Set aside for the purpose of the user.
Section Data Communications Channel (D1, D2, D3)*	A 192 kb/s message-based channel that is used for alarms, maintenance, control, monitoring, and other communication needs between section terminating equipment.

* Defined only for STS-1 #1 of an STS-N signal.

Line overhead

Table A-4 “Line Overhead Bytes” identifies the location and function of each line overhead byte.

Table A-4 Line Overhead Bytes

Byte	Location and Function
Pointer (H1, H2)	Two bytes indicating the offset in bytes between the pointer action byte (H3) and the first byte (J1) of the STS-1 synchronous payload envelope (SPE).
Pointer Action (H3)	Allocated for frequency justification.
Line Bit Interleaved Parity (BIP-8) (B2)	Provided for line performance monitoring in all STS-1 signals within an STS-N signal.
Automatic Protection Switching (APS) (K1, K2)*	Two bytes used for APS signaling between line level entities. In addition, bits 6, 7, and 8 of K2 are used for line alarm indication signal (AIS) and line far-end receive failure (FERF).
Line Data Communications Channel (D4 - D12)	This is a 576 kb/s message-based channel.
Synchronization Status (S1)	• Located in the first STS-1 of an STS-N. • Conveys the synchronization status of the Network Element.
Growth (Z1)	• Located in the second through Nth STS-1 of an STS-N. • Reserved for future growth.
Line Orderwire (E2)*	Allocated to be used as an express orderwire between line entities.

* Defined only for STS-1 #1 of an STS-N signal.

STS-1 path overhead

The STS-1 path overhead is assigned to and remains with the STS-1 SPE until the payload is demultiplexed and is used for functions that are necessary to transport all synchronous payload envelopes.

Use Table A-5 “STS-1 Path Overhead Bytes” to determine the location and function of each STS-1 path overhead byte.

Table A-5 STS-1 Path Overhead Bytes

Byte	Location and Function
STS-1 Path Trace (J1)	Repetitively transmits a 64 byte, fixed length string so that an STS-1 path receiving terminal can verify its continued connection to the intended transmitter.
STS-1 Path Bit Interleaved Parity (BIP-8) (B3)	Provides each STS-1 path performance monitoring. This byte is calculated over all bits of the previous STS-1 SPE before scrambling.
STS-1 Path Signal Label (C2)	Indicates the construction of the STS-1 synchronous payload envelope (SPE).
Path Status (G1)	Conveys the STS-1 path terminating status, performance, and remote defect indication (RDI) signal conditions back to an originating STS-1 path terminating equipment.
Path User Channel (F2)	Reserved for user communication.
Indicator (H4)	Provides a general multiframe indicator for VT-structured payloads.
Path Growth (Z3 - Z4)	Reserved for future growth.
Tandem Connection (Z5)	Allocated for Tandem Connection Maintenance and the Path Data Channel, as specified by ANSI T1.105.05.

SPE values

Table A-6, “Synchronous Payload Envelopes” lists the types of STS-1 synchronous payload envelope values and their meanings. The system can generate 00, 01, or 04 and can carry any of the other values within the path layer overhead.

Table A-6 Synchronous Payload Envelopes

Hexidecimal Code	STS-1 SPE
00	Unequipped
01	Equipped nonspecific payload
02	VT-Structured STS-1 SPE
04	Asynchronous mapping for DS3
12	DS4NA Asynchronous mapping
13	Mapping for ATM
14	Mapping for DQDB
15	Asynchronous mapping FDDI

VT path overhead

Virtual tributary (VT) path overhead provides important functions for managing sub-STS-1 payloads; such as, error checking, path status, and signal label. These functions are similar to those provided for STS-1 paths.

SONET Digital Multiplexing

Introduction

SONET provides the following two multiplexing schemes:

- Asynchronous
- Synchronous

Asynchronous multiplexing

When fiber optic facilities are used to carry DS3 signals, the signal consists of a combination of the following payload signals:

- 28 DS1s
- 14 DS1s
- 7 DS2s

M23 format

Typically, 28 DS1 signals are multiplexed into a DS3 signal, using the M23 format. The M23 format involves bit interleaving of four DS1 signals into a DS2 signal and then bit interleaving of seven DS2 signals into a DS3. In addition, the DS3 rate is not a direct multiple of the DS1 or the DS2 rates due to the bit-stuffing synchronization technique used in asynchronous multiplexing.

Disadvantages of M23 format

When using an M23 format, identification of DS0s contained in any DS-N signal is complex, and DS0s cannot be directly extracted. An asynchronous DS3 signal must be demultiplexed down to the DS1 level to access and cross-connect DS0 and DS1 signals. In addition, the M23 format does not provide an end-to-end overhead channel for use by OAM&P groups.

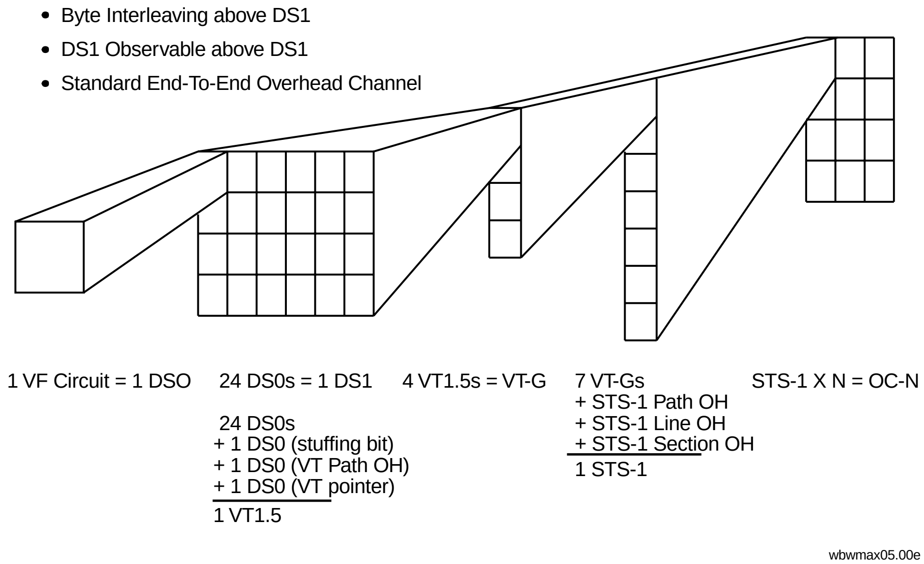
Synchronous multiplexing

Synchronous multiplexing is the SONET method of byte interleaving DS1s to a higher signal rate, which permits economical extraction of a single DS1 without the need to demultiplex the entire STS-1 SPE. In addition, SONET provides overhead channels for use by OAM&P groups.

Figure of synchronous multiplexing

Figure A-4 “Synchronous Multiplexing” illustrates the SONET technique of mapping a single asynchronous DS1 signal into an STS-1 SPE.

Figure A-4 Synchronous Multiplexing



Transporting SONET payloads

Sub-DS3 asynchronous signals (DS1, DS1C, DS2, and E1) are *byte interleaved* into a digital signal called a virtual tributary (VT). The VT is a structure designed for the transport and switching of sub-DS3 payloads. There are four sizes of VTs: 1.5, 2, 3, and 6.

Table Digital signals DS1 and DS3 are the most important asynchronous signals in the current network. Broadband payloads, such as ATM, are also of great importance.

Table A-7 “SPE Payloads” provides the digital signals that can be transported as SONET payloads.

Table A-7 SPE Payloads

Input Tributary	Voice Channels (DS0s)	Rate	SONET Signal	Rate
DS1	24 DS0s	1.544 Mb/s	VT1.5	1.728 Mb/s
E1 (CEPT)	32 DS0s	2.048 Mb/s	VT2	2.304 Mb/s
DS1C	48 DS0s	3.152 Mb/s	VT3	3.456 Mb/s
DS2	96 DS0s	6.312 Mb/s	VT6	6.912 Mb/s
DS3	672 DS0s	44.736 Mb/s	STS-1	51.840 Mb/s
DS4NA	2016 DS0s	139.264 Mb/s	STS-3c	155.520 Mb/s
ATM	2016 DS0s	149.760 Mb/s	STS-3c	155.520 Mb/s
FDDI	2016 DS0s	125.000 Mb/s	STS-3c	155.520 Mb/s

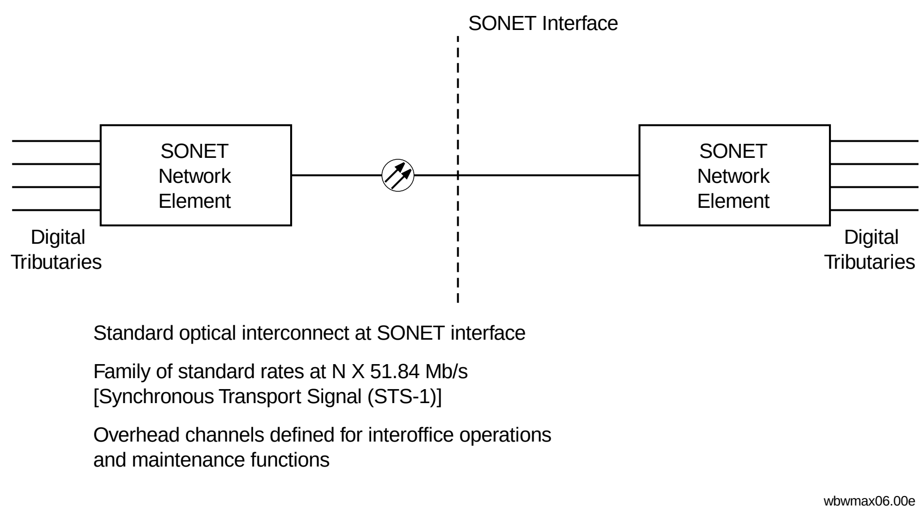
SONET Interface

Introduction This section describes the SONET interface.

Description The SONET interface provides the optical mid-span meet between SONET network elements. A SONET network element is the hardware and software that affects the termination or repeating of a SONET standard signal.

Figure of SONET interface Figure A-5 "SONET Interface" displays the SONET interface.

Figure A-5 SONET Interface



SONET Multiplexing Process

Introduction

SONET provides for multiplexing of asynchronous DS1s, synchronous DS1s, and asynchronous DS3s.

Multiplexing Process

The following describes the process for multiplexing a signal.

1 Input DS1 or DS3 tributary is mapped.

In the case of DS1 inputs, three time slots (DS0s) are added to the incoming signal, becoming a VT1.5.

An asynchronous DS1 that fully meets the specified rate is mapped into the VT1.5 SPE as clear channel input since no framing is needed.

- Each VT1.5 carries a single DS1 payload.
- Four VT1.5s are bundled into a VT group (VT-G).
- Seven VT-Gs are byte interleaved into an STS-1 frame.

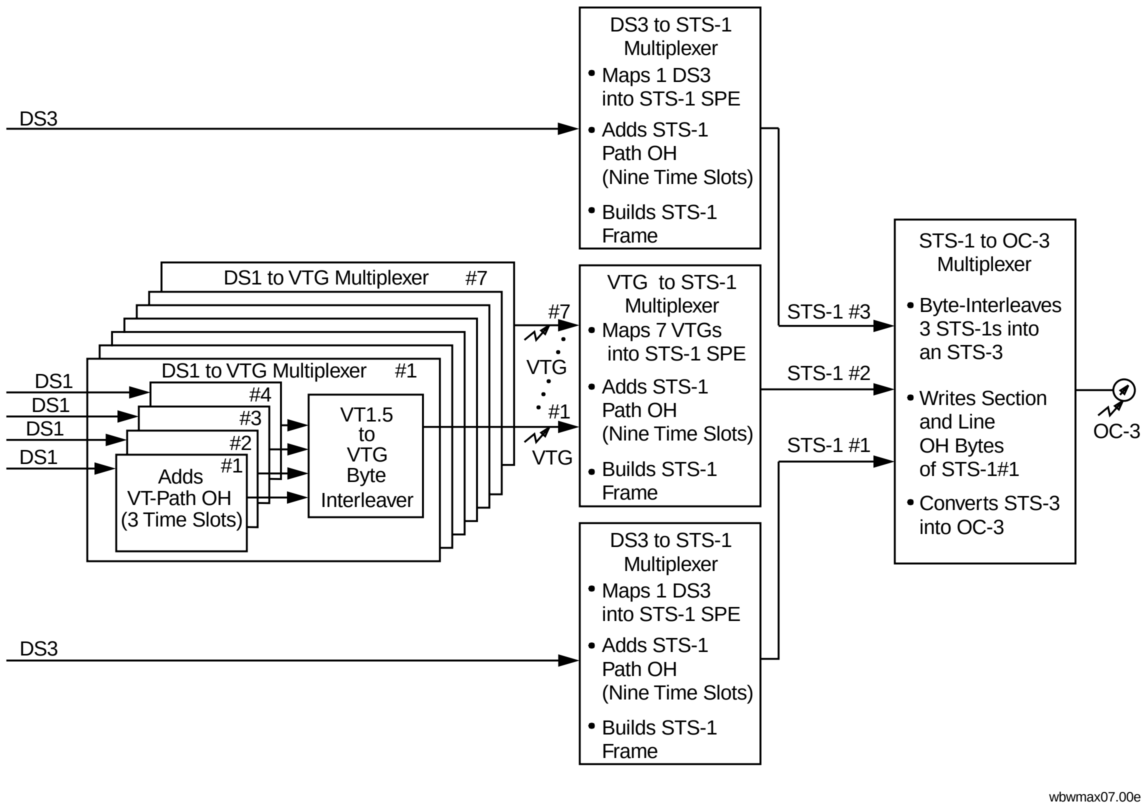
Important! The VT-G to-STS-1 multiplex is a simple byte interleaving process, so individual VT signals are easily observable within the STS-1. Thus, cross-connections and add/drop can be accomplished without the back-to-back mux/demux steps required by asynchronous signal formats.

2 After VTs are multiplexed into the STS-1 SPE, the path, line, and section overhead is added.

3 Scrambled STS-N signal is transported to the optical stage.

Figure SONET Multiplexing Process illustrates the SONET multiplexing process.

Figure A-6 SONET Multiplexing Process



SONET Demultiplexing Process

Introduction

Demultiplexing is the inverse of multiplexing. This topic describes how to demultiplex a signal.

Demultiplexing Process

The following describes the process for demultiplexing an STS-1 signal to a DS1 signal.

1 The unscrambled STS-1 signal from the optical conversion stages is processed to extract the section and line overhead and accurately locate the SPE.

2 The STS-1 path overhead is processed to locate the VTs. The individual VTs are then processed to extract VT overhead and, via the VT pointer, accurately locate the DS1.

3 The DS1 is desynchronized, providing a standard DS1 signal to the asynchronous network.

Key points

Remember the following key points when demultiplexing a signal:

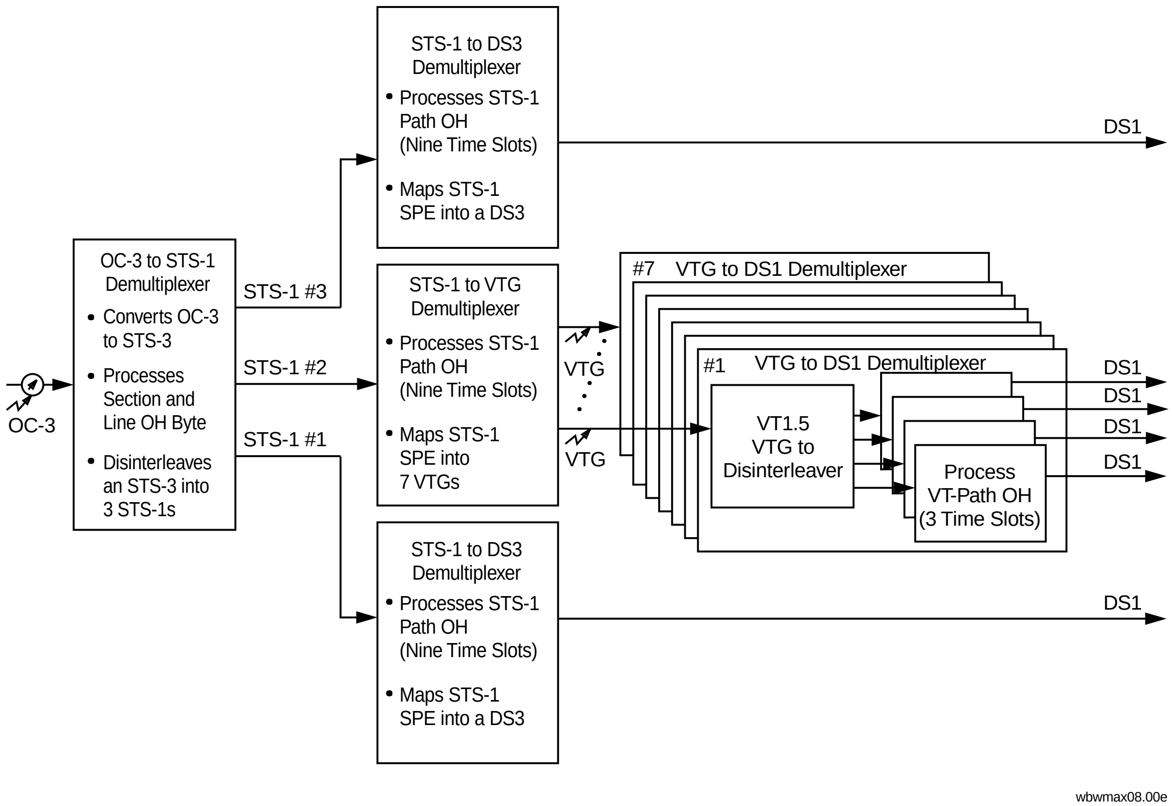
- The SONET frame is a fixed time (125 *m*s) and no bit-stuffing is used.
- The synchronous payload envelope (SPE) can *float* within the frame. This is to permit compensation for small variations in frequency between the clocks of the two systems that may occur if the systems are independently timed (plesiochronous timing). The SPE can also *drift* across the 125-*m*s frame boundary.

  Important! SONET STS pointers are used to locate the SPE relative to the transport overhead.

Figure of SONET demultiplexing process

Figure A-7 “SONET Demultiplexing Process” illustrates the SONET demultiplexing process.

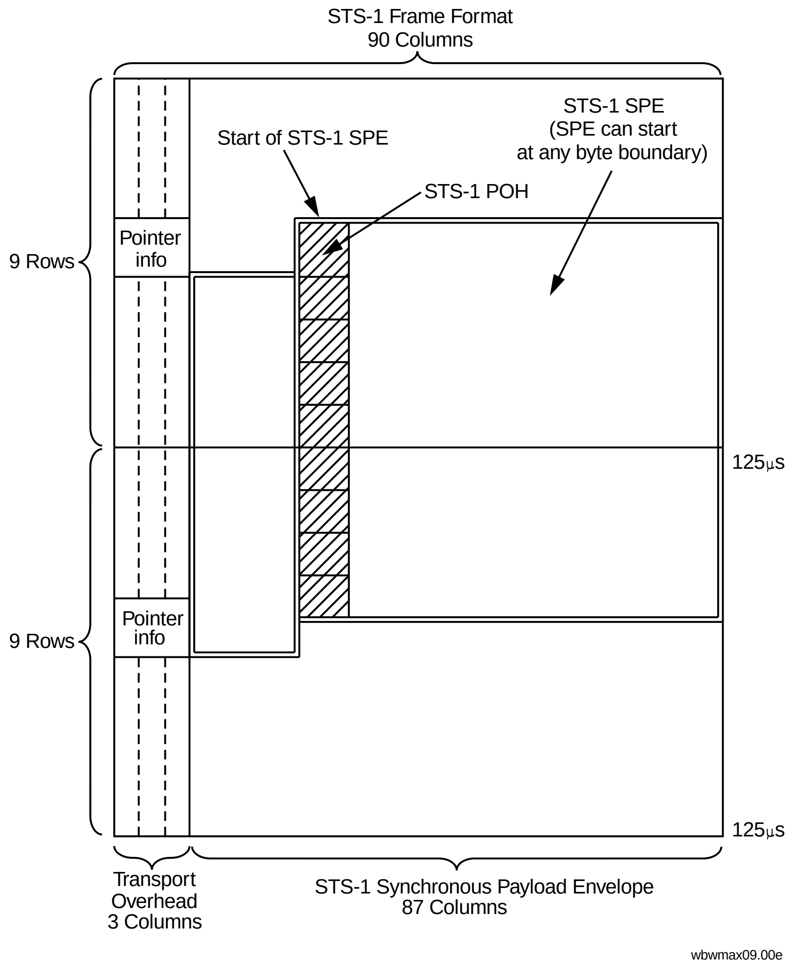
Figure A-7 SONET Demultiplexing Process



SPE figure

STS-1 SPE in Interior of STS-1 Frame illustrates the SPE floating within an STS-1 frame.

Figure A-8 STS-1 SPE in Interior of STS-1 Frame



SONET Transport Rates

Introduction

Higher rate SONET signals are created by byte-interleaving N STS-1s to form an N STS-1 signal.

Creating higher rate signals

The desired N STS-1s are created by:

- Adjusting all payload pointers and regenerating the section and line overhead bytes to be in phase with each other and the outgoing multiplexed signal
- Scrambling and converting the N STS-1 to an optical carrier – level N (OC-*N*) signal

SONET transport rates

Table A-8 “SONET Transport Rates” displays the SONET transport rates.

Table A-8 SONET Transport Rates

OC Level	Line Rate (Mb/s)	Capacity
OC-1	51.84	28 DS1s or 1 DS3
OC-3	155.52	84 DS1s or 3 DS3s
OC-12	622.08	336 DS1s or 12 DS3s
OC-48	2488.32	1344 DS1s or 48 DS3s
OC-192	9953.28	5376 DS1s or 192 DS3s

Appendix B: Port Unit Data Sheets

Overview

Purpose

This chapter provides data sheets for the port units in WaveStar TDM 2.5G/10G (2-Fiber).

Composition of Data Sheets

The data sheets provide technical specifications about each type of port unit used in WaveStar TDM 2.5G/10G (2-Fiber) in a singular location. Some information in the data sheets is also included in other chapters of this document.

Using the data sheets

The different port units are arranged so that information about each type of port unit may be pulled from Appendix B intact.

□

Port Unit and Software Compatibility

Overview

Purpose

This section provides compatibility information for the WaveStar TDM 2.5G/10G (2-Fiber) port units and software.

□

Port Unit and Software Compatibility

Standard port unit codes, names, and compatible software

The following table shows the standard port units and the compatible software.

Code	Name	Compatible Software Release						
		2.5G 2.0.0	2.5G 3.0.1	10G 1.0.0	2.5G/ 10G 4.0.0	2.5G/ 10G 4.1.x	2.5G/ 10G 5.x.x	2.5G/ 10G 6.x.x
LEY17	DS3EC1/8 Port Unit	X	X	X	X	X	X	X
LEY309	GE1/SX2 Port Unit						X	X
SEN3	OBA					X	X	X
SEN4	OBPA						X	X
LEY13	OC12/STM4/1.3LR2 Port Unit	X	X	X	X	X	X	X
LEY14	OC12/STM4/1.3SR2 Port Unit		X	X	X	X	X	X
LEY15	OC3/STM1/1.3LR4 Port Unit	X	X	X	X	X	X	X
LEY16	OC3/STM1/1.3SR4 Port Unit		X	X	X	X	X	X
LEY23	OC3/STM1/1.3SR8 Port Unit						X	X
LEY7	OC48/STM16/1.3LR1 Port Unit	X	X	X	X	X	X	X
LEY8	OC48/STM16/1.5LR1 Port Unit	X	X	X	X	X	X	X
LEY50 - LEY65	OC48/STM16 /DWDM01 - 16 Port Unit	X	X	X	X	X	X	X
LEY80 - LEY95	OC48/STM16/POU9590 - POU9210 Port Unit		X		X	X	X	X
LEY101 - LEY180	OC48/STM16/WDM9585 - WDM9190 Port Unit				X	X	X	X
LEY182	OC48/STM16/1.3VSR1 Port Unit						X	X
LEY67	OC192/STM64/1.5SR1 Port Unit			X	X	X	X	X
LEY69	OC192/STM64/1.5IR1 Port Unit				X	X	X	X
LEY97	OC192/STM64/1.5IRS1 Port unit				X	X	X	X

Code	Name	Compatible Software Release						
		2.5G 2.0.0	2.5G 3.0.1	10G 1.0.0	2.5G/ 10G 4.0.0	2.5G/ 10G 4.1.x	2.5G/ 10G 5.x.x	2.5G/ 10G 6.x.x
LEY201 - LEY240	OC192/STM64/WDM9580 - WDM9190 Port Unit				X	X	X	X
LEY284 - LEY299	OC192/STM64/POU9590 - POU9210 Port Unit				X	X	X	X

NEBS Level 3 Compliant Circuit Pack Codes, Names, and Compatible Software

The following table shows the NEBS level 3 compliant circuit packs/port units and the compatible software.

Code	Name	Compatible Software Release						
		2.5G 2.0.0	2.5G 3.0.1	10G 1.0.0	2.5G/ 10G 4.0.0	2.5G/ 10G 4.1.x	2.5G/ 10G 5.x.x	2.5G/ 10G 6.x.x
LEY17AE	DS3EC1/8 Port Unit	X	X	X	X	X	X	X
LEY309AE	GE1/SX2 Port Unit						X	X
LEY310AE	GE1/LX2 Port Unit							X
SEN3AE	OBA					X	X	X
SEN4AE	OBPA						X	X
LEY13AE	OC12/STM4/1.3LR2 Port Unit	X	X	X	X	X	X	X
LEY14AE	OC12/STM4/1.3SR2 Port Unit		X	X	X	X	X	X
LEY15AE	OC3/STM1/1.3LR4 Port Unit	X	X	X	X	X	X	X
LEY16AE	OC3/STM1/1.3SR4 Port Unit		X	X	X	X	X	X
LEY23AE	OC3/STM1/1.3SR8						X	X
LEY7AE	OC48/STM16/1.3LR1 Port Unit	X	X	X	X	X	X	X
LEY8AE	OC48/STM16/1.5LR1 Port Unit	X	X	X	X	X	X	X
LEY50AE - LEY65AE	OC48/STM16/DWDM01 - 16 Port Unit	X	X	X	X	X	X	X
LEY80AE - LEY95AE	OC48/STM16/POUxxxx Port Unit		X		X	X	X	X

Code	Name	Compatible Software Release						
		2.5G 2.0.0	**2.5G 3.0.1**	**10G 1.0.0**	**2.5G/ 10G 4.0.0**	**2.5G/ 10G 4.1.x**	**2.5G/ 10G 5.x.x**	**2.5G/ 10G 6.x.x**
LEY101AE - LEY180AE	OC48/STM16/WDM9585 - WDM9190 Port Unit				X	X	X	X
LEY182AE	OC48/STM16/1.3VSR1 Port Unit						X	X
LEY67AE	OC192/STM64/1.5SR1 Port Unit			X	X	X	X	X
LEY69AE	OC192/STM64/1.5IR1 Port Unit				X	X	X	X
LEY97AE	OC192/STM64/1.5IRS1 Port Unit					X	X	X
LEY201AE - LEY240AE	OC192/STM64/WDM9580 - WDM9190 Port Unit				X	X	X	X
LEY284AE - LEY299AE	OC192/STM64/POU9590 - POU9210 Port Unit				X	X	X	X
LEY384AE -LEY399AE	OC192/STM64/POU9580 -POU9220 Port Unit						X	X

□

OC192/STM64 Port Unit Data Sheets

Overview

Purpose This section provides detailed information concerning all OC192/STM64 port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

OC192/STM64/1.5SR1 (LEY67/LEY67AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/1.5SR1 (short reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity

Each OC192/STM64/1.5SR1 port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access

The table below describes OC-192 capabilities.

Table B-1 OC192/STM64/1.5SR1 Access

Specification	Description
Interface	short-reach (40 km) interface[a]
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. 50 km can be achieved with forward error correction (FEC). The actual value must be calculated using measured data (see Figure B-1).

Protection switching

The table below describes protection switching information per high speed line.

Table B-2 Protection Switching for OC192/STM64/1.5SR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/1.5SR1 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC192/STM64/1.5SR1 port units is 800 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC192/STM64/1.5SR1 port units.

Table B-3 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

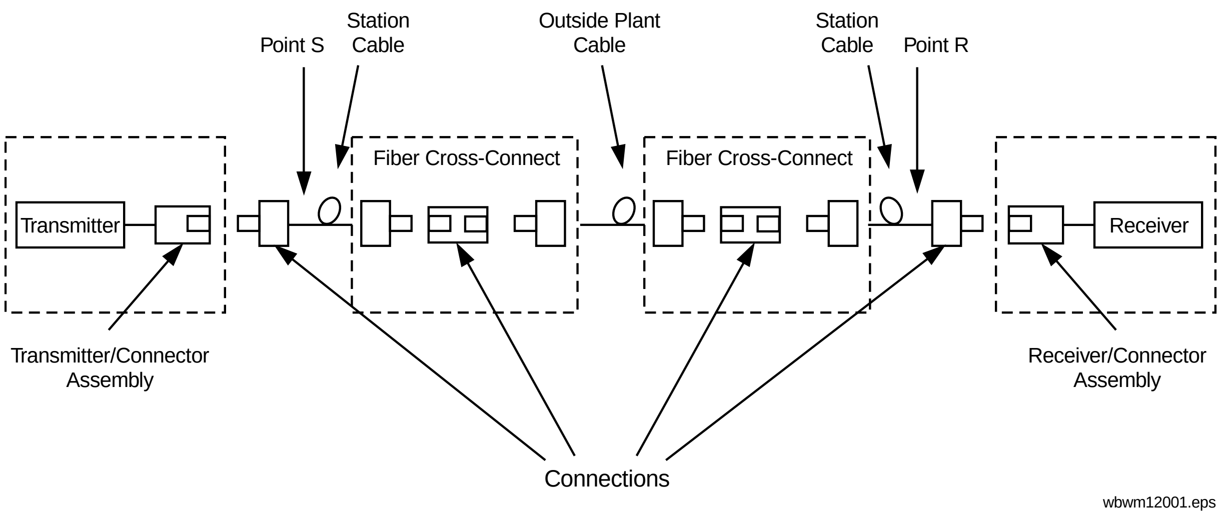
The table below provides transmission specifications for the OC192/STM64/1.5SR1 port units.

Table B-4 Transmission Specifications for OC192/STM64/1.5SR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Electro-absorptive Modulated Laser (EML)

Optical system interfaces The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-1 Optical System Interfaces



Optical requirements and loss budgets

The following table lists the optical requirements and loss budgets for the OC192/STM64/1.5SR1 port units.

Table B-5 Optical Loss Budgets for the OC192/STM64/1.5SR1 Port Units

Parameter	OC192/STM64/1.5SR1 Port Unit[(a)]
Maximum Transmitter Output Power (P_{Tmax}) [(b)]	2.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [(c)]	–4.0 dBm
Maximum Received Power (P_{Rmax}) [(d)]	–13.0 dBm
Receiver Sensitivity (P_{Rmin}) [(c) (d)]	–21.0 dBm
Minimum System Gain (S-R)	17.0 dB
Optical Path Penalty (P_O)	2.0 dB
Minimum Loss Budget[(e)]	10.0 dB
Maximum Loss Budget[(f)]	15.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-1.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.
(e) This value assumes that the maximum received power limitations are not exceeded.
(f) Dispersion is limited to 40 km for short-reach optics. (50 km can be achieved with FEC.)

OC192/STM64/1.5IR1 (LEY69/LEY69AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/1.5IR1 (extended intermediate reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity

Each OC192/STM64/1.5IR1 port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access

The following table describes OC-192 capabilities.

Table B-6 OC192/STM64/1.5IR1 Access

Specification	Description
Interface	Extended intermediate-reach (60 km) interface
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Protection switching

The following table describes protection switching information per high speed line.

Table B-7 Protection Switching for OC192/STM64/1.5IR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/1.5IR1 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC192/STM64/1.5IR1 port units is 1200 ps/nm.

Optical return loss

The following table provides the optical return loss for a system using OC192/STM64/1.5IR1 port units.

Table B-8 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The following tables provides transmission specifications for the OC192/STM64/1.5IR1 port units.

Table B-9 Transmission Specifications for OC192/STM64/1.5IR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber:
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	2.0 nm (RMS)
Optical Source	CW[a] Laser with a Mach-Zender Modulator

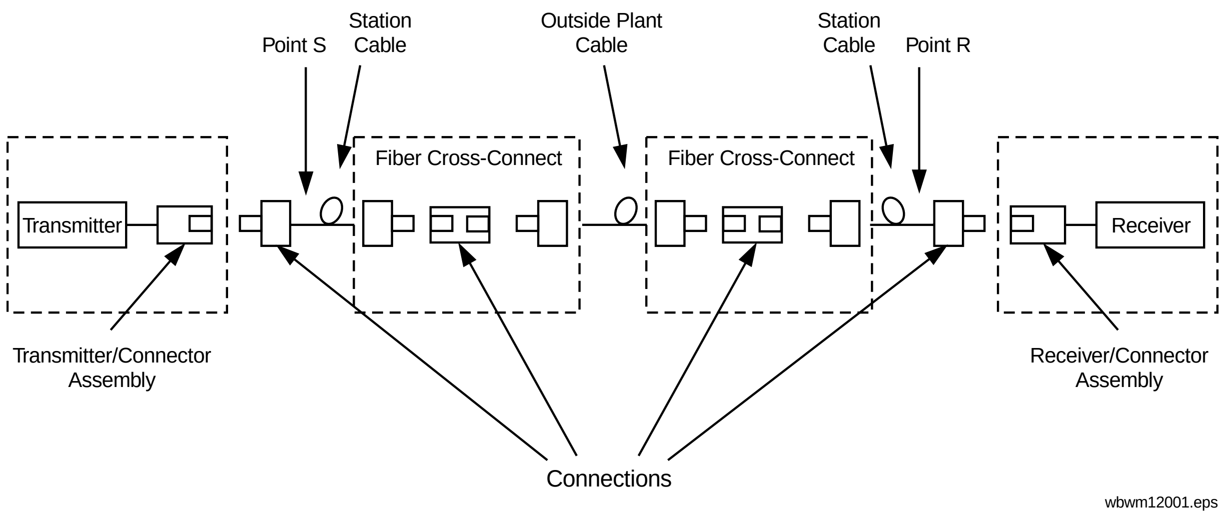
Notes

(a) Continuous Wave

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-2 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC192/STM64/1.5IR1 port units.

Table B-10 Optical Loss Budgets for the OC192/STM64/1.5IR1 Port Units

Parameter	**OC192/STM64/1.5IR1 Port Units** [(a)]
Maximum Transmitter Output Power (P_{Tmax}) [(b)]	2.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [(c)]	–1.0 dBm
Maximum Received Power (P_{Rmax}) [(d)]	–8.0 dBm
Receiver Sensitivity (P_{Rmin}) [(c) (d)]	–21.0 dBm
Minimum System Gain (S-R)	20.0 dB
Optical Path Penalty (P_O)	2.0 dB
Minimum Loss Budget	10.0 dB
Maximum Loss Budget	18.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-2.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.

OC192/STM64/1.5IRS1 (LEY97/LEY97AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/1.5IRS1 (intermediate reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

OC192/STM64/1.5IRS1 port units are capable of transmitting and receiving one intermediate reach OC-192/STM-64 signal with strong forward error correction (SFEC) and a pin receiver in the 1.5 µm range (up to 40 km).

Capacity

Each OC192/STM64/1.5IRS1 port unit supports one bidirectional (one receive and one transmit) OC-192/STM-64 formatted optical signal. The capacity may be translated to 192 STS-1/64 STM-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192/STM-64 access

The following table describes OC-192/STM-64 capabilities.

Table B-11 OC192/STM64/1.5IRS1 Access

Specification	Description
Interface	Extended intermediate-reach (40 km) interface
Growth Increment	One OC-192/STM-64 per port unit
Line Code	Scrambled NRZ

Protection switching

The following table describes protection switching information per high speed line.

Table B-12 Protection Switching for OC192/STM64/1.5IRS1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/1.5IRS1 port unit, is Class I in the FDA/CDRH Classification SystemLevel 1 in the IEC Classification System.

Optical dispersion

The optical dispersion for the OC192/STM64/1.5IRS1 port units is 800 ps/nm.

Optical return loss

The following table provides the optical return loss for a system using OC192/STM64/1.5IRS1 port units.

Table B-13 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The following table provides transmission specifications for the OC192/STM64/1.5IRS1 port units.

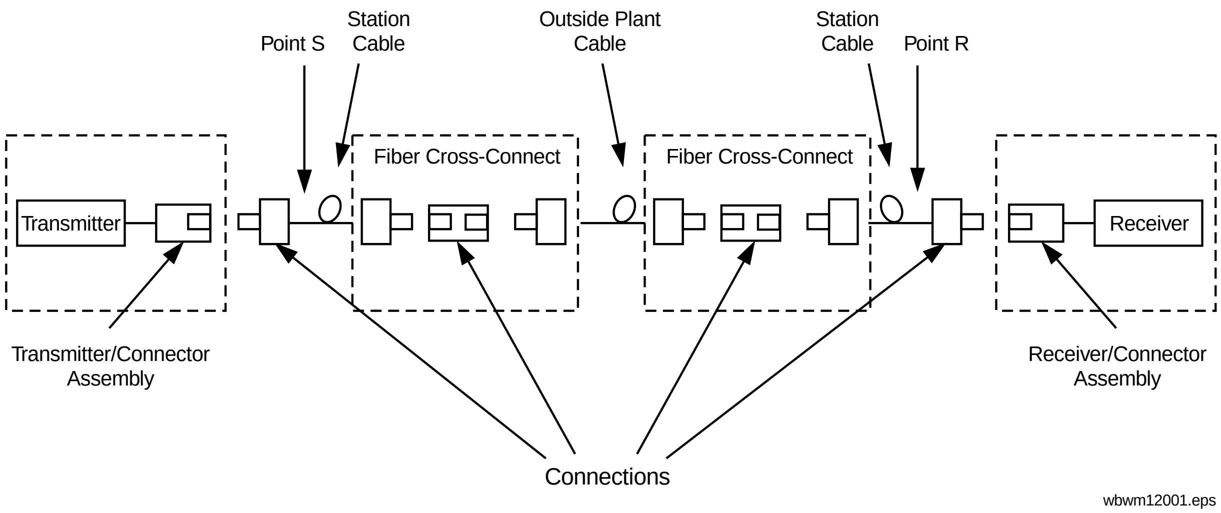
Table B-14 Transmission Specifications for OC192/STM64/1.5IRS1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	2c.0 nm (RMS)
Optical Source	Electro-absorptive Modulated Laser (EML)

Optical system interfaces

Figure B-3, Optical System Interfaces (page B-19) illustrates the optical path between the transmitter and the receiver.

Figure B-3 Optical System Interfaces



Optical requirements and loss budgets

The following table lists the optical requirements and loss budgets for the OC192/STM64/1.5IRS1 port units.

Table B-15 Optical Loss Budgets for the OC192/STM64/1.5IRS1 Port Units

Parameter	OC192/STM64/1.5IRS1 Port Unit[a]
Maximum Transmitter Output Power (P_{Tmax})[b]	2.0 dBm
Minimum Transmitter Output Power (P_{Tmin})[c]	–1.0 dBm
Maximum Received Power (P_{Rmax})[d]	–3.0 dBm
Receiver Sensitivity (P_{Rmin})[c,d]	–14.0 dBm
Minimum System Gain (S-R)	13.0 dB
Optical Path Penalty (P_O)	2.0 dB
Minimum Loss Budget	5.0 dB
Maximum Loss Budget	11.0 dB

a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.

b) Transmit and receive points are referenced as points S and R in Figure B-3.

c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.

d) These values are measured at a BER of $1x10^{-12}$

OC192/STM64/1.5LR1 (LEY69/LEY69AE Plus SEN3AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/1.5LR1 (long reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

The OC192/STM64/1.5LR1 make up

The OC192/STM64/1.5LR1 port unit is actually a combination of two port units working together. In order to achieve long-reach capabilities at the OC-192 level, the OC192/STM64/1.5IR1 (extended intermediate-reach) port unit must be combined with and Optical Booster Amplifier (OBA). When the OC-192 port units are used in conjuction with the OBA port unit, a maximum transmission distance of up to 80 km is achieved.

Important! All specifications below are derived from the combination of the OC192/STM64/1.5IR1 (extended intermediate-reach) port unit and the OBA port unit.

Optical Booster Amplifier

For information on the OBA port units themselves, refer to the “Optical Amplifier Port Unit Data Sheets” section later in this appendix.

Capacity

Each OC192/STM64/1.5LR1 port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access

The table below describes OC-192 capabilities.

Table B-16 OC192/STM64/1.5LR1 Access

Specification	Description
Interface	Extended long-reach (80 km) interface
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-17 Protection Switching for OC192/STM64/1.5LR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/1.5LR1 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC192/STM64/1.5LR1 port units (the LEY69AE paired with the SEN3AE) is 1600 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC192/STM64/1.5LR1 port units.

Table B-18 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC192/STM64/1.5LR1 port units.

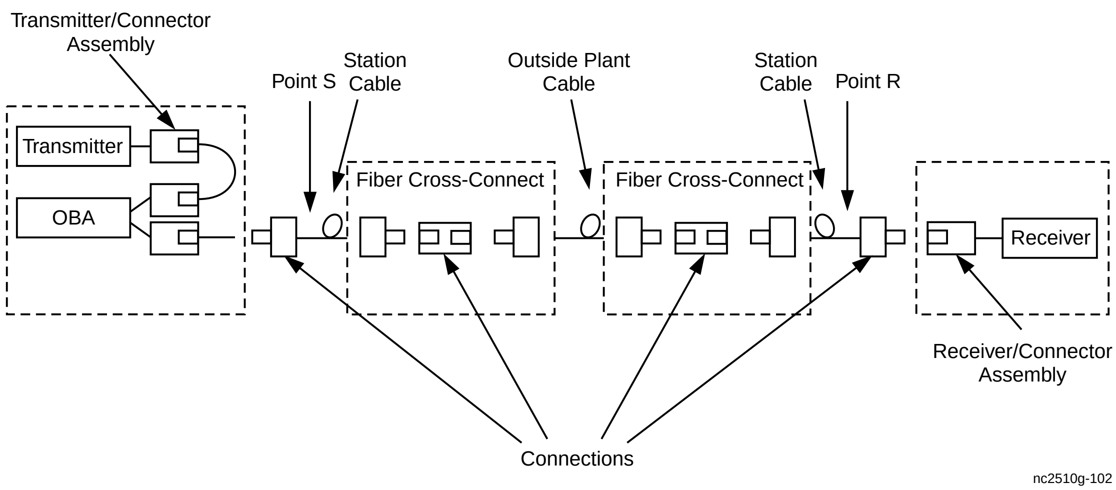
Table B-19 Transmission Specifications for OC192/STM64/1.5LR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber:
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	1.0 nm (RMS)
Optical Source	Continuous Wave (CW) Laser with a Mach Zender Modulator (MZM)]

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-4 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC192/STM64/1.5LR1 port units.

Table B-20 Optical Loss Budgets for the OC192/STM64/1.5LR1 Port Units

Parameter	OC192/STM64/1.5LR1 Port Units [a] [e] [f]	
	Using LEY69/LEY69AE	Using LEY97/LEY97AE
Maximum Transmitter Output Power (P_{Tmax}) [b]	+13.0 dBm	+13.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [c]	+10.0 dBm	+10.0 dBm
Maximum Received Power (P_{Rmax}) [d]	-8.0 dBm	-3.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	21.0 dBm	14.0 dBm
Minimum System Gain (S-R)	18.0 dB	13.0 dB
Optical Path Penalty (P_O)	2.0 dB	2.0 dB
Minimum Loss Budget	16.0 dB	11.0 dB
Maximum Loss Budget	29.0 dB	22.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.

(b) Transmit and receive points are referenced as points S and R in Figure B-4.

(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.

(e) The SEN3AE (OBA) should not be paried with LEY67/LEY67AE. The SEN3AE can be paired with LEY97/LEY97AE, but it will not meet standards dispersion requirements for an OC192 long-reach interface.

(f) The automatic laser shutdown (ALS) feature can only be used if the paired OC192/STM64 port unit is an LEY69AE, LEY97AE, or LEY228AE.

□

OC192/STM64/1.5VLR1 (LEY228AE Plus SEN4AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/1.5VLR1 (long reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

The OC192/STM64/1.5VLR1 make-up

The OC192/STM64/1.5VLR1 port unit is actually a combination of two port units working together. In order to achieve very long-reach capabilities at the OC-192 level, the LEY228AE port unit must be combined with an Optical Booster Pre-Amplifier (OBPA) and Dispersion Compensating Fiber (DCF). When the OC-192 port units are used in conjuction with the OBPA port units, a maximum transmission distance of up to 120km is achieved.

Whenever the OBPA port units are used, the use of Dispersion Compensating Fiber (DCF) is required. The DCF must be used between the OBPA port unit and the OC-192 port unit on the receiving end of the signal.

> **Important!** All specifications below are derived from the combination of the LEY228AE port unit plus the OBPA port unit.

OBPA port units

For information on the OBPA port units themselves, refer to the "Optical Amplifier Port Unit Data Sheets" section later in this appendix.

Capacity Each LEY228AE port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access The table below describes OC-192 capabilities.

Table B-21 OC192/STM64/1.5VLR1 Access

Specification	Description
Interface	Extended long-reach (120 km) interface
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-22 Protection Switching for OC192/STM64/1.5VLR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the LEY228AE port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the LEY228AE port units.

- LEY228AE + SEN4AE without DCMs – 1200 ps/nm
- LEY228AE + SEN4AE with DCM-40 as pre compensation and DCM-50 as post compensation – 2400 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC192/STM64/1.5VLR1 port units.

Table B-23 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC192/STM64/1.5VLR1 port units.

Table B-24 Transmission Specifications for OC192/STM64/1.5VLR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber:
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelength	1552.52 nm
Spectral Width	2.0 nm (RMS)
Optical Source	CW[(a)] Laser with a Mach Zender Modulator

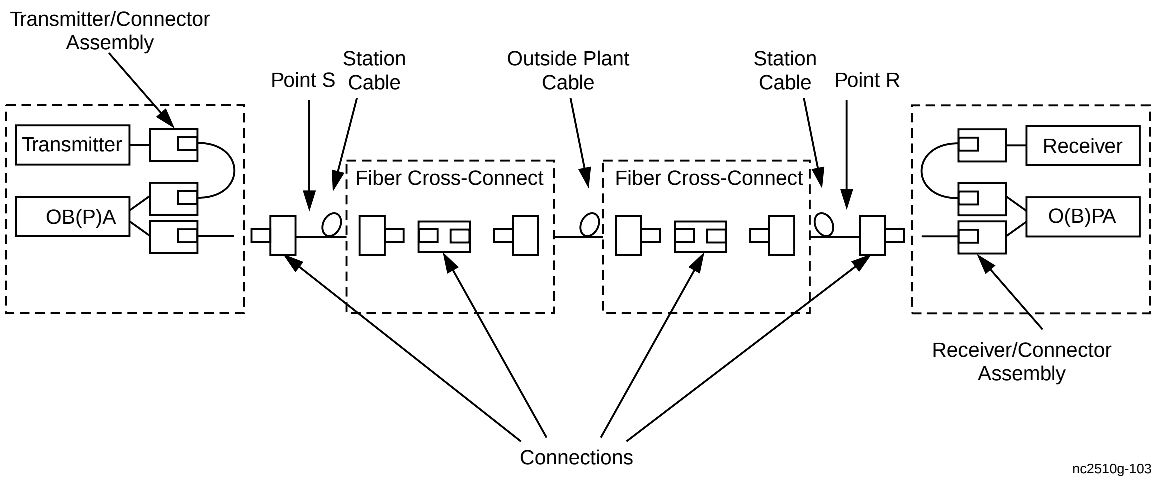
Notes

(a) Continuous Wave

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-5 Optical System Interfaces



In the figure above, the parentheses ( ) indicate the function that is not being used. OB(P)A indicates that the optical booster amplifier function is being used. O(B)PA indicates that the pre-amplifier function is being used.

Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC192/STM64/1.5VLR1 port units.

Table B-25 Optical Loss Budgets for the OC192/STM64/1.5VLR1 Port Units

Parameter	OC192/STM64/1.5VLR1 Port Units [(a)]
Maximum Transmitter Output Power (P_{Tmax}) [(b)]	13.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [(c)]	10.0 dBm
Maximum Received Power (P_{Rmax}) [(d)]	–9.0 dBm
Receiver Sensitivity (P_{Rmin}) [(c) (d)]	–25.0 dBm
Minimum System Gain (S-R)	19.0 dB
Optical Path Penalty (P_O)	2.0 dB
Minimum Loss Budget	22.0 dB
Maximum Loss Budget	33.0 dB

Notes

(a) All values assume that non-dispersion-shifted, standard single-mode (SSMF) fiber is used. Non-dispersion-shifted SSMF, requires pre compensation (DCM-40) and post compensation (DCM-50). Non-zero dispersion-shifted fiber (DSF), such as Lucent Technologies TrueWave, may be used. Using TrueWave fiber eliminates the need for DCMs in most applications. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion-shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-5.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.

OC192/STM64/WDM (LEY201/LEY201AE - LEY240/LEY240AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC192/STM64/WDM passive port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity

Each OC192/STM64/WDM port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access

The table below describes OC-192 capabilities.

Table B-26 OC192/STM64/WDM Access

Specification	Description
Interface	Compatible with WaveStar OLS 1.6T
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-27 Protection Switching for OC192/STM64/WDM Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/WDM port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC192/STM64/WDM port units is compatible with WaveStar® OLS 1.6T. For additional information, refer to the *WaveStar® Optical Line System (OLS) 1.6T Applications Planning Guide* (APG) and *WaveStar® Optical Line System (OLS) 1.6T Applications Ordering Guide* (AOG).

Optical return loss

The table below provides the optical return loss for a system using OC192/STM64/WDM port units.

Table B-28 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC192/STM64/WDM port units.

Table B-29 Transmission Specifications for OC192/STM64/WDM Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	2.0 nm (RMS)
Optical Source	CW[(a)] Laser with a Mach-Zender Modulator

Notes

(a) Continuous Wave

Operating wavelengths

The table below lists the operating wavelengths for the OC192/STM64/WDM port units.

Table B-30 OC192/STM64/WDM Port Unit Operating Wavelengths

Port Unit	Wavelength
OC192/STM64/WDM9580	1531.12 nm
OC192/STM64/WDM9570	1531.90 nm
OC192/STM64/WDM9560	1532.68 nm
OC192/STM64/WDM9550	1533.47 nm
OC192/STM64/WDM9540	1534.25 nm
OC192/STM64/WDM9530	1535.04 nm
OC192/STM64/WDM9520	1535.82 nm
OC192/STM64/WDM9510	1536.61 nm
OC192/STM64/WDM9500	1537.40 nm
OC192/STM64/WDM9490	1538.19 nm
OC192/STM64/WDM9480	1538.98 nm
OC192/STM64/WDM9470	1539.77 nm
OC192/STM64/WDM9460	1540.56 nm
OC192/STM64/WDM9450	1541.35 nm
OC192/STM64/WDM9440	1542.14 nm
OC192/STM64/WDM9430	1542.94 nm
OC192/STM64/WDM9420	1543.73 nm
OC192/STM64/WDM9410	1544.53 nm
OC192/STM64/WDM9400	1545.32 nm
OC192/STM64/WDM9390	1546.12 nm
OC192/STM64/WDM9380	1546.92 nm
OC192/STM64/WDM9370	1547.72 nm
OC192/STM64/WDM9360	1548.52 nm
OC192/STM64/WDM9350	1549.32 nm
OC192/STM64/WDM9340	1550.12 nm
OC192/STM64/WDM9330	1550.92 nm
OC192/STM64/WDM9320	1551.72 nm
OC192/STM64/WDM9310	1552.52 nm

Port Unit	Wavelength
OC192/STM64/WDM9300	1553.33 nm
OC192/STM64/WDM9290	1554.13 nm
OC192/STM64/WDM9280	1554.94 nm
OC192/STM64/WDM9270	1555.75 nm
OC192/STM64/WDM9260	1556.56 nm
OC192/STM64/WDM9250	1557.36 nm
OC192/STM64/WDM9240	1558.17 nm
OC192/STM64/WDM9230	1558.98 nm
OC192/STM64/WDM9220	1559.79 nm
OC192/STM64/WDM9210	1560.61 nm
OC192/STM64/WDM9200	1562.42 nm
OC192/STM64/WDM9190	1562.23 nm

Optical requirements and loss budgets

Because OC192/STM64/WDM port units interface with WaveStar OLS 1.6T, refer to the *WaveStar® Optical Line System (OLS) 1.6T Applications Planning Guide* (APG) to calculate loss budgets.

□

OC192/STM64/POU (LEY284/LEY284AE - LEY299/LEY299AE and LEY348AE - LEY399AE) Data Sheet

Overview This data sheet contains technical specifications for the OC192/STM64/POU passive port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity Each OC192/STM64/POU port unit supports one bidirectional (one receive and one transmit) OC-192 formatted optical signal. The capacity may be translated to 192 STS-1 equivalents or 129,024 two-way voice circuits per port unit.

OC-192 access The table below describes OC-192 capabilities.

Table B-31 OC192/STM64/POU Access

Specification	Description
Interface	Short-reach (40 km) interface
Growth Increment	One OC-192 per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-32 Protection Switching for OC192/STM64/POU Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC192/STM64/POU port unit, is Class I in the FDA/CDRH Classification System

Optical dispersion

The optical dispersion for the OC192/STM64/POU port units is 1200 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC192/STM64/POU port units.

Table B-33 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC192/STM64/POU port units.

Table B-34 Transmission Specifications for OC192/STM64/POU Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 9.953 Gb/s Output: 9.953 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	0.07 nm (RMS)
Optical Source	CW[a] Laser with a Mach-Zender Modulator

Notes

(a) Continuous Wave

Operating wavelengths

The table below lists the operating wavelengths for the OC192/STM64/POU port units.

Table B-35 OC192/STM64/POU Port Unit Operating Wavelengths

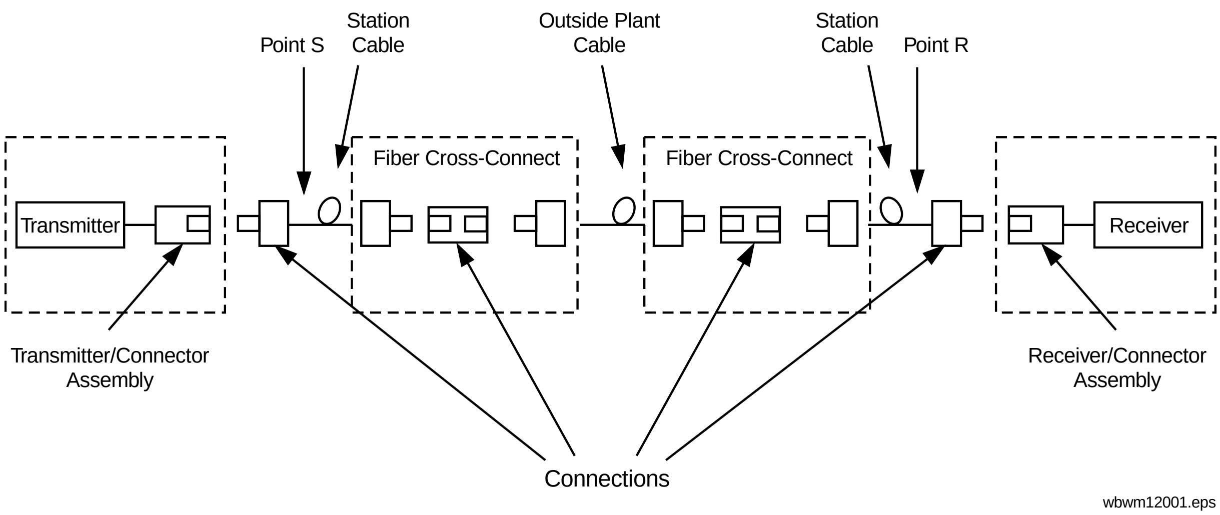
Port Unit	Wavelength
OC192/STM64/POU9590	1530.33 nm
OC192/STM64/POU9580	1531.12 nm
OC192/STM64/POU9570	1531.90 nm
OC192/STM64/POU9560	1532.68 nm
OC192/STM64/POU9550	1533.47 nm
OC192/STM64/POU9540	1534.25 nm
OC192/STM64/POU9530	1535.04 nm
OC192/STM64/POU9520	1535.82 nm
OC192/STM64/POU9490	1538.19 nm
OC192/STM64/POU9480	1538.98 nm
OC192/STM64/POU9470	1539.77 nm
OC192/STM64/POU9460	1540.56 nm
OC192/STM64/POU9450	1541.35 nm
OC192/STM64/POU9440	1542.14 nm
OC192/STM64/POU9430	1542.94 nm
OC192/STM64/POU9420	1543.73 nm
OC192/STM64/POU9380	1546.92 nm
OC192/STM64/POU9370	1547.72 nm
OC192/STM64/POU9360	1548.51 nm
OC192/STM64/POU9350	1549.32 nm
OC192/STM64/POU9340	1550.12 nm
OC192/STM64/POU9330	1550.92 nm
OC192/STM64/POU9320	1551.72 nm
OC192/STM64/POU9310	1552.52 nm
OC192/STM64/POU9280	1554.94 nm
OC192/STM64/POU9270	1555.75 nm
OC192/STM64/POU9260	1556.55 nm
OC192/STM64/POU9250	1557.36 nm

Port Unit	Wavelength
OC192/STM64/POU9240	1558.17 nm
OC192/STM64/POU9230	1558.98 nm
OC192/STM64/POU9220	1559.79 nm
OC192/STM64/POU9210	1560.61 nm

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-6 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC192/STM64/POU port units.

Table B-36 Optical Loss Budgets for the OC192/STM64/POU Port Units

Parameter	**OC192/STM64/POU Port Unit[(a)]**	
	16CH-MUX and 16CH-DMUX	**16CH-MUXINT and 16CH-DMUXINT**
Maximum Transmitter Output Power (P_{Tmax})[(b)]	2.0 dBm	2.0 dBm
Minimum Transmitter Output Power (P_{Tmin})[(c)]	–1.0 dBm	–1.0 dBm
Maximum Received Power (P_{Rmax})[(d)]	–8.0 dBm	–8.0 dBm
Receiver Sensitivity ($P_{Rmin)(3,4)}$)[(c)(d)]	–21.0 dBm	–21.0 dBm
Minimum System Gain (S-R)	20.0 dB	20.0 dB
Optical Path Penalty (P_O)	2.0 dB	2.0 dB
Minimum Loss Budget	6.4 dB	10.2 dB
Maximum Loss Budget	18.0 dB [(e)] 11.6 dB	18.0 dB [(f)] 7.8 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-3.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of $1x10^{-12}$.
(e) When using the 16CH-MUX and 16CH-DMUX with the OC192/STM64/POU port units, you must subtract 6.4 dB from the maximum loss budget to compensate for the mux/demux functions.
(f) When using the 16CH-MUXINT and 16CH-DMUXINT with the OC192/STM64/POU port units, you must subtract 10.2 dB from the maximum loss budget to compensate for the mux/demux functions. This is true for all applications, whether or not wavelengths are interleaved with those from the 16CH-MUX and 16CH-DMUX.

OC48/STM16 Port Unit Data Sheets

Overview

Purpose This section provides detailed information concerning all OC48/STM16 port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

OC48/STM16/1.3VSR1 (LEY182/LEY182AE) Data Sheet

Overview This data sheet contains technical specifications for the OC48/STM16/1.3VSR1 (very short-reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity Each OC48/STM16/1.3VSR1 port unit supports one bidirectional (one receive and one transmit) OC-48 formatted optical signal. The capacity may be translated to 48 STS-1 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access The table below describes OC-48 capabilities.

Table B-37 OC48/STM16/1.3VSR1 Access

Specification	Description
Interface	very short-reach (1-2 km) interface
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-38 Protection Switching for OC48/STM16/1.3VSR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/1.3VSR1 port unit, is Class IIIB in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/1.3VSR1 port units is 12 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/1.3VSR1 port units.

Table B-39 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–14.0 dB
Maximum discrete reflectance	–14.0 dB

Transmission specifications

The table below provides transmission specifications for the OC48/STM16/1.3VSR1 port units.

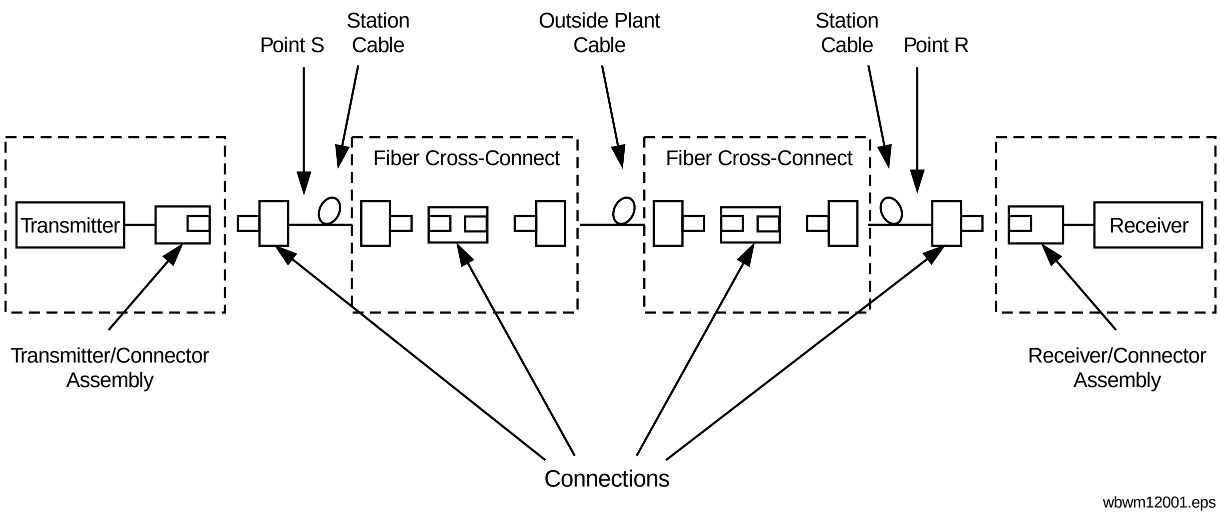
Table B-40 Transmission Specifications for OC48/STM16/1.3VSR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths	Minimum: 1280 nm Maximum: 1335 nm
Spectral Width	3.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-7 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC48/STM16/1.3VSR1 port units.

Table B-41 Optical Loss Budgets for the OC48/STM16/1.3VSR1 Port Units

Parameter	OC48/STM16/1.3VSR1 Port Unit [a]
Maximum Transmitter Output Power (P_{Tmax}) [b]	-1.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [c]	–6.0 dBm
Maximum Received Power (P_{Rmax})[d]	–1.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–14.0 dBm
Minimum System Gain (S-R)	5.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget [e]	0.0 dB
Maximum Loss Budget[f]	4.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-6.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10(<sup>-12).
(e) This value assumes that the maximum received power limitations are not exceeded.
(f) Loss is dispersion limited and not power limited.

OC48/STM16/1.3LR1 (LEY7/LEY7AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC48/STM16/1.3LR1 (long reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity

Each OC48/STM16/1.3LR1 port unit supports one bidirectional (one receive and one transmit) OC-48 formatted optical signal. The capacity may be translated to 48 STS-1 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access

The table below describes OC-48 capabilities.

Table B-42 OC48/STM16/1.3LR1 Access

Specification	Description
Interface	Long-reach (51 km) interface [a]
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure 1-12).

Protection switching

The table below describes protection switching information per high speed line.

Table B-43 Protection Switching for OC48/STM16/1.3LR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/1.3LR1 port unit, is Class IIIB in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/1.3LR1 port units is 200 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/1.3LR1 port units.

Table B-44 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC48/STM16/1.3LR1 port units.

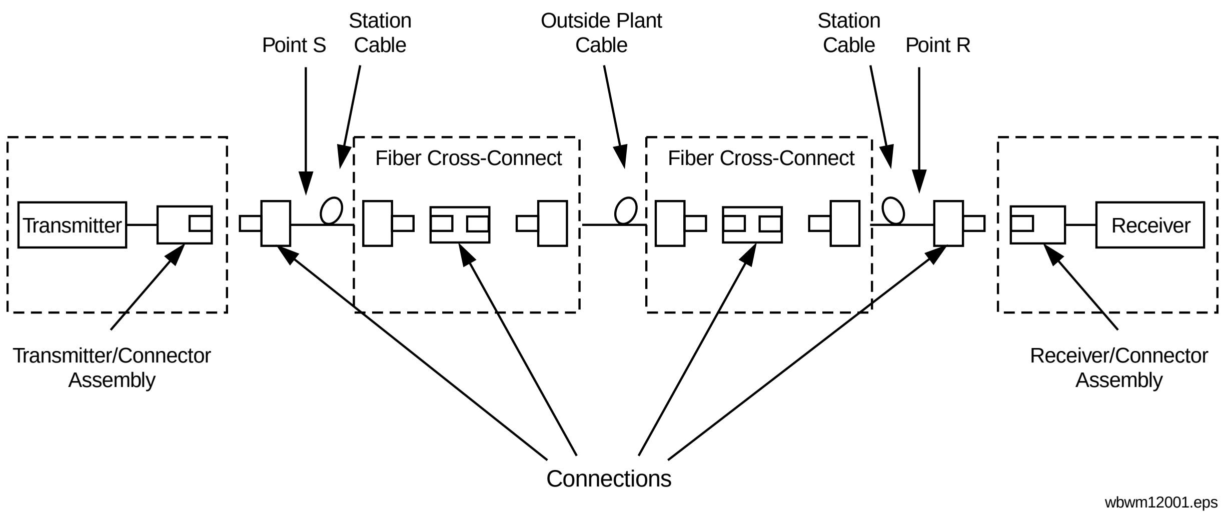
Table B-45 Transmission Specifications for OC48/STM16/1.3LR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths	Minimum: 1280 nm Maximum: 1335 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-8 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC48/STM16/1.3LR1 port units.

Table B-46 Optical Loss Budgets for the OC48/STM16/1.3LR1 Port Units

Parameter	**OC48/STM16/1.3LR1 Port Unit** [a]
Maximum Transmitter Output Power (P_{Tmax}) [b]	3.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [c]	–2.0 dBm
Maximum Received Power (P_{Rmax}) [d]	–9.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–27.0 dBm
Minimum System Gain (S-R)	25.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget [e]	10.0 dB
Maximum Loss Budget[f]	24.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-7.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10(<sup>-12).
(e) This value assumes that the maximum received power limitations are not exceeded.
(f) Dispersion is limited to 92 km for long reach optics.

OC48/STM16/1.5LR1 (LEY8/LEY8AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC48/STM16/1.5LR1 (long reach) port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity

Each OC48/STM16/1.5LR1 port unit supports one bidirectional (one receive and one transmit) OC-48 formatted optical signal. The capacity may be translated to 48 STS-11 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access

The table below describes OC-48 capabilities.

Table B-47 OC48/STM16/1.5LR1 Access

Specification	Description
Interface	Long-reach (80 km) interface[a]
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure B-8).

Protection switching

The table below describes protection switching information per high speed line.

Table B-48 Protection Switching for OC48/STM16/1.5LR1 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/1.5LR1 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/1.5LR1 port units is 1800 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/1.5LR1 port units.

Table B-49 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC48/STM16/1.5LR1 port units.

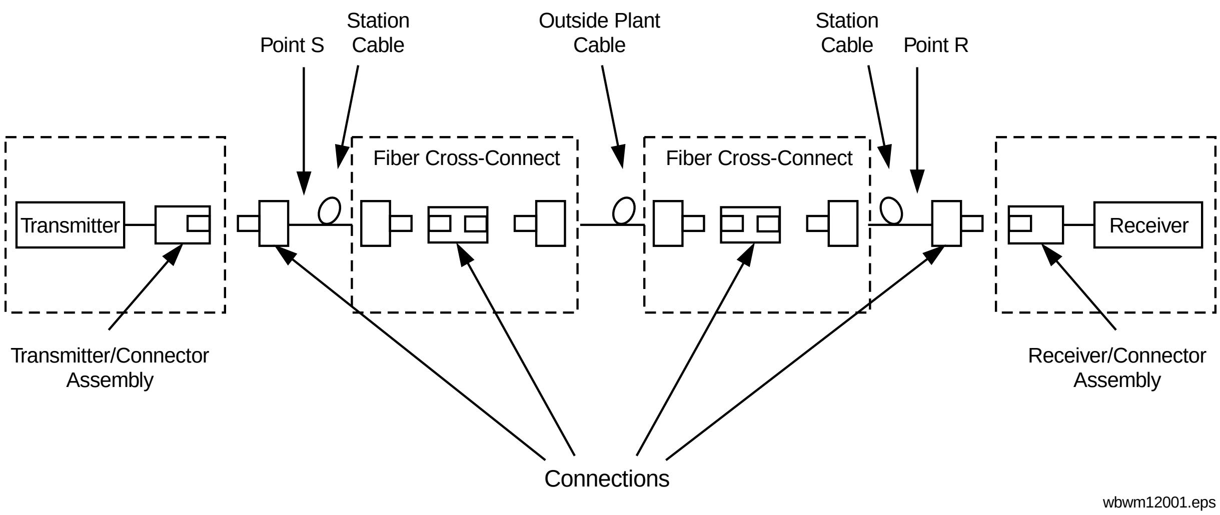
Table B-50 Transmission Specifications for OC48/STM16/1.5LR1 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths	Minimum: 1530 nm Maximum: 1565 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-9 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC48/STM16/1.5LR1 port units.

Table B-51 Optical Loss Budgets for the OC48/STM16/1.5LR1 Port Units

Parameter	**OC48/STM16/1.5LR1 Port Unit** [(a)]
Maximum Transmitter Output Power ($P_{Tmax)}$[(b)]	3.0 dBm
Minimum Transmitter Output Power ($P_{Tmin)}$[(c)]	–2.0 dBm
Maximum Received Power ($P_{Rmax)}$[(d)]	–9.0 dBm
Receiver Sensitivity ($P_{Rmin)}$[(c) (d)]	–28.0 dBm
Minimum System Gain (S-R)	26.0 dB
Optical Path Penalty (P_O)	2.0 dB
Minimum Loss Budget[(e)]	10.0 dB
Maximum Loss Budget[(f)]	24.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-8.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.
(e) This value assumes that the maximum received power limitations are not exceeded.
(f) Dispersion is limited to 92 km for long-reach optics.

OC48/STM16/DWDM01-16 (LEY50/LEY50AE - LEY65/LEY65AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC48/STM16/DWDM01-16 port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity

Each OC48/STM16/DWDM01-16 port unit supports one bidirectional (one receive and one transmit) OC-48 formatted, ITU-compatible optical signal. The capacity may be translated to 48 STS-1 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access

The table below describes OC-48 capabilities.

Table B-52 OC48/STM16/DWDM01-16 Access

Specification	Description
Interface	Long-reach (80 km) interface[a]
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value.

Protection switching

The table below describes protection switching information per high speed line.

Table B-53 Protection Switching for OC48/STM16/DWDM01-16 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/DWDM01-16 port units, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/DWDM01-16 port units is 1800 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/DWDM01-16 port units.

Table B-54 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The following table provides transmission specifications for the OC48/STM16/DWDM01-16 port units.

Table B-55 Transmission Specifications for OC48/STM16/DWDM01-16

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths [a]	Minimum: 1549 nm Maximum: 1560 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Notes

(a) Refer to Table B-40 for a complete list of the operating wavelengths.

Operating wavelengths

The following table lists the operating wavelengths for the OC48/STM16/DWDM01-16 port units.

Table B-56 OC48/STM16/DWDM01-16 Port Unit Operating Wavelengths

Port Unit	Wavelength
OC48/STM16/DWDM01	1549.32 nm
OC48/STM16/DWDM02	1550.92 nm
OC48/STM16/DWDM03	1552.52 nm
OC48/STM16/DWDM04	1554.13 nm
OC48/STM16/DWDM05	1555.75 nm
OC48/STM16/DWDM06	1557.36 nm
OC48/STM16/DWDM07	1558.98 nm
OC48/STM16/DWDM08	1560.61 nm
OC48/STM16/DWDM09	1548.52 nm
OC48/STM16/DWDM10	1550.12 nm
OC48/STM16/DWDM11	1551.72 nm
OC48/STM16/DWDM12	1553.33 nm
OC48/STM16/DWDM13	1554.94 nm
OC48/STM16/DWDM14	1556.56 nm
OC48/STM16/DWDM15	1558.17 nm
OC48/STM16/DWDM16	1559.79 nm

Optical requirements and loss budgets

Because OC48/STM16/DWDM01-16 port units interface with Metropolis EON, refer to the *Metropolis EON Applications and Planning Guide* to calculate loss budgets.

OC48/STM16/WDM (LEY101/LEY101AE - LEY180/LEY180AE) Data Sheet

Overview This data sheet contains technical specifications for the OC48/STM16/WDM port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity Each OC48/STM16/WDM port unit supports one bidirectional (one receive and one transmit) OC-48 formatted, ITU-compatible optical signal. The capacity may be translated to 48 STS-1 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access The table below describes OC-48 capabilities.

Table B-57 OC48/STM16/WDM Access

Specification	Description
Interface	Long-reach (80 km) interface [a]
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value.

Protection switching

The table below describes protection switching information per high speed line.

Table B-58 Protection Switching for OC48/STM16/WDM Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER ≥10-3 line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/WDM port units, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/WDM port units is 1800 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/WDM port units.

Table B-59 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC48/STM16/WDM port units.

Table B-60 Transmission Specifications for OC48/STM16/WDM

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths	Minimum: 1549 nm Maximum: 1560 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Operating wavelengths

The table below lists the operating wavelengths for the OC48/STM16/WDM port units.

Table B-61 OC48/STM16/WDM Port Unit Operating Wavelengths

Port Unit	Wavelength
OC48/STM16/WDM9585	1530.72 nm
OC48/STM16/WDM9580	1531.11 nm
OC48/STM16/WDM9575	1531.50 nm
OC48/STM16/WDM9570	1531.89 nm
OC48/STM16/WDM9565	1532.28 nm
OC48/STM16/WDM9560	1532.68 nm
OC48/STM16/WDM9555	1533.07 nm
OC48/STM16/WDM9550	1533.46 nm
OC48/STM16/WDM9545	1533.85 nm
OC48/STM16/WDM9540	1534.25 nm
OC48/STM16/WDM9535	1534.64 nm
OC48/STM16/WDM9530	1535.03 nm
OC48/STM16/WDM9525	1535.42 nm
OC48/STM16/WDM9520	1535.82 nm
OC48/STM16/WDM9515	1536.21 nm
OC48/STM16/WDM9510	1536.60 nm
OC48/STM16/WDM9505	1537.00 nm
OC48/STM16/WDM9500	1537.39 nm
OC48/STM16/WDM9495	1537.79 nm
OC48/STM16/WDM9490	1538.18 nm
OC48/STM16/WDM9485	1538.58 nm
OC48/STM16/WDM9480	1538.97 nm
OC48/STM16/WDM9475	1539.37nm
OC48/STM16/WDM9470	1539.76 nm
OC48/STM16/WDM9465	1540.16 nm
OC48/STM16/WDM9460	1540.55 nm
OC48/STM16/WDM9455	1540.95 nm
OC48/STM16/WDM9450	1541.34 nm

Port Unit	Wavelength
OC48/STM16/WDM9445	1541.74 nm
OC48/STM16/WDM9440	1542.14 nm
OC48/STM16/WDM9435	1542.53 nm
OC48/STM16/WDM9430	1542.93 nm
OC48/STM16/WDM9425	1543.33 nm
OC48/STM16/WDM9420	1543.73 nm
OC48/STM16/WDM9415	1544.12 nm
OC48/STM16/WDM9410	1544.52 nm
OC48/STM16/WDM9405	1544.92 nm
OC48/STM16/WDM9400	1545.32 nm
OC48/STM16/WDM9395	1545.72 nm
OC48/STM16/WDM9390	1546.11 nm
OC48/STM16/WDM9385	1546.51 nm
OC48/STM16/WDM9380	1546.91 nm
OC48/STM16/WDM9375	1547.31 nm
OC48/STM16/WDM9370	1547.71 nm
OC48/STM16/WDM9365	1548.11 nm
OC48/STM16/WDM9360	1548.51 nm
OC48/STM16/WDM9355	1548.91 nm
OC48/STM16/WDM9350	1549.31 nm
OC48/STM16/WDM9345	1549.71 nm
OC48/STM16/WDM9340	1550.11 nm
OC48/STM16/WDM9335	1550.51 nm
OC48/STM16/WDM9330	1550.91 nm
OC48/STM16/WDM9325	1551.31 nm
OC48/STM16/WDM9320	1551.72 nm
OC48/STM16/WDM9315	1552.12 nm
OC48/STM16/WDM9310	1552.52 nm
OC48/STM16/WDM9305	1552.92 nm
OC48/STM16/WDM9300	1553.32 nm
OC48/STM16/WDM9295	1553.73 nm
OC48/STM16/WDM9290	1554.13 nm

Port Unit	Wavelength
OC48/STM16/WDM9285	1554.53 nm
OC48/STM16/WDM9280	1554.94 nm
OC48/STM16/WDM9275	1555.34 nm
OC48/STM16/WDM9270	1555.74 nm
OC48/STM16/WDM9265	1556.15 nm
OC48/STM16/WDM9260	1556.55 nm
OC48/STM16/WDM9255	1556.95 nm
OC48/STM16/WDM9250	1557.36 nm
OC48/STM16/WDM9245	1557.76 nm
OC48/STM16/WDM9240	1558.17 nm
OC48/STM16/WDM9235	1558.57 nm
OC48/STM16/WDM9230	1558.98 nm
OC48/STM16/WDM9225	1559.38 nm
OC48/STM16/WDM9220	1559.79 nm
OC48/STM16/WDM9215	1560.20 nm
OC48/STM16/WDM9210	1560.60 nm
OC48/STM16/WDM9205	1561.01 nm
OC48/STM16/WDM9200	1561.41 nm
OC48/STM16/WDM9195	1561.82 nm
OC48/STM16/WDM9190	1562.23 nm

Optical requirements and loss budgets

Because OC48/STM16/WDM9190-9585 port units interface with Metropolis EON, refer to the *Metropolis EON Applications and Planning Guide* to calculate loss budgets.

OC48/STM16/POU (LEY80AE - LEY95AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC48/STM16/POU port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity

Each OC48/STM16/POU port unit supports one bidirectional (one receive and one transmit) OC-48 formatted, ITU-compatible optical signal. The capacity may be translated to 48 STS-1 equivalents or 32,256 two-way voice circuits per port unit.

OC-48 access

The table below describes OC-48 capabilities.

Table B-62 OC48/STM16/POU Access

Specification	Description
Interface	Long-reach (80 km) interface[a]
Growth Increment	One OC-48 per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value.

Protection switching

The table below describes protection switching information per high speed line.

Table B-63 Protection Switching for OC48/STM16/POU Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC48/STM16/POU port units, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC48/STM16/POU port units is 1800 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC48/STM16/POU port units.

Table B-64 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC48/STM16POU port units.

Table B-65 Transmission Specifications for OC48/STM16/POU

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 2.488 Gb/s Output: 2.488 Gb/s
Transmitter Wavelengths[a]	Minimum: 1549 nm Maximum: 1560 nm
Spectral Width	0.2 nm (RMS)
Optical Source	Electro-absorptive Modulated Laser (EML)

Notes

(a) Refer to Table B-40 for a complete list of the operating wavelengths.

Operating wavelengths

The table below lists the operating wavelengths for the OC48/STM16/POU port units.

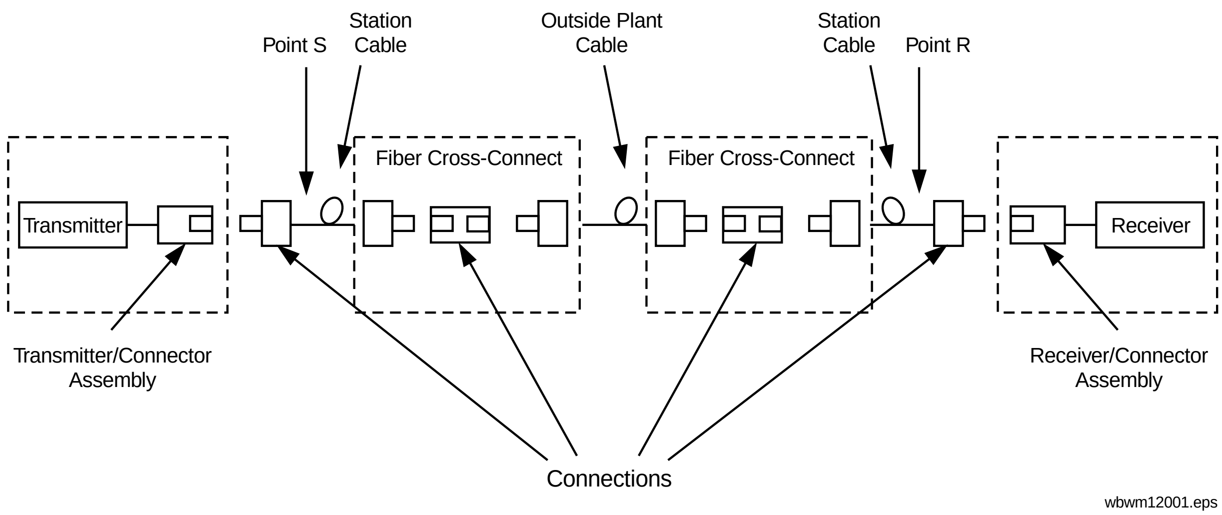
Table B-66 OC48/STM16/POU Port Unit Operating Wavelengths

Port Unit	Wavelength
OC48/STM16/POU9590	1530.33 nm
OC48/STM16/POU9570	1531.90 nm
OC48/STM16/POU9550	1533.47 nm
OC48/STM16/POU9530	1535.04 nm
OC48/STM16/POU9490	1538.19 nm
OC48/STM16/POU9470	1539.77 nm
OC48/STM16/POU9450	1541.35 nm
OC48/STM16/POU9430	1542.94 nm
OC48/STM16/POU9370	1547.72 nm
OC48/STM16/POU9350	1549.32 nm
OC48/STM16/POU9330	1550.92 nm
OC48/STM16/POU9310	1552.52 nm
OC48/STM16/POU9270	1555.75 nm
OC48/STM16/POU9250	1557.36 nm
OC48/STM16/POU9230	1558.98 nm
OC48/STM16/POU9210	1560.61 nm

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-10 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC48/STM16/POU port units.

Table B-67 Optical Loss Budgets for the OC48/STM16/POU Port Units

Parameter	**OC48/STM16/POU Port Unit[(a)] with**	
	16CH-MUX and 16CH-DMUX	**16CH-MUXINT and 16CH-DMUXINT**
Maximum Transmitter Output Power (P_{Tmax}) [(b)]	1 dBm	1 dBm
Minimum Transmitter Output Power (P_{Tmin}) [(c)]	-2.8 dBm	-2.8 dBm
Maximum Received Power (P_{Rmax}) [(d)]	-9 dBm	-9 dBm
Receiver Sensitivity (P_{Rmin}) [(c)] [(d)]	-28 dBm	-28 dBm
Minimum System Gain (S-R)	25.2 dBm	25.2 dBm
Optical Path Penalty (P_O)	2 dBm	2 dBm
Minimum Loss Budget	6.4 dBm	10.2 dBm
Maximum Loss Budget	23.2 dB[(e)] 16.8 dB	23.2 dB[(f)] 13.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.

(b) Transmit and receive points are referenced as points S and R in Figure B-9.

(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.

(d) These values are measured at a BER of 1×10^{-12}.

(e) When using the 16CH-MUX and 16CH-DMUX with the OC48/STM16/POU port units, you must subtract 6.4 dB from the maximum loss budget to compensate for the mux/demux functions.

(f) When using the 16CH-MUXINT and 16CH-DMUXINT with the OC48/STM16/POU port units, you must subtract 10.2 dB from the maximum loss budget to compensate for the mux/demux functions. This is true for all applications, whether or not the wavelengths are interleaved with those from the 16CH-MUX and 16CH-DMUX.

□

OC12/STM4 Port Unit Data Sheets

Overview

Purpose This section provides detailed information concerning all OC12/STM4 port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

OC12/STM4/1.3LR2 (LEY13AE) Data Sheet

Overview This data sheet contains technical specifications for the OC12/STM4/1.3LR2 (long reach) port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity Each OC12/STM4/1.3LR2 port unit supports two bidirectional (one receive and one transmit) OC-12 formatted optical signals. The capacity may be translated to 24 STS-1 equivalents or 16,128 two-way voice circuits per port unit.

OC-12 access The table below describes OC-12 access capabilities.

Table B-68 OC12/STM4/1.3LR2 Access

Specification	Description
Interface	Long-reach (51 km) interface[a]
Growth Increment	Two OC-12s per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure B-7).

Protection switching

The table below describes protection switching information per high speed line.

Table B-69 Protection Switching for OC12/STM4/1.3LR2 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC12/STM4/1.3LR2 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC12/STM4/1.3LR2 port units is 200 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC12/STM4/1.3LR2 port units.

Table B-70 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC12/STM4/1.3LR2 port units.

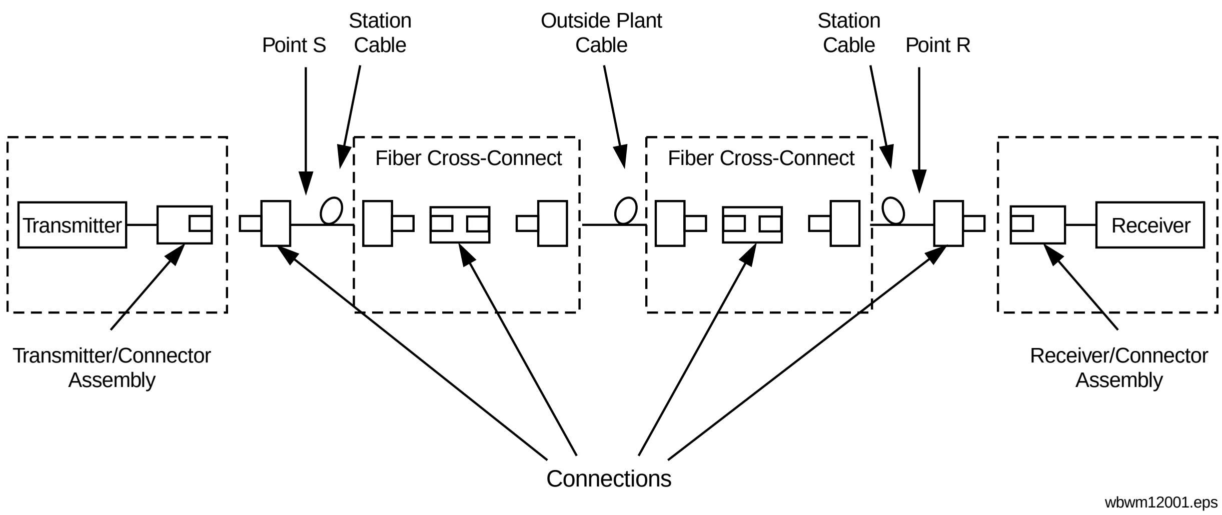
Table B-71 Transmission Specifications for OC12/STM4/1.3LR2 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 622.08 Mb/s Output: 622.08 Mb/s
Transmitter Wavelengths	Minimum: 1298 nm Maximum: 1325 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-11 Optical System Interfaces



Optical requirements and loss budgets

The following table lists the optical requirements and loss budgets for the OC12/STM4/1.3LR2 port units.

Table B-72 Optical Loss Budgets for the OC12/STM4/1.3LR2 Port Units

Parameter	OC12/STM4/1.3LR2 Port Unit[a]
Maximum Transmitter Output Power ($P_{Tmax)}$ [b]	2.0 dBm
Minimum Transmitter Output Power ($P_{Tmin)}$ [c]	–2.5 dBm
Maximum Received Power ($P_{Rmax)}$ [d]	–8.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–30.5 dBm
Minimum System Gain (S-R)	28.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget[e]	10.0 dB
Maximum Loss Budget	27.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-8.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.
(e) This value assumes that the maximum received power limitations are not exceeded.

OC12/STM4/1.3SR2 (LEY14AE) Data Sheet

Overview This data sheet contains technical specifications for the OC12/STM4/1.3SR2 (short reach) port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity Each OC12/STM4/1.3SR2 port unit supports two bidirectional (one receive and one transmit) OC-12 formatted optical signals. The capacity may be translated to 24 STS-11 equivalents or 16,128 two-way voice circuits per port unit.

OC-12 access The table below describes OC-12 access capabilities.

Table B-73 OC12/STM4/1.3SR2 Access

Specification	Description
Interface	Short-reach (15 km) interface[a]
Growth Increment	Two OC-12s per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure B-8).

Protection switching

The table below describes protection switching information per high speed line.

Table B-74 Protection Switching for OC12/STM4/1.3SR2 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC12/STM4/1.3SR2 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC12/STM4/1.3SR2 port units is 200 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC12/STM4/1.3SR2 port units.

Table B-75 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC12/STM4/1.3SR2 port units.

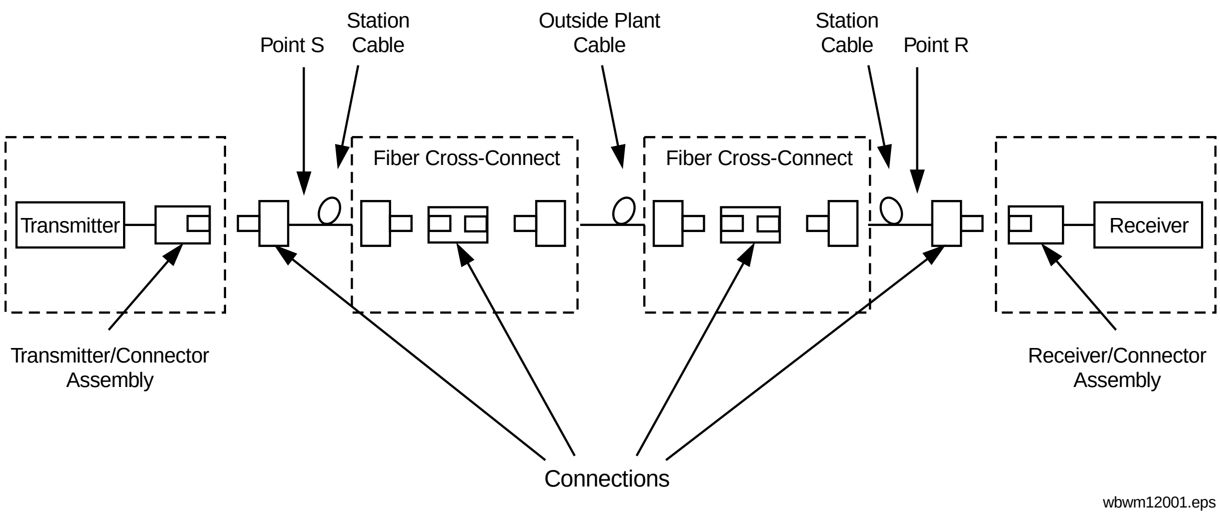
Table B-76 Transmission Specifications for OC12/STM4/1.3SR2 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 622.08 Mb/s Output: 622.08 Mb/s
Transmitter Wavelengths	Minimum: 1298 nm Maximum: 1325 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-12 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC12/STM4/1.3SR2 port units.

Table B-77 Optical Loss Budgets for the OC12/STM4/1.3SR2 Port Units

Parameter	OC12/STM4/1.3SR2 Port Unit[a]
Maximum Transmitter Output Power (P_{Tmax})[b]	–8.0 dBm
Minimum Transmitter Output Power (P_{Tmin})[c]	–15.0 dBm
Maximum Received Power (P_{Rmax}) [d]	–8.0 dBm
Receiver Sensitivity (P_{Rmin})[c] [d]	–28.0 dBm
Minimum System Gain (S-R)	13.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget[e]	0.0 dB
Maximum Loss Budget[f]	12.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-8.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10-12.
(e) This value assumes that the maximum received power limitations are not exceeded.
(f) Dispersion is limited to 92 km for long-reach optics.

OC3/STM1 Port Unit Data Sheets

Overview

Purpose

This section provides detailed information concerning all OC3/STM1 port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

OC3/STM1/1.3LR4 (LEY15AE) Data Sheet

Overview This data sheet contains technical specifications for the OC3/STM1/1.3LR4 (long reach) port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity Each OC3/STM1/1.3LR4 port unit supports four bidirectional (one receive and one transmit) OC-3 formatted optical signals. The capacity may be translated to 12 STS-1 equivalents or 8,064 two-way voice circuits per port unit.

OC-3 access The table below describes OC-3 access capabilities.

Table B-78 OC3/STM1/1.3LR2 Access

Specification	Description
Interface	Long-reach (51 km) interface[a]
Growth Increment	Four OC-3s per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure B-9).

Protection switching

The table below describes protection switching information per high speed line.

Table B-79 Protection Switching for OC3/STM1/1.3LR4 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC3/STM1/1.3LR4 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC3/STM1/1.3LR4 port units is 300 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC3/STM1/1.3LR4 port units.

Table B-80 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

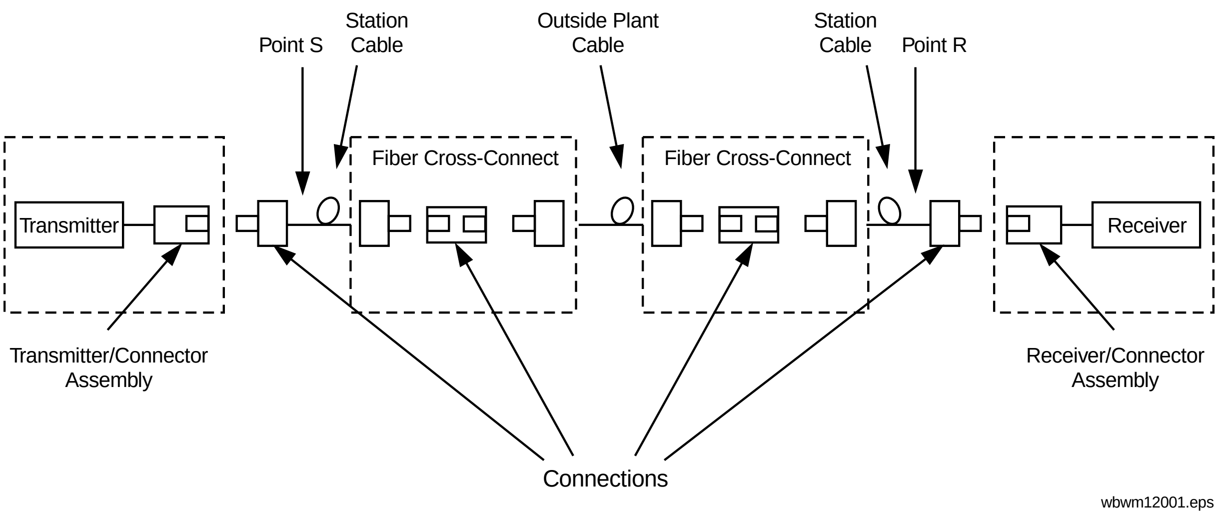
The table below provides transmission specifications for the OC3/STM1/1.3LR4 port units.

Table B-81 Transmission Specifications for OC3/STM1/1.3LR4 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 155.52 Mb/s Output: 155.52 Mb/s
Transmitter Wavelengths	Minimum: 1298 nm Maximum: 1325 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser

Optical system interfaces The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-13 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC3/STM1/1.3LR4 port units.

Table B-82 Optical Loss Budgets for the OC3/STM1/1.3LR4 Port Units

Parameter	OC3/STM1/1.3LR4 Port Unit[a]
Maximum Transmitter Output Power (P_{Tmax}) [b]	0.0 dBm
Minimum Transmitter Output Power (P_{Tmin})[c]	–5.0 dBm
Maximum Received Power (P_{Rmax}) [d]	–10.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–34.0 dBm
Minimum System Gain (S-R)	29.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget[e]	10.0 dB
Maximum Loss Budget	28.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-9.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10(<sup>-12).
(e) This value assumes that the maximum received power limitations are not exceeded.

OC3/STM1/1.3IR-SR8 (LEY23AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC3/STM1/1.3IR-SR8 (intermediate-short reach) port units that are used in WaveStar TDM 2.5G/10G (2-Fiber).

Capacity

Each OC3/STM1/1.3IR-SR8 port unit supports four bidirectional (one receive and one transmit) OC-3 formatted optical signals. The capacity may be translated to 12 STS-1 equivalents or 8,064 two-way voice circuits per port unit.

OC-3 access

The table below describes OC-3 access capabilities.

Table B-83 OC3/STM1/1.3IR-SR8 Access

Specification	Description
Interface	Intermediate-short reach (15-25 km) interface
Growth Increment	Eight OC-3s per port unit
Line Code	Scrambled NRZ

Protection switching

The table below describes protection switching information per high speed line.

Table B-84 Protection Switching for OC3/STM1/1.3IR-SR8 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC3/STM1/1.3IR-SR8 port unit, is Class I in the FDA/CDRH Classification System.

Optical return loss

The table below provides the optical return loss for a system using OC3/STM1/1.3IR-SR8 port units.

Table B-85 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC3/STM1/1.3IR-SR8 port units.

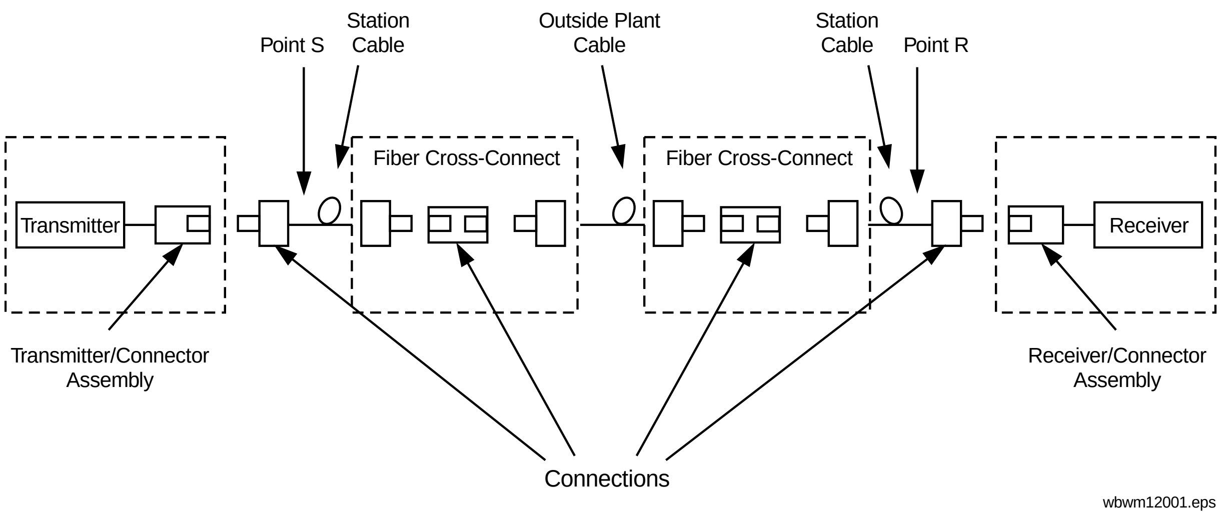
Table B-86 Transmission Specifications for OC3/STM1/1.3IR-SR8 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 155.52 Mb/s Output: 155.52 Mb/s
Transmitter Wavelengths	Minimum: 1298 nm Maximum: 1325 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser or Fabre-Perot laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-14 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC3/STM1/1.3IR-SR8 port units.

Table B-87 Optical Loss Budgets for the OC3/STM1/1.3IR-SR8 Port Units

Parameter	OC3/STM1/1.3IR-SR8 Port Unit[a]
Maximum Transmitter Output Power (P_{Tmax}) [b]	–8.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [c]	–15.0 dBm
Maximum Received Power (P_{Rmax}) [d]	–8.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–28.0 dBm
Minimum System Gain (S-R)	13.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget[e]	0.0 dB
Maximum Loss Budget	12.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-10.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10(<sup>-12).
(e) This value assumes that the maximum received power limitations are not exceeded.

OC3/STM1/1.3SR4 (LEY16/LEY16AE) Data Sheet

Overview

This data sheet contains technical specifications for the OC3/STM1/1.3SR4 (short reach) port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity

Each OC3/STM1/1.3SR4 port unit supports four bidirectional (one receive and one transmit) OC-3 formatted optical signals. The capacity may be translated to 12 STS-1 equivalents or 8,064 two-way voice circuits per port unit.

OC-3 access

The table below describes OC-3 access capabilities.

Table B-88 OC3/STM1/1.3SR4 Access

Specification	Description
Interface	Short-reach (15 km) interface[a]
Growth Increment	Four OC-3s per port unit
Line Code	Scrambled NRZ

Notes

(a) This number is a typical value. The actual value must be calculated using measured data (see Figure B-10).

Protection switching

The table below describes protection switching information per high speed line.

Table B-89 Protection Switching for OC3/STM1/1.3SR4 Port Units

Specification	Length of Time
Switching Bit Error Rate (BER)	10^{-3} to 10^{-9} (user provisionable)
Restoral BER	One-tenth of the switching BER
Switching Time	60 msec (BER $\geq 10^{-3}$ line signal failure)

Optical safety

Optical safety data on laser-containing port units, such as the OC3/STM1/1.3SR4 port unit, is Class I in the FDA/CDRH Classification System.

Optical dispersion

The optical dispersion for the OC3/STM1/1.3SR4 port units is 300 ps/nm.

Optical return loss

The table below provides the optical return loss for a system using OC3/STM1/1.3SR4 port units.

Table B-90 Optical Return Loss

Specification	Amount
Maximum system optical return loss	24.0 dB
Maximum receiver reflectance	–27.0 dB
Maximum discrete reflectance	–27.0 dB

Transmission specifications

The table below provides transmission specifications for the OC3/STM1/1.3SR4 port units.

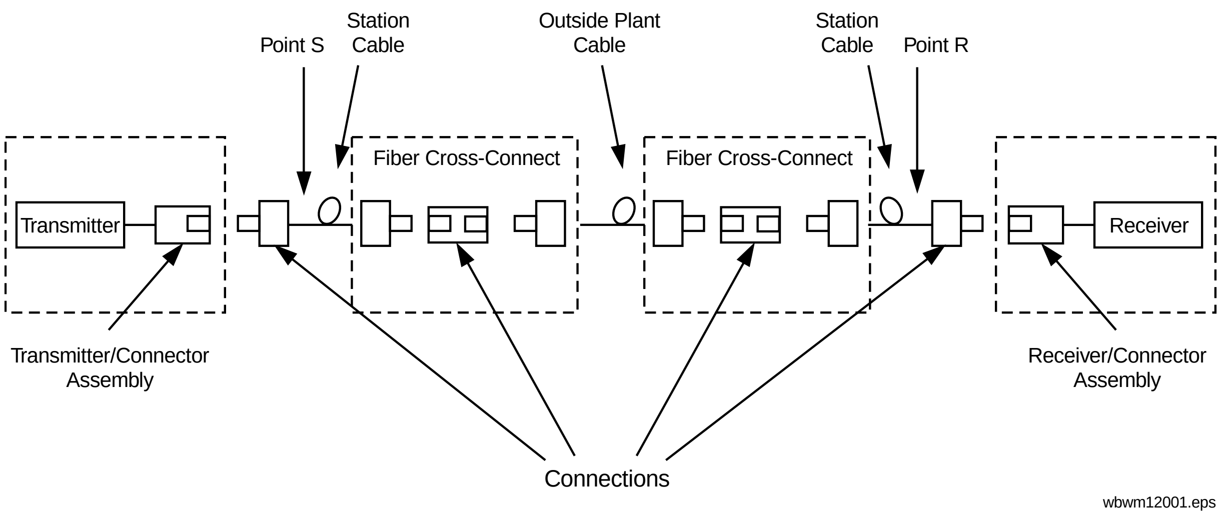
Table B-91 Transmission Specifications for OC3/STM1/1.3SR4 Port Units

Specification	Description
Transmission Medium	Input Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber Output Fiber: Standard Single-Mode Non-Dispersion Shifted Fiber
Operating Connector Interfaces	Universal build-out block and optional ST-type, FC-type, or SC-type lightguide build-out (LBO) connectors for optical attenuation
Optical Line Rate	Input: 155.52 Mb/s Output: 155.52 Mb/s
Transmitter Wavelengths	Minimum: 1298 nm Maximum: 1325 nm
Spectral Width	2.0 nm (RMS)
Optical Source	Distributed Feedback (DFB) laser or Fabre-Perot laser

Optical system interfaces

The figure below illustrates the optical path between the transmitter and the receiver.

Figure B-15 Optical System Interfaces



Optical requirements and loss budgets

The table below lists the optical requirements and loss budgets for the OC3/STM1/1.3SR4 port units.

Table B-92 Optical Loss Budgets for the OC3/STM1/1.3SR4 Port Units

Parameter	OC3/STM1/1.3SR4 Port Unit[a]
Maximum Transmitter Output Power (P_{Tmax}) [b]	–8.0 dBm
Minimum Transmitter Output Power (P_{Tmin}) [c]	–15.0 dBm
Maximum Received Power (P_{Rmax}) [d]	–8.0 dBm
Receiver Sensitivity (P_{Rmin}) [c] [d]	–28.0 dBm
Minimum System Gain (S-R)	13.0 dB
Optical Path Penalty (P_O)	1.0 dB
Minimum Loss Budget[e]	0.0 dB
Maximum Loss Budget	12.0 dB

Notes

(a) All values assume that standard single-mode non-dispersion shifted fiber is used. Dispersion shifted fiber may be used. WaveStar TDM 2.5G/10G (2-Fiber) complies with Telcordia Technologies and ITU requirements for dispersion shifted fiber.
(b) Transmit and receive points are referenced as points S and R in Figure B-10.
(c) These values include transmitter/receiver connectors at 0.7 dB each (worst case) and the system margins.
(d) These values are measured at a BER of 1x10(<sup>-12).
(e) This value assumes that the maximum received power limitations are not exceeded.

DS3EC1/8 Port Unit Data Sheet

Overview

Purpose

This section provides detailed information concerning all DS3/EC1 port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

DS3EC1/8 (LEY17AE) Data Sheet

Overview

This data sheet contains technical specifications for the DS3EC1/8 port units that are used in WaveStar 2.5G/10G (2-Fiber).

Capacity

Each DS3EC1/8 port unit supports eight DS3-rate or EC-1-rate bidirectional lines (eight receive and eight transmit).

Transmission medium

One unbalanced coaxial line is used for each direction of transmission. Therefore, two coaxial lines are used for each of the eight bidirectional ports on a DS3EC1/8 port unit.

Line rate

Each bidirectional port on the DS3EC1/8 port unit may be provisioned to transmit and receive one of the following:

- One DS3 signal with a nominal rate of 44.736 Mb/s ±895 b/s (±20 ppm)
- One EC-1 signal with a nominal rate of 51.840 Mb/s ±1037 b/s (±20 ppm)

Line code

The line code for the DS3EC1/8 port units is bipolar with 3-zero substitution (B3ZS).

Bipolar violation monitoring

Bipolar violation monitoring (BVM) is provided for the incoming B3ZS signal of each bidirectional port in a DS3EC1/8 port unit. The BVM feature can be enabled or disabled on a per port basis.

BNC connectors

The physical interface for each port, both the transmit and receive directions, of the DS3EC1/8 port unit is a 75-ohm BNC connector. The BNC connectors are located on the DS3EC1/8 Connector Panels.

Line build-out

Because the DS3EC1/8 port units are designed to accept the entire signal range, external line build-outs are not required.

Optical Amplifier Port Unit Data Sheets

Overview

Purpose

This section provides detailed information concerning the Optical Booster Amplifier (OBA) and Optical Booster Pre-Amplifier (OBPA) port units available for use with the WaveStar TDM 2.5G/10G (2-Fiber).

Optical Booster Amplifier (SEN3AE) Data Sheet

Overview This data sheet contains technical specifications for the OBA port units that are used in WaveStar TDM 2.5G/10G (2-Fiber) and WaveStar BandWidth Manager.

Optical Input The table below lists the optical input specifications for the OBA port (OBA in).

Table B-93 Optical Input Specifications for the Optical Booster Amplifier Port (OBA in)

Type	Conditions	min.	max.	Unit
Wavelength range		1530	1560	nm
Signal input power P_{Sin}		-10	+2	dBm
Optical return loss	limited by optical connector		35	dB
Residual pump power at input port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm
ASE-power at input port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm

Optical Output

The table below lists the optical output specifications for the OBA port (OBA out).

Table B-94 Optical Output Specifications for the Optical Booster Amplifier Port (OBA out)

Type	Conditions	min.	max.	Unit
Wavelength range		1530	1560	nm
Nominal signal output power P_{Sout}		+12.0		dBm
Signal output power P_{Sout} (BOL), including connector tolerance	BOL	+11.3	+12.4	dBm
Signal output power P_{Sout} (EOL), including connector tolerance	EOL	+10.0	+13.0	dBm
Residual pump power at output port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm
ASE-power at output port	λ_p = 980 nm; P_{Sin} = -9 dBm		0	dBm
Noise figure	λ = 1530 to 1560 nm; P_{Sin} = -9 dBm; -10 °C ≤ T_{case} (EOM) ≤ +75 °C		7	dB

Optical Booster Pre-Amplifier (SEN4AE) Data Sheet

Overview

This data sheet contains technical specifications for the OBPA port units that are used in WaveStar 2.5G/10G (2-Fiber).

Warning

The OBPA section is only operated in combination with an OC192/STM64/1.5IR1 port unit to allow spans of 120km to be reached.

Optical Input

The table below lists the optical input specifications for the optical pre-amplifier port (OPA in).

Table B-95 Optical Input Specifications for the Optical Pre-Amplifier Port (OPA in)

Type	Conditions	min.	max.	Unit
Wavelength range		1552.52 ± 0.15		nm
Signal input power P_{Sin}	BER = 10^{-12}	-25	-9	dBm
Optical return loss	limited by optical connector		35	dB
Tone frequency for LOS detection		197.557 ± 20		kHz
Bandwidth for tone frequency	3 dB	6.0	8.0	kHz

The table below lists the optical input specifications for the OBA port (OBA in).

Table B-96 Optical Input Specifications for the Optical Booster Amplifier Port (OBA in)

Type	Conditions	min.	max.	Unit
Wavelength range		1530	1560	nm
Signal input power P_{Sin}		-10	+2	dBm
Optical return loss	limited by optical connector		35	dB
Residual pump power at input port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm
ASE-power at input port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm

Optical Output

The table below lists the optical output specifications for the OBPA port (OPA out).

Table B-97 Optical Output Specifications for the Optical Pre-Amplifier Port (OPA out)

Type	Conditions	min.	max.	Unit
Wavelength range		1552.52 ± 0.15		nm
Signal output power P_{Sout}, including connector tolerance	BOL; includes 7 dB LBO at pre-amplifier output port	-12	-9	dBm
Signal output power when LOS is detected	no signal input		-15	dBm
Small signal gain, without connector losses	λ = 1552.52 nm; $P_{Sin} \leq$ -25 dBm	23		dB
Noise figure	λ = 1552.52 nm; $P_{Sin} \leq$ -25 dBm; -10 °C $\leq T_{case}$ (EOM) $\leq$ +75 °C		5.0	dB

The table below lists the optical output specifications for the OBA port (OBA out).

Table B-98 Optical Output Specifications for the Optical Booster Amplifier Port (OBA out)

Type	Conditions	min.	max.	Unit
Wavelength range		1530	1560	nm
Nominal signal output power P_{Sout}		+12.0		dBm
Signal output power P_{Sout} (BOL), including connector tolerance	BOL	+11.3	+12.4	dBm
Signal output power P_{Sout} (EOL), including connector tolerance	EOL	+10.0	+13.0	dBm
Residual pump power at output port	λ_p = 980 nm; P_{Sin} = -9 dBm		-20	dBm
ASE-power at output port	λ_p = 980 nm; P_{Sin} = -9 dBm		0	dBm
Noise figure	λ = 1530 to 1560 nm; P_{Sin} = -9 dBm; -10 °C ≤ T_{case} (EOM) ≤ +75 °C		7	dB

Gigabit Ethernet Interface Port Units

Overview

Purpose

This section provides detailed information concerning Gigabit Ethernet GE1/SX2 and GE1/LX2 Interface port units available for use for the WaveStar TDM 2.5G/10G (2-Fiber).

□

GE1/SX2 (LEY309AE) Interface Port Unit Data Sheet

Capacity

The GE1/SX2 port unit supports 2 fully independent bidirectional ports. Ethernet frames received from a GE1/SX2 port are mapped into STS-1s using virtual concatenation. The number of STS-1s per virtual concatenated path can be user provisioned as ≤21 STS-1s at single STS-1 intervals. This offers an effective capacity over a network of 50 to 1050 Mbit/s in steps of 50 Mbit/s

Protection Switching

The GE1/SX2 port unit supports standard BLSR and UPSR protection schemes on the individual STS-1s that are part of the virtually concatenated path

Optical Safety

The GE1/SX2 port unit uses a Low Power Laser.

Ethernet Standards Compliance

The GE1/SX2 interface port unit complies to the standards listed in the tables below.

GE1/SX2 Operating range

The table below describes the various operating ranges for the GE1/SX2 port unit over each optical fiber type.

Table B-99 GE1/SX2 Operating Ranges

Fiber Type	Modal Bandwidth @ 850nm (min. overfilled launch) (MHz - km)	Minimum range (meters)
62.5 µ m MMF	160	2 to 220
62.5 µ m MMF	200	2 to 275
50 µ m MMF	400	2 to 500
50 µ m MMF	500	2 to 550
10 µ m SMF	N/A	Not supported

GE1/SX2 Transmission Characteristics

The table below provides the specific transmission characteristics for the GE1/SX2 port unit.

Table B-100 GE1/SX2 Transmission

Description	62.5 μ m MMF	50 μ m MMF	Unit
Transmitter type	Shortwave Laser		
Signaling speed (range)	1.25 + 100 ppm		GBd
Wavelength (range)	770 to 860		nm
Trise/Tfall (max, 20-80%; l > 830 nm)	0.26		ns
Trise/Tfall (max, 20-80%; l <830 nm)	0.21		ns
RMS spectral width (max)	0.85		nm
Average launch power (max)	See footnote[a]		dBm
Average launch power (min)	-9.5		dBm
Average launch power of OFF transmitter (max)[b]	N/A		dBm
Extinction ratio (min)	9		dB
RIN (max)	-117		dB/Hz
Coupled Power Ratio (CPR)[c]	9<CPR		dB

Notes

a) The GE1/SX2 launch power shall be the lesser of the class 1 safety limit as defined dy 38.7.2 or the average receive power (max) defined by the following table.
b) During all conditions when the PMA is powered, the ac signal (data) into the transmit port will be valid encoded 8B/10B patterns (this is a requirement of the PCS layers) except for short durations during system power-on-reset or diagnostics when the PMA is placed in a loopback mode.
c) Radial overfilled launches, while they meet CPR ranges, should be avoided.

GE1/SX2 Receive characteristics

The table below provides the specific receive characteristics for the GE1/SX2 port unit.

Table B-101 GE1/SX2 Receive

Description	**62.5 µ m MMF**	**50 µ m MMF**	**Unit**
Signaling speed (range)	1.25 + 100 ppm		GBd
Wavelength (range)	770 to 860		nm
Average receive power (max)	0		dBm
Receive sensitivity	-17		dBm
Return loss (min)	12		dB
Stressed receive sensitivity[a, b]	12.5	13.5	dBm
Vertical eye-closure penalty[c]	2.60	2.20	dB
Receive electrical 3 dB upper cutoff frequency (max)	1500		MHz

Notes

a) Measured with conformance test signal at TP3 for BER = 10 E-12 at the eye center.
b) Measured with a transmit signal having a 9 dB extinction ratio. If another extinction ratio is used, the stressed recieved sensitivity should be corrected for the extinction ratio penalty.
c) Vertical eye-closure penalty is a test condition for measuring stressed recieve sensitivity. It is not a required characteristic of the reciever.

GE1/SX2 Power budget and loss penalties

The table below provides the worst-case power budget and link penalties for a GE1/SX2 port unit.

Table B-102 Worst-case GE1/SX2 Power Budget and Penalties [1]

Parameter	**62.5 µ m MMF**		**50 µ m MMF**		**Unit**
Modal bandwidth as measured at 850 nm (minimum, overfilled launch)	160	200	400	500	MHz - km
Low power budget	7.5	7.5	7.5	7.5	dB
Operating distance	220	275	500	550	m
Channel insertion loss[b, c]	2.38	2.60	3.37	3.56	dB
Link power penalties[c]	4.27	4.29	4.07	3.57	dB
Unallocated margin in link power budget[c]	0.84	0.60	0.05	0.37	dB

Notes

a) Link penalties are used for link budget calculations. They are requirements and are not meant to be tested.
b) Operating distances used to calculate the channel insertion loss are the maximum values
c) A wavelength of 830 nm is used to calculate channel insertion loss, link power penalties, and unallocated margin.

□

GE1/LX2 (LEY310AE) Data Sheet

Capacity

The GE1/LX2 port unit supports 2 fully independent bidirectional ports. Ethernet frames received from a GE1/LX2 port are mapped into STS-1s using virtual concatenation. The number of STS-1s per virtual concatenated path can be user provisioned as up to 21 STS-1s at single STS-1 intervals. This offers an effective capacity over a network of 50 to 1050 Mbit/s in steps of 50 Mbit/s.

Protection Switching

The GE1/LX2 port unit supports standard BLSR and UPSR protection schemes on the individual STS-1s that are part of the virtually concatenated path.

Optical Safety

The GE1/LX2 port unit uses a Low Power Laser.

Ethernet Standards Compliance

The GE1/LX2 interface port unit complies to the standards listed in the tables below.

GE1/LX2 Operating range

The table below describes the various operating ranges for the GE1/LX2 port unit over each optical fiber type.

Table B-103 GE1/LX2 Operating Ranges

Fiber Type	Modal Bandwidth @ 1300 nm (min. overfilled launch) (MHz - km)	Minimum range (meters)
62.5 µ m MMF	500	2 to 550
50 µ m MMF	400	2 to 550
50 µ m MMF	500	2 to 550
10 µ m SMF	N/A	2 to 5000

GE1/LX2 Transmission Characteristics

The table below provides the specific transmission characteristics for the GE1/LX2 port unit.

Table B-104 GE1/LX2 Transmission

Description	**62.5 µ m MMF**	**50 µ m MMF**	**10 µm SMF**	**Unit**
Transmitter type	Longwave Laser			
Signaling speed (range)	1.25 +/– 100 ppm			GBd
Wavelength (range)	1270 to 1335			nm
Trise/Tfall (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)	N/A			dBm
Extinction ratio (min)	9			dB
RIN (max)	-120			dB/Hz
Coupled Power Ratio (CPR)[a]	28 < CPR < 40	12 > CPR < 20	N/A	dB

a) Due to dual media (single-mode and multimode) support of the GE1/LX2 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.

GE1/LX2 Receive characteristics

The table below provides the specific receive characteristics for the GE1/LX2 port unit.

Table B-105 GE1/LX2 Receive

Description	Value	Unit
Signaling speed (range)	1.25 +/– 100 ppm	GBd
Wavelength (range)	1270 to 1335	nm
Average receive power (max)	-3	dBm
Receive sensitivity	-20	dBm
Return loss (min)	12	dB
Stressed receive sensitivity[a,b]	-14.4	dBm
Vertical eye-closure penalty[c]	2.60	dB
Receive electrical 3 dB upper cutoff frequency (max)	1500	MHz

a) Measured with conformance test signal at TP3 for BER = 10 E-12 at the eye center.
b) Measured with a transmit signal having a 9 dB extinction ratio. If another extinction ratio is used, the stressed recieved sensitivity should be corrected for the extinction ratio penalty.
c) Vertical eye-closure penalty is a test condition for measuring stressed recieve sensitivity. It is not a required characteristic of the reciever.

GE1/LX2 Power budget and loss penalties

The table below provides the worst-case power budget and link penalties for a GE1/LX2 port unit.

Table B-106 Worst-case GE1/LX2 Power Budget and Penalties

Parameter	**62.5 μm MMF**	**50 μm MMF**		10 μm SMF	**Unit**
Modal bandwidth as measured at 850 nm (minimum, overfilled launch)	500	400	500	N/A	MHz - km
Link power budget	8.5	8.5	8.5	9.0	dB
Operating distance	550	550	550	5000	m
Channel insertion loss[a,b]	2.35	2.35	2.35	4.57	dB
Link power penalties[b]	3.48	5.08	3.96	3.27	dB
Unallocated margin in link power budget[b]	2.67	1.07	2.19	1.16	dB

a) Operating distances used to calculate the channel insertion loss are the maximum values
b) A wavelength of 1270 nm is used to calculate channel insertion loss, link power penalties, and unallocated margin.

□

Glossary

Numerics ***5ESS***® **(Number 5 Electronic Switching System)**

A

ABN (Abnormal (condition)

ABS (Absent)

AC (Alternating Current)

ACO (Alarm Cut-Off)

ACT (Active)

ADM (Add/Drop Multiplexer)

ADR (Add/Drop Ring)

AGNE (Alarm Gateway Network Element)

AID (Access Identifier)

AIS (Alarm Indication Signal)

AITS A(cknowledged Information Transfer Service)
Confirmed mode of operation of the LAPD protocol.

AMI (Alternate Mark Inversion)

ANSI (American National Standards Institute)

APD (Avalanche PhotoDiode)

APS (Automatic Protection Switch)

ASAP (Alarm Severity Assignment Profile)

AS&C (Alarm, Status, and Control)

APSD (Automatic Power Shutdown)

ASCII (American Standard Code for Information Interchange)

ASN.1 (Abstract Syntax Notation 1)

ATM (Asynchronous Transfer Mode)

AUTO (Automatic)

AVAIL (Available)

B

B3ZS (Bipolar 3-Zero Substitution)

B8ZS (Bipolar 8-Zero Substitution)

BCLAN (Board Controller Local Area Network)

BDFB (Battery Distribution and Fuse Bay)

BER (Bit Error Rate)

BITS Building Integrated Timing Supply)

BLK (Blank)

BLSR (Bidirectional Line-Switched Ring)

BOC (Bell Operating Company)

C **CCITT (Comité Consultatif International Télégrafique & Téléphonique)**

CD ((Chromatic Dispersion)

CDRH (Center for Devices and Radiological Health)

CEPT (Conférence Européenne des Administrations des Postes et des Télécommunications)

CIT (Craft Interface Terminal)

CL (Clear)

CLEI (Common Language Equipment Identifier)

CLLI (Common Language Location Identifier)

CMIP (Common Management Information Protocol.)
OSI standard protocol for OAM&P information exchange.

CMISE (Common Management Information Service Element)

CO (Central Office)

CP (Circuit Pack)

CPE (Customer Premises Equipment)

CR (Critical (alarm)

CSMA/CD (Carrier Sense Multiple Access with Collision Detection)

CS&O (Lucent Technologies Customer Support and Operations)

CSU (Channel Service Unit)

CTIP (Customer Training and Information Products)

CTS **(Customer Technical Support within Lucent Technologies)**

CV **(Coding Violation)**

D **DACS** **(Digital Access Cross-Connect System)**

dB **(Decibels)**

DC **(Direct Current)**

DCC **(Data Communications Channel)**

DCCr **(Data Communications Channel (section)**

DCCm **(Data Communications Channel (line)**

DCE **(Data Communications Equipment)**

DCM **(Dispersion Compensation Module)**

DCN **(Data Communications Network)**

DCS **(Digital Cross-Connect System)**

DPLL **(Digital Phase Locked Loop)**

DRI **(Dual Ring Interworking)**

DRAM **(Dynamic Random Access Memory)**

DS0, DS1, DS3 **(Digital Signal Levels 0, 1, 3)**

DS3EC1/8 **(8 Port DS3 or EC1 interface port unit)**

DS-N **(Digital Signal, Level N)**

DS-NE **(Directory Service Network Element)**

DSX **(Digital Cross-Connect Frame)**

DTE **(Data Terminating Equipment)**

DTMF **(Dual Tone Multifrequency)**

DWDM **(Dense Wavelength Division Multiplexing)**

E **EBER** **(Equivalent Bit Error Rate)**

EC **(Echo Canceller)**

EC-1, EC-N **(Electrical Carrier, Levels 1 and N)**

ECI **(Equipment Catalog Item)**

EEPROM **(Electrically Erasable Programmable Read-Only Memory)**

EF **(Equipment Fail)**

EIA **(Electronic Industries Association)**

EM **(Event Management)**

EMC **(Electromagnetic Compatibility)**

EMI **(Electromagnetic Interference)**

EMS **(Element Management System)**

EPROM **(Erasable Programmable Read-Only Memory)**

EQ **(Equipped)**

EQPT **(Equipment)**

ES **(Errored Seconds)**

ESD (Electrostatic Discharge)

ESF (Extended Super Frame (DS1 signal format)

ETSI (European Telecommunications Standards Institute)

EVT (Event)

F **FCC** (Federal Communications Commission)

FDA (Food and Drug Administration)

FDDI (Fiber Distributed Data Interface)

FE (Far End)

FEBE (Far End Block Error)

FEPROM (Flash EPROM)

FIT (Failure in Time)

G **GB** (Gigabytes)

GE1 ((Gigabit Ethernet)

Gb/s (Gigabits per second)

GHz (Gigahertz)

GNE (Gateway Network Element)

GR-XXX (Telcordia (Bellcore) General Requirement-XXX)

H **HDLC** (High-Level Data Link Control)

HS **(High Speed)**

HW **(Hardware)**

Hz **(Hertz)**

I **IAO LAN** **(Intraoffice Local Area Network)**

ID **(Identifier)**

IEC **(International Electrotechnical Commission)**

IEEE **(Institute of Electrical and Electronics Engineers)**

I/O **(Input/Output)**

IMF **(Infant Mortality Factor)**

“ **(Inches)**

INTFC **(Interface)**

IS **(In Service)**

ISDN **(Integrated Services Digital Network)**

ITCO **(Independent Telephone Company)**

ITM **(Integrated Transport Management)**

ITM-NM **(Integrated Transport Management Network Module)**

ITM SNC **(Integrated Transport Management SubNetwork Controller)**

ITU **(International Telecommunications Union)**

ITU-R (International Telecommunications Union — Radio standardization sector. Formerly known as CCIR: Comité Consultatif International Radio; International Radio Consultative Committee.)

ITU-T (International Telecommunications Union — Telecommunication standardization sector. Formerly known as CCITT: Comité Consultatif International Télégrafique & Téléphonique; International Telegraph and Telephone Consultative Committee.)

IXC (Interexchange Carrier)

K

Kb/s (Kilobits per second)

L

LAN (Local Area Network)

LATA (Local Access and Transport Area)

LBC (Laser Bias Current)

LBFC (Laser Backface Currents)

LBO (Lightguide Build-Out)

LCAS (Link Capacity Adjustment Scheme)

LCN (Local Communications Network)

LCT (Large Capacity Terminal)

LEC (Local Exchange Carrier)

LED (Light-Emitting Diode)

LGX (Lightguide Cross-Connect)

LOF (Loss of Frame)

LOP (Loss of Pointer)

LOS (Loss of Signal)

LPBK (Loopback)

LS (Low Speed)

LTE (Line Terminating Equipment)

M μ **(Microns)**

μ**m (micrometer)**

MB (Megabytes)

Mb/s (Megabits per second)

MCOND (Maintenance Condition)

MEM (Memory)

Metropolis^{TM} EON (Metropolis^{TM} Enhanced Optical Networks)
MIPS (Millions of Instructions Per Second)

MJ (Major (alarm)

MML (Human-Machine Language)

MN (Minor (alarm)

ms (Millisecond)

MTBF (Mean Time Between Failures)

MTBMA (Mean Time Between Maintenance Activities)

MTTR (Mean Time To Repair)

N **NA** **(Not Applicable)**

NCC **(Network Communication Controller)**

NE **(Network Element)**

NEBS **(Network Equipment-Building System)**

nm **(Nanometer) (10-9 meters)**

NMA **(Network Monitoring and Analysis System)**

NMON **(Not Monitored)**

NMS **(Network Management System)**

NORM **(Normal)**

NPPA **(Non-Preemptible Protection Access)**

NRZ **(Nonreturn to Zero)**

NSA **(Non-Service Affecting)**

NSAP Address **(Network Service Access Point Address (used in the OSI network layer 3)**

NTF **(No Trouble Found)**

NVM **(Non-Volatile Memory)**

O **O&M** **(Operation and Maintenance)**

OA **(Optical Amplifier)**

OALAN **(Overhead Access Local Area Network)**

OAM&P (Operations, Administration, Maintenance, and Provisioning)

OBA (Optical Booster Amplifier)

OBPA (Optical Booster Pre-Amplifier)

OC, OC-N (Optical Carrier)

OC-1 (Optical Carrier, Level 1 Signal (51.84 Mb/s)

OC-3 (Optical Carrier, Level 3 Signal (155.52 Mb/s)

OC-3c (Optical Carrier, Level 3 Concatenated Signal (155.52 Mb/s)

OC-12 (Optical Carrier, Level 12 Signal (622.08 Mb/s)

OC-48 (Optical Carrier, Level 48 (2488.32 Mb/s) (2.5 Gb/s)

OC-192 (Optical Carrier, Level 192 (9953.28 Mb/s) (10 Gb/s)

OC3/STM1/1.3LR4 (Optical Carrier 3/Synchronous Transport Module 1 port unit in the 1.3µ range with four bidirectional long reach ports.)

OC3/STM1/1.3LR4 (Optical Carrier 3/Synchronous Transport Module 1 port unit in the 1.3µ range with four bidirectional long reach ports.)

OC3/STM1/1.3SR4 (Optical Carrier 3/Synchronous Transport Module 1 port unit in the 1.3µ range with four bidirectional short reach ports.)

OC3/STM1/1.3SR4 (Optical Carrier 3/Synchronous Transport Module 1 port unit in the 1.3µ range with four bidirectional short reach ports.)

OC12/STM4/1.3LR2 (Optical Carrier 12/Synchronous Transport Module 4 port unit in the 1.3µ range with two bidirectional long reach ports.)

OC12/STM4/1.3LR2 (Optical Carrier 12/Synchronous Transport Module 4 port unit in the 1.3µ range with two bidirectional long reach ports.)

OC12/STM4/1.3SR2 (Optical Carrier 12/Synchronous Transport Module 4 port unit in the 1.3µ range with two bidirectional short reach ports.)

OC48/STM16/1.3LR1 (Optical Carrier 48/Synchronous Transport Module 16 port unit in the 1.3μ range with one bidirectional long reach port.)

OC48/STM16/1.3LR1 (Optical Carrier 48/Synchronous Transport Module 16 port unit in the 1.3μ range with one bidirectional long reach port.)

OC48/STM16/1.5LR1 (Optical Carrier 48/Synchronous Transport Module 16 port unit in the 1.5μ range with one bidirectional long reach port.)

OC48/STM16/1.5LR1 (Optical Carrier 48/Synchronous Transport Module 16 port unit in the 1.5μ range with one bidirectional long reach port.)

OC48/STM16/DWDM01-16 (Optical Carrier 48/Synchronous Transport Module 16 port unit in 16 different wavelengths that are compatible with ITU wavelengths.)

OC48/STM16/DWDM01-16 (Optical Carrier 48/Synchronous Transport Module 16 port unit in 16 different wavelengths that are compatible with ITU wavelengths.)

OC192/STM64/1.5SR1 (Optical Carrier 192/Synchronous Transport Module 64 port unit in the 1.5μ range with one bidirectional short/ intermediate reach port.)

OC-AIM (Optical Channel Alarm Indication Message)

OI (Operations Interworking)

OLS (Optical Line System)

OOF (Out-of-Frame)

OOS (Out-of-Service)

OPS/INE (Operations System for Intelligent Network Elements)

OS (Operations System)

OSI (Open Systems Interconnect)

OSMINE **(Operations Systems Modifications for the Integration of Network Elements)**

P **PCB** **(Printed Circuit Board)**

PCM **(Pulse Code Modulation)**

PCMCIA **(Personal Computer Memory Card International Association)**

PDH **(Plesiochronous Digital Hierarchy)**

PM **(Performance Monitoring)**

PMD **(Polarization Mode Dispersion)**

POH **(Path Overhead)**

POP **(Point of Presence)**

POTS **(Plain Old Telephone Service)**

PPROC/STS192 **((Pointer Processor circuit pack for 192 STS-1/64 STM-1 equivalents)**

PPROC/STS384 **((Pointer Processor circuit pack for 384 STS-1/128 STM-1 equivalents)**

PRI **(Primary)**

PROTN **(Protection)**

PROV **(Provisioned)**

PSDN **(Public Switched Data Network)**

PSTN **(Public Switched Telephone Network)**

PTE **(Path Terminating Equipment)**

PTY **(Parity)**

PVC **(Permanent Virtual Circuit)**

PWR **(Power)**

PWR ON **(Power On)**

Q **QOS** **(Quality of Service)**

QRSS **(Quasi-Random Signal Source)**

R **RAM** **(Random Access Memory)**

RCV **(Receive)**

RCVR **(Receiver)**

RDI **(Remote Defect Indication)**

RF **(Radio Frequency)**

RFI **(Remote Failure Indication)**

RPP **(Reliability Prediction Procedure)**

RT **(Remote Terminal)**

RTAC **(Regional Technical Assistance Center)**

RTRV **(Retrieve)**

RZ **(Return to Zero)**

S **SA** **(Service Affecting)**

SDH (Synchronous Digital Hierarchy)

SDS (Standard Directory Service based on ANSI recommendation T1.245)

SEC (Secondary)

SES (Severely Errored Seconds)

SF (Super Frame (DS1 signal format)

SMF (Single-Mode Fiber)

SNMS (SubNetwork Management System)

SNR (Signal-to-Noise Ratio)

SOH (Section Overhead)

SONET (Synchronous Optical Network)

SPE (Synchronous Payload Envelope)

STBY (Standby)

STS (Synchronous Transport Signal)

STS-1, STS-N (Synchronous Transport Signal, Levels 1 and N)

STS-3 (Synchronous Transport, Level 3)

STS-3c (Synchronous Transport, Level 3 Concatenated Signal)

STS-12 (Synchronous Transport, Level 12)

STS-12c (Synchronous Transport, Level 12Concatenated Signal)

SVC (Switched Virtual Circuit)

SWITCH/DS3EC1 (Electrical Protection Switch for up to 96 DS3 or EC-1

signals port unit)

SWITCH/STS576 (576X576 STS-1/192x192 STM-1 Switch circuit pack)

SWITCH/STS768 (768X768 STS-1/256x256 STM-1 Switch circuit pack)

SYNC (Synchronizer)

T TA (Technical Advisory)

TABS (Telemetry Asynchronous Byte Serial (Protocol)

TARP (Target Identifiers Address Resolution Protocol)

TBD (To Be Determined)

TBOS (Telemetry Byte-Oriented Serial (Protocol)

TCA (Threshold-Crossing Alert)

TCP/IP (Transmission Control Protocol/Internet Protocol)

TDM (Time Division Multiplexing)

THz (Terrahertz (1012 Hz)

TID (Target Identifier)

TIRKS (Trunks Integrated Records Keeping System)

TL1 (Transaction Language 1)

TR (Technical Requirement)

TSA (Time Slot Assignment)

TSI (Time Slot Interchange)

TSO (Technical Support Organization)

TU (Tributary Unit)

U **UAS (Unavailable Seconds)**

UITS (Unacknowledged Information Transfer Service. Unconfirmed mode of LAPD operation.)

UNEQ (Path Unequipped)

UPSR (Unidirectional Path-Switched Ring)

V **V (Volts)**

VAC (Volts Alternating Current)

VBA (Virtual Bandwidth Allocation)

VDC (Volts Direct Current)

VF (Voice frequency)

VM (Violation Monitor)

VMR (Violation, Monitor, and Removal)

VCG (Virtual Concatenated Group)

VT (Virtual Tributary)

VT1.5 (Virtual Tributary, Level 1.5)

VT-G (Virtual Tributary Group)

W **WAD (Wavelength Add/Drop)**

WAN (Wide Area Network)

***WaveStarTM* OLS 1.6T (400G) *(WaveStarTM* Optical Line System 1.6 Terabits)**

***WaveStarTM* SNMS *(WaveStarTM* SubNetwork Management System (formerly known as ITM SNC [Integrated Transport Management SubNetwork Controller])**

WDCS (Wideband Digital Cross-Connect System)

WDM (Wavelength Division Multiplexing)

X **X.25 (An ITU standard defining the connection between a terminal and a public packet-switched network)**

Lucent Technologies
Bell Labs Innovations

Glossary

Numerics

0×1 Line Operation
0×1 means unprotected operation. The connection between network elements has one bidirectional line (no protection line).

1+1 Line Protection
A protection architecture in which the transmitting equipment transmits a valid signal on both the working and protection lines. The receiving equipment monitors both lines. Based on performance criteria and OS control, the receiving equipment chooses one line as the active line and designates the other as the standby line.

576×576 STS-1 Switch (SWITCH/STS576)
The SWITCH/STS576 circuit pack provides a 576×576 STS-1 equivalent cross-connect function.

A

Absent (ABS)
Used to indicate that a given circuit pack is not installed.

Access Identifier (AID)
A technical specification for explicitly naming entities (both physical and logical) of an NE using a grammar comprised of ASCII text, keywords, and grammar rules.

Active (ACT)
Used to indicate that a circuit pack or module is in-service and currently providing service functions.

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 Correlation
The search for a directly-reported alarm that can account for a given symptomatic condition.

Alarm Cut-Off (ACO)
A button on the user panel used to silence audible alarms.

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.

Association
A logical connection between manager and agent through which management information can be exchanged.

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.

Autolock
Action taken by the system in the event of circuit pack failure/trouble. System switches to protection and prevents a return to the working circuit pack even if the trouble clears. Multiple protection switches on a circuit pack during a short period of time cause the system to autolock the pack.

Automatic (AUTO)
One possible state of a port or slot. When a port is in the AUTO state and a good signal is detected, the port automatically enters the IS (in-service) state. When a slot is in the AUTO state and a circuit pack is detected, the slot automatically enters the EQ (equipped) state.

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

Backup
The backup and restoration features provide the capability to recover from loss of NE data because of such factors as human error, power failure, NE design flaws, and software bugs.

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. BLSRs are functionally equivalent to SDH Multiplexer Section Shared Protection Rings (MS-SPRings).

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.

Bipolar 3-Zero Substitution (B3ZS)

A line coding technique that replaces three consecutive zeros with a bit sequence having special characteristics accomplishing two objectives: first, this bit sequence accommodates the density requirements of the ones for digital T3 carrier, second, the sequence is recognizable at the destination (due to deliberate bipolar violations) and is removed to produce the original signal.

Bipolar 8-Zero Substitution (B8ZS)

A line coding technique that replaces eight consecutive zeros with a bit sequence having special characteristics accomplishing two objectives: First, this bit sequence accommodates the density requirements of the ones for digital T1 carrier; Second, the sequence is recognizable at the destination (due to deliberate bipolar violations) and is removed to produce the original signal.

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).

Blank (BLK)
The status of a circuit pack slot that contains a bus extender (blank) circuit pack.

Board Controller Local Area Network (BCLAN)
The internal local area network that provides communications between the line and board controllers on the circuit packs associated with a high-speed line.

Bridge Cross-Connection
The setting up of a cross-connection leg with the same input tributary as that of an existing cross-connection leg. Thus, forming a 1:2 bridge from an input tributary to two output tributaries.

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

Building Integrated Timing Supply (BITS)
A single clock that provides all the DS1 and/or composite clock timing reference to all other clocks in that building.

Byte
Refers to a group of eight consecutive binary digits.

C

C-Bit
A framing format used for DS3 signals produced by multiplexing 28 DS1s into a DS3. This format provides for enhanced performance monitoring of both near-end and far-end entities.

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.

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.

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 that bipolar violations of the signal have occurred.

Collocated

System elements that are located in the same location.

Command Group

An administrator-defined group that defines commands to which a user has access.

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).

Co-Resident

A hardware configuration where two applications can be active at the same time independently on the same hardware and software platform without interfering with each others functioning.

Correlation

A process where related hard failure alarms are identified.

Craft Interface Terminal (CIT)

The user interface terminal used by craft personnel to communicate with a 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.

Crosstalk

An unwanted signal introduced into one transmission line from another.

Current Value

The value currently assigned to a provisionable parameter.

D **Data**

A collection of system parameters and their associated values.

Database Administrator

A user who administers the database of the application.

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.

Data Communications Equipment (DCE)

The equipment that provides signal conversion and coding between the data terminating 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.

Data Terminating Equipment (DTE)

The equipment that originates data for transmission and accepts transmitted data.

DDM-1000

Lucent Technologies' Dual DS3 Multiplexer – A digital multiplexer that multiplexes DS1, DS1C, or DS2 signals into a DS3 signal or a 90 Mb/s or 180 Mb/s optical signal.

DDM-2000

Lucent Technologies SONET-ready network multiplexer that can function as a lightwave terminal. It is designed primarily for loop feeder and interoffice applications that work in existing asynchronous as well as the emerging SONET networks. Multiplexers that multiplex DS1, DS3, or EC-1 inputs into EC-1, OC-1, OC-3, or OC-12 outputs.

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

Default Provisioning
The parameter values that are preprogrammed as shipped from the factory.

Defect
A limited interruption of the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis.

Demultiplexer
A device that splits a combined signal into individual signals at the receiver end of transmission.

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

Dense Wavelength Division Multiplexing (DWDM)
Transmitting two or more signals of different wavelengths simultaneously over a single fiber.

Deprovisioning
The inverse order of provisioning. To manually remove/delete a parameter that has (or parameters that have) previously been provisioned.

Digital Cross-Connect Panel (DSX)
A panel designed to interconnect equipment that operates at a designated rate. For example, a DSX-3 interconnects equipment operating at the DS3 rate.

Digital Cross-Connect System (DCS)
An electronic switching system, found in telephone central offices, that switches groups of signals from one route to another without the need to demultiplex them. An optical cross-connect is an optical switch that routes wavelength channels from one fiber route to another without first converting them into electricity and back.

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

Digital Signal Levels 0, 1, 3 (DS0, DS1, DS3)
An ANSI-defined signal or service level corresponding to the following: DS0 is 64 Kb/s, DS1 is 1.544 Mb/s (equivalent to T1), and DS3 is 44.736 Mb/s (equivalent to 28 T1 channels or T3).

Directory Service Network Element (DSNE)
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. A DSNE can also be a GNE.

Dispersion
Time-broadening of a transmitted light pulse.

Dispersion Shifted Optical Fiber
1330/1550 nm minimum dispersion wavelength.

Divergence
When there is unequal amplification of incoming wavelengths, the result is a power divergence between wavelengths.

Doping
The addition of impurities to a substance in order to attain desired properties.

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.

DS3EC1/8

Port unit that provides 8 bidirectional ports at the DS3-rate or EC-1-rate.

DS3EC1/8

Port unit that provides 8 bidirectional ports at the DS3-rate or EC-1-rate.

DS3EC1 Connector Panel

The two panels on one or both sides of a shelf containing DS3EC1/8 port units. The DS3EC1 Connector Panels provide an interface between the DS3EC1/8 port units and the backplane via BNC connectors.

DS3EC1 Connector Panel

The DS3EC1 Connector Panels provide an interface between the DS3EC1/8 port units and the backplane via BNC connectors.

DS3 Format

Specifies the line format of a DS3 interface port, such as M23 or C-bit parity.

DS3 Idle Signal
A signal that can be applied to any output port that is not cross-connected to an input port. This signal lets downstream network elements know that the facility is operating normally even though it is not sending a normal DS3 signal.

DS3 Interface Port
Port on a circuit pack for DS3 connectors.

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

DSX-1, 2, 3
Digital cross-connect used to interconnect equipment, provide patch capability, and provide test access at the DS1, DS2, or DS3 level.

Dual Ring Interworking (DRI)
A topology in which two rings are interconnected at two nodes on each ring and operate so that inter-ring traffic is not lost in the event of a node or link failure at an interconnecting point.

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.

Electronic Industries Association (EIA)
A trade association of the electronic industry that establishes electrical and functional standards.

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

Entity
A specific piece of hardware (usually a circuit pack, slot, or module) that has been assigned a name recognized by the system.

Entity Identifier
The name used by the system to refer to a circuit pack, memory device, or communications link.

Equipment Protection
Relates to the DS3 electrical interfaces, which are protected by 1xN equipment protection. This means that protection switching for electrical interfaces is supported at the level of the port unit (circuit pack).

Equipment Protection
Relates to the DS3 electrical interfaces, which are protected by 1xN equipment protection. This means that protection switching for electrical interfaces is supported at the level of the port unit (circuit pack).

Equipped (EQ)
Status of a circuit pack or interface module that is in the system database and physically in the frame, but not yet provisioned.

Erbium
A soft rare earth element used in metallurgy and nuclear research.

Erbium Doped Fiber Amplifier (EDFA)
An amplifier that performs by having a light signal pass through a section of erbium-doped fiber and using the laser pump diode to amplify the signal.

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.

Establish
A user initiated command, at the *WaveStarTM* CIT, to create an entity and its associated attributes in the absence of certain hardware.

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.

Event Driven
A required characteristic of a network element or software system: NEs are reactive systems, primarily viewed as systems that wait for and then handle events. Events are provided by the external interface packages, the hardware resource packages, and also by the software itself.

Express Ring
One of multiple applications provided by the WaveStar 10G (OC-192) product. An express ring is a 10G-bit 2-fiber BLSR that is built using spare (available) fibers at an existing OC-48 NE which has exhausted it's STS-1 capacity. The express ring is physically parallel to the existing OC-48 ring. As a contrast and where spare fibers are not available, an express ring cannot be constructed and the existing OC-48 ring must be upgraded to an OC-192 ring.

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.

Extra traffic
Unprotected traffic that is carried over protection channels when their capacity is not used for the protection of working traffic.

F **Facility**

A one- or two-way circuit that carries a transmission signal.

Failures in Time (FIT)

Circuit pack failure rates per 10^9 hours as calculated using the method described in *Reliability Prediction Procedure for Electronic Equipment*, Telcordia Method I, Issue 5, September 1995.

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 (Remote Detect Indication).

Fault

Term used when a circuit pack has a hard (not temporary) fault and cannot perform its normal function.

Fault Management

Collecting, processing, and forwarding of autonomous messages from network elements.

Fiber Distributed Data Interface (FDDI)

Fiber interface that connects computers and distributes data among them.

Flash EPROM

A technology that combines the nonvolatility of EPROM with the in-circuit reprogrammability of EEPROM (electrically-erasable PROM).

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

Forced
Term used when a circuit pack (either working or protection) has been locked into a service-providing state by user command.

Frame
The smallest block of digital data being transmitted.

Frame Relay (FR)
A form of packet switching that relies on high-quality phone lines to minimize errors. It is very good at handling high-speed, bursty data over wide area networks. The frames are variable lengths and error checking is done at the end points.

Framework
An assembly of equipment units, such as a rack, that is capable of housing .

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 ADR
Lucent Technologies' OC-48 rate Add/Drop Rings lightwave Terminal for 2-fiber BLSRs. It is designed primarily for interoffice applications. It supports adds, drop, and through connections for DS3/EC-1, OC-3, IS-3, and OC-12.

G

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

H **Hairpinning**

A network topology in which tributary traffic is routed into and then back out of a single network element without being placed on a ring for transport. This cross-connection capability can bring traffic in from one remote site, cross-connect it at a different signal level, and transmit it to other remote sites without consuming any of the ring's capacity.

Hard Failure

An unrecoverable nonsymptomatic (primary) failure that causes signal impairment or interferes with critical network functions, such as DCC operation.

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.

Hot Standby

A circuit pack ready for fast, automatic placement into operation to replace an active circuit pack. It has the same signal as the service going through it, so that choice is all that is required.

Human Machine Language (MML)

A standard language developed by the ITU for describing the interaction between humans and dumb terminals.

I **Idle**

An output port not cross-connected to an input port.

Idle Code

A signal transmitted downstream automatically from an idle output port. It can also be transmitted downstream by a manual command from a cross-connected output port.

Insert
To physically insert a circuit pack into a slot, thus causing a system-initiated restoral of an entity into service and/or creation of an entity and associated attributes.

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.

Integrated Transport Management SubNetwork Controller (ITM SNC)
Lucent Technologies' SONET element management layer system that provides fault, configuration, and security functions through the use of a GUI.

J

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

L

Lead Time
The time interval between placement of a product order and receipt of the product.

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 Controller Local Area Network (LCLAN)
The internal local area network that provides communications between the controlled circuit packs.

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 signal.

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

Literal Character
A letter, digit, or symbol that is entered in a command. The first hyphen in UNIT-{1-64} is a literal character; the braces and the second hyphen are not literal characters.

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.

Location
An identifier for a specific circuit pack, interface module, interface port, or communications link.

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 Budget
Loss (in dB) of optical power due to the span transmission medium (includes fiber loss and splice losses).

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

M23-Format
A standard framing format used for DS3 signals produced by multiplexing 28 DS1s into a DS3 (sometimes referred to as M13-format, without C-bit parity).

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

Maintenance Condition
An equipment state in which some normal service functions are suspended, either because of a problem or to perform special functions (copy memory) that can not be performed while normal service is being provided.

Manual Switch State

A protection group shall enter the Manual Switch State upon the initiation and successful completion of the Manual Switch command. The protection group leaves the Manual Switch state by means of the Clear or Forced Switch commands. While in the Manual Switch state the system may switch the active unit automatically if required for protection switching.

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.

Mediation Device (MD)

Allows for exchange of management information between Operations System and Network Elements.

Mesh Network

A standard topology used in Wide Area Networks to allow multiple routes between hosts in a network. Mesh topologies are relatively immune to bottleneck and component failure due to the variety of paths traffic can be routed around failed or busy components. The design is relatively expensive in terms of the cabling costs. A mesh network where every node is connected to every other node is known as a fully connected network.

Mid-Span Meet

The capability to interface between two lightwave network elements of different vendors. This applies to high-speed optical interfaces.

Minor (MN)

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.

Multiplexer

A device (circuit pack) that combines two or more transmission signals into a combined signal on a shared medium.

Multiplexing

The process of combining multiple signals into a larger signal at the transmitter by a multiplexer. The large signal is then split into the original smaller signals at the receiver by a demultiplexer.

N

Network Element (NE)

A node in a telecommunication network that supports network transport services and is directly manageable by a management system.

Network Monitoring and Analysis (NMA)

An operations system designed by Telcordia which is used to monitor network facilities.

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

A network element in a ring or, more generally, in any type of network. In a network element supporting interfaces to more than one ring, node refers to an interface that is in a particular ring. Node is also defined as all equipment that is controlled by one system controller. A node is not always directly manageable by a management system.

Non-Preemptible Protection Access (NPPA)

Non-preemptible protection access increases the available span capacity for traffic which does not require protection by a ring, but which cannot be preempted.

Non-Revertive Switching

In non-revertive switching, an active and standby line exist on the network. When a protection switch occurs, the standby line is selected to support traffic, thereby becoming the active line. The original active line then becomes the standby line. This status remains in effect even when the fault clears. That is, there is no automatic switch back to the original status.

Non-Volatile Memory (NVM)

Memory that retains its stored data after power has been removed. An example of NVM would be a hard disk.

No Request State

This is the routine-operation quiet state in which no external command activities are occurring.

Not Monitored (NMON)

A provisioning state for equipment that is not monitored or alarmed.

O

Open Ring Network

A network formed of a linear chain-shaped configuration of network elements. Each network element connects to two others, one on each side, except for two network elements at the ends which are connected on only one side. A closed ring can be formed by adding a connection between the two end nodes.

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, WaveStar 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.

Operations System for Intelligent Network Elements (OPS/INE)
A Telcordia configuration management operations system.

Operator
A user of the system with operator-level user privileges.

Optical Carrier 3/Synchronous Transport Module 1 (OC3/STM1)
The OC3/STM1 port unit provides a bidirectional port at the OC-3 rate.

Optical Carrier 3/Synchronous Transport Module 1 (OC3/STM1)
The OC3/STM1 port unit provides a bidirectional port which is provisionable at either the OC-12- or STM-1-rate.

Optical Carrier 12/Synchronous Transport Module 4 (OC12/STM4)
The OC12/STM4 port unit provides a bidirectional port at the OC-12 rate.

Optical Carrier 12/Synchronous Transport Module 4 (OC12/STM4)
The OC12/STM4 port unit provides a bidirectional port which is provisionable at either the OC-12- or STM-4-rate.

Optical Carrier 48/Synchronous Transport Module 16 (OC48/STM16)
The OC48/STM16 port unit provides a bidirectional port at the OC-48 rate.

Optical Carrier 48/Synchronous Transport Module 16 (OC48/STM16)

The OC48/STM16 port unit provides a bidirectional port which is provisionable at either the OC-48- or STM-16-rate.

Optical Carrier 192/Synchronous Transport Module 64 (OC192/STM64)

The OC192/STM64 port unit provides a bidirectional port which is provisionable at either the OC-192- or STM-64-rate.

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 Channel

An OC-N/STM-N wavelength within an optical line signal. Multiple channels, differing by 1.5µ in wavelength, are multiplexed into one signal.

Optical Line Signal

A multiplexed optical signal containing multiple wavelengths or channels.

Orderwire (OW)

A dedicated voice-grade line for communications between maintenance and repair personnel.

Original Value Provisioning

Preprogramming of a system’s original values at the factory. These values can be overridden using local or remote provisioning.

Outage

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

Out-of-Service

The circuit pack is not providing its normal service function (removed from either the working or protection state) either because of a system problem or because the pack has been removed from service.

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).

Peripheral Control and Timing Facility Interface (PCTFI)
A proprietary physical link interface supporting the transport of 21×2 Mb/s signals.

Platform
A family of equipment and software configurations designed to support a particular application.

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.

Polarization Mode Dispersion (PMD)
Output pulse broadening due to random coupling of the two polarization modes in an optical fiber.

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.

Port Unit
An interface circuit pack that receives and transmits optical and electrical signals.

Preprovisioning

The process by which the user specifies parameter values for an entity in advance of some of the equipment being present. These parameters are maintained only in NVM. These modifications are initiated locally or remotely by either a CIT or an OS. Preprovisioning provides for the decoupling of manual intervention tasks (for example, install circuit packs) from those tasks associated with configuring the node to provide services (for example, specifying the entities to be cross-connected).

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 failure or signal degrade defect.

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.

Protection Access

To provision traffic to be carried by protection tributaries when the port tributaries are not being used to carry the protected working traffic.

Protection Group Configuration

The members of a group and their roles, for example, working protection, line number, etc.

Protection Path

One of two signals entering a path selector used for path protection switching or dual ring interworking. The other is the working path. The designations working and protection are provisioned by the user, whereas the terms active path and standby path indicate the current protection state.

Protection State
When the working unit is currently considered active by the system and that it is carrying traffic. The "active unit state" specifically refers to the receive direction of operation — since protection switching is unidirectional.

Provisioned (PROV)
Indicating that a circuit pack is ready to perform its intended function. A provisioned circuit pack can be active (ACT), in-service (IS), standby (STBY), provisioned out-of-service (POS), or out-of-service (OOS).

Provisioning
The modification of certain programmable parameters that define how the node functions with various installed entities. These modifications are initiated locally or remotely by either a CIT or an OS. They may arrive at the node via the IAO LAN, CIT port, or any DCC channel. The provisioned data is maintained in NVM and/or hardware registers.

R

Reactive Maintenance
Refers to detecting defects/failures and clearing them.

Receive-Direction
The direction towards the Network Element.

Regeneration
The process of reconstructing a digital signal to eliminate the effects of noise and distortion.

Reliability
The ability of a software system performing its required functions under stated conditions for a stated period of time. The probability for an equipment to fulfill its function. Some of the ways in which reliability is measured are: MTBF (Mean Time Between Failures) expressed in hours; Availability = (MTBF)/(MTBF+MTTR)(%) [where MTTR = mean time to restore]; outage in minutes per year; failures per hour; percentage of failures per 1,000 hours.

Remote Defect Indication (RDI)

An indication returned to a transmitting terminal that the receiving terminal has detected an incoming section failure. [Previously called far-end-receive failure (FERF).]

Remote Failure Indication (RFI)

A signal that alerts upstream path-terminating equipment that a downstream failure has been alarmed along the path. This action prevents multiple alarms from being activated for the same failure and ensures that a technician is dispatched to correct the failure. (Previously called yellow signals.)

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.

Revertive

A protection switching mode in which, after a protection switch occurs, the equipment returns to the nominal configuration (that is, the working equipment is active, and the protection equipment is standby) after any failure conditions that caused a protection switch to occur, clear, or after any external switch commands are reset. (See “Non-Revertive.”)

Revertive Switching

In revertive switching, there is a working and protection high-speed line, circuit pack, etc. When a protection switch occurs, the protection line, circuit pack, etc. is selected. When the fault clears, service “reverts” to the working line.

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.

Router
An interface between two networks. While routers are like bridges, they work differently. Routers provide more functionality than bridges. For example, they can find the best route between any two networks, even if there are several different networks in between. Routers also provide network management capabilities such as load balancing, partitioning of the network, and trouble-shooting.

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.

Section Layer
The second of the four levels in a standard SONET signal, used to transport an STS frame across a physical medium. This layer uses the photonic layer to form the physical transport.

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

Server
Computer in a computer network that performs dedicated main tasks which generally require sufficient performance.

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) occur.

Service
The operational mode of a physical entity that indicates that the entity is providing service. This designation will change with each switch action.

Signal-to-Noise Ratio (SNR)
The relative strength of signal compared to noise.

Signal Rate
An attribute that defines the bit-rate and format of the signal. The signal rate is defined by the STS-N path-level signal bit-rate and format including the presence or absence of concatenation.

Single-Ended Operations
Provides operations support from a single location to remote Network Elements in the same SONET subnetwork. With this capability you can perform operations, administration, maintenance, and provisioning on a centralized basis. The remote Network Elements can be those that are specified for the current release.

Single-Mode Fiber (SM)
An 8-μ 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.

Slot
A physical position in a shelf designed for holding a circuit pack and connecting it to the backplane. This term is also used loosely to refer to the collection of ports or tributaries connected to a physical circuit pack placed in a slot.

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.

Span Growth
A type of growth in which one wavelength is added to all lines before the next wavelength is added.

Squelch Map
This map contains information for each cross-connection in a ring and indicates the source and destination nodes for the low-speed circuit that is part of the cross-connection. This information is used to prevent traffic misconnection in rings with isolated nodes or segments.

Standby
The circuit pack is in service but is not providing service functions. It is ready to be used to replace a similar circuit pack either by protection or by duplex switching.

Standby Path
One of two signals entering a constituent path selector, the standby path is the path not currently being selected.

State

The state of a circuit pack indicates whether it is defective or normal (ready for normal use).

Status

The indication of a short-term change in the system.

STS-1E

Now referred to as EC-1. A signal typically carried by coaxial cables from one equipment location to another. The term EC-1 refers to the organization and data rate of the signal and also to the voltage template the signal must conform to and the impedances for which the voltage template is valid.

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.

SubNetwork Management System (SNMS)

An Element Management System providing centralized, remote support for Lucent's WaveStar network elements. SNMS functions include configuration, fault, performance, and security management. This system can administer single NEs or subnetworks.

Suppression

A process where service-affecting alarms that have been identified as an "effect" are not displayed to a user.

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 Payload
Payloads that can be derived from a network transmission signal by removing integral numbers of bits from every frame. Therefore, no variable bit-stuffing rate adjustments are required to fit the payload in the transmission signal.

Synchronous Payload Envelope (SPE)
The combined payload and path overhead of an STS-1, STS-3c, STS-12c or STS-48c signal.

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.

Synchronous Transport Signal, Level N, Concatenated (STS-Nc)
A concatenated SONET payload signal at the STS-N rate, where N equals 3, 12, or 48. For example, an STS-3c signal is constructed by concatenating three STS-1 signals into a signal that uses a single path overhead, rather than three.

T

T1

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

T2

A carrier system that transmits at the rate of 6.312 Mbps (a DS2 signal).

T3

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

Target Identifier (TID)

A provisionable parameter that is used to identify a particular Network Element within a network. It is a character string of up to 20 characters where the characters are letters, digits, or hyphens (-).

Transmission Control Protocol/Internet Protocol (TCP/IP)

An open network standard that defines how devices from different manufacturers communicate with each other over interconnected networks. TCP/IP protocols are the foundation of the Internet.

Telcordia Technologies

Telcordia Technologies (formerly Bellcore) is a well-recognized telecommunications' standards organization.

Through (or Continue) Cross-Connection

A cross-connection within a ring, where the input and output tributaries have the same tributary number but are in lines opposite each other.

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.

Time Slot Assignment (TSA)

A capability that allows any tributary in a ring to be cross-connected to any tributary in any lower-rate, non-ring interface or to the same-numbered tributary in the opposite side of the ring.

Time Slot Interchange (TSI)

The ability of the user to assign cross-connections between any tributaries of any lines within a Network Element. Three types of TSI can be defined: Hairpin TSI, Interring TSI (between rings), and Intraring TSI (within rings).

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.

Tributary

A path-level unit of bandwidth within a port, or the constituent signal(s) being carried in this unit of bandwidth, for example, an STS-1 tributary within an OC-N port.

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.

Two-Way Point-to-Point Cross-Connection
A two-legged interconnection, that supports two-way transmission, between two and only two tributaries.

Two-Way Roll
The operation which moves a two-way cross-connection between tributary i and tributary j to a two-way cross-connection between the same tributary i and a new tributary k with a single user command.

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.

User Privilege
Permits a user must perform on the computer system on which the system software runs.

User-to-Network Interface (UNI)
The specifications for the procedures and protocols between a user and the Asynchronous Transfer Mode (ATM) network.

V

Value
A number, text string, or other menu selection associated with a parameter.

Variable
An item of data named by an identifier. Each variable has a type, such as Int or Object, and a scope.

Violation Monitor and Removal (VMR)
A provisionable mode for DS3 output that causes parity violations to be monitored and corrected before the DS3 signal is B3ZS encoded.

Virtual
Refers to artificial objects created by a computer to help the system control shared resources.

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

Virtual Concatenation
SONET or SDH implementation of inverse multiplexing that allows the characteristic information of a virtual concatenated STS-n-Xv or VC-n-Xv layer network to be transported via a bundle of X STS-n or VC-n network connections.

Virtual Concatenated Group
A group of X individual STS-n or VC-n network connections that are virtually concatenated to offer larger payload bandwidth. The notation STS-n-Xv or VC-n-Xv is used to refer to virtual concatenation.

Virtual Tributary (VT)
A structure designed for transport and switching of sub-STS-1 payloads. There are currently four sizes: VT1.5 (1.728 Mb/s), VT2 (2.304 Mb/s), VT3 (3.456 Mb/s), and VT6 (6.912 Mb/s).

Virtual Tributary Group (VT-G)
A 9-row by 12-column structure (108 bytes) that carries one or more VTs of the same size. Seven VT groups (756 bytes) are byte interleaved with the VT-organized synchronous payload envelope.

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

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

VT1.5 Tributary

A SONET logical signal with a data rate of 1.728 Mbps. In the 9-row structure of the STS-1 SPE, a VT1.5 occupies three columns. VT-structured STS-1 SPEs are divided into seven VT groups. Each VT group occupies twelve columns of the 9-row structure and, for VT1.5s, contains four VTs per group.

W

Wait-to-Restore (WTR)

Applies to revertive switching operation. The protection group enters the WTR state when all Equipment Fail (EF) conditions are cleared, but the system has not yet reverted back to its working line. The protection group remains in the WTR state until the Wait-to-Restore timer completes the WTR time interval.

Wait to Restore Time (WRT)

Corresponds to the time to wait before switching back after a failure has cleared (in a revertive protection scheme). The WRT can be between 0 and 15 minutes, in increments of one minute.

Wavelength Add/Drop (WAD)

The process of adding and dropping wavelengths to provide more efficient transmission.

Wavelength Division Multiplexing (WDM)

A means of increasing the information-carrying capacity of an optical fiber by simultaneously transmitting signals at different wavelengths.

Wavelength Interchange

The ability to change the wavelength associated with an OC-N signal into another wavelength.

WaveStar Optical Line System

Lucent Technologies' lightwave transmission system. Utilizing DWDM technology, the system combines multiple signals of different wavelengths, transmits the resulting signal over a single fiber, and then demultiplexes the signal at the receive end.

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.

Working
Label attached to a physical entity. In case of revertive switching the working line or unit is the entity that is carrying service under normal operation. In case of nonrevertive switching the label has no particular meaning.

Working State
A working unit that is currently considered active by the system and is carrying traffic in the working state.

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.

Z

Zero Code Suppression
A technique used to reduce the number of consecutive zeros in a line-coded signal (B3ZS, B8ZS).

Index