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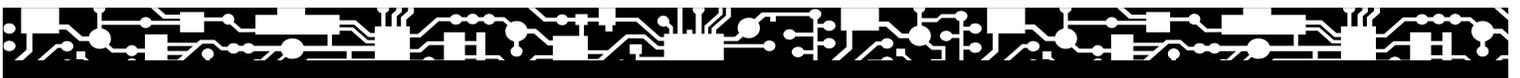
LambdaXtreme™ Transport

Applications and Planning Guide

Release 1.1

Product Development Manager   1 800-645-6759 (continental U.S.)
                                1-317-322-6848 (international)

Notice

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The ordering number for this document is 365-575-780R1.1. For ordering information, refer to the Documentation Support section of Chapter 7, Product Support.

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About this information product

Purpose This Applications and Planning Guide (APG) provides specific information about the features, applications, operation, and engineering, of LambdaXtreme™ Transport. The following sections cover the feature highlights, network applications, and product information.

Reason for reissue This document is reissued to support the added features of Release 1.1 to LambdaXtreme™ Transport.

Safety labels Refer to the *User Operations Guide* and/or *Alarms, Messages, and Trouble Clearing Guide* for safety label information.

Intended audience This APG is primarily intended for network planners, engineers, customer technical support personnel, and account executives. It may be used by anyone desiring specific information about the features, applications, operation, and engineering of LambdaXtreme™ Transport.

How to use this information product

This book is organized as follows:

- This section describes the purpose, intended audiences, reason for reissue, and the organization of this document.

- Chapter 1, "Introduction", presents a summary description of LambdaXtreme™ Transport.

- Chapter 2, "Features", describes the major features of LambdaXtreme™ Transport. Each feature is described in greater detail in Chapter 3, "Network Topologies" and in Chapter 4, "LambdaXtreme™ Transport Description" .

- Chapter 3, "Network Topologies", describes Point-to-Point, Linear Add/Drop, and Mesh topologies of LambdaXtreme™ Transport.

- Chapter 4, "LambdaXtreme™ Transport Description", describes the LambdaXtreme™ Transport system architecture. After providing a high level system overview, each circuit pack is introduced and described. The power system is also described.

- Chapter 5, "System Planning and Engineering", summarizes the information required to plan the procurement and deployment of LambdaXtreme™ Transport.

- Chapter 6, "OAM&P", describes the Operations, Administration, Maintenance, and Provisioning features of LambdaXtreme™ Transport.

- Chapter 7, "Product Support", describes how Lucent Technologies supports LambdaXtreme™ Transport.

- Chapter 8, " Technical Specifications", provides LambdaXtreme™ Transport technical specifications.

- The ″Glossary″ defines many of the terms found within this document.

- The ″Index″ provides page numbers for key words and subject names.

Conventions used

There are no special typographical conventions used in this document.

How to comment

To comment on this information product online, go to *http://www.lucent-info.com/comments* or email your comments to ctiphotline@lucent.com (mailto:ctiphotline@lucent.com).

1   Introduction

Overview

Purpose   This chapter provides high-level information on the LambdaXtreme™ Transport System, including system description, features, benefits, plus quality and reliability statements.

Contents

System Overview

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Background

LambdaXtreme™ Transport is Lucent Technologies' third generation Dense Wave Division Multiplexing (DWDM) fiber optic transmission system. It uses Raman amplification, Ultra Forward Error Correction (UFEC), and Soliton transmission to provide customers with ultra long haul optical networks. LambdaXtreme™ Transport is a part of a larger portfolio of Lucent products that provide customers with an intelligent optical layer for their networks.

Start-up costs and growth issues are addressed in the modular design of LambdaXtreme™ Transport. Customers can purchase a cost-effective customized system that will satisfy current and future network needs. With in-service upgrades, LambdaXtreme™ Transport expands easily to bring additional service capacity without affecting existing service.

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The LambdaXtreme™ Transport System

One platform; two different systems

Using one design platform, LambdaXtreme™ Transport can be deployed as a 10 Gbps system (called 10G) or as a 40 Gbps system (called 40G). Circuit pack differences facilitate these differing systems. Note that all distances shown here are for 23 dB spans.

Highlights of the 10G and 40G systems are:

- 10G — a 10 Gbps system for transmission of 128 channels giving a capacity of 1.28 Tbps. Payload (per channel) can be one OC-192/STM-64 or four multiplexed OC-48/STM-16 signals.
    - using Long Haul (LH) transponders, the reach is up to 2000 km
    - using Ultra Long Haul (ULH) transponders, the reach is 2000–4000 km
- 40G — a 40 Gbps Ultra High Capacity (UHC) system for transmission of 64 channels for a capacity of 2.56 Tbps and a reach of up to 1000 km. Payload (per channel) is four multiplexed OC-192/STM-64 or four 10GbE WAN PHY signals.

Refer to Figure 1-1, "Capacity and Reach" (1-4) for a representation of the reach and transmission capacity of LambdaXtreme™ Transport.

Figure 1-1 Capacity and Reach
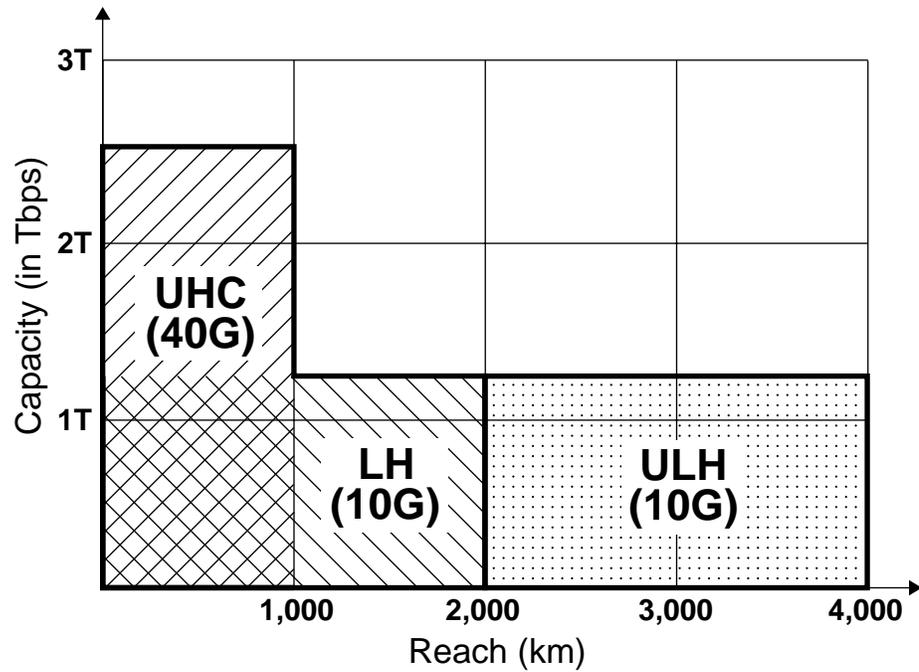
Important! The 10G LH and 10G ULH transponders can be mixed on the same system; however, the 10G and 40G transponders cannot be mixed.

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Features List

Overview	Listed below are the main features of the LambdaXtreme™ Transport system. The common platform features apply to the 10G and 40G systems. The features that are particular to the 10G system and the 40G system are then listed. For further information on these features, refer to Chapter 2, "Features".
Bell Labs innovations	LambdaXtreme™ Transport features are enhanced by the following Bell Labs innovations:

- EDFA/Raman amplification
- Soliton transmission
- single extended L Band transmission
- dynamic power and gain equalization

Common platform features

Those features common to all LambdaXtreme™ Transport systems are summarized below:

- 2 unidirectional fibers, single extended L Band (called *UltraBand*™) End Terminals and Repeaters
- remotable bays (up to 100 meters)
- robust OAM&P capability, including fast boot time
- scalability without service interruption
- automatic power reduction (APR) for Laser Safety in the event of an interruption in transmission
- optical channel performance monitoring (PM)
- high-capacity supervisory channel for system maintenance, remote provisioning, and PM
- auto fault detection, isolation, alarm, provisioning, and recovery
- * *WaveWrapper*™ formatting on the line side supports transparent transport
- system security
- Craft Interface Terminal (CIT) with Graphical User Interface (GUI)
- Gateway Network Element (GNE) operations
- visual indicators
- double shelf, transparent plastic front covers

- TL1 interface from LambdaXtreme™ Transport to Element Management Systems (EMSs) over TCP/IP
- compliance to NEBS Level 3, ETSI, and ITU-T standards
- customer-accessible optical monitor ports

*WaveWrapper is a pre-standards version of transparent ITU-T G.709 digital wrapper.

10G system features   Those features particular to the 10G system are summarized below:

- supports 128 wavelengths at 10 Gbps for a capacity of 1.28 Tbps
- reach of a 10G system:
  - LH transponders support a reach of 2000 km (20 x 100 km 23 dB spans) for G.655 fiber (TW-RS, LEAF*, TW-Classic, and TW-Plus) and G.652 fiber (SSMF)
  - ULH transponders support a reach of 4000 km (40 x 100 km 23 dB spans) for G.655 fiber (TW-RS and LEAF*)
- an Optical Add/Drop Multiplexer (OADM) Terminal for add/drop capability of up to 64 channels
- small footprint:
  - for an all-LH system, the first (system) bay holds 26 wavelengths; full 1.28 Tbps End Terminal is housed in three bays
  - for an all-ULH system, the first (system bay holds 12 wavelengths; full 1.28 Tbps End Terminal is housed in six bays
  - a mixed LH/ULH End Terminal would be housed in one to six bays, depending on the mixture and number of wavelengths
- LH Optical Translator client interfaces
  - 10G Add/Drop LH: OC-192/STM-64 VSR, I-64.1r
  - 10G Add/Drop LH: OC-192/STM-64 IR-2, S-64.2b
  - 10GbE WAN PHY Add/Drop OC-192/STM-64 IR-2, S-64.2b
  - 10G Muxing LH: 4 x OC-48/STM-16, SR-1, I-16

- ULH Optical Translator client interfaces:

  - 10G Add/Drop ULH: OC-192/STM-64 VSR, I-64.1r

  - 10G Add/Drop ULH: OC-192/STM-64 IR-2, S-64.2b

  - 10GbE WAN PHY Add/Drop OC-192/STM-64 IR-2, S-64.2b

- compatible optics with *LambdaUnite*™ MultiService Switch (MSS)

*In this document, all references to LEAF apply to the post-1998 LEAF fiber, also known as E-LEAF.

40G system features   Those features particular to the 40G UHC system are summarized below:

- supports 64 wavelengths at 40 Gbps for a capacity of 2.56 Tbps

- supports a reach of 1000 km (10 x 100 km 23 dB spans) for G.655 fiber (TW-RS, LEAF*, TW-Classic, and TW-Plus) and G.652 fiber (SSMF)

- small footprint: first (system) bay holds 8 wavelengths; full 2.56 Tbps End terminal is housed in 4 bays

- Optical Translator client interface:

  - 40G Muxing UHC : 4 x OC-192/STM-64, IR-2, S-64.2b, 10GbE WAN PHY interface

*In this document, all references to LEAF apply to the post-1998 LEAF fiber, also known as E-LEAF.

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Benefits

Categories LambdaXtreme™ Transport benefits can be grouped into three major categories: transport benefits, operational benefits, and expanding systems benefits. Each category is listed below.

Transport benefits LambdaXtreme™ Transport drives down transport costs (cost/Gbps/km) by:

- Supporting multiple systems on a single platform, enabling reductions in inventory, sparing and training costs

- Including a high-capacity OADM that removes the need for expensive optical-electronic-optical conversion of express traffic, reducing network element costs

- Transmitting in a single, extended L-band, enabling ultra long haul and high capacity without the added cost and associated Optical Signal to Noise Ratio (OSNR) losses of combiners and splitters required by dual C+L band solutions

- Transmitting at 40 Gbps wavelengths increases port densities, reducing overall hardware costs

- Supporting compatible optics between LambdaXtreme™ Transport and *LambdaUnite*™ MSS, which eliminate the need for optical transponders on LambdaXtreme™ Transport, reducing overall system costs

Operational benefits LambdaXtreme™ Transport drives down operational costs (cost/managed-bit/km) through:

- Lowest power consumption in the industry, compared to current competitors

- Industry-leading high-density footprint that reduces co-location leasing costs

- Equipment Bays that can be located 100 meters apart to maximize utilization of available space

- Software configurable high-capacity OADM provides remote, on-demand, provisioning and supports automatic connectivity

- Dynamic gain equalization that removes the need for manual provisioning of static filters at site

- Optical Monitoring (OMON) that provides enhanced optical signal health monitoring, and enables distributed Software based Control of Transmission (SCOT) to automatically maintain error-free transmission

- Automated attenuation of channel power that removes requirement for manual measurement and installation of LBOs (Line Build Outs) for incoming line signals

- Network element level auto-discovery/auto-provisioning of an optical connectivity and auto-update of newly installed optical transponders reduces manual provisioning requirements

- Optical Line System (OLS) Network Topology and Neighbor NE auto-discovery

- User-friendly GUI on the CIT with point-and-click access to network elements for fast and simple maintenance and on-site provisioning

Expanding systems benefits

LambdaXtreme™ Transport expands systems for additional revenue generation by enhancing optical layer functionality via:

- Multi-rate client interfaces with varying reach capabilities support different system needs

- Fully transparent multiplexing of OC-48/STM-16 and OC-192/STM-64 into 10 Gbps and 40 Gbps systems respectively enables carriers to provide true wavelength services directly through LambdaXtreme™ Transport

- Compatible optics with *LambdaUnite* MSS enables seamless sub-wavelength management

- Transmission at 40 Gbps provides interfaces for next-generation 40 Gbps client interfaces

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Value Propositions

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Easy deployment LambdaXtreme™ Transport is easy to install

- At system set-up, there is no need to do any optical power adjustments

- As new channels are added, the system performs automatic adjustments on the OA's power levels, etc.

- Remotable Bays, up to 100 meters away from each other

- Circuit packs automatically report themselves to the system

- High-speed Supervisory channel enables fast software downloads

- Any LambdaXtreme™ Transport Network Element (NE) is an operations gateway into any other in the same sub-network via GNE functionality

- Minimal Data Communications Network (DCN) related provisioning

- Reduction in installation time

  - Improved fiber routing

  - Improved and simplified installation procedures

- Simplified connectors: all the optical connections from the system to the outside use SC connectors (ST and FC connectors are optional)

Efficient operation LambdaXtreme™ Transport is easy to operate

- User-friendly, intuitive GUI navigation

- Scalability without service interruption

- Raman amplification failures are rarely traffic-affecting

- Robust OAM&P capability including fast warm re-boot and transmission restoration time (warm reboot is typically 5–8 minutes, with system boot in less than 3½ minutes; typical time to have error free transmission is 5–8 minutes but could be longer depending on channel loading and system length).

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Laser Safety and Lucent Products

Safety policy
Lucent Technologies is committed to the design of optical fiber transmission equipment that minimizes operator and service personnel exposure to potentially hazardous levels of optical energy during service and operation. However, the continued safe use of optical transmission, optical cables, and passive optical connection equipment requires a partnership with customers to assure that these systems are deployed and maintained in a safe manner. While automatic laser power reduction systems in Lucent's higher power transmission equipment respond quickly to reduce laser emissions to safe levels in the event of a fiber disconnection or break, network operators must take proper action in the event of an alarm.

In a typical network, our optical cables and passive optical connection equipment can carry signals from various vendor sources that may have different degrees of safety controls. We urge our customers to properly assess the power of these sources to ensure that their safety controls are adequate.

To strengthen our partnership and to assure the continued safe deployment and use of optical networks, we urge you to use the following standards as your guides for laser safety for your customers and employees.

In the U.S.:

- *ANSI Z136.1 — American National Standard for Safe Use of Laser*

- *ANSI Z136.2 — American National Standard for Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources*

Elsewhere:

- *IEC 60825 Safety of Laser Products Part 1: Equipment classification, requirements and user's guide*

- *IEC 60825 Safety of Laser Products Part 2: Safety of optical fibre communication systems*

It should be noted that recent studies* in Europe have suggested that power as low as 50 mW can ignite certain hazardous (classified) gaseous/vapor/mist/dust environments under worst case, dusty conditions. Standards are being written, both in the US and the International Electrotechnical Commission (IEC), to address optical

installations in hazardous (classified) environments. If you must deploy high power systems in such environments, you should assess the impact.

*Carleton, F.B., Bothe, H., Proust, Ch., Hawksworth, S., Prenormative research on the use of optics in potentially explosive atmospheres — PROPEX-EUR 19617 EN. European Commission, 2000 (Brussels, Belgium), November 1999.

Further information on laser safety

For a full discussion on laser safety, refer to the section titled "About This Document" in the *LambdaXtreme*™ *Transport User Operations Guide*. The same information is also presented in the *LambdaXtreme*™ *Transport Alarm Messages and Trouble Clearing Guide*.

Fiber labeling

We recommend that fiber connections to/from OAs and RPs leading to the Outside Plant (OSP) be labeled at the interconnect panels and Lightguide Cross-connects (LGX) to warn against removing the fiber. Removal could cause damage to the connector.

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Quality and Reliability

Overview   Lucent Technologies is committed to providing its customers with products of the highest level of quality and reliability in the industry. LambdaXtreme™ Transport is a prime example of this commitment.

Quality statement   Lucent Technologies is committed to achieving sustained business excellence by integrating quality principles and methods into everything done and at every level of the company to:

- anticipate and meet customer's needs and exceed their expectations — every time

- continuously improve practices in order to deliver the world's best and most innovative communications solutions — faster and more cost-effectively than competitors

Registration   LambdaXtreme™ Transport is TL 9000 registered and is ISO 9001:2000 certified.

Product life cycle reliability   Each stage of the LambdaXtreme™ Transport life cycle 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

- prototype testing during development

- design change control

- manufacturing and product testing

- product quality assurance

- product field performance

Critical product development elements   During product development, strict adherence to the following elements ensures product quality and 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 manufacturing elements

During manufacturing and field deployment, strict adherence to the following elements ensures product quality and reliability:

- pre-manufacturing
- qualification
- accelerated product testing
- product screening
- production quality tracking
- failure mode analysis
- feedback and corrective actions

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2 Features

Overview

Purpose This chapter briefly describes the major features of the LambdaXtreme™ Transport system. First the common platform features are described, followed by a separate discussion of the 10G and 40G systems. The chapter concludes with a discussion of interworking between LambdaXtreme™ Transport and other Lucent products.

Contents

Release 1.1 System Features

Feature set for R1.1   Release 1.1 of LambdaXtreme™ Transport adds the following set of features to the Release 1.0 offering:

- 10G *Ethernet*™ (10GbE) WAN PHY support on IR-2 interfaces
  - 10G Add/Drop OC-192/STM-64 IR-2, S-64.2b OTs (LH and ULH)
  - 40G Muxing UHC: 4 x OC-192/STM-64, IR-2, S-64.2b
- Updated Engineering Rules for various fiber types

OS support for R1.1   LambdaXtreme™ Transport Release 1.1 will provide support for the following management systems:

- *Navis*™ Optical EMS R9 (at 31 July 2002)
- *Navis* Optical NMS R7 (at 31 July 2002)

CIT support for R1.1   The CIT for LambdaXtreme™ Transport now supports *Windows*™ XP.

Upgrading from R1.0 to R1.1   The upgrade from LambdaXtreme™ Transport Release 1.0 to Release 1.1 is *not* service affecting.

With the R1.0 code and database in both the active and inactive directories, the general procedure is to:

1. backup the database to ensure that the current provisioning is saved in the database and at the remote system
2. move the new code to the inactive directory
3. swap the new code with the old code
4. execute the new code

Refer to *LambdaXtreme™ Transport Software Release Description* for detailed instructions.

Important! Upgrade all nodes in an OLS as quickly as possible. Having different software releases running on different nodes may cause supervisory communications to fail. Copy the new software to all nodes. Reset the farthest away nodes and then the closer nodes. If the local node gets upgraded first, it may no longer be able to communicate with the farther away nodes.

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R1.1 compatibility   LambdaXtreme™ Transport R1.1 fully supports new circuit packs that are compatible with R1.0 even if they have additional, non-transparent capabilities and a new apparatus code.

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Common Platform Features

Quick start-up and reboot times	LambdaXtreme™ Transport has a fast, warm re-boot and transmission restoration time of (typically) 5–8 minutes. The system will boot in less than 3½ minutes. A typical time to have error-free transmission is 5–8 minutes, but could be longer depending on channel loading and system length. This capability facilitates effective operations management and efficient use of time for service repairs or system reboot.
Remotable bays	LambdaXtreme™ Transport system design allows groups of additional growth bays to be located up to 100 meters from the system bay, allowing more flexibility at the installation location.
Craft Interface Terminal (CIT) with GUI	The CIT provides operational control of all nodes in the system. For further details, see the *LambdaXtreme™ Transport User Operations Guide*.

LambdaXtreme™ Transport TL1 interface to EMS over TCP/IP

The LambdaXtreme™ Transport TL1 interface provides for communication with one or more Element Management Systems (EMS); for example, the *Navis*™ Optical Element Management System. This interface supports the following:

- *Fault Management* — the node can send notifications of alarms to the EMS, and the EMS can get alarm status from the node and provision any fault-related parameters to the node. Refer to the *LambdaXtreme™ Transport Alarm Message and Trouble Clearing Guide* for details.

- *Configuration Management* — the configuration capabilities enable the EMS to access the equipment view from the node and provision any configuration-related parameters to the node. Refer to the *LambdaXtreme™ Transport User Operations Guide* for details.

- *Performance Monitoring* — the performance management capabilities enable the EMS to set and define performance thresholds and monitor the myriad of PM parameters. Refer to the *LambdaXtreme™ Transport User Operations Guide* for details.

Scalability without service interruction   LambdaXtreme™ Transport allows the service provider to upgrade to a larger system capacity without the loss of service to existing channels on the system. The modular design allows for the installation of only one bay (the System bay — which handles the DWDM signal) for End terminals. Other bays/components can be added when necessary.

Optical monitor ports   Optical monitor taps are accessible by the client. They provide the ability to diagnose and troubleshoot performance problems.

Automatic power reduction   Output power of amplifiers and pumps is automatically reduced to Class 1 Hazard Level 1M safety standards when connections are broken between high power circuit packs.

Optical channel performance monitoring at Repeaters   From a CIT, or an EMS, you can do per-channel optical power monitoring at each Repeater to facilitate proactive maintenance and fault isolation.

Supervisory channel   A high-capacity supervisory channel for system control maintenance and performance monitoring supports

- a 155 Mbps data signal (OC-3)
- two data links for message-based system control between Network Elements (NEs):
    - Node-Node Data Link — 154 Mbps
    - Orderwire Data Link — 1 Mbps

Auto features   LambdaXtreme™ Transport supports auto fault detection, isolation, alarm, recovery, discovery, and provisioning. Each is briefly explained below.

Automatic fault detection

LambdaXtreme™ Transport continuously monitors internal system conditions and incoming channels and reports failed circuit packs, optical lines, and optical channels.

Automatic fault isolation

LambdaXtreme™ Transport diagnoses and isolates failed circuit packs or channels. Cause and effect detection in the same location greatly minimizes time to repair in a large system.

Automatic failure alarming

LambdaXtreme™ Transport reports failures, by alarm messages and office alarm relays.

Automatic fault recovery

LambdaXtreme™ Transport recovers from power faults or hits and resets circuit packs automatically.

Automatic discovery of circuit packs

LambdaXtreme™ Transport provides automatic discovery of circuit packs.

Automatic provisioning of optical channels

LambdaXtreme™ Transport provisions connections automatically based on the presence of valid incoming client signals, throughout the system.

OLS Network Topology and Neighbor Discovery

LambdaXtreme™ Transport NEs automatically discover neighbor NEs connected to optical supervisory channel ports. LambdaXtreme™ Transport NEs also auto discover their OLS Network Topology and connectivity arrangement (East/West).

System security   LambdaXtreme™ Transport supports multiple user logins with passwords on a TL1 interface.

Gateway Network Element (GNE) operations   LambdaXtreme™ Transport supports GNE operations in the following ways:

- allows any NE to be a GNE
- routes TL1 messages over the Supervisory Data Link to/from other NEs

Optical, physical, and environmental standards   LambdaXtreme™ Transport operates in a standard office environment and is compliant with telecommunications standards for NEBS, ANSI, UL, CE, CSI, ITU-T, Telcordia, and ETSI.

Double-shelf, transparent front covers   Double-shelf, transparent, plastic front covers allow operators ease of troubleshooting for visibly detecting performance status (by observing LEDs) of various components within the system.

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10G System Features

Long Haul and Ultra Long Haul

Depending on the desired reach, which is determined by the type of Optical Translators (OTs) used, the 10G system can have Long Haul (LH) or Ultra Long Haul (ULH) uses.

LH OTs have a reach of 2000 km (20 spans, 100 km/23 dB loss) and ULH OTs have a reach of 4000 km (40 spans, 100 km/23 dB loss).

1.28 Tbps capacity

LambdaXtreme™ Transport can transmit 1.28 trillion bits per second (128 channels in a DWDM signal at 10 Gbps per channel)

Transmission characteristics are

- unidirectional, 2-fiber system
- G.655 fiber (TWRS, LEAF, TW-Classic, and TW-Plus) or G.652 fiber (SSMF) for LH
- G.655 fiber (TWRS or LEAF) or G.652 SSMF for ULH

***WaveWrapper*™ Optical Translators**

LH uses *WaveWrapper* add/drop OTs with Forward Error Correction (FEC) for 10 Gbps transport in the DWDM signal. The OTs have Very Short Reach (VSR, Type I-64.1r) and Intermediate Reach (IR, Type S-64, 2b) client interfaces — 60 wavelengths per Extension Bay. Both SONET/SDH and 10G *Ethernet*™ WAN PHY interfaces are supported.

ULH uses *WaveWrapper* add/drop OTs with Ultra FEC for 10 Gbps transport with Very Short Reach (VSR, Type I-64.1r) and Intermediate Reach (IR, Type S-64, 2b) client interfaces — 28 wavelengths per Extension Bay. Both SONET/SDH and 10G *Ethernet* WAN PHY interfaces are supported.

4:1 (2.5G to 10G) Multiplexing for LH

LH uses *WaveWrapper* MUX OTs with FEC that transparently multiplex four 2.5 Gbps signals into one 10 Gbps signal for transport in a DWDM signal with Short Reach (SR-1, Type I-16) client interface.

LH compatible optics

LH 10G has compatible optics with *LambdaUnite*™ MultiService Switch (MSS).

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Optical Add/Drop Multiplexer (OADM)   LH and ULH can have a remotely provisionable OADM with 64-channel add/drop capability. Up to eight OADM sites can be cascaded on a single system. Separation of east and west circuit packs provides for independent operation of the two sides, that is, no common point of failure.

Reduced footprint   An LH End Terminal can accommodate all 128 wavelengths (channels) in only 3 bays of equipment. A minimum startup configuration can accommodate up to 26 channels in 1 bay.

For LH systems using an OADM terminal, the OADM Terminal can add/drop 64 channels and pass 64 channels in only 4 bays of equipment. A minimum startup OADM configuration can accommodate up to 35 add/drop wavelengths in 2 bays.

A ULH End Terminal can accommodate all 128 wavelengths (channels) in only 6 bays of equipment. A minimum startup configuration can accommodate up to 12 channels in 1 bay.

For ULH systems using an OADM terminal, the OADM Terminal can add/drop 64 channels and pass 64 channels in only 4 bays of equipment. A minimum startup OADM configuration can accommodate up to 17 wavelengths in 2 bays.

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40G System Features

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2.56 Tbps capacity The LambdaXtreme™ Transport Ultra High Capacity (UHC) system can transmit 2.56 trillion bits per second over a total reach of 1000 km (10 spans, 100 km/23 dB loss).

UHC Transmission characteristics are

- unidirectional, 2-fiber system

- 64 channels at 40 Gbps per channel, in a DWDM signal

- G.655 fibers (TWRS, LEAF, TW-Classic, TW+) and G.652 fiber (SSMF)

4:1 (10G to 40G) Multiplexing UHC uses *WaveWrapper*™ add/drop OTs with FEC to transparently multiplex four 10 Gbps signals into one 40 Gbps signal for transport with Intermediate Reach (IR, Type S-64.2b) client interface. Both 10G SONET/SDH and 10G *Ethernet*™ WAN PHY interfaces are supported.

40G compatible optics UHC 40G has compatible optics with Lucent's *LambdaUnite*™ MSS.

Reduced footprint A UHC End Terminal can accommodate all 64 wavelengths (channels) in only 4 bays of equipment. A minimum startup configuration can accommodate up to 8 channels in 1 bay.

□

Interworking

Overview   LambdaXtreme™ Transport has compatible optics with Lucent's *LambdaUnite*™ MSS.

Compatible optics with *LambdaUnite* **MSS**   Compatible optics with *LambdaUnite* MSS allows signals from *LambdaUnite* MSS to be accepted by LambdaXtreme™ Transport without the use of Optical Translators. ("Compatible optics" is when the wavelength of the interfacing external equipment is the same as that used in LambdaXtreme™ Transport transponders.) See Figure 2-1, "Compatible Optics with LambdaUnite™ MSS" (2-10) for an illustration.

Figure 2-1 Compatible Optics with LambdaUnite™ MSS

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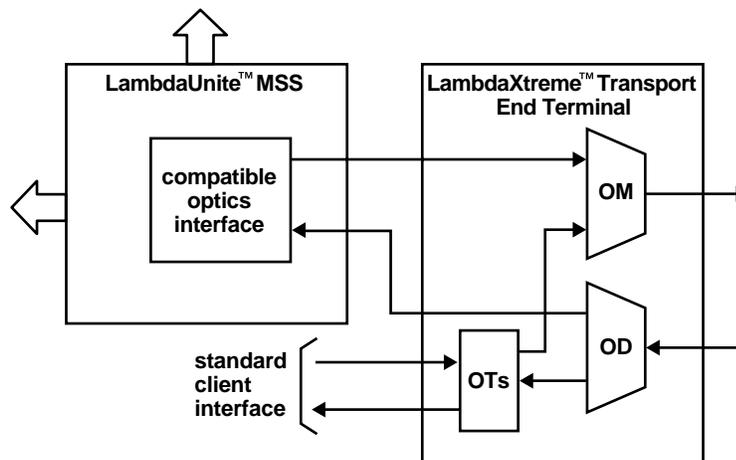
Typical applications are

- at the edge of DWDM point-to-point links, where *LambdaUnite* MSS provides protection while LambdaXtreme™ Transport is used for transport, as illustrated in the sketch below:

LambdaUnite™ MSS   LambdaUnite™ MSS

[ ] ↔ [LambdaXtreme™ Transport] ↔ [ ]

- at the edge of a DWDM (mesh-based) backbone, where *LambdaUnite* MSS grooms the traffic coming from the SDH/SONET/GbE WAN PHY networks and provides protection mechanisms at these layers while LambdaXtreme™ Transport transports these signals over the DWDM backbone and interfaces to *LambdaRouter*™ All Optical Switch (AOS) equipment, as illustrated in the sketch below:

LambdaUnite™ MSS   LambdaRouter™ AOS

[ ] ↔ [LambdaXtreme™ Transport] ↔ [✕]

- between DWDM backbone networks of different operators, where *LambdaUnite* MSS is a handshake point to interface between the two DWDM networks, as illustrated in the sketch below:

LambdaUnite™ MSS

[LambdaXtreme™ Transport] ↔ [ ] ↔ [Other Vendor Equipment]

□
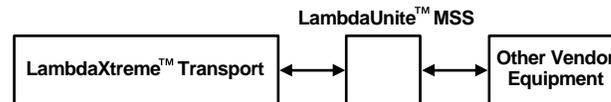
3   Network Topologies

Overview

Purpose   This chapter provides information on the types of topologies used for LambdaXtreme™ Transport.

Contents

Topologies

Three topologies   LambdaXtreme™ Transport can be deployed in three topologies:

- point to point
- linear add/drop chain
- mesh

Each topology is discussed below.

☐

Point-to-Point Systems

Description   In a simple point-to-point system (a system without a repeater) one Network Element (NE) has 2-fiber communication with one other NE. There is a full complement of Add channels in the transmit direction and a full complement of Drop channels in the receive direction. The NEs are End Terminals. End Terminals are discussed in detail in the next chapter.

When a point-to-point configuration has the End Terminals separated by more than a distance of specified span loss as prescribed in the Engineering Rules, then one or more Repeaters are required. Repeaters have no add/drop capability; they are discussed in detail in the next chapter.

Diagrams   See Figure 3-1, "Point-to-Point Configuration without a Repeater" (3-3) for a basic diagram of a simple point-to-point configuration.

Figure 3-1   Point-to-Point Configuration without a Repeater
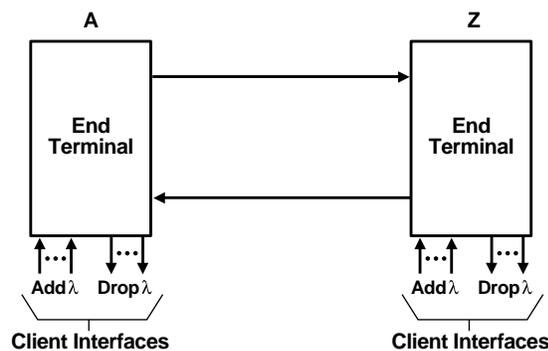
See Figure 3-2, "Point-to-Point Configuration with Repeaters" (3-4) for a basic diagram of a point-to-point configuration with Repeaters.

Figure 3-2 Point-to-Point Configuration with Repeaters
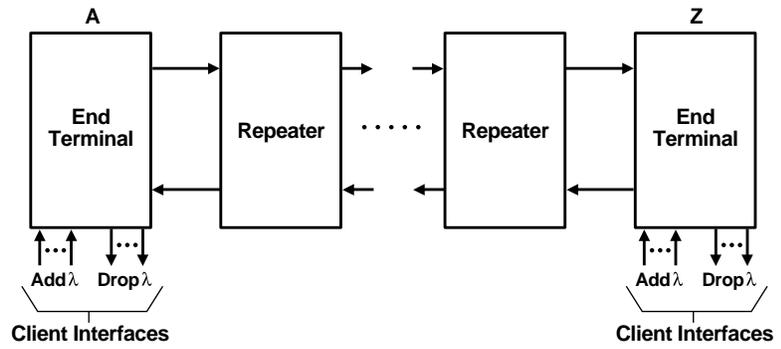
Linear Add/Drop Chains

Description   A linear add/drop chain is like a point-to-point system, except that in between the two End Terminals there are provisions for adding and dropping wavelengths. When a linear add/drop chain has the NEs separated by more than a distance of specified span loss as prescribed in the Engineering Rules, then one or more Repeaters are required. Repeaters have no add/drop capability; they are discussed in detail in the next chapter.

The add/drop site can be done in either of two ways:

- Using an Optical Add/Drop Multiplexer (OADM) — this arrangement, available in 10G systems, provides full add/drop capability for 64 channels; the other 64 channels cannot be added or dropped. See Figure 3-3, "Linear Add/Drop Chain with OADM" (3-5) for a simplified block diagram.

- Using End Terminals, arranged back-to-back — this arrangement, available in 10G and 40G systems, provides extended reach and add/drop capability for all of the wavelengths on the optical line. See Figure 3-4, "Linear Add/Drop Chain with Back-to-Back End Terminals" (3-6) for a simplified block diagram.

Diagrams   See Figure 3-3, "Linear Add/Drop Chain with OADM" (3-5) for a simplified block diagram of a linear add/drop chain with End Terminals on the far end, and an OADM to provide regeneration and 64 channels of add/drop capability. One or more Repeaters can be used in between the nodes.

Figure 3-3 Linear Add/Drop Chain with OADM
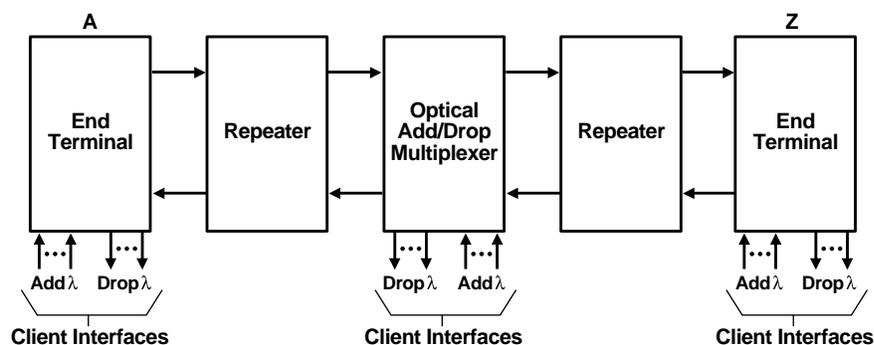
See Figure 3-4, "Linear Add/Drop Chain with Back-to-Back End Terminals" (3-6) for a simplified block diagram of a linear add/drop chain with End Terminals on the far end, and a back-to-back arrangement of End Terminals to provide regeneration and full add/drop capability. Repeaters are not employed in this illustration.

Figure 3-4 Linear Add/Drop Chain with Back-to-Back End Terminals

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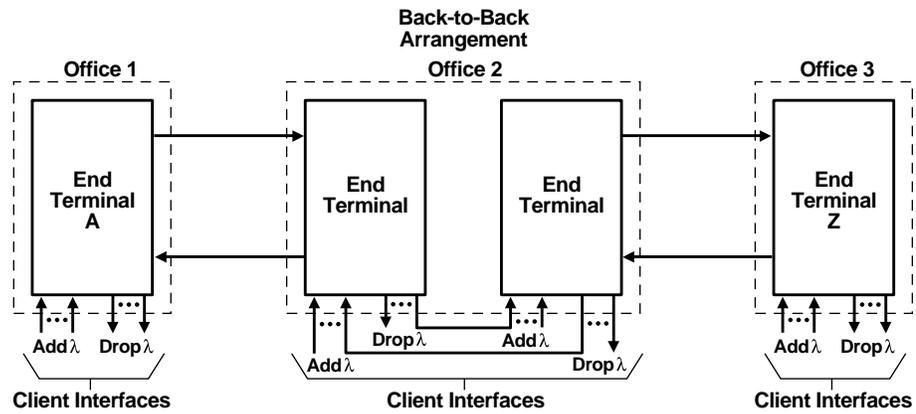
Mesh Systems

Description In a mesh architecture, a node can have a dedicated connection to some or all other nodes in a network. A mesh architecture provides resiliency by providing multiple paths to a node.

Usage LambdaXtreme™ Transport is an essential element of the Multiservice all optical core mesh network. In the Multiservice all optical core mesh network architecture the optical cross connect grooms together all the potential DWDM traffic in a given metropolitan area that originates from the high capacity SONET/SDH, ATM and IP nodes. It provides flexible routing of the groomed traffic to the appropriate destinations over the associated LambdaXtreme™ Transport system. LambdaXtreme™ Transport multiplexes all the optical signals received from the optical switch into a DWDM signal and transports it to the destined end location. The high capacity modular LH/ULH/UHC transport between optical switch nodes provided by LambdaXtreme™ Transport facilitates the flexible mesh restoration capabilities. Depending on the traffic demand, the optical switch may terminate on one or more LambdaXtreme™ Transport End Terminals or on the LambdaXtreme™ Transport OADM as indicated in .

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Mesh system block diagram The illustration below shows a mesh Multiservice All Optical Core Network Solution using LambdaXtreme™ Transport.

Figure 3-5 Multiservice All Optical Core Network Solution

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Bell Labs Innovations
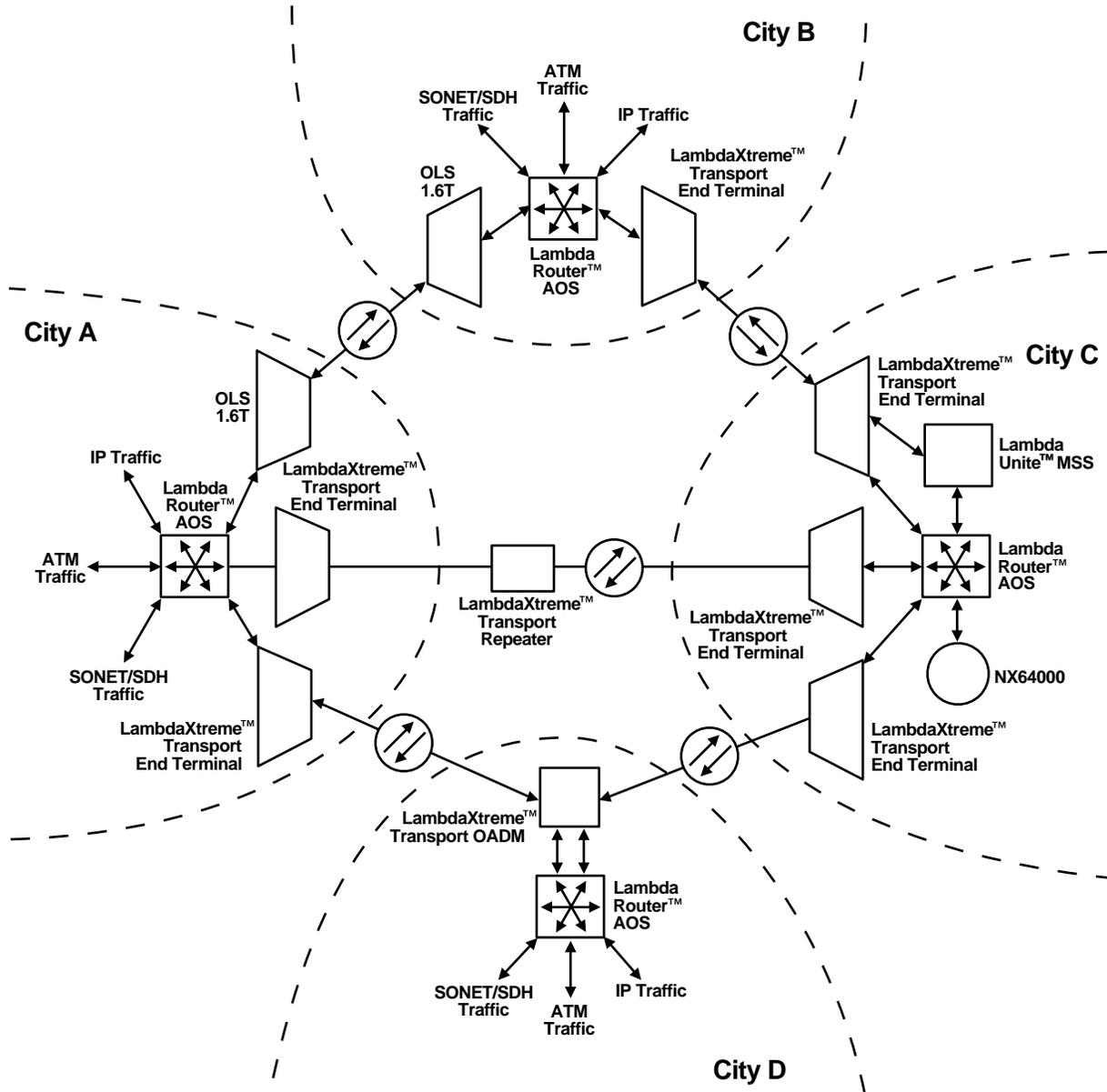
4 LambdaXtreme™ Transport Description

Overview

Purpose This chapter describes LambdaXtreme™ Transport operation, terminals, transmission circuit packs, control circuit packs, optical supervisory channel (OSC), and power.

Contents

Understanding LambdaXtreme™ Transport

Overview

Purpose   This section describes the operation of 10G and 40G systems and provides a list of the system components in a LambdaXtreme™ Transport system. A LambdaXtreme™ Transport "system" is defined as two End Terminals and everything in between those End Terminals.

Contents

Principle of Operation

....

10G block diagram and description

Figure 4-1, " 10G Simplified Functional Block Diagram" (4-3) shows a *simplified* block diagram of a typical LambdaXtreme™ Transport 10G system. The illustration shows a linear add/drop chain consisting of an End Terminal at each end, a Repeater, and an Optical Add/Drop Multiplexer (OADM) Terminal. The discussion follows signals going from Terminal A to Terminal Z on the diagram. A second line from Terminal Z to Terminal A is shown for completeness, but is not discussed; it follows the same functional theory, but in the opposite direction. Each terminal has a Supervisory (SUPVY) pack with a counterpropagating supervisory signal that facilitates communications between adjacent Network Elements (NEs).

Refer to the next two Sections — "Terminals" (4-9) and "Transmission Circuit Packs" (4-24) — for additional information on terminals and their transmission components.

Figure 4-1 10G Simplified Functional Block Diagram
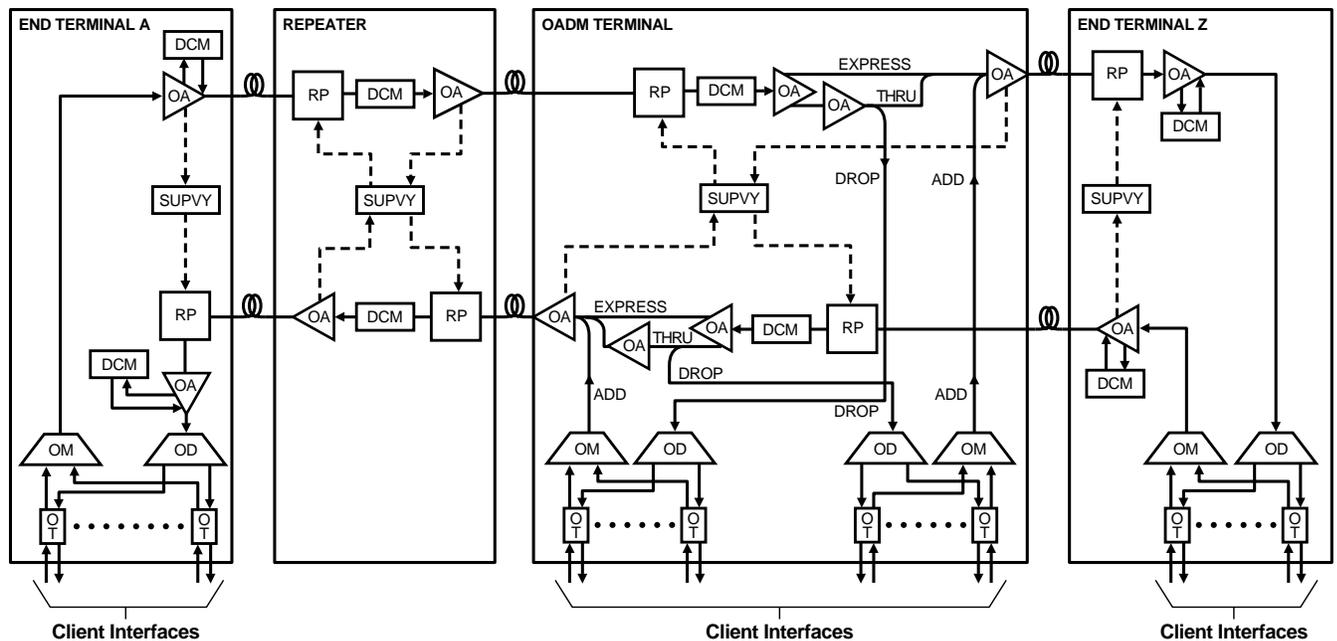
At End Terminal A

Signals from client equipment to be transmitted at the LambdaXtreme™ Transport line rates are conditioned as needed by Optical Translators (OTs). The OTs put the client signal onto the assigned wavelength. The individual wavelengths are multiplexed onto one DWDM line by the Optical Multiplexers (OMs). The Optical Amplifier (OA) boosts the power level and provides the copropagating pump power to the outside plant fiber (OSP) in the same direction as the transmitted signal to provide Raman amplification of the signal in the OSP.

The DCM (Dispersion Compensation Module) at the output OA provides pre compensation dispersion.

Through the Repeater

Raman amplification of the span is provided by launching counterpropagating high power light of selected wavelengths into the span. The light from these Raman pumps provides amplification to the signals as they travel along the fiber. The power of the signal channels remains higher than would be the case in the absence of Raman pumping and this leads to higher Optical Signal to Noise Ratio (OSNR). The DCM provides the required line dispersion compensation for the previous span. The OA amplifies the signal in the NE and provides Raman amplification in the Outside Plant Fiber (OSP) by supplying copropagating Raman power to the OSP. The boosted DWDM signal is then transmitted to the OADM Terminal.

At the OADM Terminal

At the OADM Terminal, the DWDM signal from the Repeater is first boosted by a counterpropagating Raman Pump (RP), amplified by OA(s) and separated into 3 groups of channels.

- *Express channels* — channels that are not available for the client at an OADM site.

- *Through channels* — channels that are available for dropping at this OADM, but they are passing through and not being dropped at this site.

- *Drop channels* — channels that are being dropped at the OADM site for usage by the client. These channels are demultiplexed by an OD and adapted for the client interface by OTs.

Add channels from the client are adapted for the LambdaXtreme™ Transport wavelengths (OTs), multiplexed (OMs), and added to the DWDM signal line for transmission to the receiving End Terminal Z.

At End Terminal Z

Signals from the DWDM receive line are boosted by a counterpropagating RP, amplified by the OA, demultiplexed into separate channels by the ODs, adapted by the OTs, and delivered to the client equipment.

The DCM at the input OA provides post compensation dispersion.

40G simplified block diagram

Figure 4-2, "40G Simplified Block Diagram" (4-6) shows a simplified block diagram of a point-to-point LambdaXtreme™ Transport 40G Ultra High Capacity System. The illustration shows an End Terminal at each end and a Repeater between the End Terminals. The discussion follows signals going from a client interface at End Terminal A, through a Repeater and on to a client interface at End Terminal Z. A line from End Terminal Z to End Terminal A is shown for completeness, but is not discussed; it follows the same functional theory, but in the opposite direction. Each Terminal has a SUPVY pack with a counterpropagating supervisory signal that facilitates communications between adjacent NEs.

Refer to the next two Sections (Terminals and Transmission Circuit Packs) for additional information on terminals and their components.

Figure 4-2 40G Simplified Block Diagram
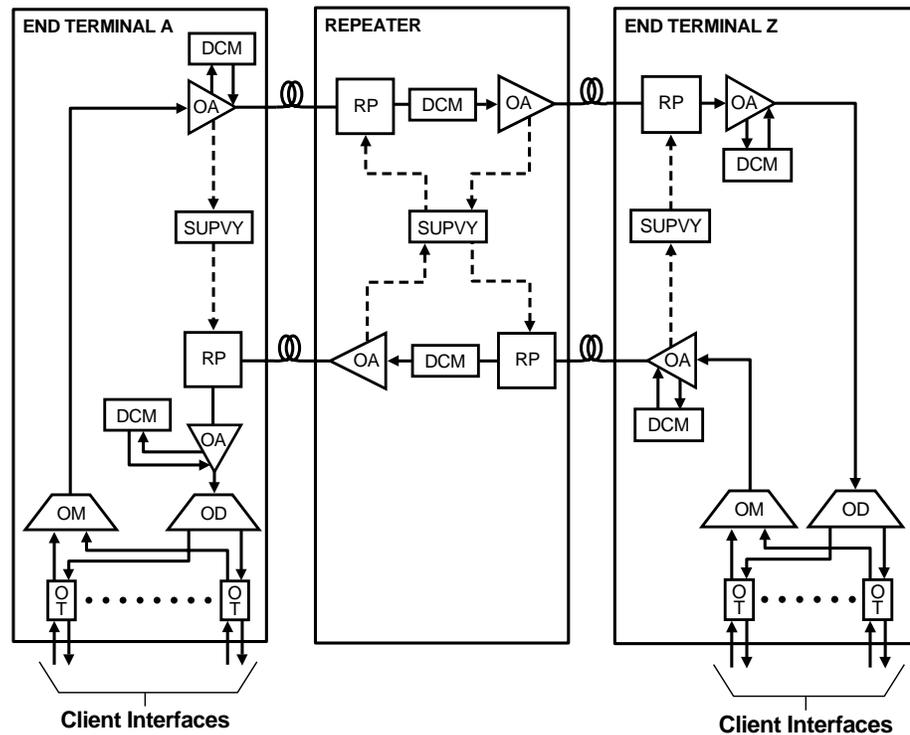
At End Terminal A

Signals from client equipment to be transmitted at the LambdaXtreme™ Transport line rates are conditioned as needed by Optical Translators (OTs). The OTs put the client signal onto the assigned wavelength. The individual wavelengths are multiplexed onto one DWDM line by the Optical Multiplexers (OMs). The OA boosts the power level and supplies copropagating pump power to the outside plant fiber (OSP) in the same direction as the transmitted signal to provide Raman amplification of the signal in the OSP.

The DCM at the output OA provides pre compensation dispersion.

Through the Repeater

At the Repeater, a Raman Pump (RP) amplifies the incoming signal by supplying counterpropagating Raman power. The OA boosts the power level and supplies counterpropagating and copropagating pump

power to provide Raman amplification of the signal. The boosted DWDM signal is then transmitted to End Terminal Z.

The DCM provides the required line dispersion compensation for the previous span.

At End Terminal Z

Signals from the DWDM receive line are boosted by a counterpropagating RP, amplified by the OA, demultiplexed into separate channels by the ODs, adapted by the OTs, and delivered to the client equipment.

The DCM at the input OA provides post compensation dispersion.

□

System Components

Types of system components

There are five categories of components in the LambdaXtreme™ Transport product:

- Terminals
  - End Terminal
  - Repeater
  - Optical Add/Drop Multiplexer
- Transmission Circuit Packs
  - Optical Translator (OT)
  - Optical Multiplexer (OM)
  - Optical Demultiplexer (OD)
  - Optical Amplifier (OA)
  - Raman Pump (RP)
  - Growth Raman Pump (RPG)
  - Optical Monitor (OMON)
  - Dispersion Compensation Module (DCM)
- Control Circuit Packs
  - Network Element Controller (NCTL)
  - Shelf Controller (SCTL)
  - System Input/Output (SIO)
  - Controller Input/Output (CIO)
  - Fan Assembly
- Optical Supervisory Channel (Supervisory pack, SUPVY)
- Power
  - Power Filter (PWR)

Each type of component is discussed in detail in the following sections of this chapter.

Terminals

Overview

Purpose This section provides functional descriptions of LambdaXtreme™ Transport Network Elements (NEs), which are: End Terminals, Optical Add/Drop Multiplexers (OADMs), and Repeaters.

Software Control of Transmission (SCOT) SCOT includes software architecture and algorithms for dynamic control of transmission. SCOT automatically adjusts the Raman pump power and available variable optical attenuators to optimize transmission during startup, occurrence of transients, addition and deletion of channels, APR recovery and addition of growth packs. SCOT automatically adjusts each Raman pump to flatten the signal channels. Signal channels are measured by an Optical Monitor (OMON) and the Raman pumps are adjusted according to a proprietary algorithm to flatten the signals with the fewest iterations possible.

NETYPE Each NE is composed of one or more bays working together to form a system. Each NE has a designation called ***NETYPE.*** NETYPE is a user-provisioned value that defines the required system configuration characteristics to the NE control system.

There are three types of NEs — NETYPES:

- End Terminals — 2F_ET
- Repeaters — 2F_RP
- OADMs — 2F_OADM

Bays There are four kinds of bays available in the system:

- System Bay
- Line Bay
- Extension Bay
- Repeater Shelf

For a description of the usage and function of each bay, refer to the discussion titled in Chapter 5.

Planning information

Refer to Chapter 5, "System Planning and Engineering" for complete planning information on all bays.

$\square$

End Terminal

Description End Terminals contain functionality that interfaces the optical signal between the LambdaXtreme™ Transport system and other network elements, a multiplexing and demultiplexing capability, and the ability to amplify the signal.

In point-to-point configurations, an End Terminal is used at each end of the network.

In linear add/drop chains, End Terminals are at each end of a chain and can also be at various points within the chain in a back-to-back arrangement where they can supply regeneration and full add/drop capability. In functional descriptions, the End Terminals at the two ends of the chain are referred to as terminals A and Z.

In mesh networks, End Terminals multiplex optical signals groomed by optical crossconnects.

Compatible optics End Terminals interface LambdaXtreme™ Transport with the client's optics. When the wavelength of the interfacing external equipment is the same as that used in LambdaXtreme™ Transport, it is said to have "compatible optics." In such cases, optical translation (OT) is not required.

**10G End Terminal
functional description**

shows a
simplified block diagram for a full-capacity 10G End Terminal.

Figure 4-3 10G End Terminal Block Diagram
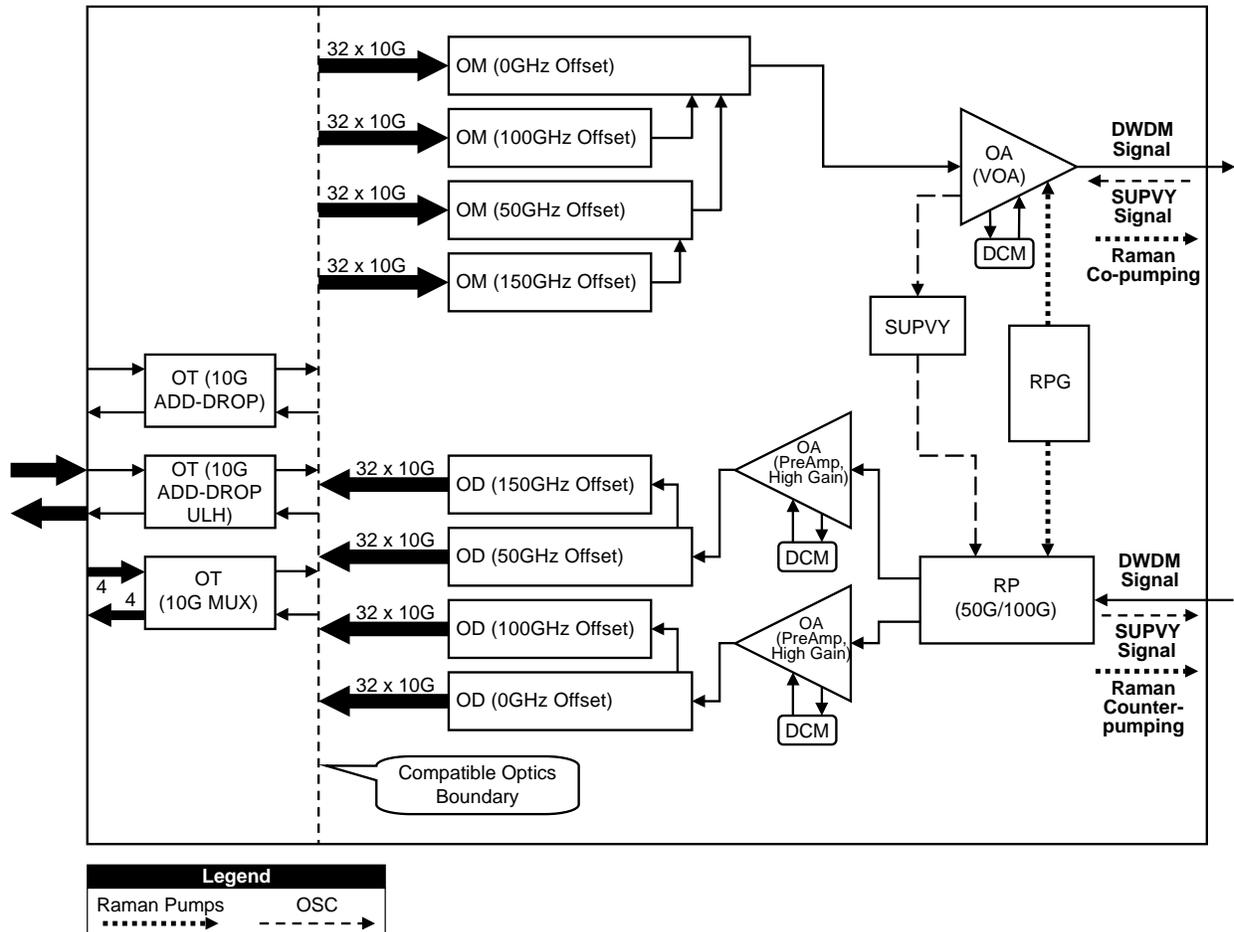
Optical signals are received from the compatible optics boundary at
the OM either direct from compatible sources or from OTs that
translate the incoming client signals to the frequency compatible with
LambdaXtreme™ Transport. These signals are multiplexed onto one
fiber, amplified by an OA (VOA), and transmitted downstream. (VOA
stands for Variable Optical Attenuator.)

In the other direction, the DWDM signal is received at the RP
(50G/150G) and sent onto an OA (PreAmp High Gain) for further
amplification. After amplification, the DWDM signal is demultiplexed

into separate channels at the OD and sent to the compatible optics boundary either direct to compatible devices or to OTs that translate the signals to the appropriate client signals.

When required to support added wavelength growth, an RPG (Growth Raman Pump) provides copropagating pumping in the transmit direction and counterpropagating pumping in the receive direction.

Also shown in the block diagram are

- Dispersion Compensation Modules (DCMs), to provide pre and post bulk dispersion compensation as required for transport of signals. The DCM at the output OA (VOA) provides pre dispersion compensation and the input OAs (PreAmp High Gain) provide post dispersion compensation.

- A Supervisory (SUPVY) pack, to provide communications from one LambdaXtreme™ Transport NE to another.

**40G End Terminal
functional description**   Figure 4-4, "40G End Terminal Block Diagram" (4-14) shows a
simplified diagram for a full-capacity 40G End Terminal. The
functional description is similar to the 10G discussion; however, note
the differences in the number and type of OTs, OMs, and ODs. Also
note that the 10G End Terminal uses an OA (PreAmp High Gain) and
the 40G End Terminal uses an OA (PreAmp Low Gain).

Figure 4-4   40G End Terminal Block Diagram
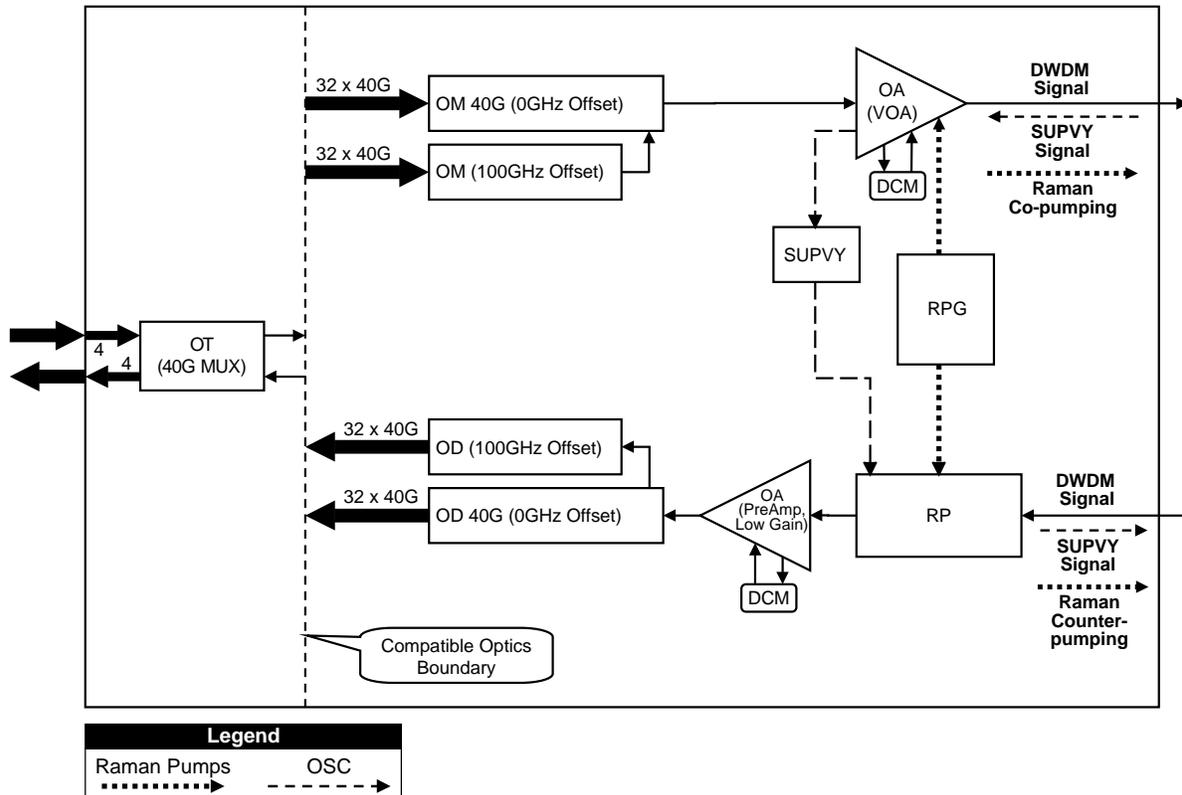
Optical signals are received from the compatible optics boundary at
the OM either direct from compatible sources or from OTs that
translate the incoming client signals to the frequency compatible with
LambdaXtreme™ Transport. These signals are multiplexed by OMs
onto one fiber, amplified by an OA (VOA), and transmitted
downstream.

In the other direction, the DWDM signal is received at an RP and sent
onto an OA (PreAmp Low Gain) for further amplification. After
amplification, the DWDM signal is demultiplexed into separate

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channels at the OD and sent to the compatible optics boundary either direct to compatible devices or to OTs that translate the signals to the appropriate client signals.

When required to support added wavelength growth, an RPG provides copropagating pumping in the transmit direction and counterpropagating pumping in the receive direction.

Also shown in the block diagram are

- Dispersion Compensation Modules (DCMs), to provide pre and post bulk dispersion compensation as required for transport of signals. The DCM at the output OA (VOA) provides pre dispersion compensation and the input OA (PreAmp Low Gain) provides post dispersion compensation.

- A Supervisory (SUPVY) pack, to provide communications from one LambdaXtreme™ Transport NE to another.

End Terminals in a back-to-back arrangement

End Terminals can be used in back-to-back arrangements for regeneration and full add/drop capability.

Figure 4-5, "End Terminals in Back-to-Back Arrangement" (4-16) shows a simplified drawing of back-to-back End Terminals used in a linear add/drop chain for adding/dropping/passing wavelengths.

At End Terminal X, the DWDM signal is received and sent to an OD for demultiplexing. In this figure, wavelengths (channels) 1 and 2 are transported to Terminal Y via OTs in both terminals then multiplexed back to a DWDM signal, amplified, and sent to the next NE. Meanwhile, wavelength number 3 is dropped at the local office (client

interface). The same arrangement exists for the End Terminal Y to End Terminal X transmission.

Figure 4-5 End Terminals in Back-to-Back Arrangement

Client Interfaces
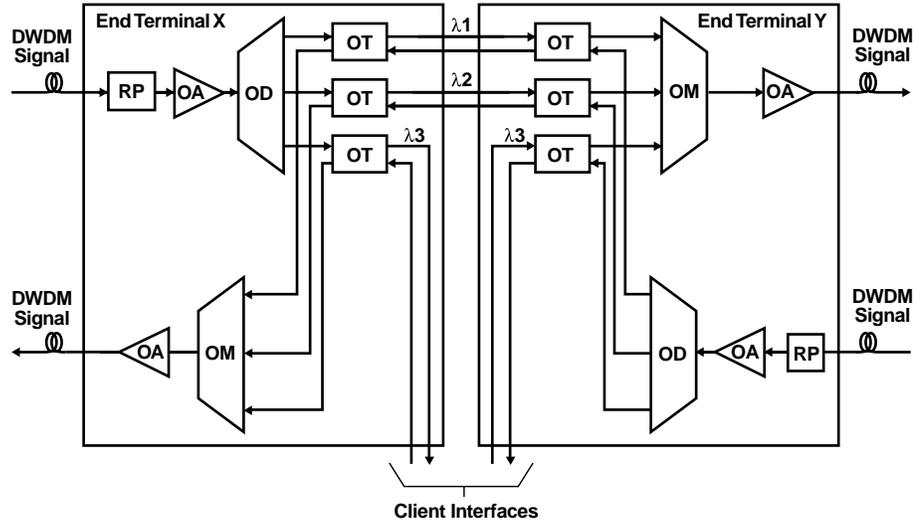
Repeater

Description   A Repeater provides reamplification; it is used between End Terminal or OADM sites that span long distances. Repeaters are used to amplify the optical signal power, enabling the signal to be transmitted over the next span of fiber. A Repeater has no add/drop or multiplexing functions.

Functional description and block diagram   Figure 4-6, "Repeater Block Diagram" (4-18) shows a simplified block diagram for a Repeater. This figure represents one option of 9 different types of Repeaters that can be constructed from three types of OAs.

Depending on the span fiber loss and channel gain flatness, one of the following OAs would be utilized per direction:

- spans with loss less than or equal to 23dB (OA Raman)

- spans with losses above 23dB (OA Raman EDFA)

- every six spans an OA with DGEF is required for channel gain flattening

The choices are made per direction of transmission separately for eastbound and westbound directions; a given Repeater configuration could be a mixture of the above OA types, depending on the loss in each direction and its relative position.

Once the correct OA is determined, the next choice is to select the matching Raman Growth Pack, when required for added wavelength growth. The matching pairs are:

- OA (Raman) requires RPG (DCF)

- OA (Raman EDFA) requires RPG (DCF)

- OA (DGEF) requires RPG

To illustrate the independent choice of OAs per direction, two combinations are shown in Figure 4-6, "Repeater Block Diagram" (4-18) (the first and third choice in the list above) due to the different span characteristics on the East and West side of the Repeater.

The SUPVY signal is added and dropped for each line at a Repeater.

Each item in the diagram is a circuit pack in the system and each of these is discussed separately and in detail later in this chapter.

Figure 4-6 Repeater Block Diagram
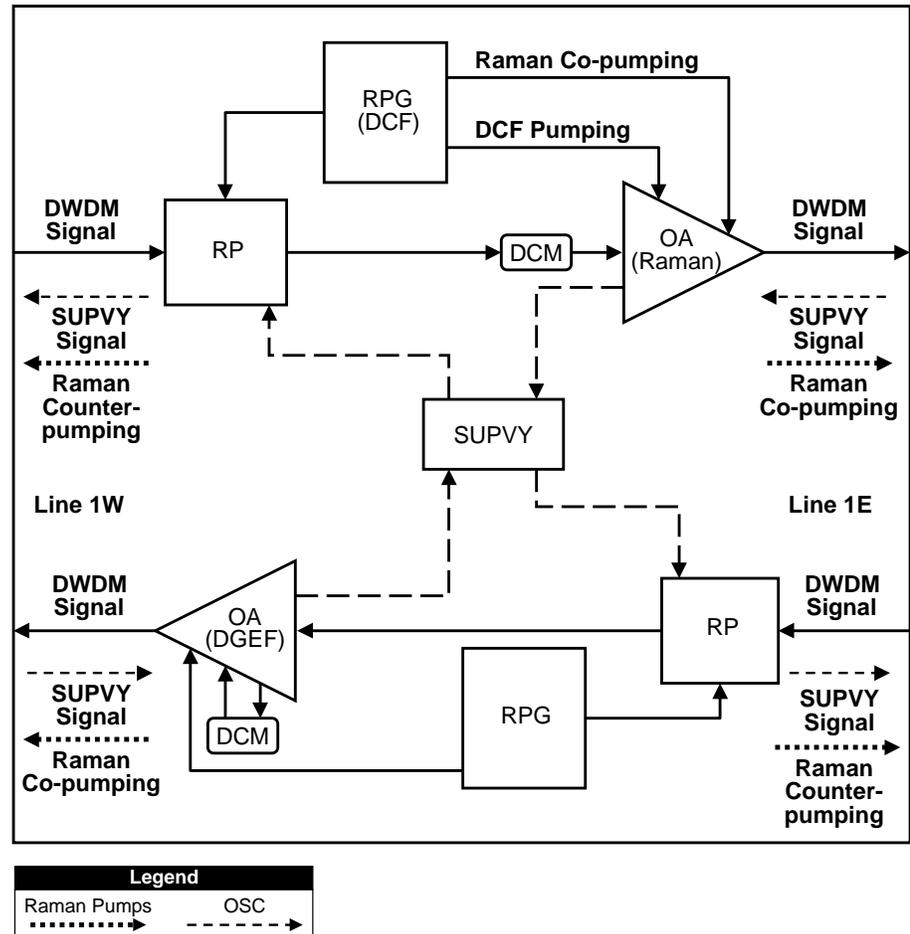
The DWDM signal (incoming at the upper left of the illustration) is received by the RP, which boosted the signal in the OSP, and sends it to the OA (Raman). The OA (Raman) and optional RPG amplify the signal by Raman pumping the DCM. In addition, the Raman OA and optional RPG provide the amplification of the signal in the 1E OSP of the following span by Raman pumping. The description is the same in the other direction except an OA (DGEF) is used to perform gain equalization (flatness) among the channels.

Also shown in the block diagram are

- DCMs, to provide dispersion compensation for the associated fibers

- supervisory (SUPVY) pack, to provide communications from one LambdaXtreme™ Transport NE to another.

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Optical Add/Drop Terminal (OADM)

Description   An OADM is used in 10G linear add/drop chains where up to 64 of the total wavelengths can be added and dropped. The total frequency grid, of 128 channels, has 64 channels that are available to the OADM and 64 channels that are not available to the OADM. Those that are available, but not accessed, are called Through channels. Those that are used are Add/Drop channels. The remaining 64 channels are not available to the OADM; they just pass through and are called Express channels. OADM terminals are only used in 10G systems.

Compatible optics   OADM Terminals interface LambdaXtreme™ Transport with the client's optics. When the wavelength of the interfacing external equipment is the same as that used in LambdaXtreme™ Transport, it is said to have "compatible optics." In such cases, optical translation (OT) is not required.

Functional description and block diagram
Figure 4-7, "OADM Block Diagram" (4-21) shows a simplified block diagram of an OADM. Each item in the diagram is a circuit pack in the system, and each of these is discussed separately and in detail later in this chapter. OADM channels can be Express, Through, Add, or Drop. Each type is discussed below.

Figure 4-7   OADM Block Diagram
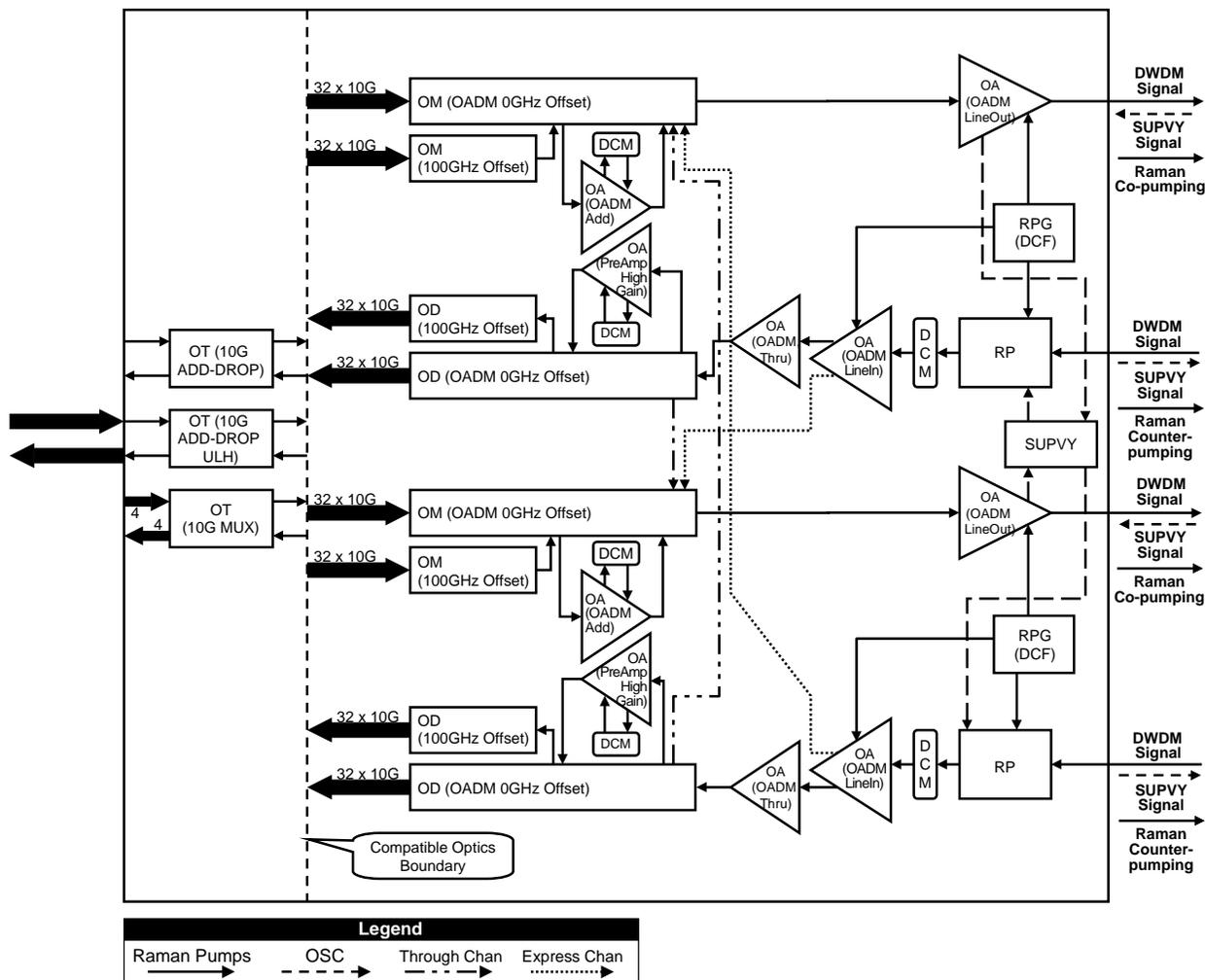
Express channels

The Express channels in a DWDM signal are received at a counterpropagating RP and sent to an OA (OADM LineIn) via a DCM. The DCM is pumped by the OA (OADM LineIn) and

optionally by the RPG (DCF). The Express channels are split from the DWDM signal and routed to the OM (OADM 0GHz Offset). At the OM, the Express channels are interleaved with the Through and Add channels (discussed below). All channels are then sent to an OA (OADM LineOut) and placed on the output line as a DWDM signal for transmission to the next NE. The OA (OADM LineOut), and optionally the RPG (DCF), provide Raman gain in the OSP.

Through channels

The Through channels in a DWDM signal are received at a counterpropagating RP and sent to an OA (OADM LineIn) via a DCM. The DCM is pumped by the OA (OADM LineIn) and optionally by the RPG (DCF). The OA (OADM LineIn) routes Through channels to the OA (OADM Thru), where they are amplified and sent to OD (OADM 0GHz Offset). Provisionable circuitry in the OD splits the Through channels from the DWDM signal and routes them to the OM (OADM 0GHz Offset) where they are interleaved with their associated Add and Express channels. All channels are then sent to an OA (OADM LineOut) and placed on the output line as a DWDM signal for transmission to the next NE. The OA (OADM LineOut), and optionally the RPG (DCF), provide Raman gain in the OSP.

Add channels

In the Add direction, signals are received from the compatible optics boundary at the OM (OADM 0GHz Offset) either direct from compatible sources or from OTs that translate the incoming signals to the frequency compatible with LambdaXtreme™ Transport. These signals are amplified by an OA (OADM Add) and sent back to the OM where provisionable circuitry sends the Add channels to be interleaved with Express and Through channels. All channels are then sent to an OA (OADM LineOut) and placed on the output line as a DWDM signal for transmission to the next NE. The OA (OADM LineOut), and optionally the RPG (DCF), provide Raman gain in the OSP.

Drop channels

In the Drop direction, the DWDM signal is received at a counterpropagating RP and sent to an OA (OADM LineIn) via a DCM. The DCM is pumped by the OA (OADM LineIn) and optionally by the RPG (DCF). The OA (OADM LineIn) routes Express channels to its associated OM. Through and Drop signals are

sent to the OA (OADM Thru), where they are amplified and sent to the associated OD. Provisionable circuitry in the OD, sends channels provisioned to be Through to the OM (OADM 0GHz Offset) and channels provisioned to be Dropped are amplified by an OA (PreAmp High Gain) and then demultiplexed in the appropriate OD. From the OD, the drop channels are sent to the compatible optics boundary either direct to compatible devices or to OTs that translate the outgoing signals to the supported client signals type.

Other circuits

Also shown in the block diagram are

- DCMs, to provide bulk dispersion compensation as required for transport of signals.

- A Supervisory (SUPVY) pack, to provide communications from one LambdaXtreme™ Transport NE to another.

OM and OD requirement

Since Express and Through channels pass through the 0GHz Offset OM and OD, they are required packs in an OADM even if there are no channels added or dropped.

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Transmission Circuit Packs

Overview

Purpose This section provides functional information on circuit packs used for transmission of optical signals in LambdaXtreme™ Transport. The transmission circuit pack types are

- Optical Translator (OT)
- Optical Multiplexer (OM)
- Optical Demultiplexer (OD)
- Optical Amplifier (OA)
- Raman Pump (RP)
- Growth Raman Pump (RPG)
- Optical Monitor (OMON)
- Dispersion Compensation Module (DCM)

Circuit pack identification All transmission circuit packs (CP) are identified by a 3-line ID located on the upper latch of the pack. The first line has the Apparatus Code (also known as the CP Code) to identify the particular pack, the second line shows the Series (version number) and the third line identifies the pack type. Refer to Engineering Drawing ED-8C861-10 for a complete list.

Channel markings on transmission packs Channels are referenced by their frequency in TeraHertz (THz) to 3 places after the decimal place (for example: channel 186.600). Port numbers on OTs, OMs and ODs are determined by using a simple conversion of the frequency: the decimal point and first and last digits are dropped to arrive at the port number. Hence, the port for the channel 186.600 THz is 8660.

Some figures in this chapter use a "wxyz" convention as a generic reference to a port number, where wxyz are the four numbers for the port. In some cases where ports are 0 GHz or 100 GHz Offsets, the designation is wxy0 on the figures for OMs and ODs. Also, where ports are 50 GHz or 150 GHz Offsets, the designation is wxy5 on the OM and OD figures.

Important! On OT packs, the letters 'wxyz' appear on the ports of the packs — the actual frequency supported is shown on the CP code.

Operating range   The operating range for LambdaXtreme™ Transport is from 186.500 THz to 192.850 THz, which corresponds to 1607.466 nm to 1554.537 nm wavelengths. This range is called *UltraBand*™. *UltraBand* is a single band that starts at the low frequency end of a standard L Band and continues on into an overlap of a portion of a standard C Band. Figure 4-8, "*UltraBand* Operating Range" (4-25) shows the relationship of the *UltraBand* operating range and that of a standard L Band and C Band.

Figure 4-8   *UltraBand* Operating Range
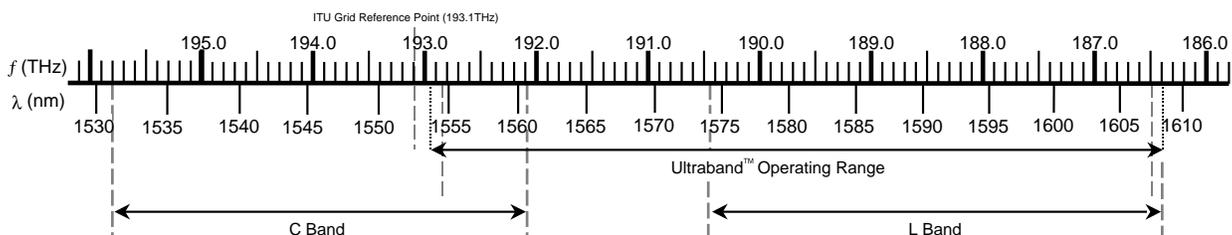
UltraBand frequency grid for LambdaXtreme™ Transport   In LambdaXtreme™ Transport, all OMs and ODs are 32-channel devices; therefore, 4 OMs and 4 ODs are required for the 128-channel capacity in 10G systems, and 2 OMs and 2 ODs are required for the 64-channel capacity in 40G UHC systems. Also, all OMs and ODs have their channels spaced 200 GHz apart. Refer to the figure below for a representation of the *UltraBand* Frequency Grid.

Figure 4-9   *UltraBand* Frequency Grid
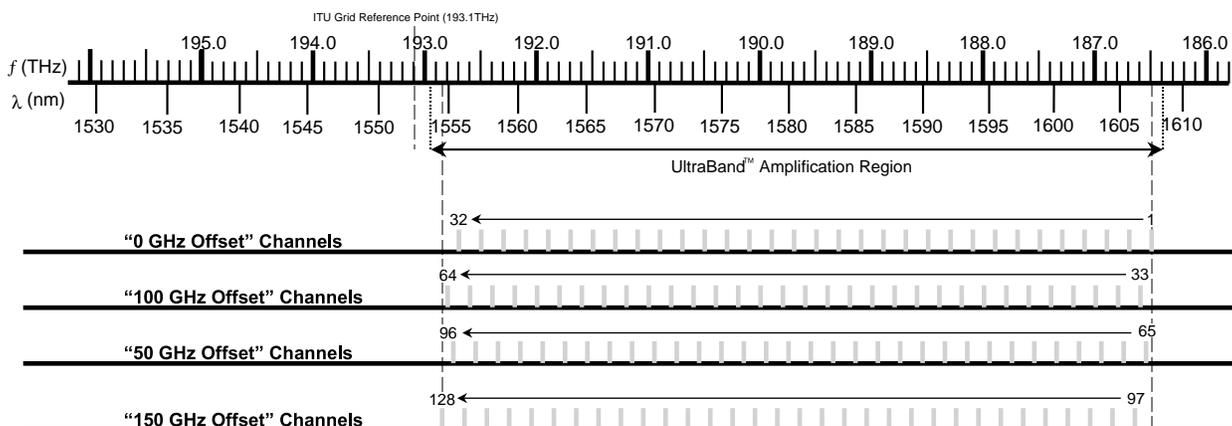
The first OM and OD pair, used in startup configurations, have the first channel at 186.500 THz, the second channel is 200 GHz higher at 186.700 THz, the third channel is 200 GHz higher at 186.900 THz, and so forth. These channel frequencies on the first OM/OD pair are called 0 GHz Offset.

The second OM and OD pair have their 32 frequency assignments 100 GHz above those of the first OM/OD pair just discussed, and are referred to as 100 GHz Offset. The lowest frequency in this OM/OD pair is at 186.600 THz, the second is 200 GHz higher at 186.800 THz, the third at 187.000 THz, and so forth.

The third OM and OD pair (10G systems only) have their 32 frequency assignments 50 GHz above the 0 GHz Offset frequencies of the first OM/OD pair, and are referred to as 50 GHz Offset. The lowest frequency in this OM/OD pair is at 186.550 THz, the second is 200 GHz higher at 186.750 THz, the third at 186.950 THz, and so forth.

The fourth OM and OD pair (10G systems only) have their 32 frequency assignments 150 GHz above the 0 GHz Offset frequencies of the first OM/OD pair, and are referred to as 150 GHz Offset. The lowest frequency in this OM/OD pair is at 186.650 THz, the second is 200 GHz higher at 186.850 THz, the third at 187.050 THz, and so forth.

Frequency assignments   The table below shows the frequency assignments for OM, OD, and OT equipment. As explained previously in this section, the 4-digit channel assignments are derived from the frequency in THz, where, for example, 186.500 THz is expressed as 8650.

Table 4-1   Frequency Assignments

0 GHz Offset (λ 1–32)		100 GHz Offset (λ 33–64)		50 GHz Offset (λ 65–96)		150 GHz Offset (λ 97–128)	
1	8650	33	8660	65	8655	97	8665
2	8670	34	8680	66	8675	98	8685
3	8690	35	8700	67	8695	99	8705
4	8710	36	8720	68	8715	100	8725
5	8730	37	8740	69	8735	101	8745
6	8750	38	8760	70	8755	102	8765

Table 4-1   Frequency Assignments   (continued)

0 GHz Offset (λ 1–32)		100 GHz Offset (λ 33–64)		50 GHz Offset (λ 65–96)		150 GHz Offset (λ 97–128)	
7	8770	39	8780	71	8775	103	8785
8	8790	40	8800	72	8795	104	8805
9	8810	41	8820	73	8815	105	8825
10	8830	42	8840	74	8835	106	8845
11	8850	43	8860	75	8855	107	8865
12	8870	44	8880	76	8875	108	8885
13	8890	45	8900	77	8895	109	8905
14	8910	46	8920	78	8915	110	8925
15	8930	47	8940	79	8935	111	8945
16	8950	48	8960	80	8955	112	8965
17	8970	49	8980	81	8975	113	8985
18	8990	50	9000	82	8995	114	9005
19	9010	51	9020	83	9015	115	9025
20	9030	52	9040	84	9035	116	9045
21	9050	53	9060	85	9055	117	9065
22	9070	54	9080	86	9075	118	9085
23	9090	55	9100	87	9095	119	9105
24	9110	56	9120	88	9115	120	9125
25	9130	57	9140	89	9135	121	9145
26	9150	58	9160	90	9155	122	9165
27	9170	59	9180	91	9175	123	9185
28	9190	60	9200	92	9195	124	9205
29	9210	61	9220	93	9215	125	9225
30	9230	62	9240	94	9235	126	9245
31	9250	63	9260	95	9255	127	9265
32	9270	64	9280	96	9275	128	9285

Fiber connectors
The fiber connectors used in LambdaXtreme™ Transport are discussed below. Some connectors use cover guards to provide switch or latch protection.

- *Client side* — All customer fibers are connected via an SC universal build out block (UBOB), which supports SC (recommended), ST, and FC customer side connectors, and an SC connector on the circuit pack side.

- *Line side* — All internal system fiber connections use Lucent Connector (LC) connectors for optical interconnect between packs and optical interfaces to the system.

- *Latch Protection* — Latch protected connectors prevent the user from being exposed to high optical power by preventing access to the connector prior to power being reduced to acceptable levels. The presence of the latch in front of the connector forces the user to unseat the circuit pack (that is, power it down) before being able to disconnect the fiber jumper. The latch protected connectors are utilized on connectors that are the source of high optical power.

- *Switch Protection* — Switch protected connectors prevent the user from being exposed to high optical power in case the connector is disconnected. The mechanical switch that is part of the connector assembly triggers Automatic Power Reduction (APR). The switch protected connectors are used to terminate high power jumpers on the circuit packs that are on the receiving side of high optical power.

LEDs
All transmission circuit packs have two LEDs on the faceplate to indicate the pack's status. The green LED is labeled ACTIVE; when it is blinking that means the pack is booting; when it is illuminated steadily that means the pack is active. Software control provides an LED test (LEDs are turned on, off, and back to current state).

The red LED is labeled FAULT; when that is blinking it means there is a signal problem coming in to the pack; when it is illuminated steadily that means the pack has an alarm condition or it is booting.

The green LED remains illuminated, even if there is an alarm, until the pack is no longer powered.

Optical Translator (OT)

OT function   Optical Translators (OTs) are transponders that are required to interface optical signals between the client and LambdaXtreme™ Transport.

Optical Translators:

- do wavelength translation between LambdaXtreme™ Transport equipment and external equipment that is not optically compatible with LambdaXtreme™ Transport

- perform optical-to-electrical (O→E) and electrical-to-optical (E→O) conversion to facilitate 3R functionality (retiming, reshaping, reamplification)

- perform fault management and performance monitoring (Non-intrusive Monitoring) on the SONET/SDH and *WaveWrapper*™ signal

Functional types of OTs   There are two functional types of OTs: Add/Drop and MUX.

- A single Add/Drop OT performs both add and drop functions for a single channel. The Add portion accepts a client signal and creates a single λ *WaveWrapper* signal to be added to the line. On the drop function, the OT drops a demultiplexed channel to the client.

- A MUX OT, in the Add direction, receives up to four signals and multiplexes them onto one *WaveWrapper* signal (or single λ) for transmission. In the Drop direction, the OT demultiplexes four signals from one *WaveWrapper* signal and places them on four separate client signals. A single pack provides both the multiplex and demultiplex operations.

  - A 10G 4:2.5 MUX OT multiplexes and demultiplexes four 2.5G signals to a 10G *WaveWrapper* signal

  - A 40G 4:10 MUX OT multiplexes and demultiplexes four 10G signals to a 40G *WaveWrapper* signal

Line side fiber   All OTs use Lucent *WaveWrapper* format on the line side.

Client side interfaces   10G OTs support the following client interfaces:

- Up to four 2.5 Gbps up to 2 km compliant with ITU-T G.957 Intra-Office (I-16) and Telcordia GR-253-CORE SR-1 standards for a 1310 nm multiple longitudinal mode (MLM) laser with a 0–7 dB attenuation range (+1 dB optical path penalty) for 10^{-12} Bit Error Ratio (BER).

- 10 Gbps up to 600 meters (VSR-600m) compliant with the ITU-T G.691 Intra-Office (I-64.1r) standard for 1310 nm MLM laser with a 0–4 dB attenuation range (+1 dB optical path penalty) for 10^{-12} (BER).

- 10 Gbps up to 40 km (IR-2) compliant with the ITU-T G.691 Short Haul (S-64.2b and Telcordia GR-1377-CORE IR-2) standards for a single longitudinal mode (SLM laser) 1550 nm with a 3–11 dB attenuation range (+2 dB optical path penalty) for 10^{-12} BER. Both SONET/SDH and 10G *Ethernet*™ WAN PHY interfaces are supported.

40G OTs support the following client interfaces:

- Up to four 10 Gbps up to 600 meters (VSR 600m) compliant with the ITU-T G.691Intra—Office (I-64.1r) standard for a multiple longitudinal mode (MLM laser) 1310 nm with a 0–4 dB attenuation range (+1 dB optical path penalty) for 10^{-12} BER.

- Up to four 10 Gbps up to 40 km (IR-2) compliant with the ITU-T G.691 Short Haul S-64.2B and Telcordia GR-1377-CORE IR-2 standards for a 1550 nm SLM laser with a 3–11 dB attenuation range (+2 dB optical path penalty) for 10^{-12} BER. Both SONET/SDH and 10G *Ethernet* WAN PHY interfaces are supported.

Client data rate support for 10G OTs   10G systems can accept client data rates of 10 Gbps or four client rates of 2.5 Gbps each.

Client data rate support for 40G OTs   40G systems can accept four client data rates of 10 Gbps each.

Channel/port markings for OTs   Refer to the discussion on channel markings in the Overview section of Transmission Circuit Packs for the channel/port conventions used for OTs.

OTs for 10G systems   10G systems are supported by three types of OTs:

- OT (10G ADD-DROP) for LH applications
- OT (10G MUX) for multiplexing four 2.5G signals to/from one 10G line in LH applications
- OT (10G ADD-DROP ULH) for ULH applications

Each type of 10G OT is discussed below, followed by an illustration of the front panels.

OT (10G ADD-DROP)

OT (10G ADD-DROP) is used in 10G Long Haul (LH) applications and has the following client-side characteristics:

- supports two types of client interfaces: 1310 nm (VSR for intra-office 600-meter applications) and 1550 nm (Intermediate Reach IR-2 applications).

    - For VSR applications: 10 Gbps up to 600m (VSR-600m) compliant with the ITU-T G.691 Intra-Office (I-64.1r) standard for a multiple longitudinal mode (MLM laser) 1310 nm with a 0–4 dB attenuation range (+1 dB optical path penalty) for 10^{-12} BER.

    - For IR applications: 10 Gbps up to 40 km (IR-2) compliant with the ITU-T G.691 Short Haul (S-64.2b and Telcordia GR-1377-CORE IR-2) standards for a single longitudinal mode (SLM laser) 1550 nm with a 3–11 dB attenuation range (+2 dB optical path penalty) for 10^{-12} BER. Both SONET/SDH and 10G *Ethernet* WAN PHY interfaces are supported.

- in the transmit direction, the OT performs Nonintrusive Monitoring (NIM)

- timing is derived by recovering the clock from the incoming data. Internal circuitry reduces clock jitter and generates a line clock to retime the transmit data.

- jitter performance

    - 10G OT packs meet the jitter requirements specified in Telcordia GR-253-CORE.

    - For concatenation of up to 70 transmission sections connected in series, the system meets the jitter performance criteria specified in ITU-T G.825.

See for a block diagram of OT (10G ADD-DROP).

Figure 4-10   OT (10G ADD-DROP) for LH — Block Diagram
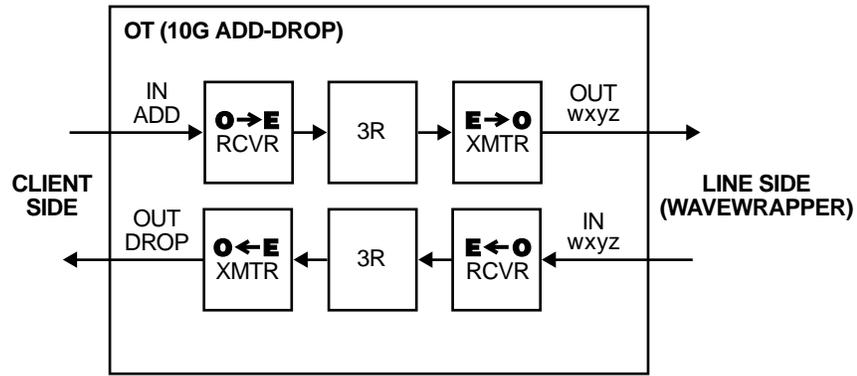
OT (10G MUX)

OT (10G MUX) transports four OC-48/STM-16 (2.5 Gbps) signals over a single 10 Gbps channel in LH applications. The client OC-48/STM-16 signals are transported transparently through LambdaXtreme™ Transport (no termination or overwriting of SONET/SDH overhead).

In one direction, the 10G MUX OT performs an optical-to-electrical conversion of four SONET/SDH-compliant OC-48/STM-16 client signals. The 10G MUX OT multiplexes these signals (electrically) into one signal, adds *WaveWrapper* OCh overhead and FEC check bytes. The signal is then transmitted on a DWDM compatible wavelength.

In the opposite direction, the 10G MUX OT receives one 10G MUX channel. This signal goes through an optical-to-electrical conversion and is then demultiplexed back into four OC-48/STM-16 client signals. An electrical-to-optical conversion is done and the four OC-48/STM-16 signals are sent to the client equipment.

The 10G MUX OT has the following characteristics:

- 2.5 Gbps up to 2 km compliant with ITU-T G.957 Intra-Office (I-16) and Telcordia GR-253-CORE SR-1 standards for a 1310 nm MLM laser with a 0–7 dB attenuation range (+1 dB optical path penalty) for 10^{-12} BER

- timing is derived by recovering the clock from the incoming data. Internal circuitry reduces clock jitter and generates a line clock to retime the transmit data.

- non-intrusive monitoring (NIM) of the SONET/SDH signals

- multiplexing of the four OC-48/STM-16 signals

- provides OCh overhead

- provides Reed Solomon FEC

See Figure 4-11, "OT (10G MUX) — Block Diagram" (4-33) for a functional block diagram of the 10G LH MUX OT.

Figure 4-11 OT (10G MUX) — Block Diagram
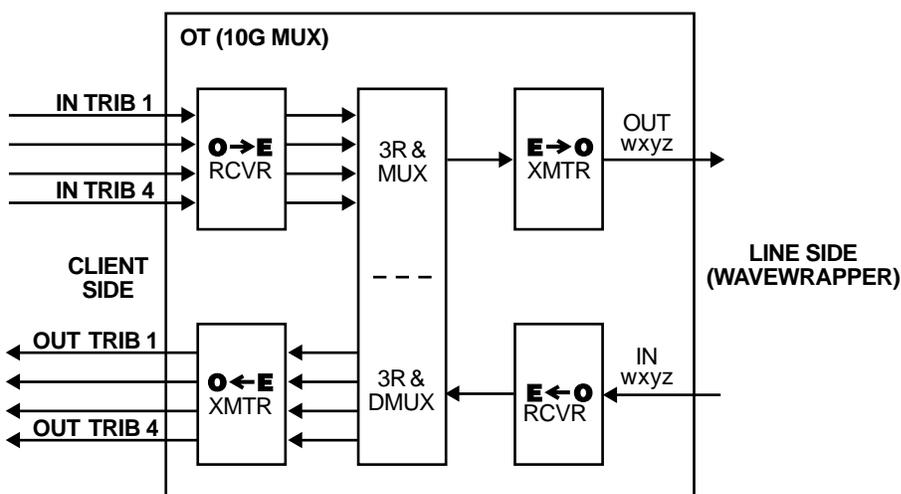
OT (10G ADD-DROP ULH)

OT (10G ADD-DROP ULH) is used in 10G Ultra Long Haul (ULH) applications and has the same characteristics as the 10G OT used in LH applications, *except for the following:*

- more sophisticated optical transmitter to obtain the narrower shaped pulses for improved ultra long haul transmission
- Standard Reed Solomon FEC is replaced by Lucent's Ultra FEC for higher coding gain

See Figure 4-12, "OT (10G ADD-DROP ULH) — Block Diagram" (4-34) for a functional block diagram of OT (10G ADD-DROP ULH).

Figure 4-12 OT (10G ADD-DROP ULH) — Block Diagram
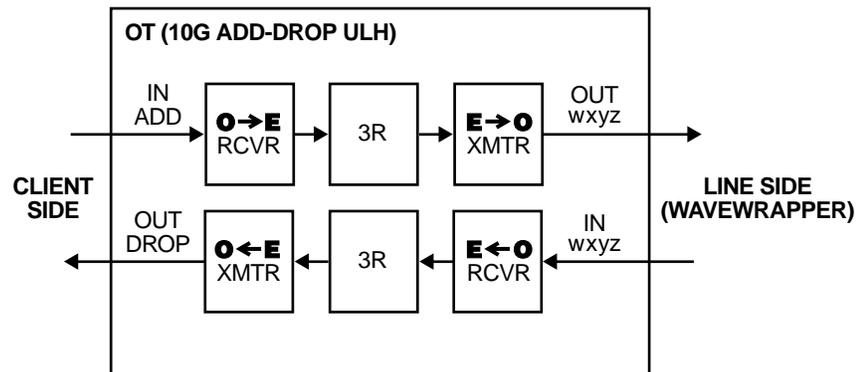
Physical labels of 10G OTs

See Figure 4-13, "10G OTs — Faceplate Drawing" (4-35) for a faceplate drawing of the three types of 10G OTs.

Figure 4-13 10G OTs — Faceplate Drawing
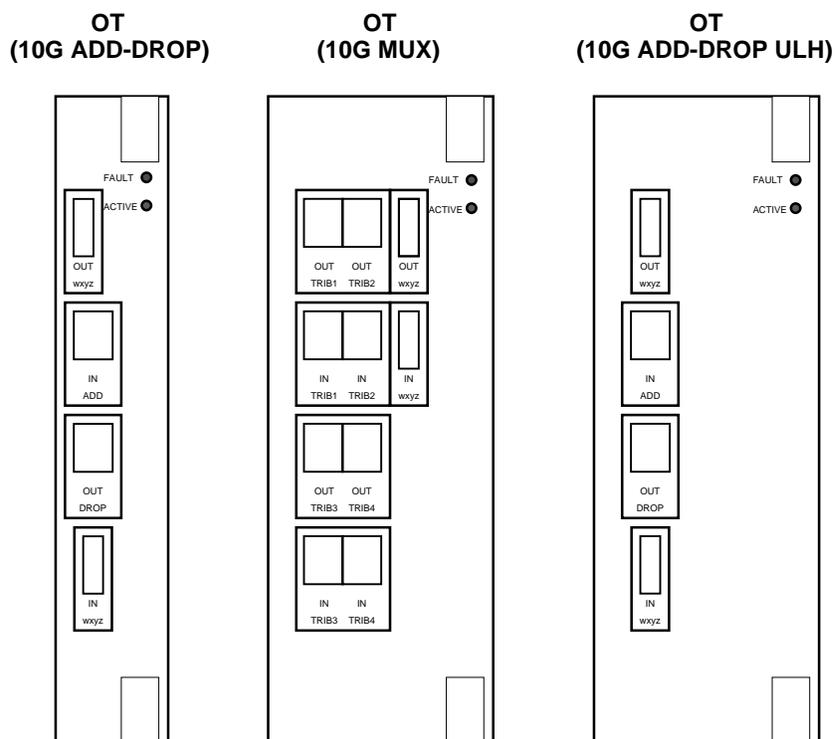
OTs for 40G systems

40G UHC systems are supported by a 4:1 MUX OT:

- OT (40G MUX) for multiplexing four 10G signals (OC-192/STM-64) to/from one 40G *WaveWrapper* line; IR and VSR applications are supported

For VSR applications: Four 10 Gbps up to 600m (VSR-600m) compliant with the ITU-T G.691 Intra-Office (I-64.1r) standard for a multiple longitudinal mode (MLM laser) 1310 nm with a 0–4 dB attenuation range (+1 dB optical path penalty) for 10^{-12} BER.

For IR applications: Four 10 Gbps up to 40 km (IR-2) compliant with ITU-T G.691 Short Haul S-64.2B and Telcordia GR-1377-CORE IR-2 standards for a 1550 nm SLM laser with a 3–11 dB attenuation range

($+2$ dB optical path penalty) for 10^{-12} BER. Both SONET/SDH and 10G *Ethernet* WAN PHY interfaces are supported.

The 40G MUX OT is discussed below, followed by an illustration of the front panel.

OT (40G MUX)

OT (40G MUX) transports four 10-Gbps signals over a single 40 Gbps channel in UHC systems. The client 10G signals are transported transparently through LambdaXtreme™ Transport (no termination or overwriting of SONET/SDH overhead).

In one direction, the 40G MUX performs an optical-to-electrical conversion of four 10G client signals. The 40G MUX OT multiplexes these signal (electrically) into one signal, adds *WaveWrapper* OCh overhead and FEC check bytes. The signal is then transmitted on a DWDM compatible wavelength.

In the opposite direction, the 40G MUX receives a data stream on one 40G MUX channel. This signal goes through an optical-to-electrical conversion and is then demultiplexed back into four 10G client signals. An electrical-to-optical conversion is done and the four 10G signals are sent to the client equipment.

OT (40G MUX) has the following characteristics:

- non-intrusive monitoring (NIM) of the SONET/SDH signals

- multiplexing of the four 10G signals

- provides OCh overhead

- provides Reed Solomon FEC

- jitter performance

  - for concatenation of up to 76 transmission sections, the system meets the jitter performance criteria specified in ITU-T G.825 and GR-253-CORE for OC-192/STM-64 signals
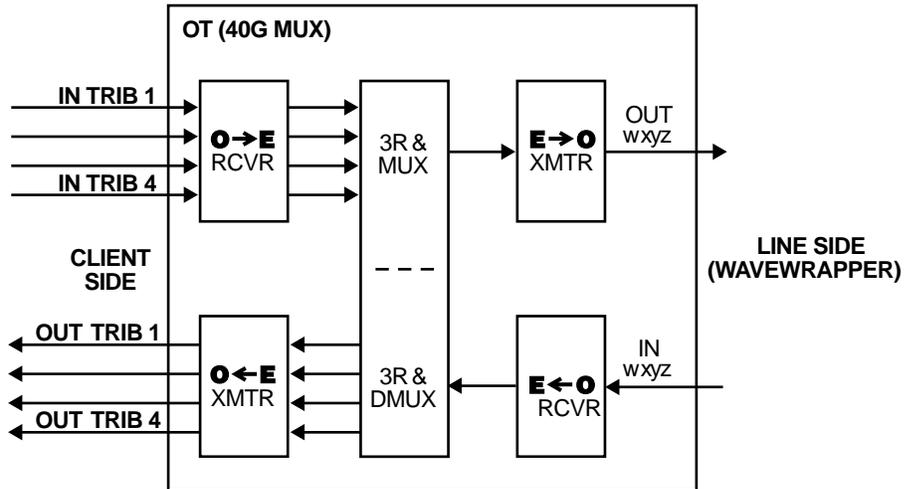
40G OT — faceplate drawing

See Figure 4-15, "40G OTs — Faceplate Drawing of 40G OTs" (4-38)
for a faceplate drawing of the OT used in 40G UHC systems.

Figure 4-15 40G OTs — Faceplate Drawing of 40G OTs
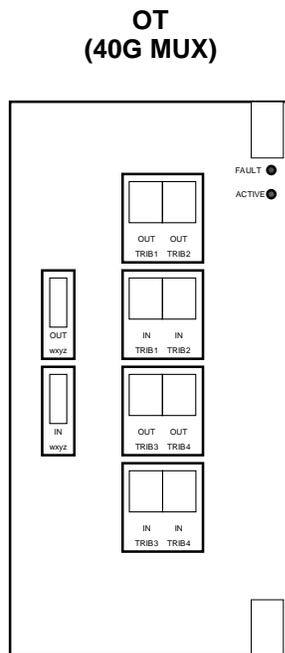
Optical Multiplexer (OM)

OM function

The Optical Multiplexer (OM) combines discrete wavelengths onto a single DWDM optical signal for transport over long distances.

OMs:

- are used in End Terminals and OADM Terminals, but not in Repeaters
- each OM can multiplex up to 32 channels

All OMs in LambdaXtreme™ Transport are 32 channel devices with the 32 input signals spaced 200 GHz apart. Since 10G systems have up to 128 channels, four OMs (in each direction) exist for 10G End Terminals. OADM terminals (with 64-channel add/drop capability) require up to two OMs (in each direction). Also, since 40G systems have up to 64 channels, up to two OMs (in each direction) exist for 40G End terminals.

Channel/port markings for OMs

Refer to the discussion on channel markings in the Overview section of Transmission Circuit Packs for the channel/port conventions used for OMs.

Types of OM circuit packs

LambdaXtreme™ Transport includes the following types of OM circuit packs:

- OM (0GHz Offset) for 10G End Terminals
- OM (50GHz Offset) for 10G End Terminals
- OM (100GHz) for 10G End Terminals, 10G OADM Terminals, and 40G End Terminals
- OM (150GHz Offset) for 10G End Terminals
- OM (OADM 0GHz Offset) for 10G OADM Terminals
- OM (40G 0GHz Offset) for 40G End Terminals

Each type of OM circuit pack is discussed separately below.

OMs for 10G End Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the OMs used in 10G End Terminals.

Functional description

All OMs are 32 channel devices with wavelengths spaced 200 GHz apart. The first OM accommodates frequencies from 186.50 THz to

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192.70 THz, in 200 GHz increments. These are marked on the front panel as 8650 to 9270, which corresponds to the 0 GHz offset grid of frequencies. The second OM accommodates frequencies from 186.60 THz to 192.80 THz, which are 100 GHz offset relative to the 32 channels on the first OM; therefore, the OM is called a 100 GHz Offset. The third and fourth OMs are interleaved with 50 GHz and 150 GHz Offsets with respect to the 0 GHz frequency grid.

LambdaXtreme™ Transport uses the following types of OMs in 10G End Terminals:

- *OM (0GHz Offset)* is used for the startup configuration in a 10G End Terminal. This OM combines (interleaves) multiplexed inputs from 100 and 50 GHz Offset OMs for transmission to an OA and the output line. This OM also provides OMON access for channel detection.

- *OM (100GHz Offset)* is used for the second set of 32 frequencies that are 100 GHz offset relative to the 0 GHz Offset grid. These 32 channels are multiplexed onto one line and sent to the 0 GHz Offset OM, where they are added to the first set of 32 channels. (This OM is the same as the 100 GHz Offset OM used in the 40G End Terminal and the OADM Terminal.)

- *OM (50GHz Offset)* is used for the third set of 32 channels that are offset 50 GHz from the 0 GHz Offset grid. The OM multiplexes the 50 GHz inputs, interleaves the 150 GHz Offset signals, and sends them to the 0 GHz Offset OM.

- *OM (150GHz Offset)* is used for the fourth set of 32 channels that are offset 150 GHz from the 0 GHz Offset grid. The OM multiplexes these inputs and sends them to the 50 GHz Offset OM.

Block diagram

See Figure 4-16, "OMs for 10G End Terminals — Block Diagram" (4-41) for a functional block diagram of the four types of OMs used in 10G End Terminals.

Figure 4-16 OMs for 10G End Terminals — Block Diagram
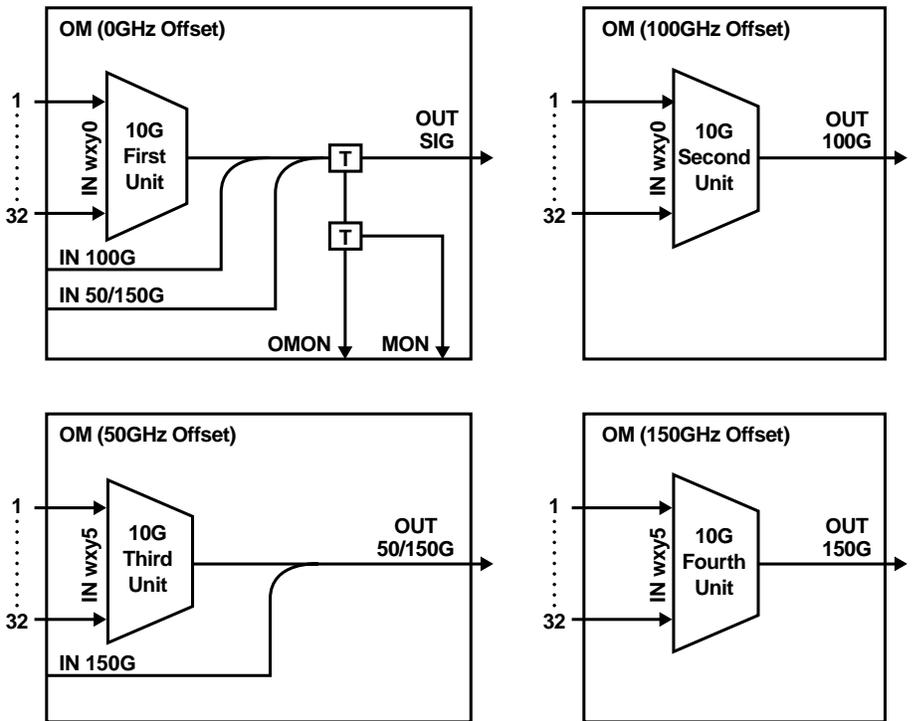
Faceplate drawing

See Figure 4-17, "OMs for 10G End Terminals — Faceplate Drawing" (4-42) for a faceplate drawing of the four types of OMs used in 10G End Terminals.

Figure 4-17 OMs for 10G End Terminals — Faceplate Drawing
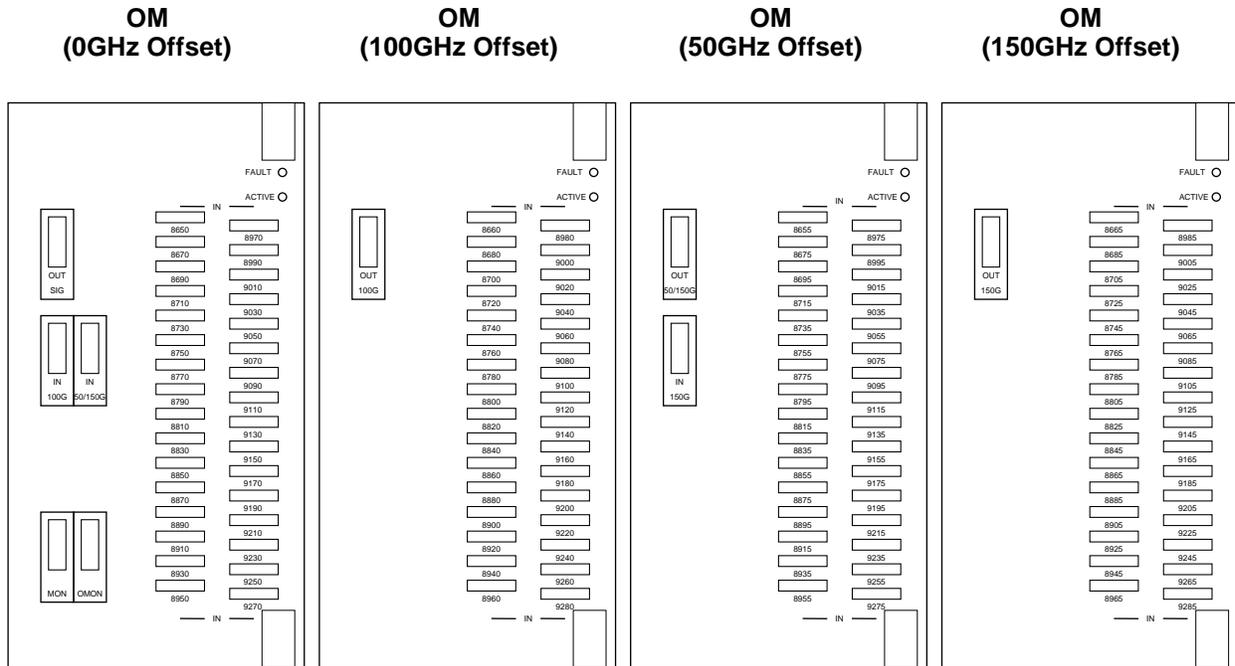
OMs for 10G OADM Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the OMs used in 10G OADM Terminals.

Functional description

All OMs are 32 channel devices with wavelengths spaced 200 GHz apart. The first OM accommodates frequencies from 186.50 THz to 192.70 THz. These are marked on the front panel as 8650 to 9270, which corresponds to the 0 GHz offset grid of frequencies. The second OM accommodates frequencies from 186.60 THz to 192.80 THz, which are 100 GHz offset relative to the 32 channels on the first OM; therefore, the OM is called a 100 GHz Offset. Each side of an OADM has a pair of these OMs.

LambdaXtreme™ Transport uses the following types of OMs in 10G
OADM Terminals.

- *OM (OADM 0GHz Offset)* is used for the startup configuration
  of an OADM Terminal to multiplex up to 32 channels input. This
  OM combines (interleaves) its multiplexed signals with Through,
  Express, and multiplexed inputs from the 100 GHz Offset OM
  for transmission to an OA and the output fiber. The OM also
  provides OMON access for channel detection.
  Note that the 0 GHz Offset OM is a required circuit pack in all
  OADM applications even if no channels are added (since the OM
  carries the Through and Express channels).

- *OM (100GHz Offset)* is used for the next set of 32 frequencies
  that are 100 GHz offset relative to the 0GHz Offset grid. These
  32 channels are multiplexed onto one fiber and sent to the 0 GHz
  Offset OM. (This 100 GHz Offset OM is the same as the 100
  GHz Offset OM used in the 10G and 40G End Terminals.)

Block diagram

See Figure 4-18, "OMs for OADM — Block Diagram" (4-43) for a
functional block diagram of the two types of OMs used in 10G
OADM Terminals.

Figure 4-18 OMs for OADM — Block Diagram

Faceplate drawing

See Figure 4-19, "OMs for OADM — Faceplate Drawing" (4-44) for a faceplate drawing of the two types of OMs used in 10G OADM Terminals.

Figure 4-19 OMs for OADM — Faceplate Drawing

OMs for 40G End Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the OMs used in 40G End Terminals.

Functional description

LambdaXtreme™ Transport uses the following types of OMs in 40G End Terminals:

- *OM (40G 0GHz Offset)* is used for the startup configuration in a 40G End Terminal. This OM combines (interleaves) multiplexed inputs from the 100 GHz Offset OM for transmission to an OA and the output line. This OM also provides OMON access for channel detection.

- *OM (100 GHz Offset)* is used for the second set of 32 frequencies that are 100 GHz offset relative to the 0GHz Offset grid. These 32 channels are multiplexed onto one line and sent to the 0 GHz Offset OM, where they are added to the first set of 32 channels. (This OM is the same as the 100 GHz Offset OM used in the 10G End Terminal and the OADM Terminal.)

Block diagram

See Figure 4-20, "OMs for 40G End Terminals — Block Diagram" (4-45) for a functional block diagram of the two types of OMs used in 40G End Terminals.

Figure 4-20 OMs for 40G End Terminals — Block Diagram
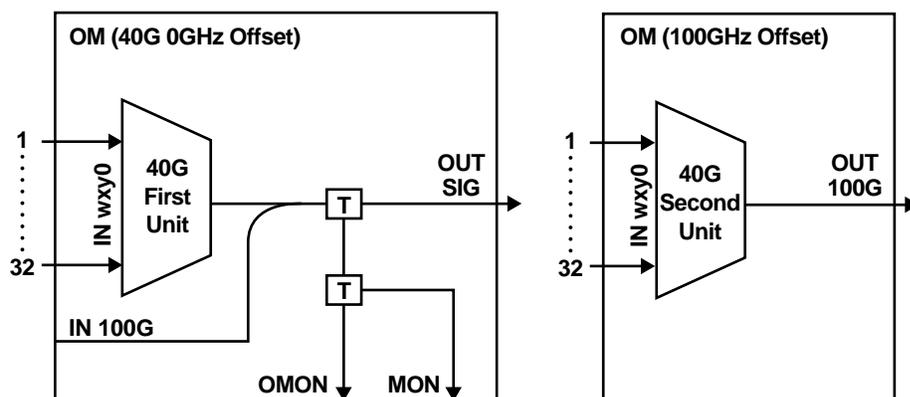
Faceplate drawing

See Figure 4-21, "OMs for 40G End Terminals— Faceplate Drawing" (4-46) for a faceplate drawing of the two types of OMs used in 40G End Terminals.

Figure 4-21 OMs for 40G End Terminals— Faceplate Drawing

**OM
(40G 0GHz Offset)**

FAULT ○
ACTIVE ○
IN
OUT SIG
IN 100G
MON OMON

8650 8970
8670 8990
8690 9010
8710 9030
8730 9050
8750 9070
8770 9090
8790 9110
8810 9130
8830 9150
8850 9170
8870 9190
8890 9210
8910 9230
8930 9250
8950 9270
IN

**OM
(100GHz Offset)**

FAULT ○
ACTIVE ○
IN
OUT 100G

8660 8980
8680 9000
8700 9020
8720 9040
8740 9060
8760 9080
8780 9100
8800 9120
8820 9140
8840 9160
8860 9180
8880 9200
8900 9220
8920 9240
8940 9260
8960 9280
IN

Optical Demultiplexer (OD)

OD function

The Optical Demultiplexer (OD) extracts individual wavelengths from the DWDM optical signal which has been generated using an OM. ODs and OMs work in concert; their operation, function, and description correlate to each other.

Some characteristics of ODs are

- they are used in End Terminals and OADM Terminals, but not in Repeaters
- each OD circuit pack can extract up to 32 channels

All ODs in LambdaXtreme™ Transport are 32 channel devices with the 32 output signals spaced 200 GHz apart. Since 10G systems have up to 128 channels, up to four ODs exist for 10G End Terminals. OADM terminals (with 64-channel add/drop capability) require up to two ODs (in each direction). Also, since 40G systems have up to 64 channels, up to two ODs exist for 40G UHC End Terminals.

Channel/port markings for ODs

Refer to the discussion on channel markings in the Overview section of Transmission Circuit Packs for the channel/port conventions used for ODs.

Types of OD circuit packs

LambdaXtreme™ Transport includes the following types of OD circuit packs:

- OD (0GHz Offset) for 10G End Terminals.
- OD (50GHz Offset) for 10G End Terminals
- OD (100GHz Offset) for 10G End Terminals, 40G End terminals, and 10G OADM Terminals
- OD (150 GHz Offset) for 10G End Terminals.
- OD (OADM 0GHz Offset) for 10G OADM Terminals
- OD (40G 0GHz Offset) for 40G End Terminals.

ODs for 10G End Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the ODs used in 10G End Terminals.

Functional description

All ODs are 32 channel devices with wavelengths spaced 200 GHz apart, in 200 GHz increments. The first OD accommodates

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See notice on first page

frequencies from 186.50 THz to 192.70 THz. These are marked on the front panel as 8650 to 9270, which corresponds to the 0 GHz offset grid of frequencies. The second OD accommodates frequencies from 186.60 THz to 192.80 THz, which are 100 GHz offset relative to the 32 channels on the first OD; therefore the OD is called a 100 GHz Offset. The third and fourth ODs are interleaved with 50 GHz and 150 GHz offsets with respect to the 0 GHz Offset frequency grid.

LambdaXtreme™ Transport uses the following types of ODs in 10G End Terminals:

- *OD (0GHz Offset)* is used for the startup configuration in a 10G End Terminal. DWDM input is received from a PreAmp High Gain OA. The de-mutliplexed signals are sent to the compatible optics boundary. When more than 32 channels are used, this OD also separates a multiplexed 100G Offset signal and sends it to the 100G Offset OD. See the descriptions in the paragraphs below for the other ODs used in 10G terminals.

- *OD (100GHz Offset)* is used for the second set of 32 channels. These 32 channels are received from the startup OD, de-multiplexed, and sent to the compatible optics boundary. The offset is 100 GHz from the frequencies of the first (0 GHz Offset for startup) OD.

- *OD (50 GHz Offset)* is used for the third set of 32 channels in a 10G End Terminal. DWDM input is received from a PreAmp High Gain OA. When more than these 32 channels are used, this OD separates a multiplexed 50G Offset signal to the 150G Offset OD. The de-mutliplexed signals are sent to the compatible optics boundary. The offset is 50 GHz from the frequencies of the first (0 GHz Offset for startup) OD. (This OD is the same as the 100 GHz Offset OD used in the 40G End Terminal and the OADM Terminal.)

- *OD (150GHz Offset)* is used for the fourth set of 32 channels. These 32 channels are received from the 50G Offset OD, de-multiplexed, and sent to the compatible optics boundary. The offset is 150 GHz from the frequencies of the first (0 GHz Offset for startup) OD.

Block diagram

See Figure 4-22, "ODs for 10G End Terminals — Block Diagram" (4-49) for a functional block diagram of the four types of ODs used in 10G End Terminals.

Figure 4-22 ODs for 10G End Terminals — Block Diagram
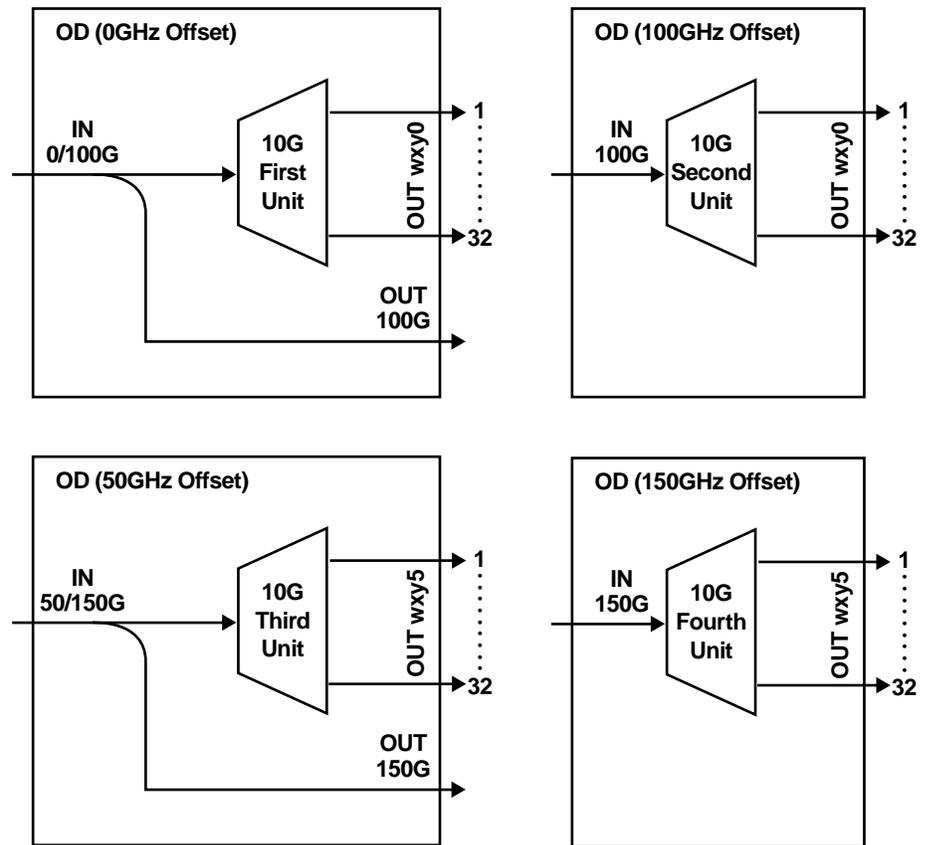
Faceplate drawing

See Figure 4-23, "ODs for 10G End Terminals — Faceplate Drawing" (4-50) for an illustration of the front panel labels for 10G ODs.

Figure 4-23 ODs for 10G End Terminals — Faceplate Drawing
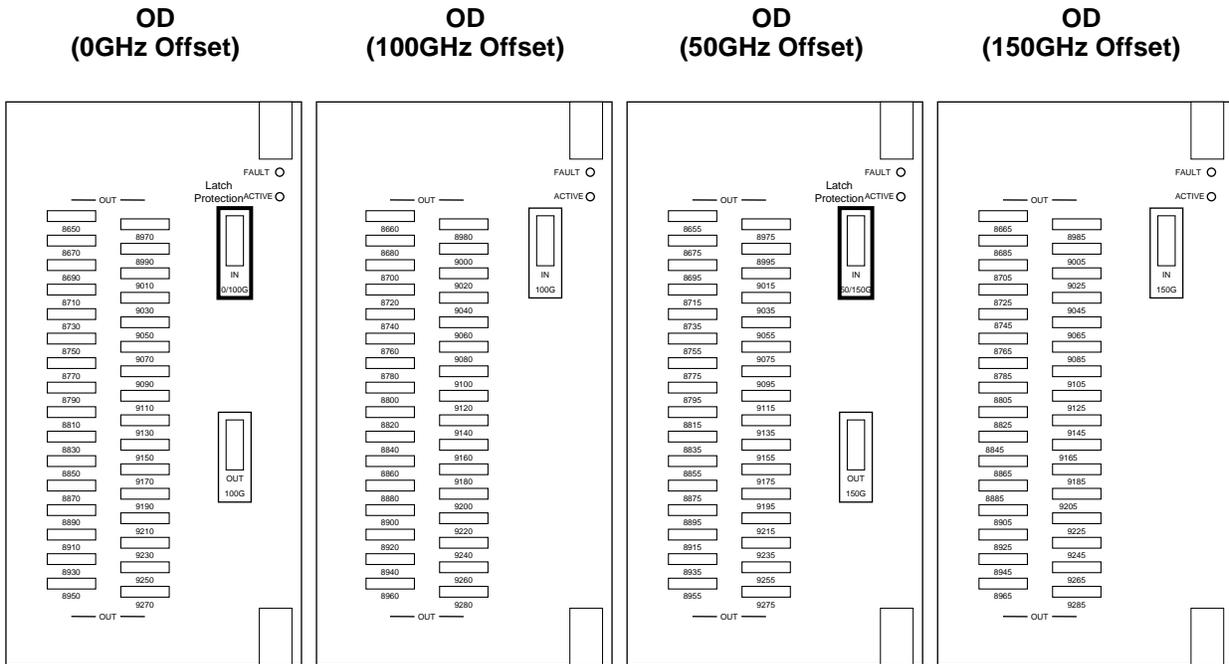
ODs for 10G OADM Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the ODs used in 10G OADM Terminals.

Functional description

All ODs are 32 channel devices with wavelengths spaced 200 GHz apart. The first OD accommodates frequencies from 186.50 THz to 192.70 THz. These are marked on the front panel as 8650 to 9270, which corresponds to the 0 GHz offset grid of frequencies. The second OD accommodates frequencies from 186.60 THz to 192.80 THz, which are 100 GHz offset relative to the 32 channels on the first OD; therefore the OD is called a 100 GHz Offset. Each side of an OADM has a pair of these ODs.
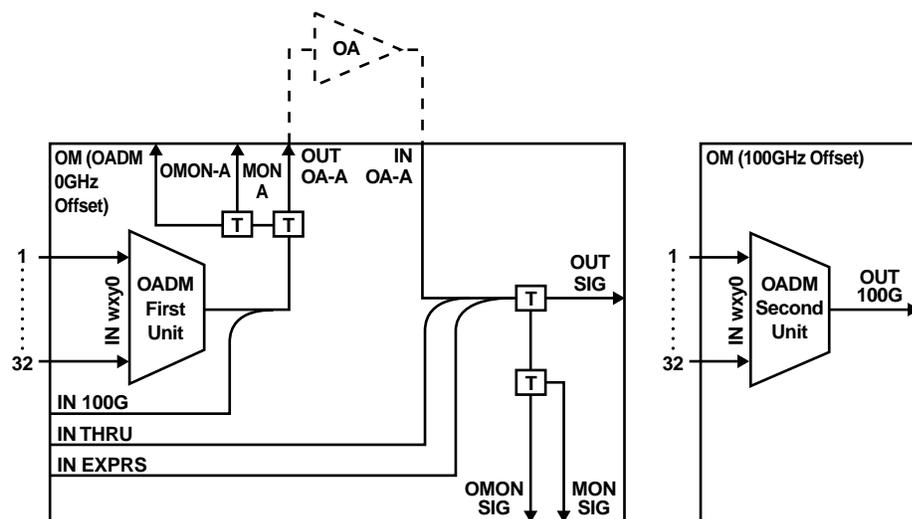
LambdaXtreme™ Transport uses the following ODs in 10G OADM Terminals:

- ***OD (OADM 0GHz Offset)*** is used for the startup configuration in an OADM Terminal to de-multiplex up to 32 channels. DWDM input is received from a PreAmp High Gain OA. Through channels are sent to the OADM OM for transmission to the next NE and the remaining channels are sent to an OA circuit pack and returned to the OD. When more than 32 channels are used, this OD separates a multiplexed 100G Offset signal to the 100G Offset OD. The de-mutliplexed signals are sent to the Compatible Optics Boundary.
  Note that the 0 GHz Offset OD is a required circuit pack in all OADM applications even if no channels are dropped (since the OD carries the Through channels).

- ***OD (100 GHz Offset)*** is used for the second set of 32 frequencies. These 32 channels are received from the startup OD, de-multiplexed, and sent to the Compatible Optics Boundary. The offset is 100 GHz from the frequencies of the first OD. (This OD is the same as for the 100 GHz Offset OD used in the 10G End Terminal and the 40G End Terminal.)

Faceplate drawing

See for a faceplate drawing of the two types of ODs used in 10G OADM Terminals.
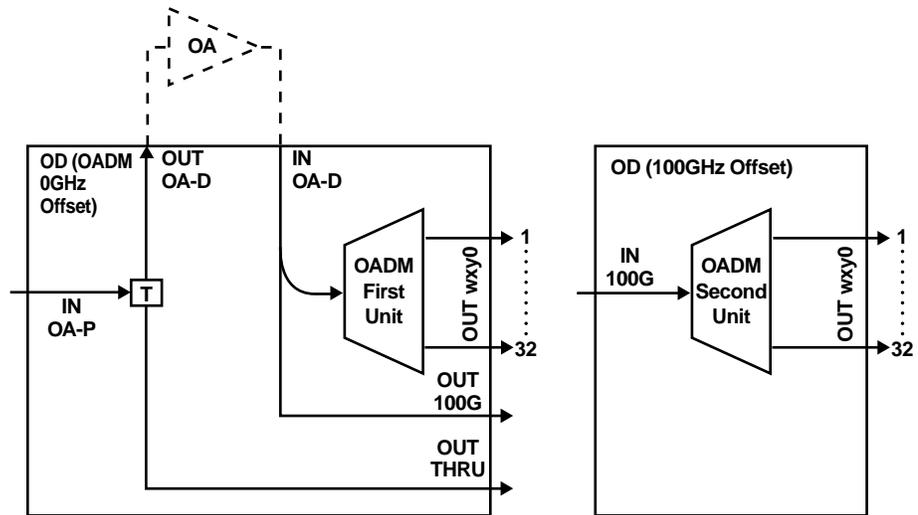
Figure 4-25 ODs for OADM — Faceplate Drawing
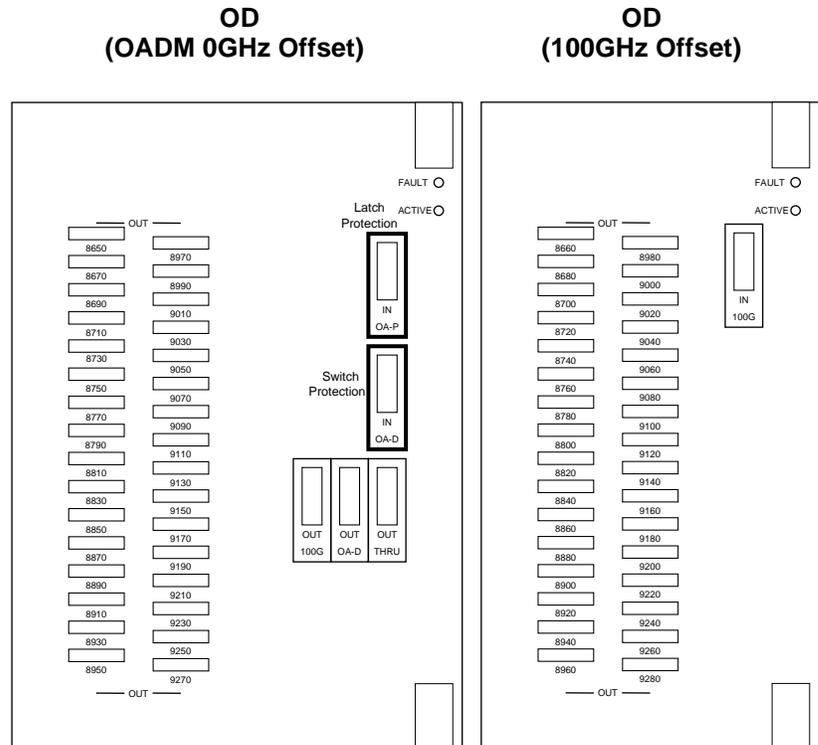
ODs for 40G End Terminals

The following paragraphs present a functional description, block diagram and faceplate drawing of the ODs used in 40G End Terminals.

Functional description

LambdaXtreme™ Transport uses the following types of ODs in 40G
End Terminals:

- *OD (40G 0GHz Offset)* is used for the startup configuration of
  the first 32 channels in a 40G End Terminal. DWDM input is
  received from a PreAmp Low Gain OA. When more than 32
  channels are used, this OD separates a multiplexed 100G Offset
  signal to the 100G Offset OD. The de-mutliplexed signals are
  sent to the compatible optics boundary.

- *OD (100GHz Offset)* is used for the second set of 32 channels.
  These 32 channels are received from the startup OD,
  de-multiplexed, and sent to the compatible optics boundary. The
  offset is 100 GHz from the frequencies of the first OD. (This OD
  is the same as for the 100 GHz Offset OD used in the 10G End
  Terminal and the OADM Terminal.)

Block diagram

See Figure 4-26, "40G ODs — Block Diagram" (4-54) for a
functional block diagram of the two types of ODs used in 40G End
Terminals.

Figure 4-26   40G ODs — Block Diagram
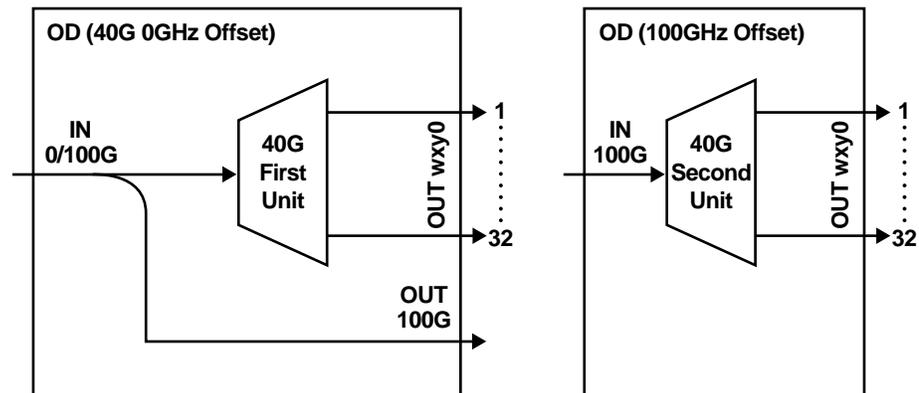
Faceplate drawing

See Figure 4-27, "40G ODs — Faceplate Drawing" (4-55) for a
faceplate drawing of the two types of ODs used in 40G End

Terminals. The 100G Offset OD used in 40G systems is the same as the 100G Offset OD used in 10G systems.

Figure 4-27   40G ODs — Faceplate Drawing
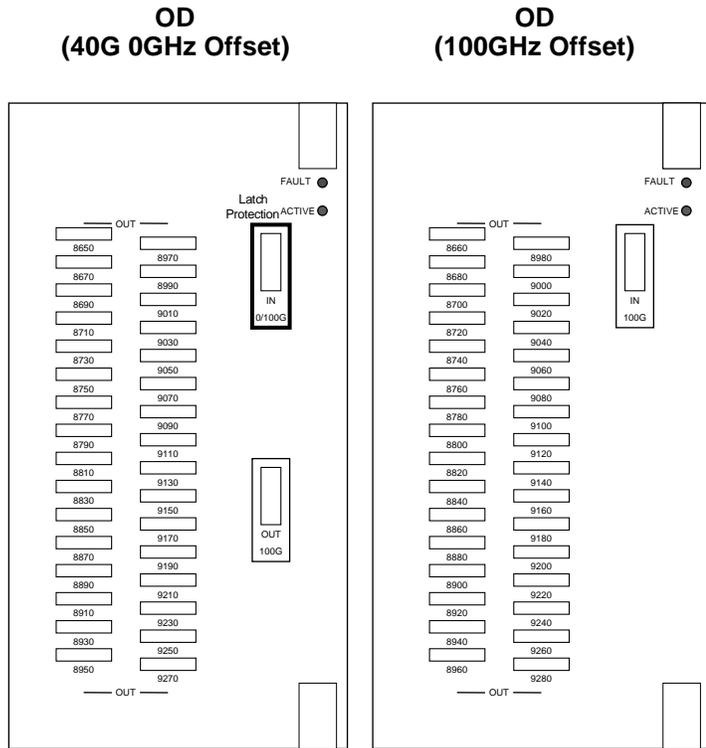
Optical Amplifier (OA)

OA function An Optical Amplifier (OA) operates in the 1553 nm to 1608 nm band (191.850 THz - 195.900 THz range) to provide uniform amplification of all the channels in a DWDM signal. See the table below for OA requirements.

All OAs provide a port (labeled MON) to provide access by a client-supplied Optical Spectrum Analyzer (OSA) and a port (labeled OMON) to the OMON circuit pack (an on-board OSA).

Types of OAs LambdaXtreme™ Transport uses three types of OAs:

- Raman amplifier
- Erbium-doped Fiber Amplifiers (EDFA)
- a hybrid Raman+EDFA amplifier

The OAs used in LambdaXtreme™ Transport are listed in the table below. Each OA is described in detail in the following paragraphs of this section.

Table 4-2   Types of OAs

OA Circuit Pack	OA Type	Applications
OA (Raman)	Raman	Repeater
OA (OADM LineIn)	Raman	OADM
OA (Raman EDFA) for losses exceeding 23dB	Raman+EDFA	Repeater
OA (VOA)	EDFA	10G and 40G End Terminals
OA (DGEF)	EDFA	Repeater
OA (PreAmp High Gain)	EDFA	10G End Terminal, OADM
OA (PreAmp Low Gain)	EDFA	40G End Terminal
OA (OADM Add)	EDFA	OADM
OA (OADM Thru)	EDFA	OADM
OA (OADM LineOut)	EDFA	OADM

OA (Raman) and OA (Raman EDFA) The following paragraphs present a functional description, block diagram and faceplate drawing of the Raman and Raman EDFA OAs.

Functional description

OA (Raman) and OA (Raman EDFA) are used in Repeaters as the output driver to transmit a DWDM signal downstream to the next NE. OAs with DGEF also provide the same function but are discussed separately, below.

The basic difference in usage are

- OA (Raman) is used in Repeaters when the span loss is ≤23dB
- OA (Raman EDFA) is used when span loss is >23dB
- OA (DGEF) is used when cumulative power divergence among channels must be reduced

OA (Raman EDFA) has an additional module containing an EDFA that adds 5dB of extra gain; otherwise the remainder of this discussion applies to both OA (Raman) and OA (Raman EDFA).

Internal counterpropagating Raman pumps boost the signal input from the DCM. Additional counterpropagating pumping is added when required (for channel growth) from the Raman expansion pack RPG (DCF) via the IN DCF port. Internal copropagating Raman pumps provide Raman amplification in the OSP via the OUT LINE port. Additional copropagating pumping is added when required (for channel growth) from the Raman expansion pack RPG (DCF) through the IN CORP port. The DWDM output is transmitted downstream to the next NE in LambdaXtreme™ Transport.

The OA also directs the incoming counterpropagated supervisory signal out the OUT SUP port to the SUPVY pack to monitor fiber continuity of the span.

Block diagram

Figure 4-28, "OA (Raman) and OA (Raman EDFA) — Block Diagram" (4-58) is a functional block diagram of the OA (Raman) and the OA (Raman EDFA). Note that the OA (Raman EDFA)

includes an erbium doped fiber amplifier stage and the OA (Raman) does not.

Figure 4-28 OA (Raman) and OA (Raman EDFA) — Block Diagram
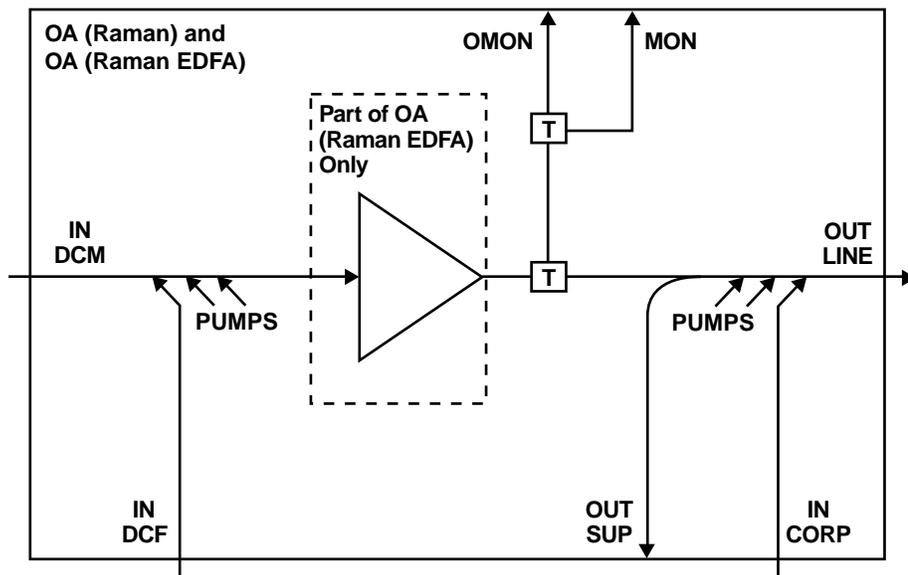
Faceplate drawing

See Figure 4-29, "OA (Raman) and OA (Raman EDFA) — Faceplate Drawing" (4-59) for a faceplate drawing of OA (Raman) and OA (Raman EDFA).

Figure 4-29 OA (Raman) and OA (Raman EDFA) — Faceplate Drawing
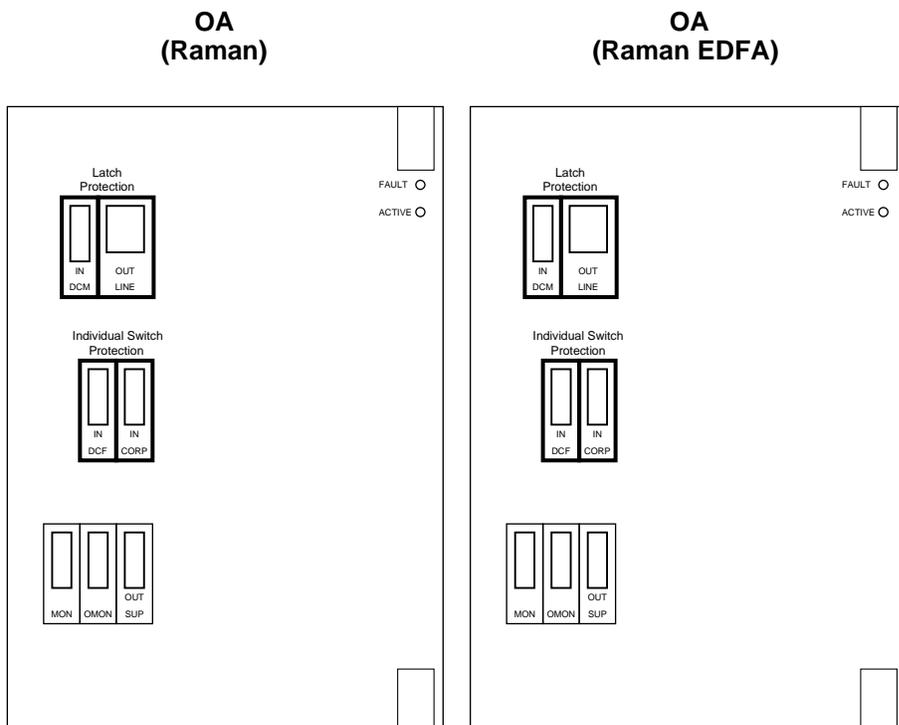
OA (VOA) and OA (DGEF)

OA (VOA) and OA (DGEF) are EDFA optical amplifiers. A functional description, block diagram, and faceplate drawing of these amplifiers follows.

Functional description of OA (VOA)

OA (VOA) is a booster amplifier in the optical multiplex section of 10G and 40G End Terminals. The OA includes a Variable Optical Attenuator to adjust the gain tilt. Internal copropagating Raman pumps boost the output in the OSP downstream of the OUT LINE port. Additional copropagating pumping is added when required (for channel growth) from the Raman expansion pack RPG (Exp) through

the IN CORP port. The DWDM output is transmitted downstream to the next NE.

OA (VOA) also directs the received counterpropagating supervisory signal out the OUT SUP port to the SUPVY pack to monitor fiber continuity of the span. The OUT/IN DCM interface with the Dispersion Compensation Module is used to overcome chromatic dispersion limits of the transmission fiber.

Functional description of OA (DGEF)

DGEF OAs are amplifiers used in certain Repeater sites when power divergence must be reduced among channels. The OA includes a Dynamic Gain Equalization Filter to adjust gain tilt and reduce power divergence. Internal copropagating Raman pumps boost the output in the OSP downstream of the OUT LINE port. Additional copropagating pumping is added when required (for channel growth) from the RPG through the IN CORP port. The DWDM output is transmitted downstream to the next NE.

OA (DGEF) also directs the received counterpropagating supervisory signal out the OUT SUP port to the SUPVY pack to monitor fiber continuity of the span. The OUT/IN DCM interface with the DCM is used to overcome chromatic dispersion limits of the transmission fiber.

Block diagram

See Figure 4-30, "OA (VOA) and OA (DGEF) — Block Diagram"
(4-61) for a functional block diagram of the OA (VOA) and OA
(DGEF) Optical Amplifiers.

Figure 4-30   OA (VOA) and OA (DGEF) — Block Diagram
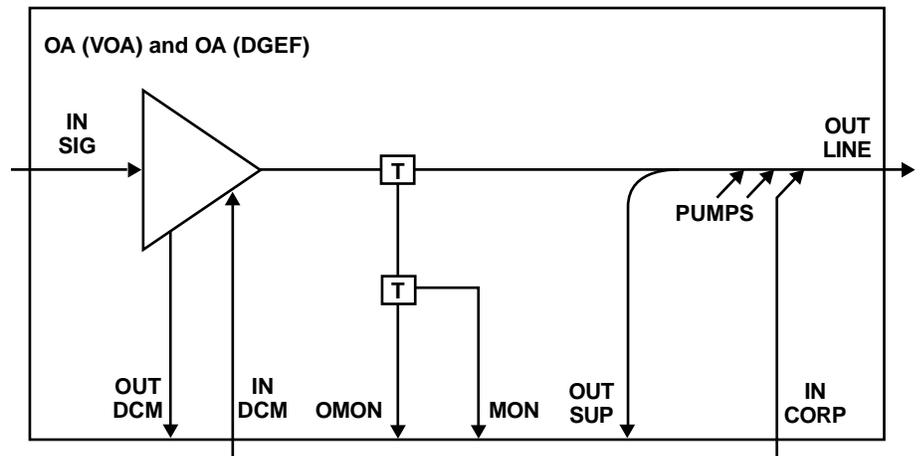
Faceplate drawing

See Figure 4-31, "OA (VOA) and OA (DGEF) — Faceplate Drawing" (4-62) for a faceplate drawing of an OA (VOA) OA and an OA (DGEF).

Figure 4-31   OA (VOA) and OA (DGEF) — Faceplate Drawing
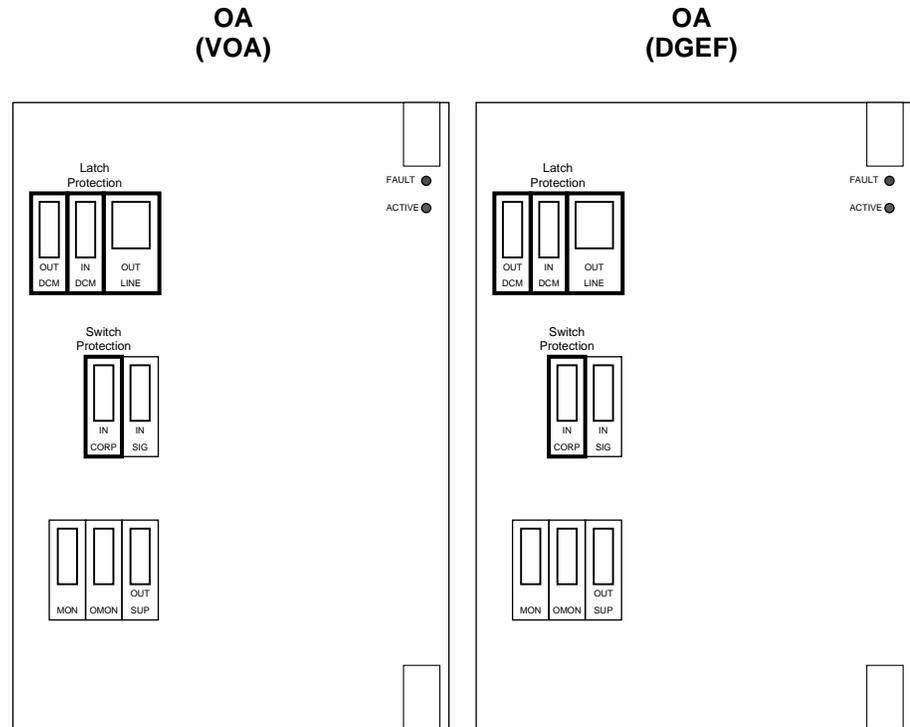
OA (PreAmp High Gain) and OA (PreAmp Low Gain)

OA (PreAmp High Gain) and OA (PreAmp Low Gain) are EDFA amplifiers. A functional description, block diagram, and faceplate drawing of these optical amplifiers follows.

Functional description

Preamp high gain OAs are used in the optical demultiplex section in 10G End Terminals and in OADM Terminals. In these terminals, there will be up to 64 channels (0 and 100 GHz Offset) amplified by one PreAmp High Gain OA. In 10G End Terminals, when more than 64 channels (50 and 150 GHz Offset) are incorporated, the terminal will have two PreAmp High Gain OAs. In an OADM, if traffic is being dropped, one PreAmp High Gain OA is required for each direction

(east/west). The OA includes a Dynamic Gain Equalization Filter to adjust gain tilt and reduce power divergence among channels. The OUT/IN DCM interface with the Dispersion Compensation Module is used to overcome chromatic dispersion limits of the transmission fiber.

Preamp low gain OAs are used in the optical demultiplex section of a 40G End Terminal. Up to 64 channels can be amplified by the OA. The OA includes a Dynamic Gain Equalization Filter to adjust gain tilt and reduce power divergence. The OUT/IN DCM interface with the Dispersion Compensation Module is used to overcome chromatic dispersion limits of the transmission fiber.

Block diagram

See Figure 4-32, "OA (PreAmp High Gain) and OA (PreAmp Low Gain) — Block Diagram" (4-63) for a functional block diagram of an OA (PreAmp High Gain) and an OA (PreAmp Low Gain).

Figure 4-32 OA (PreAmp High Gain) and OA (PreAmp Low Gain) — Block Diagram

Faceplate drawing

See for a faceplate drawing of High Gain and Low Gain Preamp OAs.
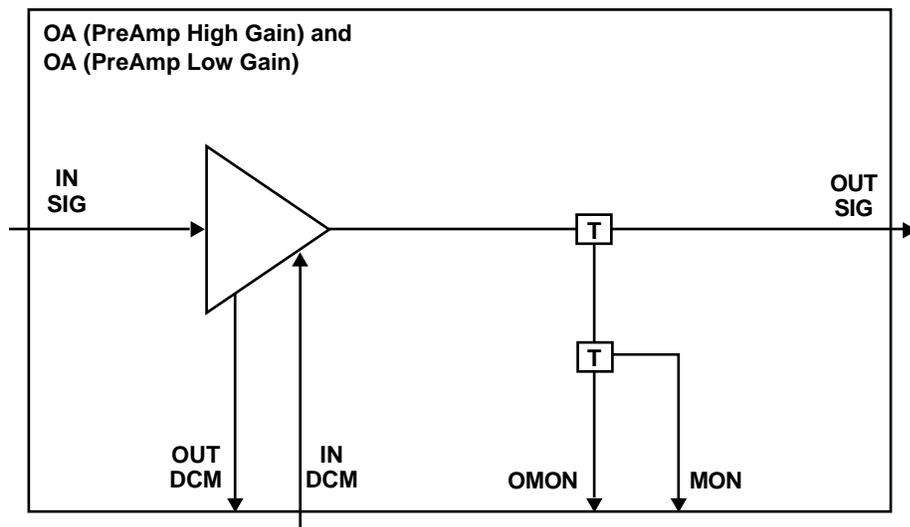
Figure 4-33   OA (PreAmp High Gain) and OA (PreAmp Low Gain) — Faceplate Drawing
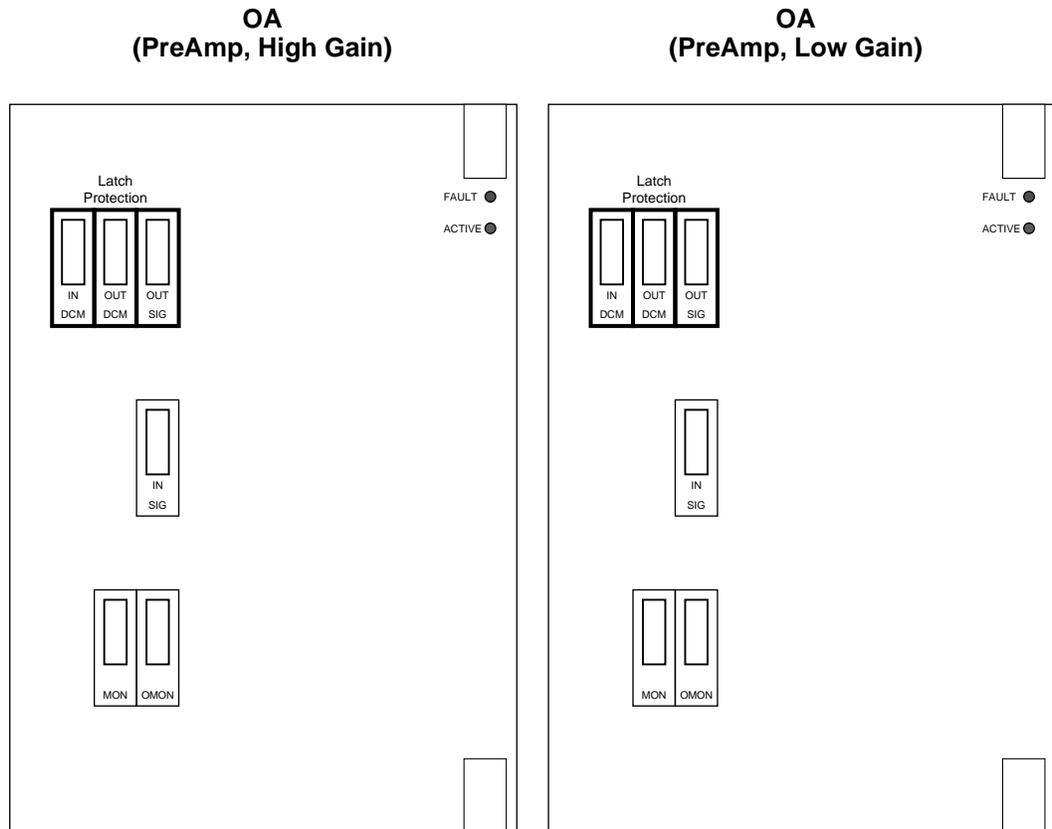
OA (OADM Add) and OA (OADM Thru)

OA (OADM Add) and OA (OADM Thru) are EDFA optical amplifiers. A functional description, block diagram, and faceplate drawing of these amplifiers is presented below.

Functional description

OA (OADM Add) is used in OADM terminals to amplify the Add signals before they are combined with the Through and Express channels. The OA includes a Variable Optical Attenuator to adjust gain tilt. The OUT/IN DCM interface with the Dispersion

Compensation Module is used to overcome chromatic dispersion limits of the transmission fiber.

OA (OADM Thru) is used in OADM terminals to amplify the Drop and Through channels.

Block diagram

See Figure 4-34, "OA (OADM Add) and OA (OADM Thru) — Block Diagram" (4-65) for a functional block diagram of OADM Add and Thru OAs.

Figure 4-34 OA (OADM Add) and OA (OADM Thru) — Block Diagram

Faceplate drawing

See for a faceplate drawing of the OADM Add and Thru OAs.
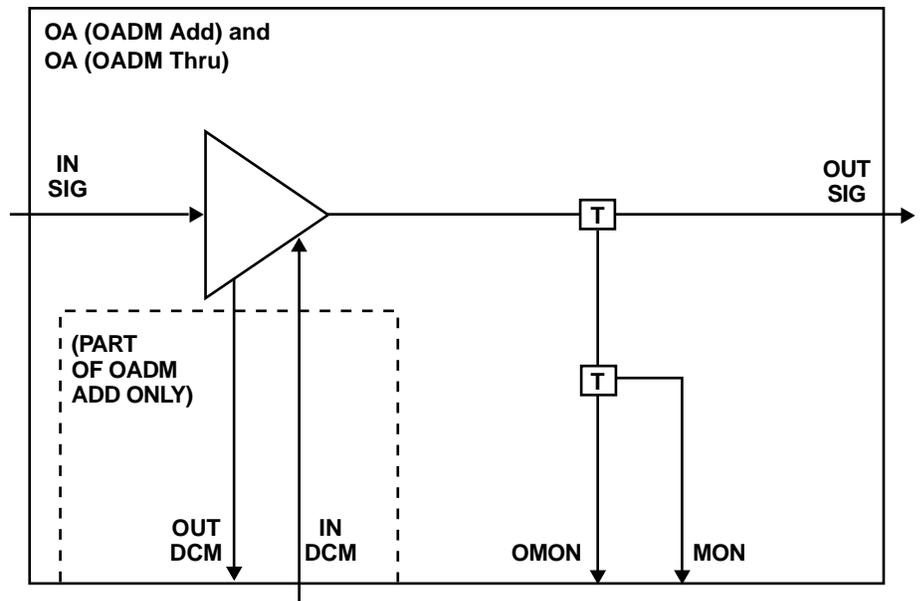
Figure 4-35 OA (OADM Add) and OA (OADM Thru) — Faceplate Drawing
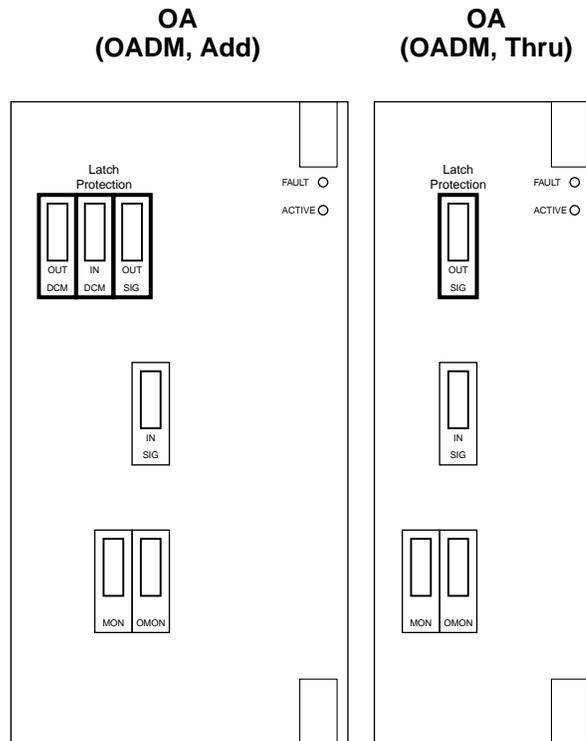
OA (OADM LineIn)   OA (OADM LineIn) is a Raman optical amplifier. A functional description, block diagram, and faceplate drawing of this amplifier is presented below.

Functional description

OA (OADM LineIn) amplifies the input DWDM signal in an OADM. Internal counterpropagating pumps boost the signal in the DCM. Additional counterpropagating pumping is added when required (for channel growth) from the Raman expansion pack RPG (DCF) through the IN DCF port. Before outputting, the channels are split into

Express and Through channel groups and transmitted to an OM and an OA, respectively.

Block diagram

is a functional block diagram of OA (OADM LineIn).

Figure 4-36 OA (OADM LineIn) — Block Diagram

Faceplate drawing

See for a faceplate drawing of the OA (OADM LineIn).
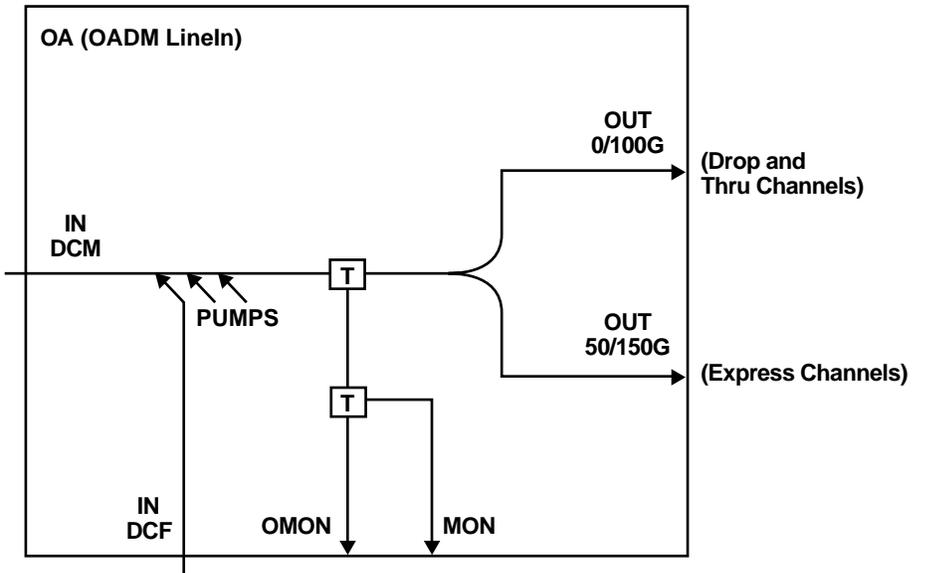
Figure 4-37   OA (OADM LineIn) — Faceplate Drawing
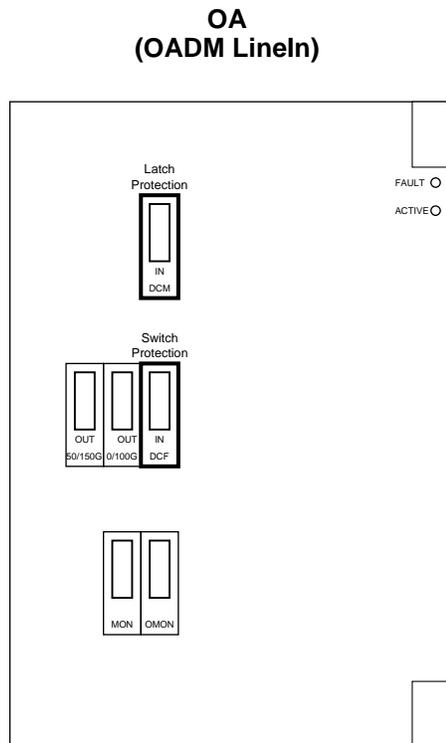
OA (OADM LineOut)   OA (OADM LineOut) is an EDFA optical amplifier. A functional description, block diagram, and faceplate drawing of this amplifier is presented below.

Functional description

OA (OADM LineOut) is a booster amplifier for the Express, Add, and Through channels in an OADM. The OA includes a Variable Optical Attenuator (VOA) to adjust gain tilt. Internal copropagating pumps boost the output in the OSP downstream of the OUT LINE port. Additional copropagating pumping is added when required (for channel growth) from the optional Raman expansion pack (RPG) through the IN CORP port. OA (OADM LineOut) also directs the

received counterpropagating supervisory signal out the OUT SUP port to the SUPVY pack to monitor fiber continuity of the span.

Block diagram

See Figure 4-38, "OA (OADM LineOut) — Block Diagram" (4-69) for a functional block diagram of OA (OADM LineOut).

Figure 4-38 OA (OADM LineOut) — Block Diagram

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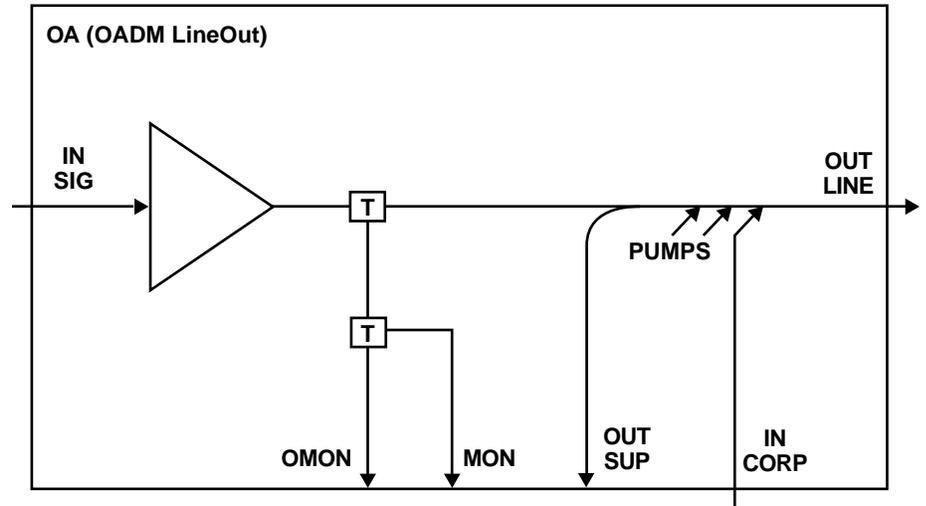
Faceplate drawing

See Figure 4-39, "OA (OADM LineOut) — Faceplate Drawing" (4-70) for a faceplate drawing of OA (OADM LineOut).

Figure 4-39 OA (OADM LineOut) — Faceplate Drawing

**OA
(OADM LineOut)**
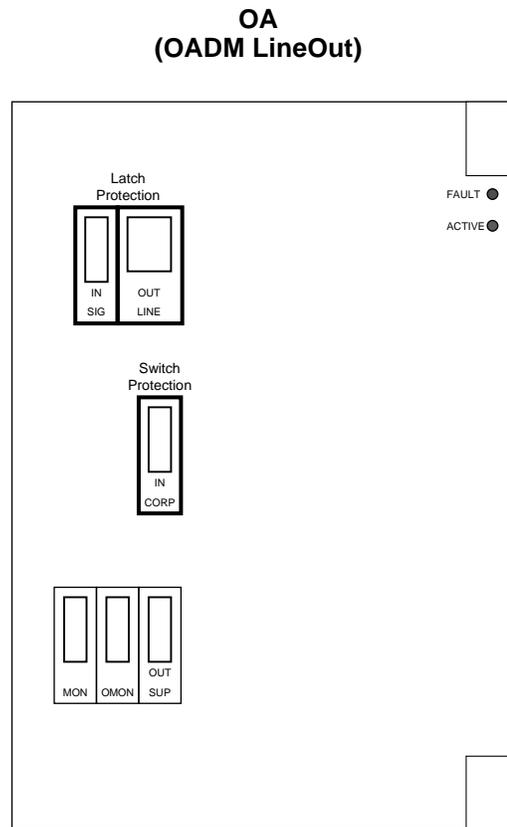
Raman Pumps (RP)

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Raman pump function   Raman pumps provide amplification/gain in the outside plant fiber to a specific range of signal wavelengths. The amplification is provided by ″pumping″ high intensity, lower wavelength (i.e. lower than the signal wavelengths) laser light into fiber that carries optical signals. The amplification in the fiber is distributed over approximately 20 kilometers from the point of pump laser injection. Typically multiple pumps are utilized to provide sufficient power and cover the full wavelength spectrum supported by LambdaXtreme™ Transport.

RP   A functional description, block diagram, and faceplate drawing of Outside Plant (OSP) Raman Pump is presented below. The designation for this pump is RP.

Functional description

RP, a startup pump, is used in 40G End Terminals, 10G OADM Terminals, and in Repeaters. Startup pumps provide counterpropagating pumping of the span for the channels with frequencies lower than 188.500 THz. When required for wavelength growth, additional counterpropagating pumping is supplied from the RPG or RPG (DCF) pack on the IN RPG port. A supervisory signal, from the SUPVY pack, is also counterpropagated from the IN SUP port to monitor fiber continuity of the span.

The DWDM signal is input on the IN LINE port, OMON and MON outputs are dropped, and the pumped signals are transmitted out the OUT SIG port downstream to an OA.

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Block diagram

See Figure 4-40, "Raman Pump (RP) — Block Diagram" (4-72) for a functional block diagram of the RP circuit pack.

Figure 4-40 Raman Pump (RP) — Block Diagram
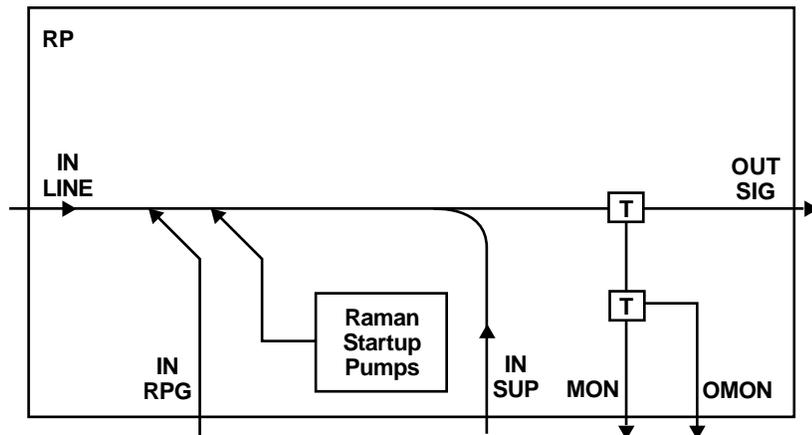
Faceplate drawing

See Figure 4-41, "Raman Pump (RP) — Faceplate Drawing" (4-73) for a faceplate drawing of the Raman Pump (RP).

Figure 4-41 Raman Pump (RP) — Faceplate Drawing

RP
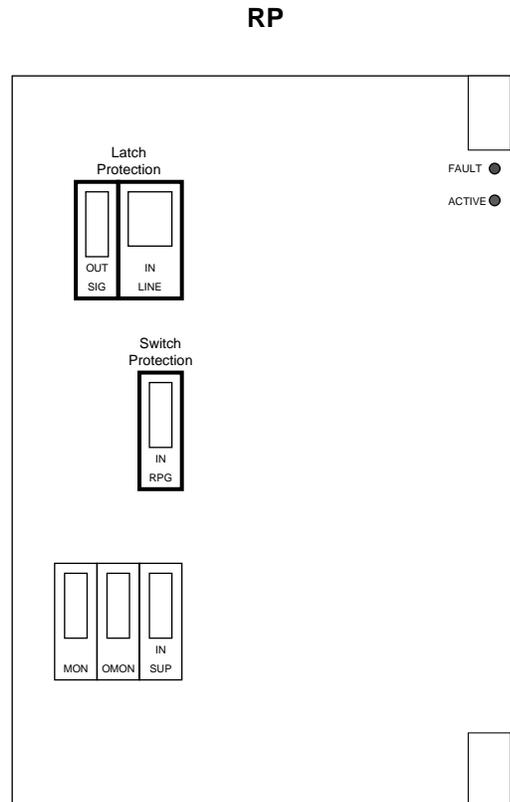
RP (50G/100G)   A functional description, block diagram, and faceplate drawing of an Outside Plant (OSP) 50G/100G Raman Pump is presented below. The designation for this pump is RP (50G/100G).

Functional description

RP (50G/100G) is used in 10G End Terminals. Startup pumps provide counterpropagating pumping of the span. When required for wavelength growth, additional counterpropagating pumping is supplied from the RPG on the IN RPG port. A supervisory signal, from the SUPVY pack, is also counterpropagated from the IN SUP port to monitor fiber continuity of the span.

The DWDM signal is input on the IN LINE port, OMON and MON outputs are dropped, the signal channels are separated into two sets of signals (0/100 GHz and 50/150 GHz) and sent to the OUT 0/100G port and to the OUT 50/150G port for transmission downstream to High Gain OAs.

Block diagram

See Figure 4-42, "RP (50G/100G) — Block Diagram" (4-74) for a functional block diagram of RP (50G/100G). The signal direction is from left to right, as deployed in the demultiplex section of the End Terminal.

Figure 4-42   RP (50G/100G) — Block Diagram
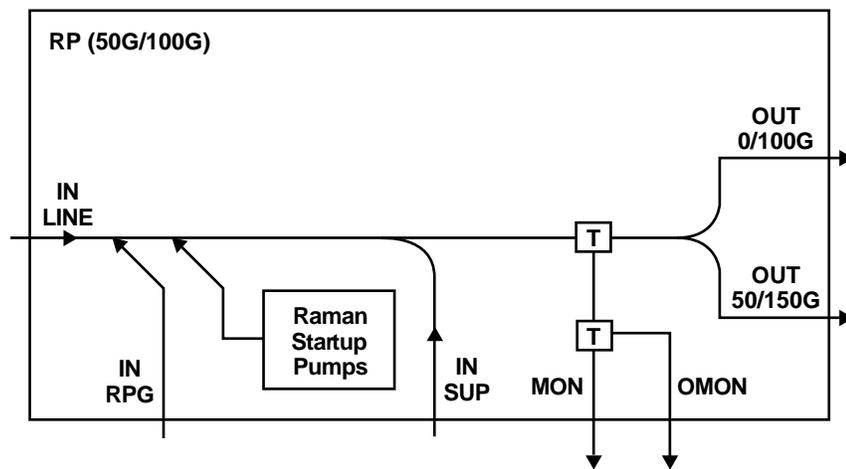
Faceplate drawing

See Figure 4-43, "RP (50/100G) — Faceplate Drawing" (4-75) for a faceplate drawing of RP (50G/100G).

Figure 4-43 RP (50/100G) — Faceplate Drawing

**RP
(50G/100G)**

```
                    Latch
                    Protection
                                                    FAULT ●
                      ┌──┐                          ACTIVE ●
                      │  │
                      └──┘
                       IN
                      LINE

                    Switch
                    Protection

              ┌──┐ ┌──┐ ┌──┐
              │  │ │  │ │  │
              └──┘ └──┘ └──┘
              OUT  OUT   IN
            50/150G 0/100G RPG

              ┌──┐ ┌──┐ ┌──┐
              │  │ │  │ │  │
              └──┘ └──┘ └──┘
                             IN
              MON  OMON     SUP
```

□
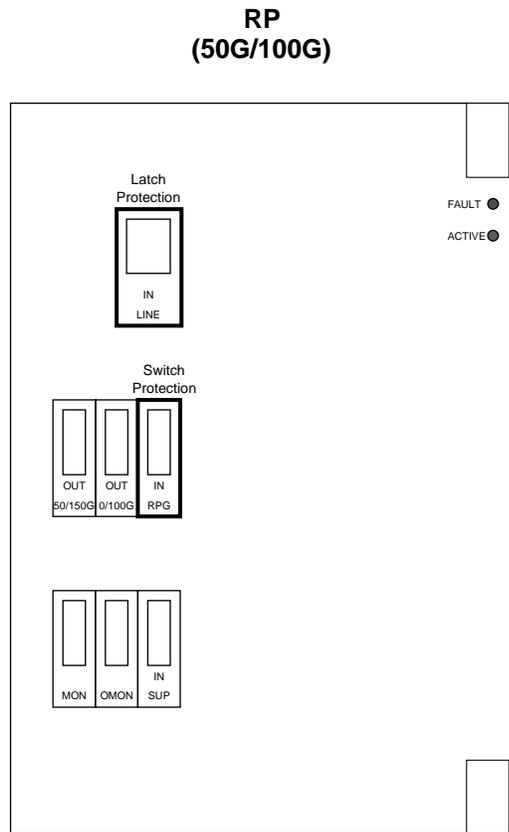
Growth Raman Pumps (RPG)

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Growth Raman Pump function

Growth Raman Pumps are optional circuit packs used when transporting channels above 188.45 THz. See Figure 5-3, "Wavelength Growth for 10G Systems" (5-16) and Figure 5-7, "Wavelength Growth for 40G Systems" (5-23) .

Raman pumps provide amplification/gain in the outside plant fiber to a specific range of signal wavelengths. The amplification is provided by ″pumping″ high intensity, lower wavelength (i.e. lower than the signal wavelength) laser light into fiber that carries optical signals. The amplification in the fiber is distributed over approximately 20 kilometers from the point of pump laser injection. Typically multiple pumps are utilized to provide sufficient power and cover the full wavelength spectrum supported by LambdaXtreme™ Transport.

Types of pumping

Raman pumping from an RP circuit pack is accomplished by boosting the incoming DWDM signal in the direction of signal propagation, counter to the signal, or to the Dispersion Compensation Module; therefore there are copropagating, counterpropagating, and DCM pumps.

- copropagating (in the same direction as the DWDM signal)
- counterpropagating (in the opposite direction of the DWDM signal).
- the DCM is also pumped in the counterpropagating direction to provide additional gain to recover some of the NE internal losses.

Removal

Growth Raman Pumps cannot be removed without interrupting the transmission.

Types of Growth Raman Pumps

The Raman Pumps required to support wavelength growth are RPG and RPG (DCF). A discussion of selection, functional description, block diagram, and faceplate drawing of these pumps is presented below.

Selecting RPGs in LambdaXtreme™ Transport NEs

When required, 10G End Terminals and 40G End Terminals use RPG pumps. When required, OADM Terminals use RPG (DCF) pumps.

....

In Repeaters, when Growth Raman Pumps are required they are selected according to the OAs that are used. The matching pairs are:

• OA (Raman) requires RPG (DCF)

• OA (Raman EDFA) requires RPG (DCF)

• OA (DGEF) requires RPG

Functional description

The RPG pack provides the Expansion Raman pumps for co- and counterpropagating pumping of the span. These pumps are added when required for wavelength growth. The output of the copropagating pumps is directed to the OUT CORP port; the output of the counterpropagating pumps is directed to the OUT RPG port.

The RPG (DCF) pack provides the Expansion Raman pumps for co- and counterpropagating pumping of the span and for Raman pumping of the DCM. These pumps are added when required for wavelength growth. The output of the copropagating pumps is directed to the OUT CORP port; the output of the counterpropagating pumps is directed to the OUT RPG port, and the output of the DCM pumps is directed to the OUT DCF port.

Block diagram for RPG packs

See Figure 4-44, "RPG — Block Diagram" (4-77) for a functional block diagram of the RPG Raman pump.

Figure 4-44 RPG — Block Diagram
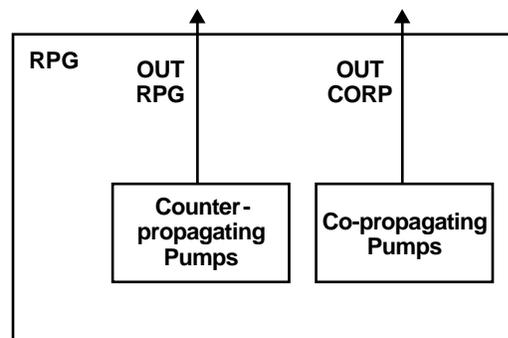
Block diagram for RPG (DCF) packs

See Figure 4-45, "RPG (DCF) — Block Diagram" (4-78) for a
functional block diagram of the RPG (DCF) Raman pumps.

Figure 4-45 RPG (DCF) — Block Diagram
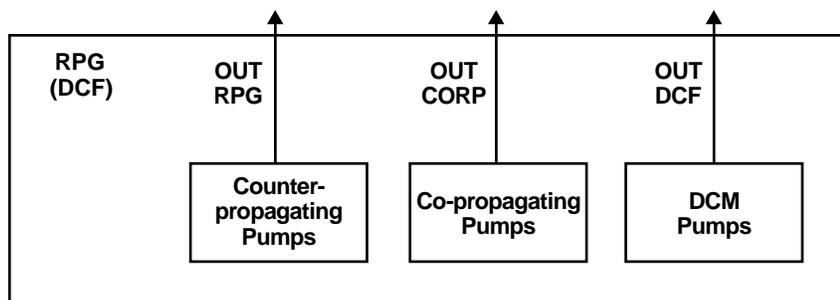
Faceplate drawing

See Figure 4-46, "Raman Pumps (Growth) — Faceplate Drawing" (4-79) for a faceplate drawing of the RPG and RPG (DCF) Raman Pumps.

Figure 4-46 Raman Pumps (Growth) — Faceplate Drawing

RPG

Latch
Protection

OUT OUT
CORP RPG

FAULT ●
ACTIVE ●

RPG (DCF)

Latch
Protection

OUT OUT OUT
CORP RPG DCF

FAULT ●
ACTIVE ●
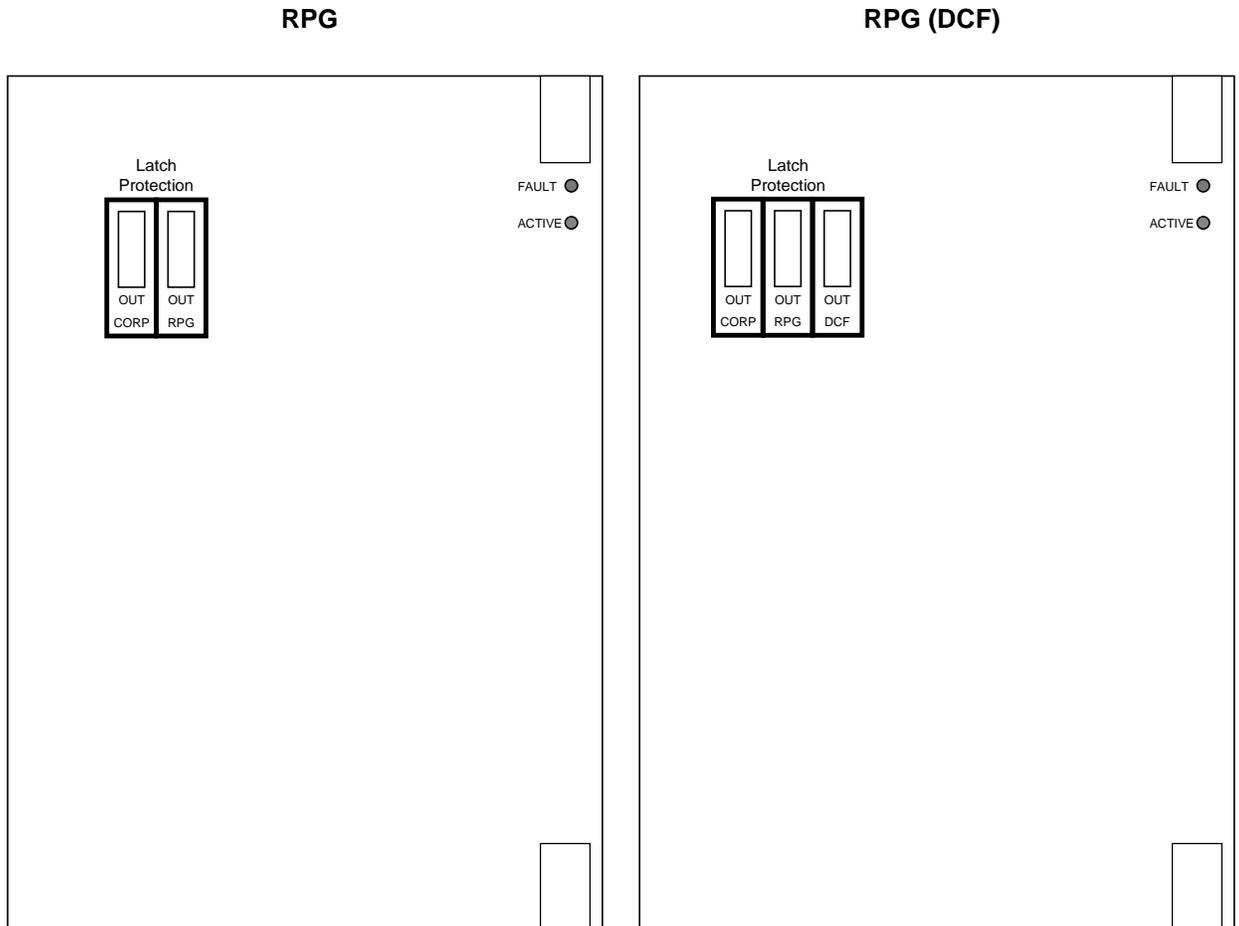
Optical Monitor (OMON)

OMON function The Optical MONitor (OMON) circuit pack scans the entire DWDM spectrum to provide Optical Spectrum Analysis (OSA) for up to 4 or 8 selected locations in an NE. The OSA provides spectral separation and detection of individual optical signal wavelengths and returns power per channel measurements for use by SCOT and Performance Monitoring.

OMON connections The OMON is an optical spectrum analyzer that can monitor multiple inputs (one at a time). Connections to the OMON are made using the OMON output port of circuit packs in LambdaXtreme™ Transport; these circuit packs are OMs, OAs, and RPs. OMON (4 Port) is used in 40G End Terminals and Repeaters; OMON (8 Port) is used in 10G End Terminals and OADMs.

Theory of operation The Optical Monitor Circuit Pack has two functional sections. The selector is an 8 x 1 (or 4 x 1) switch that selects any one of 8 (or 4) optical input ports for measurement. The OSA is an optical filter followed by one or more detectors, used to measure the optical power of each wavelength.

Functional block diagram See Figure 4-47, "OMON — Block Diagram" (4-81) for a block
diagram of an OMON.

Figure 4-47 OMON — Block Diagram
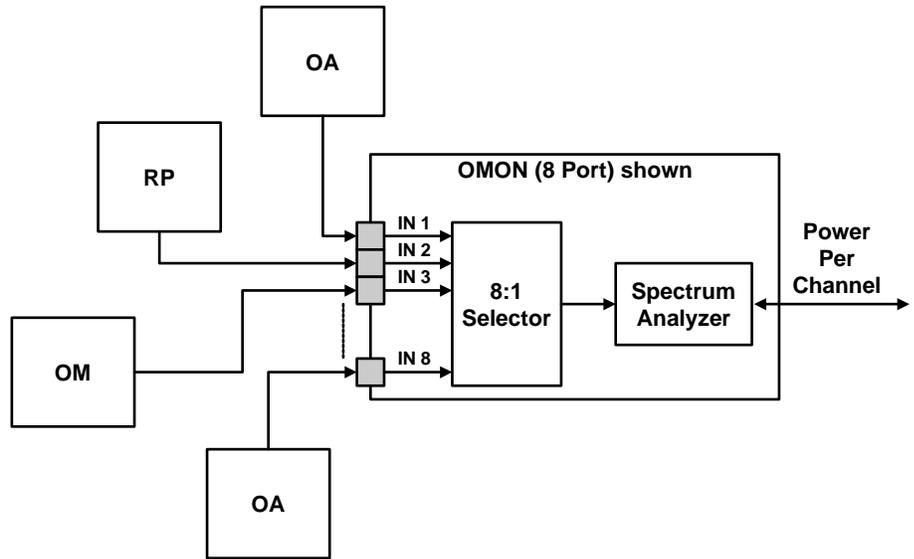
Association of OMON input ports LambdaXtreme™ Transport uses a fixed set of connections between
OMON input ports and system input and output taps based on system
configuration. Once association between OMON ports and system taps
are known (based on user provisioning of the NETYPE value)
LambdaXtreme™ Transport software audits the connections.

OMON front panel labeling   Figure 4-48, "OMON — Faceplate Drawing" (4-82) illustrates the
front panel labeling of the 4-input OMON and the 8-input OMON.

Figure 4-48   OMON — Faceplate Drawing

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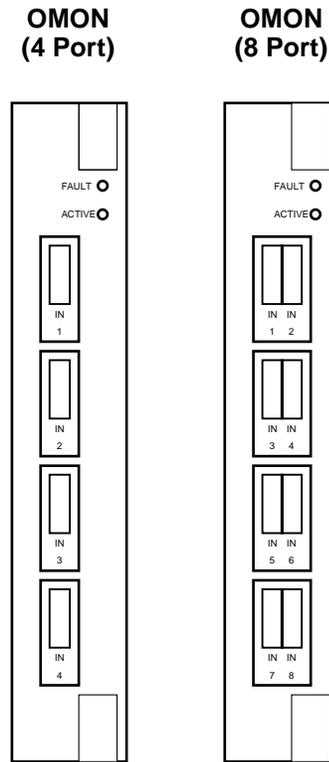
Dispersion Compensation Module (DCM)

DCM description DCMs are packages of spooled fiber located in a drawer at the bottom of each bay.

DCM function The DCM is used to overcome chromatic dispersion limits of the transmission fiber. Used in conjunction with OAs, the DCM is a module containing lengths of dispersion compensation fiber that offsets the dispersion of the outside fiber plant.

The DCM is used at all terminal types. Many different values of DCMs are available. The value of a DCM to use is dependent on the type and length of outside plant fiber that is being compensated. For more information see the discussion labeled "DCM selection" (5-12) in Chapter 5.

To determine the appropriate DCM value for your situation, fiber characterization measurements are entered into an expert system, which calculates the DCMs you will need. For more information see the discussion labeled "DCM selection" (5-12) in Chapter 5.

Shown below are the number of DCMs required for each NETYPE:

- 10G End Terminals — two or three DCMs
- 40G End Terminals — two DCMs
- Repeaters — two DCMs
- OADMs — six DCMs

Contact your Lucent account representative for complete information.

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Control Circuit Packs

Overview

Purpose This section provides a description of

- LEDs used on the faceplate of control circuit packs
- controller circuit packs: Network Element Controller (NCTL) and Shelf Controller (SCTL)
- control interface circuit packs: System Input/Output (SIO) and Controller Input/Output (CIO)
- fan assembly and office alarm panel

Circuit pack identification All control circuit packs (CP) are identified by a 3-line ID located on the upper latch of the pack. The first line has the Apparatus Code (also known as the CP Code) to identify the particular pack, the second line shows the Series (version number) and the third line identifies the pack type. Refer to Engineering Drawing ED-8C861-10 for a complete list.

LEDs All control circuit packs have two LEDs on the faceplate to indicate the pack's status. The green LED is labeled ACTIVE; when it is blinking that means the pack is booting; when it is illuminated steadily that means the pack is active. Software control provides an LED test (LEDs are turned on, off, and back to their current state).

The red LED is labeled FAULT; when it is blinking that means there is a signal problem coming in to the pack; when it is illuminated steadily that means the pack has an alarm condition or it is booting.

The green LED remains illuminated, even if there is an alarm, until the pack is no longer powered.

Controllers LambdaXtreme™ Transport controller circuit packs are

- NCTL — the highest level controller in the control hierarchy. The NCTL provides control and user interfaces at the network element level.
- SCTL — provides control at the double shelf backplane level (half of a bay).

A common controller core is used on the NCTL, SCTL, and SUPVY packs.

In addition to the controller circuit packs, each transmission circuit pack has a Board Controller Module (BCM) on board to provide communication with the SCTL and local processing for the circuit pack.

Inter-processor communication

All controllers are connected to a single 100Base-TX switched *Ethernet*™ LAN, cabled with switching hubs in the NCTL and SCTL packs. The connections between shelf controllers and the network element controller are cabled. There are also cables between the group SCTLs and the non-group SCTLs via the Control CIO packs. (Group SCTLs communicate directly with the NCTL and control other, non-group SCTLs as shown in Figure 4-49, "NE Control Hierarchy" (4-86).) All required cables are supplied with the ordered equipment. Other connections are printed in the backplane. All connections are full-duplex.

Network Element (NE) control

NE control includes the following features.

- Reset — high level controllers in the hierarchy drive signals to lower-level controllers to reset the processor.

- Equipage — high-level controllers receive indication signals from lower-level controllers when they are equipped (plugged into the backplane) or unequipped.

- Power monitor — high-level controllers receive indication signals from lower-level controllers that $-48V_{DC}$ power is present (not used for BCMs and SUPVY).

- Long-reach NE control interfaces — carried on cables up to 100 meters long. This interface is used between the NCTL and SCTL (and between SCTLs within a control group).

- Short-reach NE control interfaces — carried by backplane connectors. Used between the SCTL and BCMs and between the NCTL and SUPVY. The interface uses single-ended reset and equipage signals (no power monitor signals).

- NCTL — communicates with other NCTLs in the OLS via the SUPVY and the OSC.

Refer to the figure below for a block diagram of the NE control interface.

Figure 4-49 NE Control Hierarchy
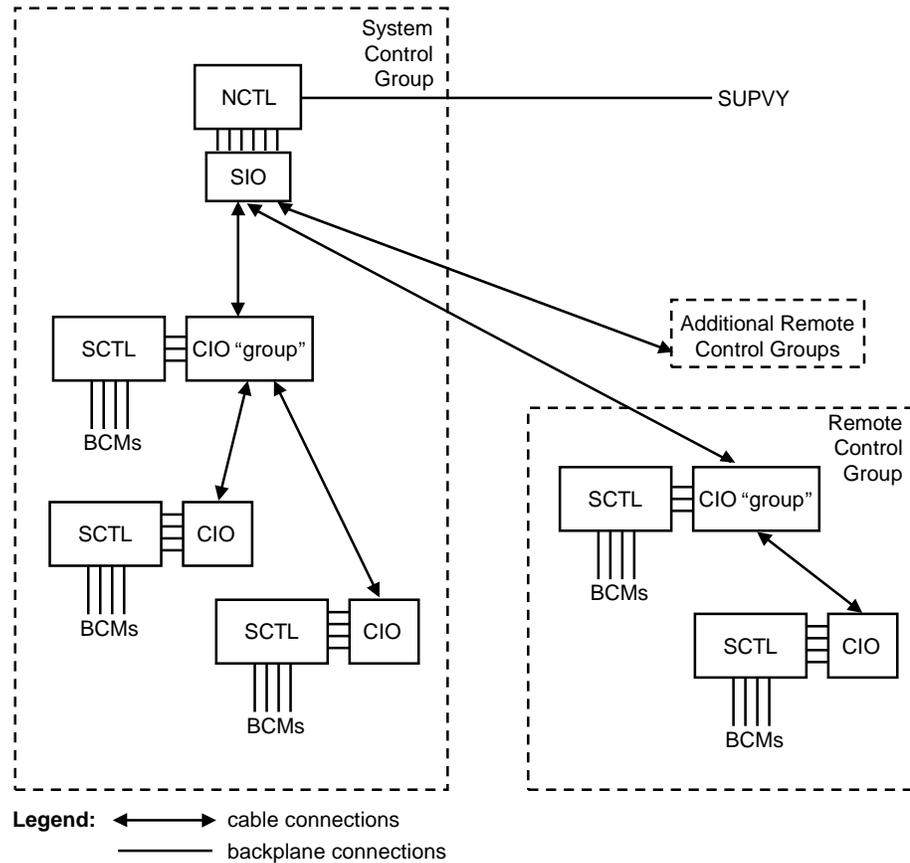
Input/Output Panels The system input/output panel (SIO) provides the physical connectors needed for NCTL and SUPVY circuit pack I/O interfaces. The controller input/output panel (CIO) provides the physical connectors needed for SCTL circuit pack I/O interfaces.

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Network Element Controller (NCTL)

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NCTL function	The NCTL provides control and user interfaces at the NE level.

EMS and CIT interfaces   The NCTL is supplied with unique *Ethernet*™ MAC addresses for the Element Management System (EMS) and Craft Interface Terminal (CIT) 100Base-TX interfaces.

EMS and CIT communications controllers serve as a firewall separating the internal network element traffic from external data traffic.

4–character display and LEDs   A 4-character display is used to display the system number (NENUM 1-800), using leading zeros.

The NCTL has a green ACTIVE LED and a red FAULT LED to indicate the operational status of the pack.

Reset and restart   The NCTL has a non-disruptive reset and restart, which is available at any time (even when the CPU is hung). It is not necessary to reseat the pack as part of the reset or restart.

Backplane interface   The backplane interface, an I^2C interface, provides a connection between the NCTL and SIO that allows the NCTL to control the SIO. The interface has 3.3 volt DC power and is protected with a 750 mA self-resetting circuit breaker.

Flash Memory Module (FMM)   A Flash Memory Module (FMM), containing the NE's database and code, is inserted into the NCTL pack. A REMOVE FLASH button warns the system that the FMM is going to be removed. The LED in the button will illuminate when it is safe to remove the card. Refer to the *LambdaXtreme*™ *Transport User Operations Guide* for the database backup procedure.

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Faceplate drawing   See Figure 4-50, "NCTL — Faceplate Drawing" (4-88) for a drawing
of the NCTL front panel. In this drawing the system number is 27.

Figure 4-50   NCTL — Faceplate Drawing

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Shelf Controller (SCTL)

SCTL function   The SCTL controls the transmission packs on its dual shelf. It performs fault correlation within the scope of the shelf controller and maintains communication with the NCTL and other shelf controllers in the same group.

Power monitor   The power monitor portion of the long-reach NE control interface to the higher-level NCTL or SCTL is implemented in the CIO panel.

4-character display   The SCTL's 4-character display shows the shelf number of the SCTL's double shelf, for example A1-3 or B1-2. There are 32 possible shelf numbers, which are derived from the shelf identification (set on the CIO pack). The shelf number display can be used as a label. For example, when troubleshooting an alarm, the alarm can have an Access Identifier (AID) which might be for a certain port on a circuit pack (for example, PORT-B1-2-3-IN_TRIB3). This is helpful to the user when locating this port to see the SCTL of that double shelf displaying B1-2.

The display can be used to verify that the CIO shelf identification switches are set correctly.

- Digit 1: A-H, J-M (control group)
- Digit 2: 1-5 (bay number)
- Digit 3: "-" (dash)
- Digit 4: 1-4 (shelf number)

LEDs   The SCTL has a green ACTIVE LED and a red FAULT LED to indicate the operational status of the pack.

Backplane interface   The backplane interface, an I^2C interface, is between the SCTL and every pack except for the SIO, NCTL, and SUPVY packs (but including the power filter, CIO, and fan assembly)

The I^2C interface has 3.3 volt DC power and is protected with a 750 mA self-resetting circuit breaker. The power is monitored.

Temperature sensors   The SCTL includes on-board temperature sensors.

Faceplate drawing   See Figure 4-51, "SCTL — Faceplate Drawing" (4-90) for a physical
representation of the SCTL pack. In this illustration the shelf where
the SCTL pack resides is A1-3.

Figure 4-51   SCTL — Faceplate Drawing

SCTL

FAULT ○

ACTIVE ○

4 Character Display

A
1
-
3

□

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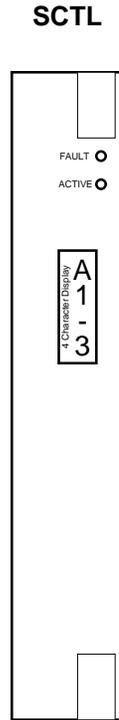
SIO Pack

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SIO function   The System Input/Output Circuit Pack is the main User Interface to
LambdaXtreme™ Transport. It provides the following functions

- connects the NCTL to SCTLs

- provides the main interface to the LambdaXtreme™ Transport
  system (OS/EMS)

- provides Orderwire interfaces

- provides the interface for office alarms, miscellaneous discretes,
  and remote restart

SIO faceplate connections   The SIO faceplate provides the following interface connections

- 12 RJ-45 jacks for connection to the SCTLs (via group CIOs) in
  the control groups

- 1 RJ-45 jack located between the latches for the CIT interface

- 1 RJ-45 jack for the EMS interface

- 2 RJ-45 jacks for the Data port interfaces (reserved for future
  use)

- 1 RJ-45 jack for the Customer LAN interface (reserved for future
  use)

- 2 RJ-45 jacks for the Private LAN interfaces (reserved for future
  use)

- 1 RJ-45 jack for External Misc. Discrete Unit TBOS control
  (reserved for future use)

- 6 DB-15S (15-pin D-Sub) connectors for 6 Orderwire interfaces

- 1 DB-15S (15-pin D-Sub) connector for the Office Alarm
  interface

- 1 DB-25S (25-pin D-Sub) connector for Miscellaneous Discrete
  I/O & Remote Restart interface

- Red and Green Fault LEDs controlled by the NCTL

- NCTL and SUPVY jacks are for Lucent use only

All RJ-45 jacks have built-in LEDs to indicate *Ethernet*™ port status.

....

SIO faceplate drawing   See Figure 4-52, "SIO — Faceplate Drawing" (4-92) for a faceplate
drawing of the System Input/Output (SIO) Panel.

Figure 4-52 SIO — Faceplate Drawing

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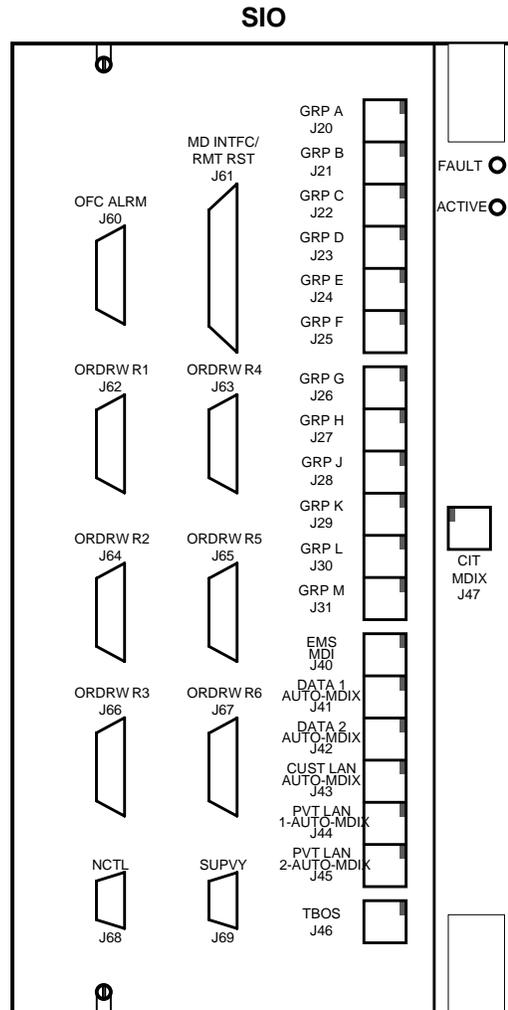
Controller Input/Output (CIO)

CIO function   The CIO pack has 10 RJ-45 jacks, with built-in LEDs to indicate *Ethernet*™port status. The jacks are labeled J1 thru J10.

Usage of the jacks depends on the location of the CIO.

- in a single shelf Repeater configuration, jack J10 connects to the NCTL pack (via the SIO panel) in the same shelf. Jacks J1 thru J9 are not used.

- in shelf 1 of the first bay in a control group (the "group" SCTL shelf in bay A-1, B-1, C-1, D1 ...):

    - Jack J10 connects to the NCTL pack (via the SIO panel) in the system control group

    - Jacks J1 thru J9 connect to lower-level SCTL packs (via CIO Panels) in remote control groups

- in other bays/shelf combinations, jack J10 connects to the higher-level "group" SCTL (via the CIO panel). Jacks J1 thru J9 are not used

Refer to the illustrations of Bay Configurations in Chapter 5 to locate and identify shelves and control packs.

For installation instructions, refer to the *LambdaXtreme™ Transport Installation Manual and System Turn-up Services* for details.

CIO faceplate drawing   See Figure 4-53, "CIO Pack — Faceplate Drawing" (4-94) for a
faceplate drawing of the CIO pack.

Figure 4-53 CIO Pack — Faceplate Drawing

CIO
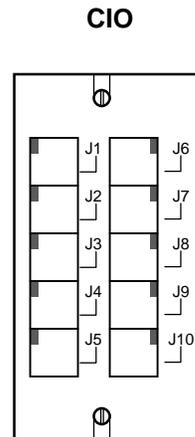
Fan Assembly and Office Alarms

Cooling Each double shelf is air-cooled by a fan assembly located between the shelves. In the System Bay, the top fan assembly is also a display for office alarms. Also, an I^{2}C (inter integrated circuit) interface is provided to allow retrieval by the SCTL of the apparatus code, version, and serial number. Refer to the *LambdaXtreme*™ *Transport Installation Manual and System Turn-up Services* for details.

See Figure 4-54, "Fan Assembly — Faceplate Drawing" (4-95) for a physical representation of the Fan Assembly with Office Alarm Display and the Fan Assembly without the Office Alarm Display.

Figure 4-54 Fan Assembly — Faceplate Drawing
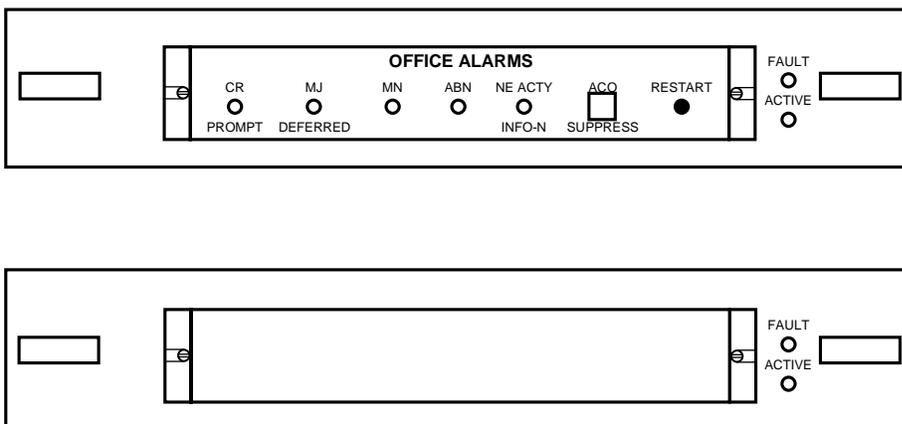
Optical Supervisory Channel (OSC)

Overview

Purpose   The Optical Supervisory Channel supports the following data flows

- node-to-node communication
- Orderwire communication

The Supervisory pack (SUPVY) facilitates the Optical Supervisory Channel. The SUPVY pack and each data flow (communication path) is discussed in the sections that follow.

OSC description   The OSC is an OC-3 signal (195.8 THz, 1531 nm) transporting an STS-3 frame between NEs.

The OSC is used as follows

- *Overhead* — In addition to framing, the overhead has B1 bytes, for performance management counts and K2 bytes for sending/receiving remote defect indication (RDI-L)
- *Payload* — The STS-3 payload carries Packet over SONET/SDH (PoS) datagrams for the various communications flows on the OSC.

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Supervisory Pack (SUPVY)

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SUPVY function   The Supervisory Pack (SUPVY) is a low-speed transmission pack that facilitates communication between LambdaXtreme™ Transport NEs. Supervisory signals are transmitted in a counterpropagating direction to the DWDM signal.

Reliability   The supervisory channel will continue to function even if there are OA or RP failures.

4–character display and LEDs   The 4-character display is left blank.

The SUPVY has a green ACTIVE LED and a red FAULT LED to indicate the operational status of the pack.

Temperature sensors   The SUPVY circuit pack includes temperature sensors located at the top and bottom of the pack.

SUPVY OSC processing block diagram   See Figure 4-55, "SUPVY — Block Diagram" (4-98) for a functional block diagram for SUPVY OSC processing .

The Optical Supervisory Channel processor includes the following components:

- Digital Communications Processor (DCP) — contains internal processors that can be programmed to support networking applications and external interfaces.

- Clock Generator — provides SONET/SDH reference clocks for the DCP and Orderwire interface. Requirements are

   - lock to a local free-running 20 ppm reference

   - lock to either of the two clocks recovered from the incoming OC-3 signals

   - operating modes controllable by software GPIO

   - generated interrupts to software via GPIO for conditions such as loss of lock on the incoming OC-3 signal

- Orderwire interface — controllable from software via the General Purpose I/O (GPIO) and permits field upgrades.

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See Figure 4-55, "SUPVY — Block Diagram" (4-98) for a block
diagram of the SUPVY pack.

Figure 4-55 SUPVY — Block Diagram

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Issue 1, June 2002
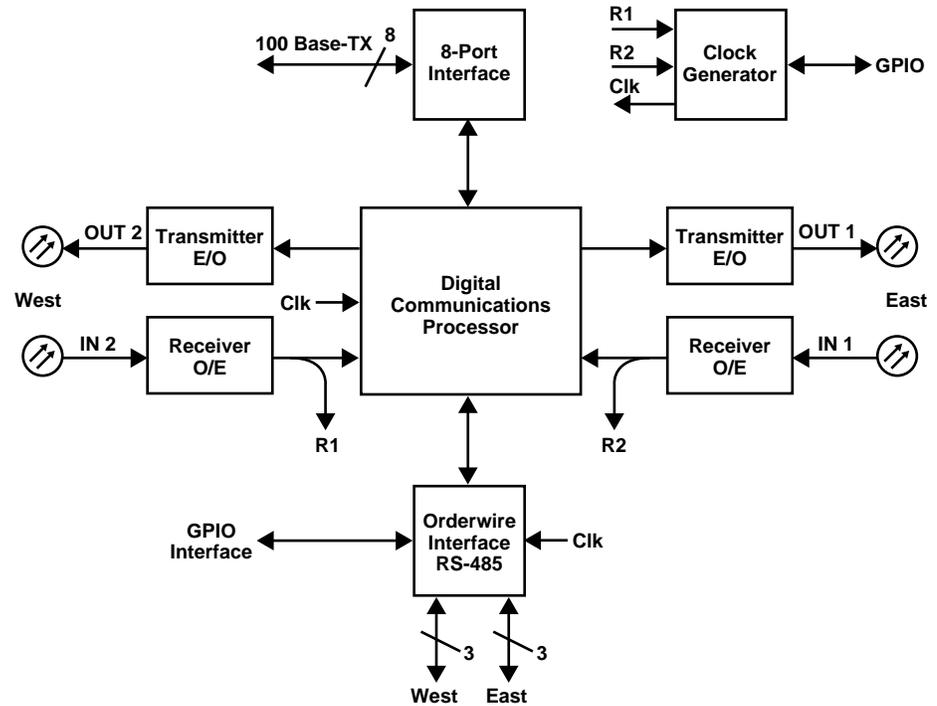
SUPVY faceplate drawing   Figure 4-56, "SUPVY — Faceplate Drawing" (4-99) illustrates the front panel labeling of a Supervisory Pack. On the IN and OUT connectors, 1 is eastward and 2 is westward.

Figure 4-56   SUPVY — Faceplate Drawing
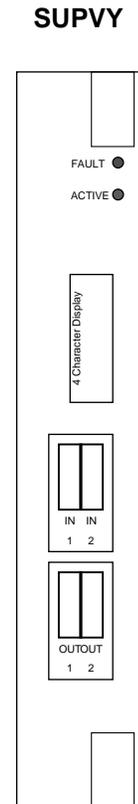
SUPVY

SUPVY maintenance support   The SUPVY pack provides the following maintenance support features.

Performance Management

The SUPVY pack maintains the following performance counts for each OC-3 interface. Software calculates unavailable seconds from the lower-level faults and counts.

- Coding violations (section)
- Errored seconds (section)
- Severely errored seconds (section)
- Severely errored framing seconds (section)

Timing reference faults

The clock generator detects loss of clock on either OC-3 receive signal.

Circuit pack faults

The SUPVY pack detects a Loss of local SONET/SDH clock, which it treats as a SUPVY pack failure.

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SUPVY Orderwire Communication

Description   In orderwire communication, connections are established across NEs using external Orderwire equipment. Figure 4-57, "SUPVY Orderwire Communication" (4-101) shows an example of Orderwire connectivity. The structure is as follows:

Three orderwire channels are carried in the East OSC and three in the West OSC. In particular, orderwire connectors 1, 2, 3 on the SIO panel correspond to channels carried on the westward OSC and connectors 4, 5, 6 correspond to channels carried on the eastward OSC. The three channels can be independently provisioned by the user as either Local (dropped to the orderwire connectors on the SIO) or Express. By appropriately provisioning orderwire channels at each NE, the user can set up orderwire connections between adjacent or across several NEs. This is illustrated in Figure 4-57, "SUPVY Orderwire Communication" (4-101) where a user has chosen to have an orderwire connection between End Terminal A and End Terminal Z spanning multiple NEs as well as multiple orderwire connections between adjacent NEs. See *LambdaXtreme*™ *Transport User Operations Guide* for the provisioning procedure. The default is Local.

There are two types of orderwire channels: 64 Kbps and 192 Kbps. Orderwire channels 1 and 2 (corresponding to connectors 1, 2, 4, and 5) are fixed at 64 Kbps. Orderwire channel 3 (corresponding to connectors 3 and 6) is fixed at 192 Kbps.

Figure 4-57 SUPVY Orderwire Communication
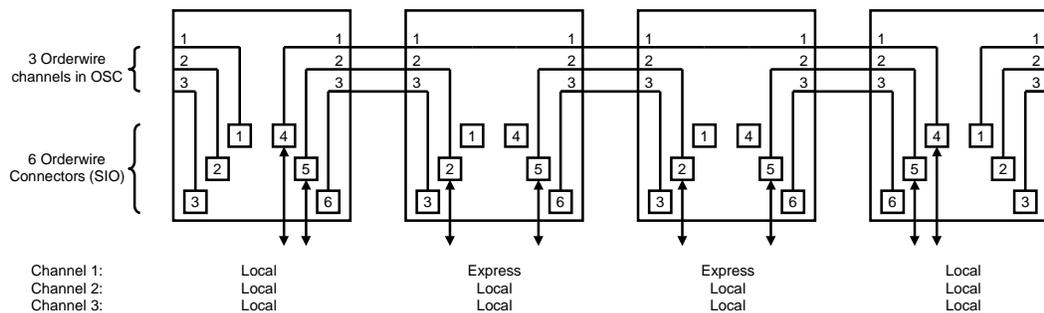
Orderwire interface description   The Orderwire interface has the following characteristics:

- Each orderwire interface consists of clock, sync, and data signals in the transmit direction (external orderwire equipment to OSC) and clock sync, and data signals in the receive direction (OSC to external orderwire equipment. The clock and sync signals are outputs of the SUPVY for both transmit and receive. The transmit data signal is an input and the receive data signal is an output of the SUPVY.

- Orderwire signals are RS-485. The drivers, receivers, and terminations are on the SUPVY pack.

- One DB-15S connector is used per orderwire interface. The connectors are on the SIO panel.

- The transmit clock is derived from the local SUPVY common clock. The receive clock automatically tracks the local SUPVY common clock of the transmitting NE.

- The transmit and receive sync signals are 125µS period, with a pulse width of one bit, regardless of the bit rate.

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Power

Overview

Purpose	This section includes information on power distribution.
Power distribution	LambdaXtreme™ Transport is powered by dual -48 V direct current (DC) feeders (A and B) for North American (and similar) applications. For ETSI (and similar) applications, LambdaXtreme™ Transport is powered by dual -60 V_{DC} feeders (A and B). For simplicity throughout this document, only -48 V_{DC} is referenced, with the understanding that in ETSI and similar applications, the A and B power feeds are actually -60 V_{DC}.[1]

There are two feeders per double shelf with two double shelves per bay.

Power filtering and fusing are performed on the double-shelf level.

Each circuit pack contains DC-to-DC converters that convert office battery voltages to the required voltages. This leads to improved system reliability with heat dissipated uniformly across LambdaXtreme™ Transport, thereby avoiding "hot spots."

[1]For CE mark compliance, the -60V source must be a SELV (Safety Extra Low Voltage) source. The product is designed to operate over ETSI 300 132-2 operational limits.

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Power Features

Power feeders   Redundant power feeds are provided to each double shelf (Repeaters have one double shelf; other terminals have two double shelves per bay). Each feeder is able to handle the entire double-shelf load.

Power filters   There is a single power line filter for each feed. Each filter is able to handle the entire load. The filter contains a 50A circuit breaker, therefore it is able to carry a full load indefinitely without tripping.

Each power filter has test points to measure the DC feed with a Digital Volt Meter. Also an I^2C (inter integrated circuit) is provided to allow retrieval of the apparatus code, version, and serial number. Refer to the *LambdaXtreme™ Transport Installation Manual and System Turn-up Services* for details.

Figure 4-58, "Power Filter — Faceplate Drawing" (4-104) is a drawing of the front panel of a power filter.

Figure 4-58 Power Filter — Faceplate Drawing

PWR
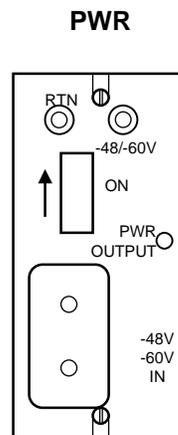
Low voltage cutoff   Low voltage cutoff occurs at -39.25 $\pm0.25V_{DC}$; however, the voltage must return to 2.25 $\pm0.25V_{DC}$ greater than the cutoff voltage before restart can occur. The power filters and on-board power modules are rated from -39.25V_{DC} to -72$V_{DC.}$

Cabling   The power feed cables within the shelf/bay are stranded and color coded, with keyed connectors. All panel mounted power connector functions are labeled.

Alarm LED power   Locally unfused -48V power is provided on all circuit packs to light the alarm LED if its local fuse opens.

□

Circuit Pack Powering

Power input   Each circuit pack has, as its supply input, two independent -48 V_{DC} supplies (-48A and -48B). If one supply line fails, the second is able to handle the entire load.

Line conditioning   Each input line is conditioned to minimize conductive noise.

In-Line fuses   Each -48 V_{DC} input on each circuit pack is fused to prevent circuit board damage.

Power up and down   The primary power supply on each circuit pack may be turned on or off externally. Note that this power up or down is done as a group among all packs in the shelf; it cannot be done on an individual pack by pack basis. "Soft Start" circuitry is included to limit in-rush current when a circuit pack is initially inserted or activated.

Power supply monitoring   Both the -48A and -48B input supplies include power supply monitoring circuitry. The monitoring is provided on the CIO pack and reported to the SCTL via the GPIO.

□

CIT Requirements

Desktop PC requirements

Table 4-3, "Client-Provided Desktop CIT Requirements" (4-107) shows the minimum and recommended requirements for the client-provided PC/Laptop to be used as the Craft Interface terminal (CIT). The recommended requirements reflect four simultaneous node managers.

Table 4-3   Client-Provided Desktop CIT Requirements

Equipment	Minimum Requirements	Recommended Requirements
Processor	350 MHz	500 MHz
RAM	128 Mbyte	256 Mbyte
Disk space	120 Mbyte	120 Mbyte
Paging File	270 Mbyte	750 Mbyte
Video	1024x768 - 256 color	1024x768 - 256 color
Network Interface	10 Base T LAN NIC	10 Base T LAN NIC
CDROM	Required	Required
Operating System	Windows 98[1]/00/NT/4.01	Windows 98[1]/00/NT/4.01/XP
Flash Disk Memory Module (an FMM card used with a PCMCIA Adapter)	Required[2]	Required[2]

Notes:

1. Refer to the procedures in the *LambdaXtreme™ Transport Installation Manual and System Turn-up Services* for setting the proper network parameters.
2. Required for the first installation only. After that, NE software upgrades can be done without inserting a flash disk into the PC Card slot.

CIT connection and access data is shown below:

• Physical interface is an RJ-45 jack.

• For User Panel connections, a shielded CAT-5e straight-through cable is required.

- For LAN jack connections, a 10 Base T cable is required.

- Pin designations/signals are:

    - 1 TD+

    - 2 TD-

    - 3 RD+

    - 6 RD-

    A desktop PC may be loaded with multiple and different releases of the CIT application software. This may be necessary when using a single PC to connect to multiple spans or systems that are using different releases of the NE software, or to multiple/different Lucent OLS products (WBM, W2.5G, and so forth). However, multiple versions of the CIT will not run at the same time. One version must be exited prior to starting another version.

□

5   System Planning and Engineering

Overview

Purpose   This chapter describes the planning and engineering aspects of the LambdaXtreme™ Transport system. It first presents the engineering rules and wavelength growth plans, followed by the bay configurations, Data Communications Network (DCN) rules, and environmental considerations.

Contents

Engineering Rules

Overview

Purpose Engineering rules are designed to optimize performance, minimize cost, and maximize configuration flexibility based on route length, quality and type of installed fiber and expected traffic demands.

Engineering Rules for LambdaXtreme™ Transport Release 1.0 optical line system consist of tables that specify the conditions under which the system meets the Bit Error Rate (BER) requirement of 10^{-16} (End Of Life). These rules are intended to provide only guidelines in regards to system reach and capacity for various fiber types. They do not provide any procedures for network design; therefore, under no circumstances should they be used as a configuration tool. Any LambdaXtreme™ Transport network design must be done by Lucent Technologies; contact your account representative for details.

Planning and engineering of a specific route involves the selection of the appropriate system(s) for a given route, validation that the minimum requirements are satisfied, followed by the selection of the appropriate network elements and specific components.

The engineering rules are divided into three broad categories, which are described in the following sections, they are:

- LambdaXtreme™ Transport system type selection (10G or 40G)
- span limitations and minimum requirements
- component selection guidelines

Definitions *System* — A LambdaXtreme™ Transport system is delimited by the End Terminals at each end. LambdaXtreme™ Transport comes in two system types, LH/ULH (10G) and UHC (40G), as described in previous chapters.

Route — A route is a Service Provider definition of the required connectivity between the service access points (central offices). A simple route support is usually provided by a single LambdaXtreme™ Transport system; however, complex routes may require the engineering of a multiple LambdaXtreme™ Transport system application.

□

LambdaXtreme™ Transport System Type Selection

Introduction   In general, depending on reach and capacity requirements of the given route, a particular system type is selected based on cost versus capabilities considerations. A single route may require one or more LambdaXtreme™ Transport systems.

Given the reach and capacity needs of the specific route, the designer will decide on the system type based on the nominal capabilities of the LambdaXtreme™ Transport system specified in the tables below.

The tables below are based on transmission simulations and preliminary lab results. They are subject to change upon further lab testing. Please refer to your Lucent account representative for any updates.

Table 5-1   Engineering Rules for TWRS

Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	10G-LH		10G-ULH		40G	
				Max No. Spans	Reach (km)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)
60	0.25	15	16	35	2100	67	4020	17	1020
80	0.25	20	21	25	2000	50	4000	13	1040
100	0.22	22	23	20	2000	40	4000	10	1000
100	0.25	25	26	20	2000	30	3000	9	900
120	0.22	26.4	27.4	16	1920	20	2400	7	840
Maximum Channel Count				128		128		64	

Table 5-2   Engineering Rules for LEAF

Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	10G-LH		10G-ULH		40G	
				Max No. Spans	Reach (km)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)
60	0.25	15	16	35	2100	67	4020	17	1020
80	0.25	20	21	25	2000	50	4000	13	1040
100	0.22	22	23	20	2000	40	4000	10	1000
100	0.25	25	26	20	2000	26	2600	8	800
120	0.22	26.4	27.4	12	1440	18	2160	5	600
Maximum Channel Count				100		100		50	

Spans preceding ET/OADMs with losses that exceed 25 dB will require special engineering.
Spans preceding DGEFs with losses that exceed 26 dB will require special engineering.

Table 5-3   Engineering Rules for SSMF

				10G-LH		10G-ULH		40G	
Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)
60	0.25	15	16	40	2400	54	3240	17	1020
80	0.25	20	21	30	2400	40	3200	13	1040
100	0.22	22	23	20	2000	32	3200	9	900
100	0.25	25	26	12	1200	20	2000	5	500
Maximum Channel Count				128		128		64	

Spans preceding ET/OADMs with losses that exceed 22 dB will require special engineering.
Spans preceding DGEFs with losses that exceed 23 dB will require special engineering.
Spans preceding EDFAs with losses that exceed 26 dB will require special engineering.

Table 5-4   Engineering Rules for TW-Classic

				10G-LH		10G-ULH		40G	
Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)
60	0.25	15	16	35	2100	67	4020	16	960
80	0.25	20	21	25	2000	50	4000	12	960
100	0.22	22	23	20	2000	40	4000	9	900
100	0.25	25	26	18	1800	22	2200	5	500
Maximum Channel Count				70		70		40	

Spans preceding ET/OADMs with losses that exceed 22 dB will require special engineering.
Spans preceding DGEFs with losses that exceed 22 dB will require special engineering.
Spans preceding EDFAs with losses that exceed 26 dB will require special engineering.

Table 5-5   Engineering Rules for TW+

				10G-LH		10G-ULH		40G	
Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)	Max No. Spans	Reach (km)
60	0.25	15	16	35	2100	60	3600	14	840
80	0.25	20	21	25	2000	43	3440	10	800
100	0.22	22	23	20	2000	33	3300	8	800
100	0.25	25	26	18	1800	22	2200	5	500
120	0.22	26.4	27.4	13	1560	17	2040	4	480
Maximum Channel Count				90		90		50	

Spans preceding ET/OADMs with losses that exceed 25 dB will require special engineering.
Spans preceding DGEFs with losses that exceed 26 dB will require special engineering.

Engineering notes   The maximum system reach in the above tables represents the
maximum system length that can support the listed number of
channels based on nominal installed fiber properties. The actual reach
of a specific system installation will depend on the properties of the
installed fiber. The knowledge of the detailed installed fiber properties
based on a specific set of Fiber Optic Characterization (FOC)
measurements (see Chapter 7, "Product Support") are pre-requisite for
the engineering of the detailed system configuration.

The above tables assume the loss coefficient at 1550 nm and nominal
dispersion values as shown in Table 5-6, "Dispersion by Fiber Type"
(5-5) below.

Table 5-6   Dispersion by Fiber Type

Fiber Type	Mean D @ 1550 nm (ps/nm*km)	Dispersion Slope ps/nm^2*km	Mean D @ 1580 nm (ps/nm*km)	Dispersion Slope ps/nm^2*km
TWRS	4.45	0.045	5.80	0.045
LEAF	4.21	0.085	6.76	0.085
SSMF	16.95	0.059	18.72	0.058
TWC	2.70	0.070	4.53	0.070
TW+	3.60	0.067	5.30	0.067

The maximum number of add/drop locations (OADMs) between two
LambdaXtreme™ Transport End Terminals in a single 10G system is
8.

OADMs will derate the system depending on fiber loss coefficient and
total span loss, as shown in the table below:

Table 5-7   OADM System Derating Factors

Span Length (km)	Loss Coeff. (dB/km)	Fiber Loss (dB)	Span Loss (dB)	Span Reduction per OADM
60	0.25	15	16	1.5
80	0.25	20	21	1.25
100	0.22	22	23	1.25
100	0.25	25	26	1
120	0.22	26.4	27.4	1

Multi-fiber routes

LambdaXtreme™ Transport supports routes with different fiber types in different spans; however, they require engineering validation to design. The maximum reach and system capacity will be determined by the most limiting fiber type.

Multiple fiber types spliced in a single span are generally not supported. The presence of mixed fiber spans in a given route will make the engineering more complex and will require additional, specific engineering effort.

Multi-OLS system

If a route cannot be accommodated by a single system as determined by the comparison of route capacity and reach requirements to the system capabilities outlined in the tables above, it will be necessary to design a multi-system solution.

The optimal way of breaking up a route into multiple systems in terms of cost and performance depends on given space availability in repeater sites and/or traffic add/drop locations.

Important! 10G LH and ULH systems can be mixed on the same fiber; however, 10G and 40G systems cannot be mixed.

Point-to-point without a Repeater

The maximum distance single span ″reach″ supported is 150 km/33 dB on ″excellent″ fiber. Refer to the section titled "Installed Fiber Considerations" (5-13) for a definition of "okay, good, and excellent" fiber. A minimum of six wavelengths is required in this case.

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Span Limitations and Minimum Requirements

Overview of limiting factors
The tables below show the span loss, reflectivity requirements and Polarization Mode Dispersion (PMD), for LambdaXtreme™ Transport.

Table 5-8   Span Loss and PMD Requirements

Parameter	Value
Maximum span loss	32.5 dB
Minimum span loss	9 dB
Maximum office connector loss	0.5 dB
Maximum splice loss within 20 km of a node	0.5 dB
Maximum splice loss more than 20 km from a node	2 dB
Maximum mean PMD for 10G	15 ps
Maximum mean PMD for 40G	3 ps
Minimum span distance	40 km

Span loss factors
Span loss consists of the Outside Plant (OSP) fiber loss and the associated office losses at both ends of the span. Office losses constitute the losses between the LambdaXtreme™ Transport NE and the outside plant fiber. See Figure 5-1, "Span Loss" (5-7).

Figure 5-1 Span Loss
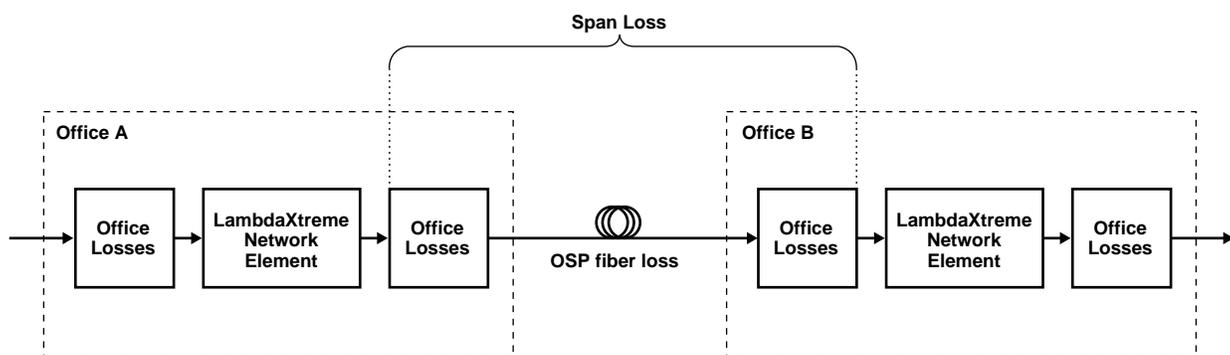
The effect of connector losses between LambdaXtreme™ Transport and the outside plant fiber is a serious concern since it will

dramatically affect the realized Raman gain. Excess loss will significantly affect the realized Raman gain with a corresponding reduction in the engineering rules (much more than dB for dB).

Important! For LambdaXtreme™ Transport, special considerations must be applied to the installation to minimize the office losses to a level of 0.5 dB at each end of the system. This implies that loss specifications include a sum total (both ends) allocation of 1 dB for connectors and splices that are not part of the actual outside plant fiber! This will support one additional standard performance connector pair between an NE and the OSP fiber, thus limiting installations to a single "interconnect" style (as opposed to "cross-connect" style) connection to the riser cable (which assumes the riser cable is connected to the outside plant fiber in a low loss splice appropriate for the fiber type). If high performance connectors are available, then more connectors can be used.

Splice loss and reflection

Splice loss affects the system negatively in two ways: by attenuating the signal and by reducing the effectiveness of the Raman pumps, thus reducing gain. Most Raman gain occurs within 20 km of the Raman pumps, so splice losses within 20 km of the Repeater nodes are particularly damaging and are required to be less than 0.5 dB. Other splice losses are required to be less than 2 dB.

Splice reflection can give rise to Multi-Path Interference (MPI), which can severely degrade system performance.

Reflectivity requirements for 10G systems are given in Table 5-9, "Span Reflectivity Requirements for a 10G System" (5-8), and for 40G systems in Table 5-10, "Span Reflectivity Requirements for a 40G System" (5-9).

Table 5-9   Span Reflectivity Requirements for a 10G System

Number of spans	One reflector can be as large as:	Two additional reflectors can be as large as:
50	-36 dB	-39 dB
40	-35 dB	-38 dB
32	-34 dB	-37 dB
25	-33 dB	-36 dB
20	-32 dB	-35 dB

**Table 5-9   Span Reflectivity Requirements for a 10G System
(continued)**

Number of spans	One reflector can be as large as:	Two additional reflectors can be as large as:
16	-31 dB	-34 dB
12	-30 dB	-33 dB
10 or fewer	-29 dB	-32 dB

Table 5-10   Span Reflectivity Requirements for a 40G System

Number of spans	One reflector can be as large as:	Two additional reflectors can be as large as:
13	-37 dB	-40 dB
10	-36 dB	-39 dB
8	-35 dB	-38 dB
6	-34 dB	-37 dB
5	-33 dB	-36 dB
4	-32 dB	-35 dB
3 or fewer	-31 dB	-34 dB

For both 10G and 40G systems, all reflections beyond the first three must be -45 dB or less.

Polarization Mode Dispersion (PMD)

The LambdaXtreme™ Transport engineering rules assume that the maximum mean PMD in LambdaXtreme™ Transport of OSNR-limited systems is 15 ps for 10G systems and 3 ps for 40G systems. The mean PMD for a system is derived from the PMD's of individual spans and system components in the transmission path.

Considering the fact that equipment and DCMs contribute to total cumulative PMD, the mean PMD for the fiber plant on a 10x100km 40G network is approximately 2.3ps. On a 30x100km span 10G network, the maximum PMD for the fiber plant is approximately 14.2ps.

Short spans   A short span is one for which the corresponding DCM is too short to provide sufficient Raman gain. In some cases (extremely short spans), a larger DCM is used to provide adequate gain, and the dispersion map error is corrected by reducing the DCM value by the same amount one span earlier or later. In other short-span cases, the Raman-pump control algorithm will compensate for this by increasing the output power of the span. One or two short spans are not a significant problem, but several consecutive short spans may result in nonlinear degradation of the signal due to the higher than normal path-average power in the spans. The solution to this problem is to combine spans where possible.

Spans can be combined if:

- there are no user-specified NEs (for example, OADMs) between the spans

- the combined loss (including connector and jumper losses) is less than the maximum loss that can be compensated for with an OA (Raman EDFA)

- the combined length is less than the maximum span length acceptable for that configuration per the Engineering Rules

□

Component Selection

The four-step selection process

After a given system has been selected, the next step is to configure the system in a way that minimizes cost while meeting the requirements for the system to work. This is a four-step process.

1. Check the system to make sure it meets the requirements just discussed. If it does not, either the route must be broken up in a different way to result in systems that do meet the requirements, or the actual physical layout of the system must be modified. For example, if there is a span that exceeds the maximum allowable loss because of a poor splice, then that splice must be redone in order to meet specifications.

2. Second, combine short spans where possible to minimize cost by minimizing the number of Repeaters deployed. (See the previous discussion on short spans.)

3. For Repeaters, select the Optical Amplifiers (OAs) to optimize OSNR versus cost. (See the discussion on OA selection, below.)

4. Select the Dispersion Compensation Modules (DCMs) to satisfy the dispersion management requirements. (See the discussion on DCM selection, below.)

5. Validate system configuration by using the Engineering Rules tables.

The above steps require detailed knowledge of the attenuation and dispersion properties of the installed fiber as well as internal system details. To obtain the optimal selection of the components, customers should contact their local account representative.

OA selection for a Repeater

The following is the nominal selection criteria for the placement of OAs in a Repeater.

*   OA (Raman) is utilized on spans that have span losses up to 23 dB (22 dB for TW-Classic).

*   OA (Raman EDFA) is utilized with spans losses in the range of 23-28 dB (22–26 dB for TW-Classic, 23–26 dB for SSMF).

*   OA (DGEF) is placed in locations where channel flattening is required. This is normally required every 6 spans.

The optimal placement of the above OA types is determined by optimizing Optical Signal to Noise Ratio (OSNR) with respect to fiber losses in all spans present in a given route. To engineer the optimal

choice of OA types and their placement, contact your local account representative.

DCM selection   The dispersion of the DWDM signals is managed to meet the requirements of the optical transmitters and receivers present in the system. To manage dispersion of the DWDM signals, LambdaXtreme™ Transport utilizes bulk DCMs placed at each of the nodes in the system. LambdaXtreme™ Transport DCM modules are placed in such a way to provide pre-, line-, and post-dispersion compensation of the DWDM signal. Figure 5-2, "Placement of DCMs in LambdaXtreme™ Transport" (5-12) below illustrates the placement of pre, line, and post compensating DCMs in the LambdaXtreme™ Transport system for a given direction.

Figure 5-2 Placement of DCMs in LambdaXtreme™ Transport
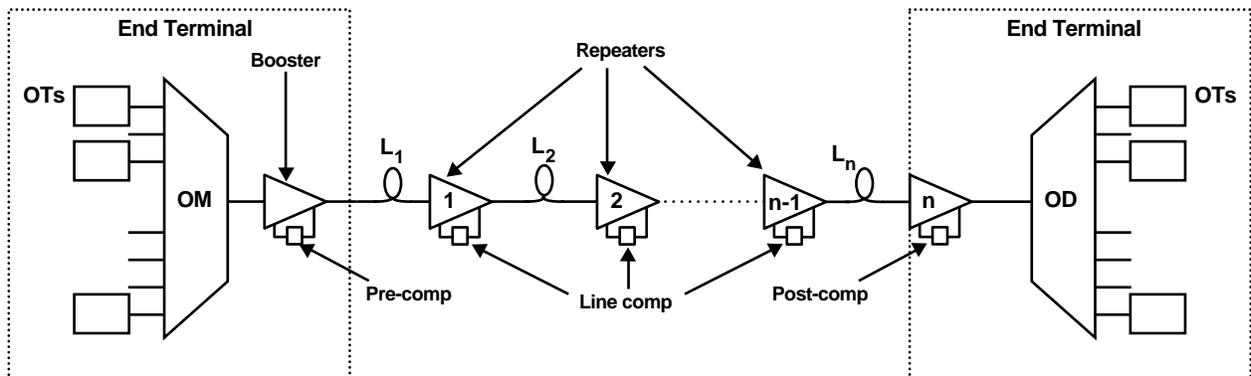
The End Terminals provide pre- and post-compensation while Repeaters provide the line compensation of the DWDM signal. The OADM nodes provide line compensation of the through/express channels and pre- and post compensation for the Add/Drop channels. LambdaXtreme™ Transport provides customized DCM modules for each of the supported fiber types.

The particular choice and placement of the DCMs is based on the dispersion characteristics of the installed fibers and will be chosen to achieve a path average residual dispersion nominally in the range of 0.15 ps/nm*km to 0.35 ps/nm*km (this range varies slightly depending on fiber type). To engineer the optimal choice of DCM types and their placement, contact the local account representative.

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Installed Fiber Considerations

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Introduction	The performance of the LambdaXtreme™ Transport system depends on the quality of the installed fiber and the connector losses between the LambdaXtreme™ Transport NE and the outside plant. Better quality fibers and low office losses will enable the support of longer individual span lengths.

The engineering rules for LambdaXtreme™ Transport depend on whether the outside plant fiber is considered "okay, good, or excellent." Definitions and engineering rules for these classifications are presented in the following paragraphs.

Quality of the installed fiber LambdaXtreme™ Transport is performance optimized for 100 km/ 23.0 dB of ″good″ non-zero dispersion shifted fibers such as TWRS and LEAF. It can also be utilized on other fiber types including SSMF, TW-Classic and TW-Plus.

Matching dispersion characteristics of installed fiber Matching dispersion characteristics of the installed fiber is a critical item for the proper operation of LambdaXtreme™ Transport as described earlier. The system is designed to accommodate OSP fiber temperature variations for a standard underground cable installation. The temperature extremes that above ground fiber will experience can cause a large enough change in the dispersion characteristic of the fiber to exceed the design limits for some combinations of system reach and amount of above-ground cable.

"Okay" outside plant fiber Outside plant fiber considered as "okay" has 0.250 dB/km installed loss. "Okay" fiber has the following characteristics.

- 0.210 dB/km for pure fiber loss at 1550 nm

- 0.025 dB/km for initial splices every 4 km at 0.10 dB/splice

- 0.015 dB/km for future splice activity for repairs to the outside plant fiber and/or for initial splices that were not as good or more frequent

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"Good" outside plant fiber

Outside plant fiber considered as "good" has 0.225 dB/km installed loss. "Good" fiber has the following characteristics.

- 0.210 dB/km for pure fiber loss at 1550 nm
- 0.010 dB/km for initial splices every 6 km at 0.06 dB/splice
- 0.005 dB/km for future splice activity for repairs to the outside plant fiber and/or for initial splices that were not as good or more frequent

"Excellent" outside plant fiber

Outside plant fiber considered as "excellent" has 0.210 dB/km installed loss. "Excellent" fiber has the following characteristics.

- 0.200 dB/km for pure fiber loss at 1550 nm
- 0.007 dB/km for initial splices every 7 km at 0.05 dB/splice
- 0.003 dB/km for future splice activity for repairs to the outside plant fiber and/or for initial splices that were not as good or more frequent

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Wavelength Growth Plans

Overview

Purpose This section describes the plans for adding channels to a LambdaXtreme™ Transport system. LambdaXtreme™ Transport provides automatic gain control and gain tilt control to ensure that transmission performance is maintained as channels are added to the system. For this mechanism to work properly, channels must be added according to the plans described in this section. Separate plans are described that are tailored for the various systems (10G and 40G).

Four recommended wavelength growth plans for 10G systems are explained in this section:

- minimum startup cost and growth
- Growth Raman Pumps (RPGs) in the initial setup
- maximum flexibility with OADM
- OADM with RPGs in the initial setup

Two recommended wavelength growth plans for 40G systems are explained in this section:

- minimum startup cost and growth
- RPGs in the initial setup

□

10G Minimum Start-up Plus Growth

Minimum start-up   This is the most cost effective wavelength growth plan for a 10G startup system. The RPG packs are not populated until the wavelength count reaches 41. Refer to for an illustration of the wavelength growth plan having the minimum start-up cost in 10G systems.

Figure 5-3 Wavelength Growth for 10G Systems
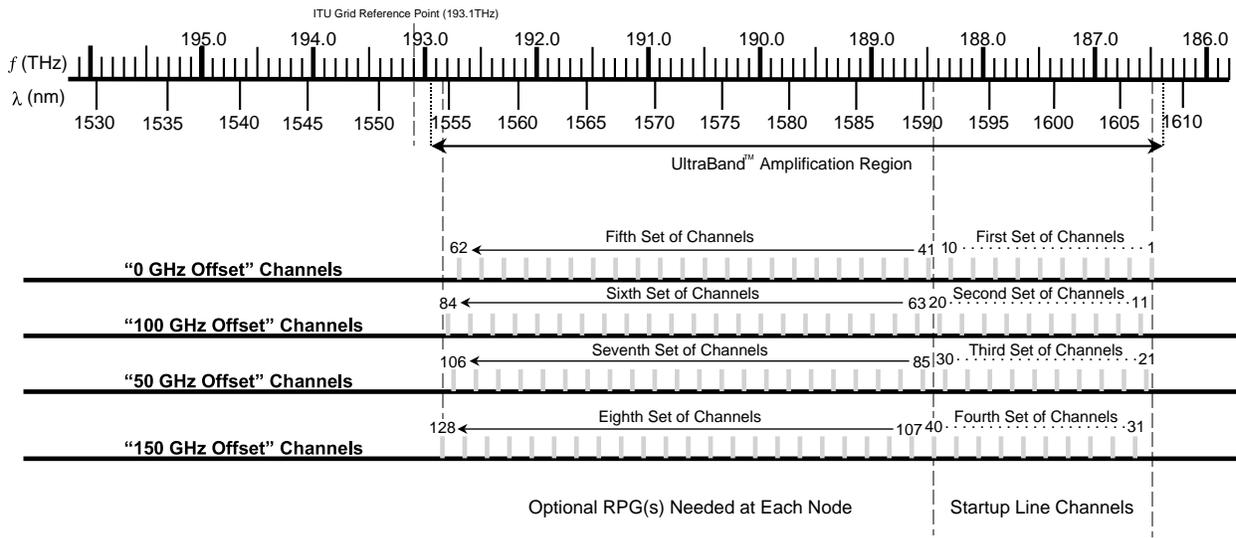
The first 40 channels are populated as described below.

- Channels 1 thru 10 to be the first 10 longest wavelength 0 GHz channels shown in the field called "First Set of Channels" (0 GHz OD/OM)

- Channels 11 thru 20 to be in the 10 longest wavelength 100 GHz Offset channels shown in the field called "Second Set of Channels" (100 GHz OD/OM)

- Channels 21 thru 30 to be in the 10 longest wavelength 50 GHz Offset channels shown in the field called "Third Set of Channels" (50 GHz OD/OM)

- Channels 31 thru 40 to be in the 10 longest wavelength 150 GHz Offset channels shown in the field called "Fourth Set of Channels" (150 GHz OD/OM)

- Note that the recommended Channels 1–40 as a group are called the Startup Line Channels.

Growth   To continue with the wavelength growth plan just described, Growth Raman Pumps are required:

- Channels 41 thru 62 would also be in the 0 GHz Offset channels, but in the field called "Fifth Set of Channels"

- Channels 63 thru 84 would also be in the 100 GHz Offset channels shown in the field called "Sixth Set of Channels"

- Channels 85 thru 106 would also be in the 50 GHz Offset channels shown in the field called "Seventh Set of Channels"

- Channels 107 thru 128 would also be in the 150 GHz Offset channels shown in the field called "Eighth Set of Channels"

Considerations   Adding channels (growing wavelengths) is based on add/drop needs and economic considerations.

In the recommended plan just presented:

- going from Channel 10 to Channel 11 will require adding 100G Offset OMs/ODs; however, if Channel 11 was kept on the 0G Offset Line it would require the addition of Raman Growth Pumps at each node.

- going from Channel 20 to Channel 21 will require adding 50G Offset OMs/ODs and a Line Bay; however, if Channel 21 was moved to the 0 GHz Offset Line, or kept on the 100G Offset Line, it would require the addition of Growth Raman Pumps at each node. Also, keep in mind that channels on the 50 GHz Line would have to be Express channels at an OADM Terminal.

- going from Channel 30 to Channel 31 will require adding 150G Offset OMs/ODs; however, if Channel 31 was moved to one of the previously discussed Lines, it would require the addition of Growth Raman Pumps at each node. Also, keep in mind that channels on the 150 GHz Line would have to be Express channels at an OADM Terminal.

Finally, Channels 41 thru 128 would be added as shown on the illustration, using the fields labeled "Fifth, Sixth, Seventh and Eighth Set of Channels."

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10G Using Initial RPG Packs

Basis of the plan   In the start-up plan just presented, the use of RPG packs was delayed as long as possible while employing up to 40 channels. If the use of RPG packs is known or anticipated, use the growth plan shown below, which has RPG packs employed in the initial setup.

Description   This plan requires RPG packs to be populated at each node. Refer to Figure 5-4, "Growth Plan Using Initial RPG Packs" (5-19) for this discussion.

- The first 32 wavelength channels are to be in the 0 GHz Offset channels (0 GHz OD/OM) shown in the field called "First Set of 32 Channels" as shown from 1–32.

- The second set of 32 channels are to be in the 100 GHz Offset channels (100 GHz OD/OM) shown in the field called "Second Set of 32 Channels" as shown from 33–64.

- The third set of 32 channels are to be in the 50 GHz Offset channels (50 GHz OD/OM) shown in the field called "Third Set of 32 Channels" as shown from 65–96.

- The fourth set of channels are to be in the 150 GHz Offset channels (150 GHz OD/OM) shown in the field called "Fourth Set of 32 Channels" as shown from 97–128.

Figure 5-4 Growth Plan Using Initial RPG Packs
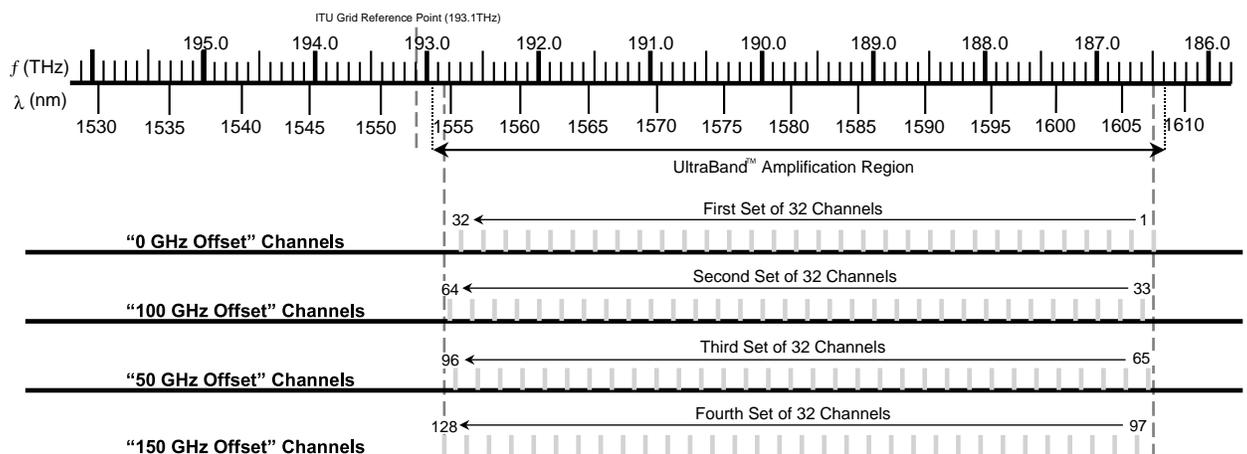
OADM Minimum Start-up and Growth

Introduction   Only even channels (0 and 100 GHz Offset channels) can be added
and/or dropped at the OADM terminals. This growth plan
recommends using odd channels (50 and 150 GHz Offset channels)
for wavelengths between End Terminals and even channels for
wavelengths at OADMs.

This growth plan requires a System Bay and a Line Bay to be
installed initially and assumes the RPG packs are not populated. (The
growth plan when RPG packs are populated initially is described later
in this section.)

Initial setup of 20/20
channels   For the initial setup, determine which wavelengths are to be Express
and which wavelengths are to be available for add/drop at the
OADM(s). The plan below shows how to arrange the first 20 Express
channels to go from End Terminal to End Terminal and how to
arrange the first 20 Add/Drop/Thru channels at the OADM. Refer to
[Figure 5-5, "Wavelength Growth for Maximum Flexibility of
OADMs" (5-21)](#) for an illustration showing this initial setup of 20/20
channels and the plan for growing the 20/20 arrangement.

End Terminal to End Terminal Express wavelengths:

- Channels 1 thru 10 to be in the 50 GHz Offset channels shown
  in the field called "First set of Express Channels"

- Channels 11 thru 20 to be in the 150 GHz Offset channels shown
  in the field called "Second Set of Express Channels"

OADM and End Terminal Add/Drop (A/D) wavelengths:

- Channels 21 thru 30 to be in the 0 GHz Offset channels shown
  in the field called "First Set of A/D Channels"

- Channels 31 thru 40 to be in the 100 GHz Offset channels shown
  in the field called "Second Set of A/D Channels"

If the channels for Express or Add/Drop exceed 20 wavelengths, then
RPG packs must be installed at each node. Channel assignments for

this situation are shown below and discussed in the block titled "Growing the 20/20 arrangement" (5-21).

Figure 5-5 Wavelength Growth for Maximum Flexibility of OADMs
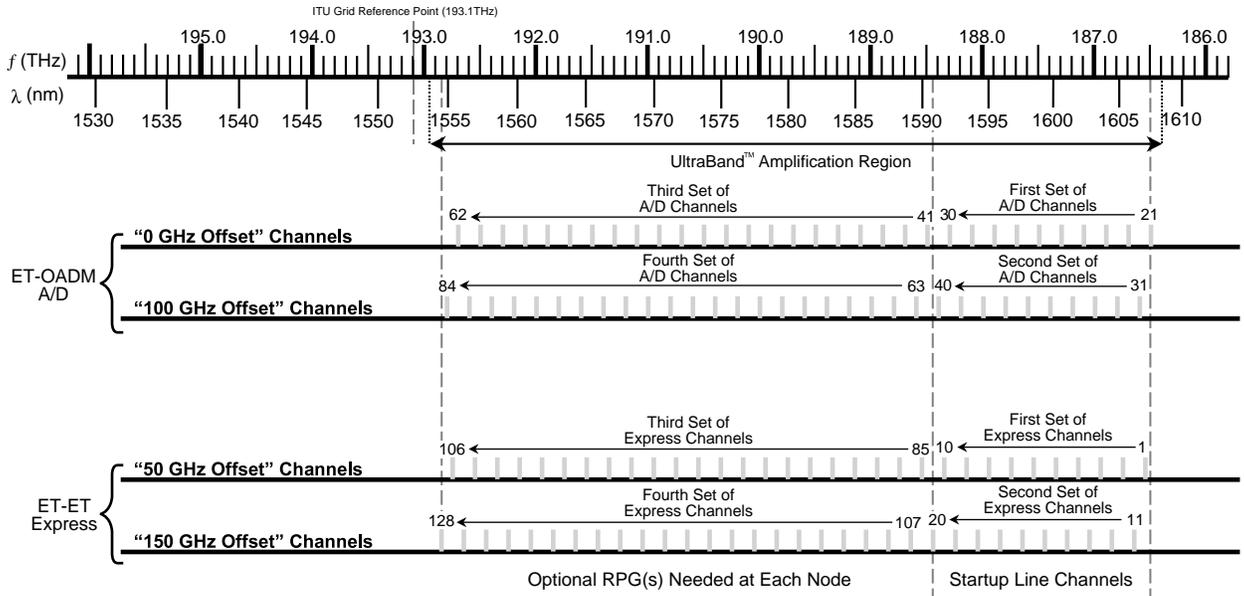
Growing the 20/20 arrangement

To increase channels beyond the 20/20 plan above, proceed as follows:

End Terminal to End Terminal Express wavelengths:

- Channels 85 thru 106 to be in the 50 GHz Offset channels as shown above in the field called "Third Set of Express Channels"

- Channels 107 thru 128 to be in the 150 GHz Offset channels as shown above in the field called "Fourth Set of Express Channels"

OADM and End Terminal Add-Drop (A/D) wavelengths:

- Channels 41 thru 62 to be in the 0 GHz Offset channels as shown above in the field called "Third Set of A/D Channels"

- Channels 63 thru 84 to be in the 100 GHz Offset channels as shown in the field called "Fourth Set of A/D Channels"

OADM Using Initial RPG Packs

Description   If RPG packs are installed initially, the following wavelength growth plan is recommended. Refer to Figure 5-6, "Growth Plan with RPGs Installed in Initial Setup" (5-22) for this discussion.

Figure 5-6 Growth Plan with RPGs Installed in Initial Setup
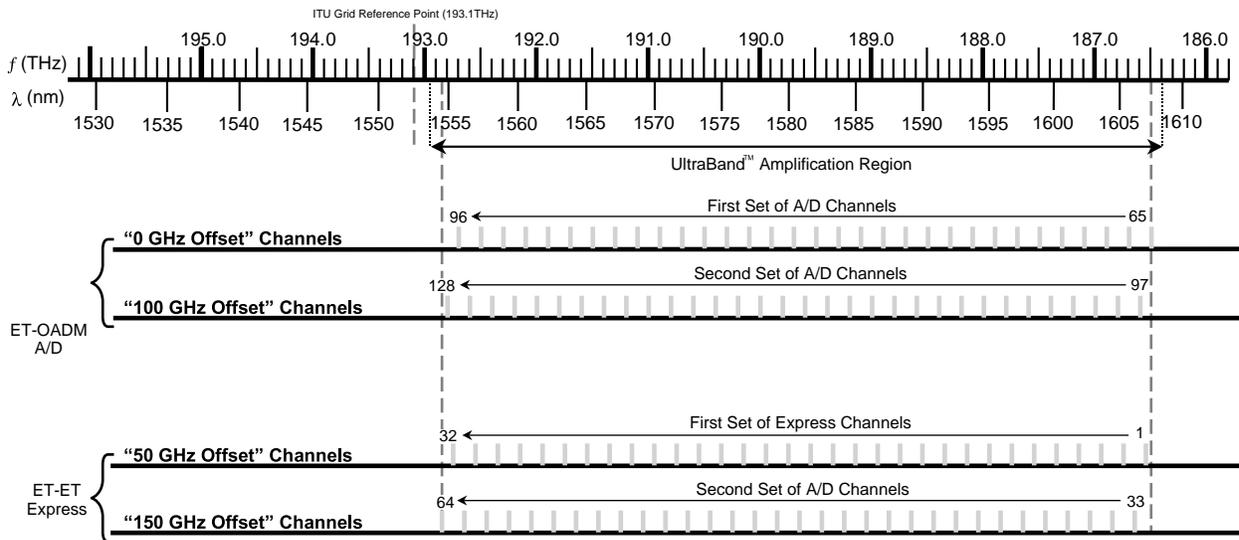
End Terminal to End Terminal Express wavelengths:

- Channels 1 thru 32 to be in the 50 GHz Offset channels as shown in the field called "First Set of Express Channels"

- Channels 33 thru 64 to be in the 150 GHz Offset channels as shown in the field called "Second Set of Express Channels"

OADM and End Terminal add-drop wavelengths:

- Channels 65 thru 96 to be in the 0 GHz Offset channels as shown in the field called "First Set of A/D Channels"

- Channels 97 thru 128 to be in the 100 GHz Offset channels as shown in the field called "Second Set of A/D Channels"

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40G Minimum Start-up and Growth

Minimum start-up   Refer to Figure 5-7, "Wavelength Growth for 40G Systems" (5-23) for an illustration of wavelength growth in 40G UHC systems. Included is the recommended growth plan.

It is recommended that the first 10 channels be the 0 GHz Offset channels shown in the field called "First Set of Channels" as shown from 1 to 10. Recommendation shows channels 11 thru 20 in the 100 GHz Offset channels, shown in the field called "Second Set of Channels." The recommended Channels 1–20, as a group, are called the Startup Line Channels.

Figure 5-7 Wavelength Growth for 40G Systems
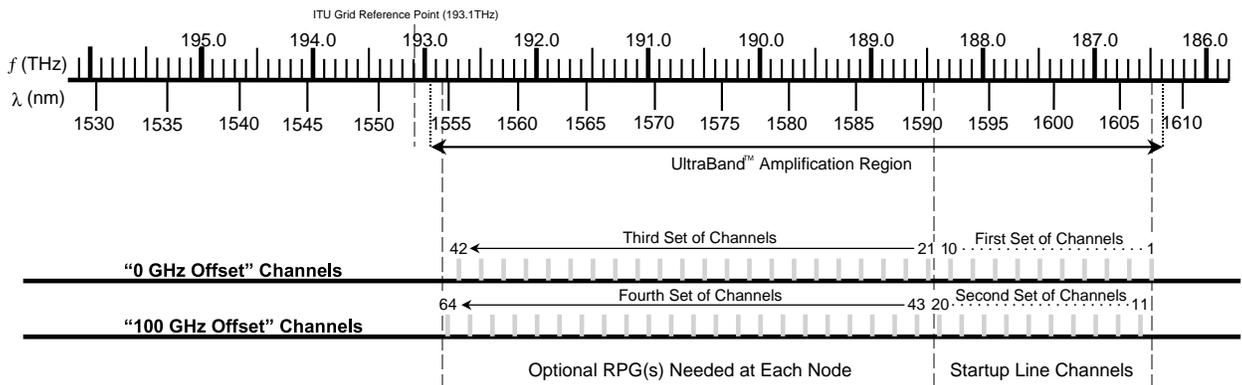
Growth   To grow the channel start-up plan, Channels 21 to 42 would also be in the 0 GHz Offset channels, but in the field called "Third Set of Channels." Channels 43 to 64 would also be in the 100 GHz Offset channels, but in the field called "Fourth Set of Channels." In this plan, adding channel 21 (and up) requires RPG packs at every node.

Considerations   Adding channels (growing wavelengths) is based on economic and performance considerations. In the recommended start-up plan, going from Channel 10 to Channel 11 will require adding 100G Offset OMs/ODs; however, if Channel 11 was kept on the 0G Offset Line it would require the addition of RPG packs at each node.

□

40G Using Initial RPG Packs

Basis of the plan   In the 40G start-up plan just presented, the use of RPG packs was delayed as long as possible while employing up to 20 channels. If the use of RPG packs is already known or anticipated, use the growth plan shown below, which has RPG packs employed in the initial setup.

Description   This plan requires RPG packs to be populated at each node. Refer to Figure 5-8, "40G Growth Plan Using Initial RPG Packs" (5-24) for this discussion.

- The first 32 wavelength channels are to be the 0 GHz Offset channels (0 GHz OD/OM) shown in the field called "First Set of 32 Channels" as shown from 1–32.

- The second set of 32 channels are to be in the 100 GHz Offset channels (100 GHz OD/OM) shown in the field called "Second Set of 32 Channels" as shown from 33–64.

Figure 5-8 40G Growth Plan Using Initial RPG Packs
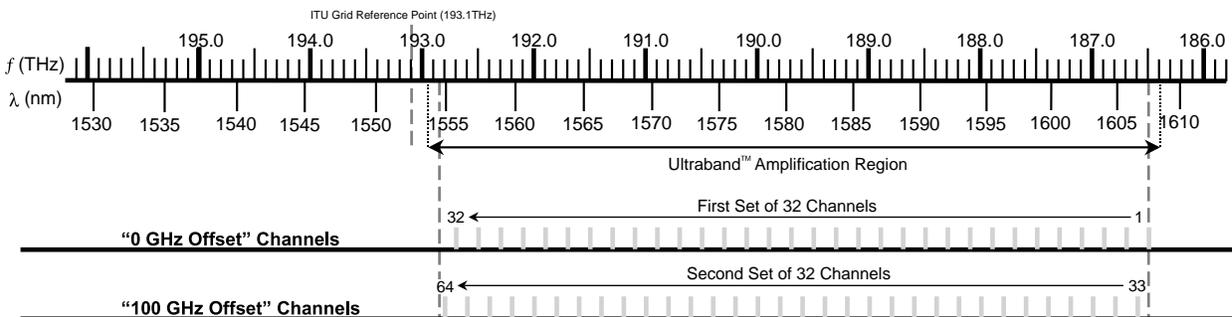
Bay Configurations

Overview

Purpose   This section describes the Bay Configurations used in LambdaXtreme™ Transport. The following pages show bay lineups for each supported system configuration. In each case the NETYPE is also listed. The NETYPE is a user-provisioned value that defines the required system configuration characteristics to the network element control system. The system software verifies that the system equipage of required circuit packs is satisfied for the specified NETYPE and alarms accordingly if required circuit packs are missing.

Types of bays   Each Network Element (NE) consists of one or more bays working together to form the system. There are four kinds of "bays" available in the system.

- *System Bay* — Every NE except the Repeater has a single System Bay. This bay contains the network controller double shelf with the Network Element Controller (NCTL) pack and other common control packs. The System Bay also contains circuit packs associated with the 64 0G/100G Offset Channels and the East line in the system.

- *Line Bay* — In 10G End Terminals, the Line Bay contains the common circuit packs associated with the second set (50G/150G Offset) of 64 channels in a 10G system.
  In OADM Terminals, the Line Bay contains the common circuit packs associated with the West line.
  Line Bays are not used in 40G UHC systems.

- *Extension Bay* — An NE may have one or more Extension Bays depending on the number of channel interfaces required.
  Extension Bays contain OT packs and associated Shelf Controller (SCTL) packs.

- *Repeater Shelf* — The Repeater is a miscellaneously-mounted network controller double shelf with the NCTL pack and other common control packs. The shelf also contains packs associated with the Repeaters for the lines.

Maximum number of bays The maximum number of bays needed for a given NETYPE is a function of the number of channels to be supported, whether OTs are used, what type of OTs are used, and if bays are restricted to specific office maximums for heat dissipation that are lower than Lucent prescribed normal operating conditions. The maximum number of bays in a LambdaXtreme™ Transport NE is 16.

- The bay descriptions and illustrations (Figures 5-9 through 5-12) show the maximum number of bays required to support all circuit packs except for the OT circuit packs. Every configuration can support additional Extension Bays and they are not shown explicitly for every configuration.

- OT packs may be inserted *only* into slots as shown in Figures 5-9 through 5-12.

- Each bay description (except the Repeater) lists the available OT slots and gives the maximum number of OT packs of a given width that can go in each bay before consideration of any thermal or power restriction. The total bay count for some typical situations is also given.

Physical configurations summary Refer to Table 5-11, "Number of Bays in a Network Element" (5-26) for a summary of the number of bays needed for a startup configuration and a fully loaded configuration of each LambdaXtreme™ Transport Network Element.

Table 5-11   Number of Bays in a Network Element

Configuration	# Bays at startup	# Bays fully loaded
10G End Terminal (w/1-slot LH OTs)	1 (up to 26 wavelengths)	3 (128 wavelengths)
10G End Terminal (w/2-slot ULH OTs)	1 (up to 12 wavelengths)	6 (128 wavelengths)
40G End Terminal	1 (up to 8 wavelengths)	4 (64 wavelengths)
10G Optical Add/Drop Multiplexer (OADM)	2 (up to 35 wavelengths with LH OTs; up to 17 wavelengths with ULH OTs)	3 for LH OTs or 4 for ULH OTs (64 wavelengths)

**Table 5-11   Number of Bays in a Network Element
(continued)**

Configuration	# Bays at startup	# Bays fully loaded
Repeater Shelf	0.5 bay, miscellaneously mounted	

Administrative groups

Bays in the LambdaXtreme™ Transport system are located together into convenient administrative groups.

- The first group in the system is the System Control Group. It has the System Bay together with any Line Bays and Extension Bays that the configuration supports. It has a maximum size of 5 bays.

- Up to 11 Remote Control Groups can be added to the system. Each Remote Control Group is composed of a maximum of 1 Extension Bay; therefore, the maximum number of bays in a LambdaXtreme™ Transport NE is 16 (5 system plus 11 remote).

- Remote Control Groups are restricted to a maximum of 100 meter control cable distance from the System Control Shelf in the first bay of the System Control Group.

- Bay to bay distance of up to 100 meters.

Control group connections

The NCTL is connected to a single control cable (carrying 100Base-TX Ethernet and long-reach control signals) to one SCTL per control group, designated the "group" SCTL. The "group" SCTL serves as a hub to the other SCTLs in the group for 100Base-TX Ethernet and long reach control. The "group" SCTL is normally the SCTL in the lower half of bay 1 in a control group, except in the case of a single shelf repeater where the "group" SCTL is the only SCTL.

Circuit packs and bay slots

Circuit packs may only be placed into the slots indicated in Figures 5-9 through 5-12 for each bay.

Node bay configurations rigidly concentrate the OM and OD packs to the minimum number of bays. They cannot be installed in any other slots. Particular wavelength "offsets" are indicated in the bay descriptions below to identify the particular OM or OD that goes into a given slot. There are fixed positions for all circuit packs, except OTs — depending on type/width.

BLANK circuit packs (cover panels) are required for all slots not occupied with other circuit packs.

**BAY/SHELF/SLOT
numbering and
identification**

In any arrangement, the first bay, in the first control group, is identified as A-1, and the second bay (if used) is A-2. Shelves in a bay are numbered from 1–4 (bottom to top). Slots are numbered from 1–15 (left to right). An Extension Bay in the first Remote Control Group is identified as B-1; then C-1 in the second Remote Control Group, followed by D-1, E-1, F-1, G-1, H-1, J-1, K-1, L-1, and M-1 in succeeding Remote Control Groups. (I-1 is not used).

Observe the following when numbering bays:

- the System Bay is always bay A-1

- a Line Bay, if used, is bay A-2

- in End Terminals, the first Extension Bay is A-3, even if there is no bay A-2

- for OADMs, we recommend the first Extension Bay be B-1. (Reserve bays A-3 through A-5, and the floor space for them, for future planning/expansion.)

- All Repeaters are numbered A-1.

When a bay is being identified, the method is to state BAY-A# (the number of the bay). When a shelf is being identified, the method is to state SHELF-A#-# (bay number followed by shelf number). And when a slot is being identified the method is to state SLOT-A#-#-# (bay number followed by shelf number followed by slot number).

Figures 5-9 thru 5-12 show slot access identifiers (AIDs) for each shelf in a bay. Note that the AIDs for packs that are wider than 30 mm are determined by the right-most slot AID that the pack occupies. This is normally the AID of the parent board that connects to the backplane.

☐

End Terminals

System NETYPE	2F_ET

All LambdaXtreme™ Transport Systems require at least two End Terminals.

Minimum startup configuration

Minimum startup of an End Terminal is one System Bay.

- Holds common packs for all 128 channels in a 128-channel (10G LH or ULH) system as well as OM, OD and OA optical packs
- Holds common packs for all 64 channels in a 64-channel (40G UHC) system as well as OM, OD and OA optical packs
- System Bay DCM/Fiber Spool Housing
  - 2 DCMs
  - 1 double tray for fiber storage
- Available OT slots:
  - SHELF-A1-1: 1 30 mm slot
  - SHELF-A1-2: 6 adjacent 30 mm slots
  - SHELF-A1-3: 9 adjacent 30 mm slots
  - SHELF-A1-4: 10 adjacent 30 mm slots

Optional Line Bay

This bay holds the common packs for the second 64 channels (50G/150G offset) in a 128-channel system. The common packs are: OM (150 Ghz Offset), OM (50 GHz Offset), OD (150 Ghz Offset), OD (50 GHz Offset), and OA (PreAmp High Gain). A Line Bay is not used in a 40G UHC System.

- DCM/Fiber Spool Housing
  - 1 DCM
  - 1 double + 1 single tray for fiber storage
- Available OT slots
  - SHELF-A2-1: 14 adjacent 30 mm slots
  - SHELF-A2-2: 6 adjacent 30 mm slots
  - SHELF-A2-3: 14 adjacent 30 mm slots
  - SHELF-A2-4: 10 adjacent 30 mm slots

Optional Extension Bay

Extension Bays are added when additional OT packs are required. Refer to <u>"Extension Bays" (5-33)</u> for additional information.

Available OT slots in an Extension Bay

The available OT slots in an Extension Bay are

- SHELF-A#-1: 15 adjacent 30 mm slots
- SHELF-A#-2: 15 adjacent 30 mm slots
- SHELF-A#-3: 15 adjacent 30 mm slots
- SHELF-A#-4: 15 adjacent 30 mm slots

OT pack density

For 30 mm-wide OT pack density:

- System Bay: 26 OT packs
- Line Bay: 44 OT packs
- Extension Bays: 60 OT packs, each Extension Bay

For 60 mm-wide OT pack density:

- System Bay: 12 OT packs
- Line Bay: 22 OT packs
- Extension Bays: 28 OT packs, each Extension Bay

For 90 mm-wide OT pack density:

- System Bay: 8 OT packs
- Line Bay: 13 OT packs
- Extension Bays: 20 OT packs, each Extension Bay

End Terminal for 10G LH and ULH 128-channel systems

Bay and channel allotment for End Terminals using LH and ULH OTs are shown in the following paragraphs.

10G LH OTs

For a 128-channel system using 30 mm-wide LH OT packs with 1 two-way channel per OT pack and no compatible optics for the system:

- System Bay: 26 channels
- Line Bay: 70 channels cumulative
- Each Extension Bay adds 60 channels
- 128-channel capacity available in 3 bays (1 System, 1 Line, 1 Extension)

10G ULH OTs

For a 128-channel system using 60 mm-wide ULH OT packs with 1 two-way channel per OT pack and no compatible optics for the system:

- System Bay: 12 channels

- Line Bay: 34 channels cumulative

- Each Extension Bay adds 28 channels

- 128 Channel capacity available in 6 bays (1 System, 1 Line, 4 Extension)

Mixed 10G Systems

A mixed LH and ULH End Terminal would have 3 to 6 bays, depending on the mix of LH and ULH OTs.

End terminal for 40G UHC 64-channel systems

For a 64-channel system using 90 mm-wide OT packs with 1 two-way channel per OT pack and no compatible optics for the system (for example, 64-channel End Terminal — 40G MUX OTs)

- System Bay: 8 channels

- Each Extension Bay adds 20 channels

- 64 Channel capacity available in 4 bays (1 System, 3 Extension)

For a 64-channel system using 90 mm-wide OT packs with 1 two-way channel per OT pack and no compatible optics for the system (for example, 64-channel End Terminal — 40G Through OTs):

- System Bay: 4 channels (two way)

- Each Extension Bay adds 10 channels

- 64 Channel (two-way) capacity available in 7 bays (1 System, 6 Extension)

Illustration   Figure 5-9, "End Terminal System Bay and Line Bay" (5-32) shows
an End Terminal having a System Bay (required) and a Line Bay.
Minimum configurations require only a System Bay. Line Bays are
only deployed in 10G systems using the 50G and 150G Offset OMs
and ODs. Line Bays are not used in 40G systems. Note that the OA
shown in SLOT-A1-2-7 is an OA (PreAmp High Gain) for a 10G
System Bay or an OA (PreAmp Low Gain) for a 40G System Bay.

Figure 5-9 End Terminal System Bay and Line Bay

System Bay | Line Bay

System Control Group

Extension Bays

....

Usage   Extension Bays are used when the System and Line Bay of an End
Terminal or OADM Terminal cannot house enough OT packs to
accommodate the number of channels in use.

DCM / Fiber Storage Housing has two double plus one single tray for
fiber storage.

Illustration   See Figure 5-10, "Extension Bay" (5-33) for an illustration of an
Extension Bay.

Figure 5-10   Extension Bay

....

Repeater Terminals

System NETYPE 2F_RPT

Components list Repeater Terminals contain the following packs:

- two OAs (one for each direction)
- two RPs (one for each direction)
- slots for two optional RPGs (depending on the number of channels used — one for each direction) Also, see table below.
- SUPVY pack
- control packs: SIO, CIO, NCTL, SCTL, OMON
- two power (PWR) packs

Matching RPGs with OAs

When RPGs are required to support channel growth, they must be chosen according to the type of OA that is used in each direction. The selection criteria is shown in the table below:

Table 5-12   Matching RPGs with OAs

Type of OA	Required RPG
OA (Raman)	RPG (DCF)
OA (Raman EDFA)	RPG (DCF)
OA (DGEF)	RPG

Stacking Repeater Terminals If you have a situation where two Repeaters (from two different systems) are in the same location, one Repeater can be stacked above the other Repeater, to save floor space. Refer to the *LambdaXtreme*™ *Transport Installation Manual and System Turn-up Services* for details.

Illustration See Figure 5-11, "Repeater Shelf — Line drawing" (5-35) for an illustration of a complete, two-way Repeater.

Figure 5-11 Repeater Shelf — Line drawing

OA	RPG	RP OSP	RP OSP
1 w	1 w	1 w	1 e

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

Fan for NCDS

S I O	N C T L	S U P V Y	OA	RPG	O M O N L	S P R	P w R	16c C I O 16b P w R 16a
			1 e	1 e				

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

DCM Storage Housing

Miscellaneous Mount Shelf

System Control Group

□
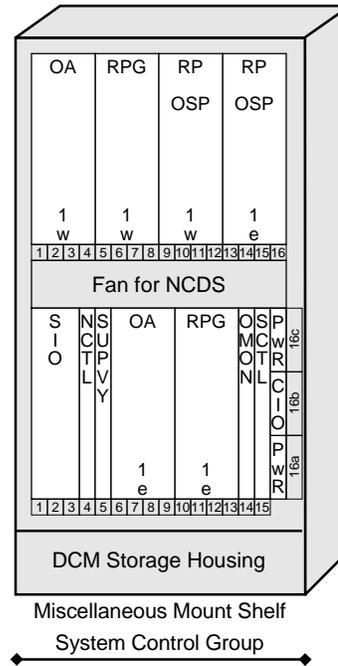
OADM Terminals

System NETYPE   2F_OADM

Important! OADM Terminals are only used in 10G systems.

Minimum startup configuration   Minimum startup that enables in-service upgrades is 1 System Bay and 1 Line Bay

- Holds common packs for all 0G and 100G Offset channels. The System Bay has the East side components and the Line Bay has the West side components.

- Available OT slots:
    - SHELF-A1–1: none
    - SHELF-A1–2: none
    - SHELF-A1–3: 9 adjacent 30 mm slots
    - SHELF-A1–4: 6 adjacent 30 mm slots
    - SHELF-A2–1: none
    - SHELF-A2–2: none
    - SHELF-A2–3: 10 adjacent 30 mm slots
    - SHELF-A2–4: 10 adjacent 30 mm slots

Optional Extension Bay   Extension Bays are added when additional OT packs are required. Refer to for additional information.

Available OT slots in an Extension Bay

The available OT slots in an Extension Bay are

- SHELF-A#-1: 15 adjacent 30 mm slots
- SHELF-A#-2: 15 adjacent 30 mm slots
- SHELF-A#-3: 15 adjacent 30 mm slots
- SHELF-A#-4: 15 adjacent 30 mm slots

OT pack density   For 30 mm-wide OT pack density:

- System Bay: 15 OT packs
- Line Bay: 20 OT packs
- Extension Bays: 60 OT packs, each Extension Bay

For 60 mm-wide OT pack density:

- System Bay: 7 OT packs
- Line Bay: 10 OT packs
- Extension Bays: 28 OT packs, each Extension Bay

For 90 mm-wide OT pack density:

- System Bay: 5 OT packs
- Line Bay: 6 OT packs
- Extension Bays: 20 OT packs, each Extension Bay

10G 128-channel systems

Bay and channel allotment for OADM Terminals using LH and ULH OTs are shown in the following paragraphs.

10G LH OTs

For a 128-channel system, with 64 channels of Add/Drop on both East and West sides using 30 mm-wide LH OT packs with 1 two-way channel per OT pack and no compatible optics for the system (for example, 128-channel OADM Terminal — 10G LH Add/Drop OT):

- BAY-A1+BAY-A2: 17 channels (per direction) cumulative (two-way) add/drop capacity in first 2 bays (1 extra slot)
- Each Extension Bay adds 30 channels (per direction)
- 64 Add/Drop Channel capacity available in 4 bays (1 System, 1 Line, 2 Extension)

10G ULH OTs

For a 128-channel system with 64 channels of Add/Drop on both East and West sides using 60 mm-wide ULH OT packs with 1 two-way channel per OT pack and no compatible optics for the system (for example, 128-channel OADM Terminal — 10G ULH Add/Drop OT or 4x2.5G to 10G LH Muxing 10G):

- BAY-A1+BAY-A2: 8 channels (per direction) cumulative (two-way) Add/Drop capacity in first 2 bays (3 extra slots)
- Each Extension Bay adds 14 channels (per direction)
- 64 Add/Drop Channel capacity available in 6 bays (1 System, 1 Line, 4 Extension)

Mixed 10G systems

A mixed LH and ULH OADM Terminal with 128 channels would have 4 to 6 bays, depending on the mix of LH and ULH OTs.

Illustration   See Figure 5-12, "OADM System Bay and Line Bay" (5-38) for an illustration of an OADM System and Line Bay. Minimum configurations require a System Bay and a Line Bay. OADM System Bays are for OTs as required and components associated with the East-side traffic; OADM Line Bays are for OTs as required and components associated with the West-side traffic.

Figure 5-12 OADM System Bay and Line Bay

System Bay

OD 32 chan 100G 1 e | OA Pre Amp High Gain Drop 1 e | OT Slots 6x 30 mm | OM 32 chan 100G 1 e

Fan for NCDS

SIO | NCULV | STPVY | OT Slots 9x 30 mm | SCTRL | PwR CIO PwR

OD 32 chan OADM 0G 1 e | OMON 1 e | OADM Line Out 1 e | OADM Add 1 e | OM 32 chan OADM 0G 1 e

Fan for HDDS

OA OADM thru 1 e | OA OADM LineIn 50G / 100G 1 e | RPG Exp, DCF 1 e | RP OSP 1 e | SCTRL | PwR CIO PwR

DCM / Fiber Storage Housing

Line Bay

OD 32 chan 100G 1 w | OT Slots 10x 30 mm | OM 32 chan 100G 1 w

Fan for HDDS

OA Pre Amp High Gain Drop 1 w | OT Slots 10x 30 mm | SCTRL | PwR CIO PwR

OD 32 chan OADM 0G 1 w | OMON 1 w | OADM Line Out 1 w | OADM Add 1 w | OM 32 chan OADM 0G 1 w

Fan for HDDS

OA OADM thru 1 w | OA OADM LineIn 50G / 100G 1 w | RPG Exp, DCF 1 w | RP OSP 1 w | SCTRL | PwR CIO PwR

DCM / Fiber Storage Housing

System Control Group

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Data Communications Network (DCN) Rules

Overview

Purpose This section presents the Data Communications Network (DCN) Engineering Rules and Topology Rules. Data Communications Network (DCN) is the internal private LambdaXtreme™ Transport network that provides IP-based messaging and routing for LambdaXtreme™ Transport network management.

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DCN Engineering Rules

Network attribute values and limits

Table 5-13, "Network Attribute Values and Limits" (5-40) lists the network attributes and their limits to aid in engineering a Data Communications Network (DCN). Following the table is a series of notes to define the parameter constraints specified in the table. Figure 5-13, "DCN Engineering Rules Illustrated" (5-41) illustrates the values and limits shown in the table.

Table 5-13   Network Attribute Values and Limits

Network Parameters Constraints	Amount
Maximum number of nodes in an OLS[1]	128
Maximum number of socket connections that can be sourced by a node[2]	128
Maximum number of unique incoming logins[3]	8
Maximum number of socket connections at CIT port[4]	5
Maximum number of socket connection at EMS port[5]	16
Maximum number of hops between nodes (to allow end-to-end communication)[6]	127
Maximum number of simultaneous file transfers[7]	16
Maximum number of same Non-Super User UID login sessions per NE	1
Maximum number of same Super User UID login sessions per NE	29

Notes:

1. ***Maximum number of nodes in an OLS:*** Nodes that are intermediate between two End Terminals. A DCN is limited to one OLS; therefore, this would also equal the total number of nodes in the whole network.

2. ***Maximum number of socket connections that can be sourced by a node:*** A socket connection is required to be sourced for each data session to a remote node from a GNE. Thus a user may simultaneously remote login to a maximum of 128 nodes via a GNE. (Note: for the CIT this only applies to cut-through mode)

3. ***Maximum number of unique incoming logins:*** The number of simultaneous logins that can be accepted by a given node over a

supervisory channel.

4. ***Maximum number of socket connections at CIT port:*** The number of
   CIT logical connections that can be simultaneously supported over the
   single physical CIT port on the NE. Note: Each logical or socket
   connection is associated with only one UID per NE. (That is, multiple
   different UID login sessions over the same socket connection are not
   allowed to the same NE).

5. ***Maximum number of socket connections at EMS port:*** The number of
   EMS logical connections that can be simultaneously supported over the
   single physical EMS port on the NE. Note: Each logical or socket
   connection is associated with only one UID per NE. (That is, multiple
   different UID login sessions over the same socket connection are not
   allowed to the same NE).

6. ***Maximum number of hops between nodes:*** Maximum number of hops
   allowed to reach from source node to a destination node.

7. ***Maximum number of simultaneous file transfers:*** Maximum number
   of software image or database transfers permitted via a GNE.

Figure 5-13 DCN Engineering Rules Illustrated
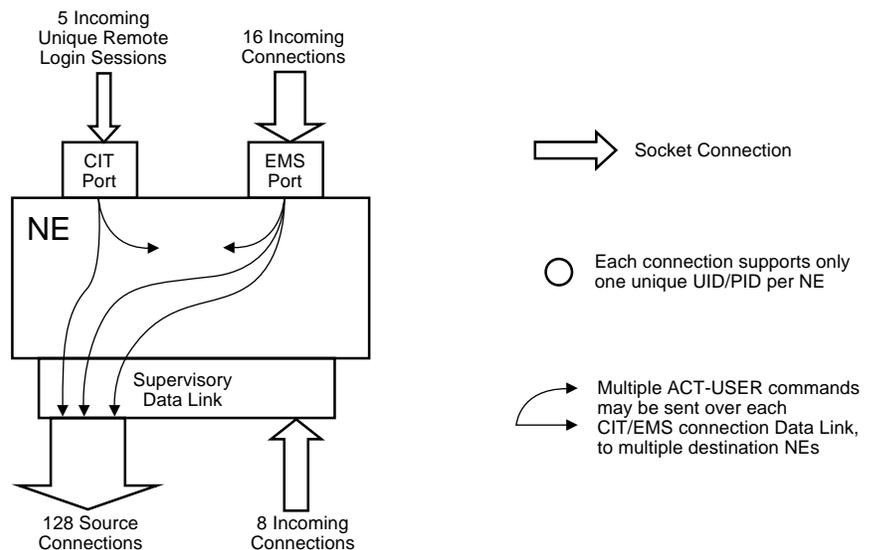
**Redundant network
management path**

LambdaXtreme™ Transport can provide a setup for a redundant
network management path between a selected EMS and the given
LambdaXtreme™ Transport Optical Line System (OLS). Dual
connections from an EMS to LambdaXtreme™ Transport OLS ensure
accessibility to the OLS in the event of a fiber cut and/or loss of DCN
connectivity at one end, as illustrated in Figure 5-14, "Redundant
Network Management Path" (5-42).

Figure 5-14 Redundant Network Management Path
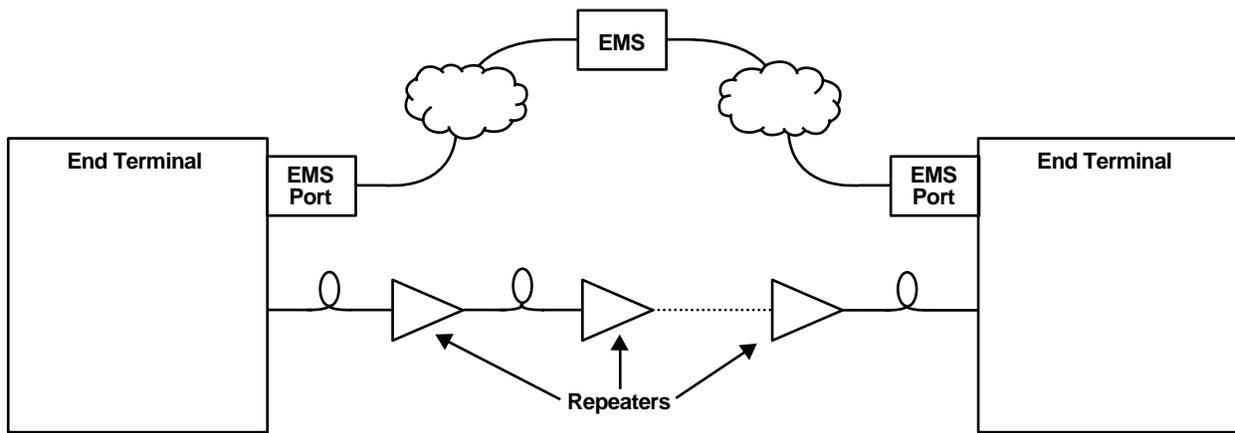
Environmental Considerations

Overview

Purpose   This section describes the environmental considerations for the
LambdaXtreme™ Transport system:

- operating specifications and standards

- standards compliance

- handling and transportation

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Environmental Specifications

Operating specifications and standards

Refer to Table 5-14, "System Environmental Operating Conditions" (5-44), for the normal environmental conditions under which LambdaXtreme™ Transport is designed to operate:

Table 5-14   System Environmental Operating Conditions

Operating Parameter	Specification
Normal Operating Temperature Range	$+5^{o}$C to $+40^{o}$C ($+41^{o}$F to $+104^{o}$F)
Short-term[1] Operating Temperature Range	-5°C to $+50^{o}$C ($+23^{o}$F to $+122^{o}$F)
Normal Operating Humidity[2]	5% to 85%
Short-term Operating Humidity	5% to 90%
Maximum Rate of Temperature Change	30°C/hr (54°F/hr)

Notes:

1. Short-term refers to a period of up to 96 consecutive hours, up to a total of 15 days in one year.

2. Non-condensing

Standards compliance

Earthquake and vibration, fire resistance, and airborne contaminant requirements meet the standards of GR-63-CORE Issue 1 (October 1995).

Electrostatic, electromagnetic, electrical grounding, and safety requirements meet standards of GR-1089-CORE Issue 1 (November, 1994) as well as NEBS Level 3.

LambdaXtreme™ Transport meets the electromagnetic compatibility requirements (EMC) of GR-1089-CORE.

LambdaXtreme™ Transport is *UL*® listed, *CSA*® certified, and CE marked.

LambdaXtreme™ Transport conforms to ITU-Recommendation K.41: Resistibility of internal interfaces of Telecommunications Centres to Surge Overvoltages, May 1998.

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Handling and Transportation Specifications

Handling and transportation

Refer to Table 5-15, "System Handling and Transportation Conditions" (5-45), for the handling and transportation conditions that apply to LambdaXtreme™ Transport.

Table 5-15   System Handling and Transportation Conditions

Operating Parameter	Specification
Vibration and Shock	Compliant with GR-63-CORE Issue 1 (October 1995)
Temperature (Storage)	-40°C to +70°C (-40°F to +158°F)
Relative Humidity (Storage)	5% to 95%
Storage/Transportation Altitude	-200 ft. to 40,000 ft. (-61m to 12,133m)

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6   OAM&P

Overview

Purpose   This chapter provides high-level, introductory information on Operations, Administration, Maintenance, and Provisioning (OAM&P) of the LambdaXtreme™ Transport system. For details describing these features and the associated procedures, refer to the *LambdaXtreme™ Transport User Operations Guide* and the *LambdaXtreme™ Transport Alarms, Messages, and Trouble Clearing Guide*.

Briefly, the OAM&P performs the following functions:

- provide individual alarm severities

- set/retrieve thresholds

- provision Threshold Crossing Alerts (TCAs)

- generate reports

- retrieve equipage data

- retrieve optical power levels (where optical monitoring is provided) at each node

- automatic reporting of alarms/events (for example, LOS)

- remote provisioning and retrieval of add/drop/thru capability at each node

- perform startups and booting

- Performance Management reporting and retrieval

Contents

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Operations

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Overview
The user/administrator has operational access to the LambdaXtreme™ Transport system primarily through the System Input/Output (SIO) interface. Refer to Figure 4-52, "SIO — Faceplate Drawing" (4-92) for an illustration of the SIO front panel.

The SIO provides access to the following interfaces:

- System controllers
- Element Management System (EMS) interface
- Supervisory channel
- Craft Interface Terminal (CIT)
- Orderwire
- miscellaneous discrete interfaces
- remote start
- office alarms
- red and green LEDs

System controllers
Each double shelf in LambdaXtreme™ Transport has a Shelf Controller (SCTL) circuit pack. The System Control Group SCTL is under control of a Network Element Controller (NCTL) and it controls the non-group SCTLs that are in the same System Group. The same is true in remote control groups. In this context, "control" means to know the equipage and to perform resets.

EMS interface
The EMS interface to the Network Element (NE) and LambdaXtreme™ Transport network is provided on the SIO.

Characteristics

The EMS interface has the following characteristics

- 10/100Base-T LAN interface
- TL1 application protocol
- TCP/IP communications protocol

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- the EMS interface message set includes input commands, output responses (solicited outputs), and autonomous outputs (alarms and events)

- the TL1 message set and application interface are usable by the CIT

Gateway Network Element (GNE)

Through the OS interface, any End Terminal or OADM within the network can be a GNE. Provisioning of a GNE is not required.

Supervisory channel

The Optical Supervisory Channel (OSC) uses an OC-3 signal, which counter propagates in relation to the direction of the transmission signals in the optical line, to provide the communications link between LambdaXtreme™ Transport ETs, Repeater nodes, and the OADM nodes within the Optical Line System (OLS).

Craft Interface Terminal (CIT)

The interface to the CIT is a 10/100Base-T LAN interface running the TL1 application protocol over TCP/IP.

A CIT user can establish a CIT-NE session with the "local" NE (the NE to which the CIT is physically connected) or with a remote NE. Communication between the local/gateway NE and the remote NE is over the LambdaXtreme™ Transport Inter-Node DCN (the Optical Supervisory Data Links). Also, the CIT may connect to the EMS interface for remote WAN/LAN/Dial-Up connection types.

CIT users can maintain multiple CIT-NE applications (logins) with several different NEs. However, a single CIT user may have only one active session to each unique NE from the same CIT. Super-Users may log in multiple times to a single NE.

Orderwire (OW)

An Orderwire is a section of the Supervisory signal used for voice communication between LambdaXtreme™ Transport nodes.

Description

Orderwire communications is established using external OW terminal sets and internal OSC capacity. Six orderwire interfaces are provided (two 64 Kbps channels and one 192 Kbps channel for East and West directions). The orderwire connections (DB-15S) are located on the front panel of the SIO circuit pack. Each Engineered Orderwire (EOW) interface consists of clock, data, and sync signals. The

orderwire data is packetized and transmitted to appropriate channels via the OSC.

External access

Features and functionality for the orderwire are provided through an external orderwire terminal.

Signals

The appropriate signals, such as RS-485 Clock, Sync, and Data are provided for input and output to implement the full complement of orderwires.

Provisioning

The orderwire interface can be provisioned as Local (orderwire signal is bridged) or Express (orderwire signal is passed through); see the *LambdaXtreme™ Transport User Operations Guide* for the procedure. Each orderwire is initially provisioned to be Local.

Miscellaneous Discrete Interfaces

LambdaXtreme™ Transport NEs have Miscellaneous Discrete Interfaces (MDIs) to provide environmental input points and control output points. The internal and external handling of these points is discussed in the paragraphs below. Refer to *LambdaXtreme™ Transport User Operations Guide.* for a detailed discussion of these interfaces, including procedures for provisioning the environmental input points and control output points.

Each LambdaXtreme™ Transport can sense any individual contact closure for the environmental input points and output an appropriate, autonomous TL1 message over the EMS-NE and CIT-NE interfaces.

Each point can be labeled by the software for EMS/CIT requests, responses, and notifications. Also, the EMS/CIT can activate/release any control output point.

Remote start

The Remote Start interface allows a user to remotely shut down, and restart, an NCTL circuit pack. This would be done if the NCTL were not responding to OS commands.

This interface also uses miscellaneously discrete interfaces to monitor certain environmental conditions, such as AC on/off, door open/closed, and to do some controls as provisioned by the customer. Refer to the *LambdaXtreme™ Transport User Operations Guide* for procedures.

Office alarms   Office alarms are displayed on a Fan Assembly and Office Alarm
                      Display Assembly. Separate LEDs display the severity level of the
                      received alarm. The severity of alarms is provisionable by using the
                      Alarm Severity Assignment (ASA) feature. Refer to *LambdaXtreme*™
                      Transport User Operations Guide. for provisioning with the ASA
                      feature and to *LambdaXtreme*™ *Transport Alarms, Messages, and*
                      Trouble Clearing Guide for procedures on clearing alarms.

NCTL and SUPVY   For internal use only.

Red and green LEDs There are two LEDs on each circuit pack (a red LED to display the
                      presence of a fault and a green LED to display that the pack is
                      active).

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                      See notice on first page   Issue 1, June 2002

Administration

Version recognition	LambdaXtreme™ Transport provides the following version recognition features:

- automatic identification of the type of circuit pack installed in each slot, including apparatus code and recognition of the manufacturing serial number

- recognition of Common Language Equipment Identifier (*CLEI*™) codes and Equipment Catalog Item codes for each circuit pack

- recognition of hardware versions (series numbers)

For a complete discussion of the LambdaXtreme™ Transport version recognition features, refer to the *LambdaXtreme™ Transport User Operations Guide.*

Security	LambdaXtreme™ Transport has a robust system of security features to protect against unauthorized access.

System security features include

- administration of external link data channels

- identity, authentication, and access control features

- logins and passwords for superuser and users

- functional command categories and corresponding authorization levels

For a complete discussion of the LambdaXtreme™ Transport security features and the procedures to implement them, refer to the *LambdaXtreme™ Transport User Operations Guide.*

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Performance Management

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Definition   **Performance Management** The in-service, non-intrusive monitoring of transmission and equipment quality.

Description   LambdaXtreme™ Transport systematically tracks the signal quality and equipment health through continuous collection and analysis of data that is obtained by observing its performance. Performance parameters may be either analog or digital for each entity that is measured for the purpose of both proactive and reactive maintenance. Refer to *LambdaXtreme™ Transport Alarms, Messages, and Trouble Clearing Guide* for details on the Performance Management feature.

Analog parameters are optical signal power measurements performed at multiplexed optical line and on a per-channel basis in a Network Element. Digital parameters are observed at Optical-Electrical-Optical interfaces from SONET/SDH and Digital *WaveWrapper*™ frames, such as Coding Violations (CV), Errored Seconds (ES), Severely Errored Seconds (SES), Forward Error Correction Error Corrected (FEC-EC) and so forth.

Many performance parameters have thresholds that are established by provisioning. Detecting a performance parameter that has crossed its threshold indicates a potential network quality or performance degradation, while the services being transported have not failed.

Performance parameters   LambdaXtreme™ Transport supports the following classes of performance parameters:

- optical line analog
- optical channel analog
- optical channel digital
- client signal digital
- supervisory channel
- supervisory digital

Registers are used to track and report performance data. Performance Management registers exist for both 15-minute and 24-hour data bins for each of the analog and digital parameters.

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Performance parameter thresholds Performance parameter thresholds are set to alert the user of performance degradation. There are two types of thresholds:

- Counter-threshold, which is associated with digital parameters and can be user provisioned

- Gauge-threshold, which is associated with analog parameters, and some can be user-provisioned

QoS alarm events Threshold crossings are reported as Quality of Service (QoS) alarm messages/event notifications on the individual, monitored parameters. A QoS alarm message is triggered whenever a monitored performance parameter crosses the high or low threshold associated with the parameter.

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Fault Management

Overview	Maintenance of a LambdaXtreme™ Transport optical network consists of Performance Management (introduced in the previous section) and Fault Management (introduced in this section). Fault management parameters include anomalies, defects, failures, alarms, conditions, and events.
Fault management definitions	**fault management** The generation and subsequent clearing of conditions and events that are related to trouble detection, sectionalization, isolation, resolution, and repair verification necessary to maintain the network. For complete coverage of LambdaXtreme™ Transport fault management procedures, refer to the *LambdaXtreme™ Transport Alarms, Messages, and Trouble Clearing Guide.*
	anomalies A discrepancy between the actual and desired characteristics of an item.
	defects A limited interruption in the ability of an item to perform a required function.
	failures The termination of the ability of an item to perform a required function.
	alarms The notification of a failure by enabling the contact closure on the alarm grid. An autonomous message is generated to report this alarm, and the fault LED on the circuit pack may be turned on or blinking depending on the severity and type of alarm.
	conditions An event that persists in time and indicates that there is a condition in the system. The condition may, or may not, be a problem.
	events Something that happens at a particular time.

There are four kinds of events:

- a condition starting
- a condition clearing
- an autonomous action by the system
- a user action

Fault management entities   The entities managed by the fault management system of
LambdaXtreme™ Transport are

- defects, integration and timing

- optical transmission section failure

- optical multiplex section failure

- optical channel overhead formats and optical channel trace

- optical channel failure

- SONET LOS and LOF failures

- J0 Byte Section trace

- supervisory channel failure

- circuit pack failures (based on external and internal parameters)

- circuit pack removal and insertion

- control system maintenance

- service-affecting alarms

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Optical Channel Provisioning

Overview   For LambdaXtreme™ Transport, an optical channel connection is defined as two connectivity paths within a LambdaXtreme™ Transport NE traveling in opposite directions. These two paths are the input and output of the same customer signal and have the same grid frequency. The connection begins from the customer source point, through the NE, to the appropriate ports at the exit point of the NE. An optical channel connection may consist of multiple point to point connections within an NE which are used to add, drop, or pass through an optical channel. Provisioning of optical channel connections is performed on the NE to enable fault and performance monitoring of the provisioned channel.

For complete coverage of provisioning LambdaXtreme™ Transport, refer to the *LambdaXtreme™ Transport User Operations Guide.*

Methods of optical channel provisioning   There are two methods of provisioning an optical channel, which are distinguished from one another by the way in which they are done and undone.

The two methods of provisioning are

- automatic provisioning — for connections with Optical Translators (OTs)
- manual provisioning — for compatible optics connections

Automatic provisioning   Automatic provisioning is accomplished for optical channels by a two-step, automatic process called autodiscovery and autoprovisioning. No provisioning commands need to be entered by the user.

When an NE discovers a newly added optical client signal to an OT, this is referred to as autodiscovery of an optical channel. Upon discovery, the NE automatically provisions the autodiscovered channel into the NE database.

Manual provisioning   Autodiscovery does not apply to compatible-optics connections, since Optical Translators (OTs) are not used on LambdaXtreme™ Transport for these types of connections. Therefore, compatible optics connections need to be provisioned manually via the CIT or EMS/NMS interfaces. For details, see the *LambdaXtreme™ Transport User Operations Guide.*

Manual provisioning requires the user to explicitly specify the connection characteristics. Optical channel connections can be entered in the NE database, retrieved (viewed) from the database, or deleted from the database.

Issuing manual provisioning commands

Manual provisioning commands can be issued by:

- CIT GUI
- EMS/NMS GUI
- CIT/EMS TL1 cut through interface

Manual provisioning commands can be issued by the EMS-TL1 interface or the CIT. For complete coverage refer to the *LambdaXtreme™ Transport User Operations Guide.*

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7   Product Support

Overview

Purpose   This chapter describes how Lucent Technologies supports the LambdaXtreme™ Transport product. Product support includes ordering equipment, engineering and installation services, technical support, warranty, documentation, and training.

Contents

Ordering

Introduction	Ordering the LambdaXtreme™ Transport system can be viewed as ordering two End Terminals, the appropriate number of Repeaters, and Optical Add/Drop Multiplexers (OADMs). Predefined kits or subsystems in each section are used to build a complete system. Additional transponders and circuit packs can be ordered to upgrade the system. Ordering replacement parts can also be done. Refer to Engineering Drawing ED-8C861-10, supplied with this document, for complete ordering information.
Engineering Drawing ED-8C861–10	See Engineering Drawing ED-8C861-10 for a list of LambdaXtreme™ Transport system and component parts (including fiber kits and installer cables). ED-8C861-10, which is supplied with this document, provides the equipment identifying codes, Comcodes, and *CLEI*™ numbers for all LambdaXtreme™ Transport entities.
	ED-8C861-10 also details the interconnect entities through system life cycle and presents floor plan data, equipment elevation views, and interconnect terminations.
Initial Order Kit	The required software and documentation for LambdaXtreme™ Transport is supplied in an Initial Order Kit. The software is on a CD-ROM and the documentation is on paper.
	The comcode for the Initial Order Kit is 109266353, and includes the following items:

- LambdaXtreme™ Transport Software Release Description on paper, comcoded as 109266585
- CD-ROM programmed with LambdaXtreme™ Transport Software R1.1.0, comcoded as 109266528
- CD-ROM programmed with LambdaXtreme™ Transport Documentation Release 1.1.0 comcoded as 109266551, comcoded as 109266528
- Application Software Right to Use Fee
- Operating System Software Right to Use Fee

Ordering software and documentation	To order software, refer to the LambdaXtreme™ Transport Release 1.0 Software Ordering Guide (365-575-797).

A CD-ROM with the LambdaXtreme™ Transport Release 1.1.0 software can be ordered separately using comcode 109266528.

The LambdaXtreme™ Transport Software Release Description (paper copy) can be ordered separately using comcode 109266585.

To order a paper copy of the complete LambdaXtreme™ Transport documentation set for Release 1.1, use comcode 109210518.

The set includes the following documents:

- Applications and Planning Guide (365-575-780R1.1)
- User Operations Guide (365-575-781R1.1)
- Installation Manual and System Turn-up Services (365-575-782R1.1)
- Alarms, Messages, and Trouble Clearing Guide (365-575-783R1.1)
- Software Ordering Guide (365-575-797)

See "Documentation Support" (7-40) for a complete discussion on how to order documentation.

Software tools for ordering equipment

Software tools (based on an engineering configurator) for ordering LambdaXtreme™ Transport equipment are available on various platforms:

- Lucent e-Commerce (contact your Lucent Account Representative)
- SITE (on the web, for the North American Region)
- TIPSYS (for the rest of the world)

Terminal Kits

To assist in ordering, there are kits for each Network Element (NE). See Table 7-1, "Selecting Terminal Kits for Ordering" (7-3). Orders are placed by NE or physical customer sites, as outlined in the table. Following the table are discussions on individual components and where they are employed.

Table 7-1   Selecting Terminal Kits for Ordering

End Terminal (ET)	Repeater Shelf	OADM Terminal
System Bay (ETSI or Seismic)	Repeater Bay (ETSI or Seismic or None)	System/Line Bays (ETSI or Seismic)

Table 7-1   Selecting Terminal Kits for Ordering   (continued)

End Terminal (ET)	Repeater Shelf	OADM Terminal
ET Common Equipment Kit (10G or 40G)	Repeater Common Equipment Kit	OADM Common Equipment Kit
Dispersion Compensation Modules (DCMs)	Dispersion Compensation Modules (DCMs)	Dispersion Compensation Modules (DCMs)
Wavelengths (OT packs)	Optical Amplifiers (OAs)	Wavelengths (OT packs)
Growth packs (RPGs)	Growth packs (RPGs)	Growth packs (RPGs)

Determining which circuit packs to order

Use the following descriptions and tables as an aid to selecting the circuit packs needed to populate the bays.

Optical Translators (OTs)

Every OT supports transmit and receive communication for a given channel, so you need an OT at each end of the channel (that is, two OTs per channel).

Three factors determine the OTs you will need for your application:

- *10G/40G line side requirements*
  On the line side, the OTs are differentiated into LH, ULH, and UHC.

  - LH OTs support 10G channel transmission up to 2000 km

  - ULH OTs support 10G channel transmission up to 4000 km

  - UHC OTs support 40G channel transmission up to 1000 km

- *Client side requirements* — On the client side, the OTs are differentiated into those with VSR and IR interfaces. VSR provides short reach interface utilizing 1310 nm; IR provides intermediate reach utilizing 1550 nm.

In addition, MUX OTs provide support for up to four client signals; OT (10G MUX) supports up to four client OC-48/STM-16 signals on a 10G system and OT (40G MUX) supports up to four client OC-192/STM-64 signals, or four 10Gb *Ethernet*™ WAN PHY signals, on a 40G system.

- *Wavelength growth plan* — One OT supports one wavelength (transmit and receive on the same OT). Selected OTs must match the wavelengths for your selected transmission wavelengths.

Each of the above OTs has a separate circuit pack identifier and comcode assigned to it. Depending on the applications' client reach requirement, transmission distance, channel/system rate and the selected growth plan the appropriate set of OTs should be selected from the tables presented in the ED-8C861-10 drawing.

OTs may be ordered individually or in kits that support the wavelength growth plan for the 10G or 40G system. There are four OTs in each 10G kit and two OTs in each 40G kit.

Optical Multiplexers (OMs) and Optical Demultiplexers (ODs)

OMs and ODs are used in complementary pairs. Use Table 7-2, "Selecting OMs/ODs for Ordering" (7-5) to determine which OMs and ODs you will need to order for usage in your terminal. Repeaters do not use OMs and ODs.

Table 7-2   Selecting OMs/ODs for Ordering

Terminal	OM/OD Circuit Packs			
	0GHz Offset Channels	100GHz Offset Channels	50GHz Offset Channels	150GHz Offset Channels
10G ET	0GHz Offset	100GHz Offset	50GHz Offset	150GHz Offset
10G OADM	OADM 0GHz Offset[1]	100GHz Offset	Not applicable	Not applicable
40G ET	40G 0GHz Offset	100GHz Offset	Not applicable	Not applicable

Notes:

1. The OADM 0GHz Offset OM and OD are required in all OADMs even if there are no channels added or dropped.

Optical Amplifiers (OAs)

Some OAs are required (Req) according to the terminal where they will be used and some are optional (Opt), depending on certain conditions. Refer to the table below.

Table 7-3   Selecting OAs for Ordering

Terminal	Condition of Usage	Req/ Opt	Qty	OA Type
10G ET	1E output line	Req	1	OA (VOA)
	0GHz and 100GHz Offsets	Req	1	OA (PreAmp High Gain)
	150GHz and 50GHz Offsets	Opt	1	OA (PreAmp High Gain)
10G OADM	1E and 1W input lines	Req	2	OA (OADM LineIn)
	1E and 1W output lines	Req	2	OA (OADM LineOut)
	Any add channels on E side	Opt	1	OA (OADM Add)
	Any add channels on W side	Opt	1	OA (OADM Add)
	Any drop channels on E side	Opt	1	OA (PreAmp High Gain)
	Any drop channels on W side	Opt	1	OA (PreAmp High Gain)
	Any thru or drop channels from E side	Opt	1	OA (OADM Thru)
	Any thru or drop channels from W side	Opt	1	OA (OADM Thru)
40G ET	Drop channels	Req	1	OA (PreAmp Low Gain)
	Add channels	Req	1	OA (VOA)
Repeater[1]	Span losses up to 23 dB	Opt	1/line	OA (Raman)
	Span losses 23–28 dB	Opt	1/line	OA (Raman EDFA)
	Channel flattening required	Opt	1/line	OA (DGEF)

Notes:

1. The selection of OAs to use in Repeaters is determined by Engineering Rules to optimize OSNR. The conditions shown are only nominal values. Actual selection of OAs for Repeaters should be determined by Lucent Technologies.

Raman Pumps (RPs)

All terminals require RPs; End Terminals require 1 and the other types require 2. See Table 7-4, "Selecting RPs for Ordering" (7-7).

Table 7-4   Selecting RPs for Ordering

Terminal	Condition of usage	Qty	Type
10G ET	Line 1E input	1	RP (50G/100G)
10G OADM	Both input lines	2	RP
40G ET	Line 1E input	1	RP
Repeater	Both input lines	2	RP

Growth Raman Pumps (RPGs)

RPGs are needed only when there are channels above 188.45 THz. In Repeaters, the RPG is matched to the type of OA used in the Repeater (in each direction). Use Table 7-5, "Selecting RPGs for Ordering" (7-7) as an aid for ordering RPGs.

Table 7-5   Selecting RPGs for Ordering

Terminal	Condition of usage	Qty	Type
10G ET	Channels above 188.45 THz	1	RPG
10G OADM	Channels above 188.45 THz	2	RPG (DCF)
40G ET	Channels above 188.45 THz	1	RPG
Repeater	Used with OA (Raman)	1/OA	RPG (DCF)
	Used with OA (Raman EDFA)	1/OA	RPG (DCF)
	Used with OA (DGEF)	1/OA	RPG

Other circuit packs

Use Table 7-6, "Selecting the Other Circuit Packs for Ordering" (7-8) to determine the quantity of the other circuit packs you will need to order.

Table 7-6   Selecting the Other Circuit Packs for Ordering

Circuit Pack	Usage	Amt
SCTL	Each double-shelf (DS) in a bay	1 per DS
NCTL	All System Bays and Repeaters	1 per NE
OMON (8–Port)	10G End Terminal	1
	OADM	2
OMON (4–Port)	40G End Terminal	1
	Repeater	1
SUPVY	All System Bays	1
CIO	Each DS in a bay	1 per DS
SIO	All System Bays and Repeaters	1
PWR	Each DS in a bay	2 per DS
Fan	Each DS in a bay	1 per DS
Blank	1 for each blank slot	As required
DCM	As determined by Engineering Rules. See "DCM selection" (5-12) for additional information.	

Fiber Optic Characterization Process

Introduction   This section describes the Fiber Optic Characterization (FOC) process for LambdaXtreme™ Transport. LambdaXtreme™ Transport operates on both common and state-of-the-art fiber types (see Chapter 8, "General System Specifications," "Transmission Medium"). In order to facilitate system/network design, engineering, and deployment and ensure system performance feasibility on a specific fiber pair, specific fiber parameters should be measured/known. These measurements have to be completed prior to starting system design and engineering.

Required OSP parameters   LambdaXtreme™ Transport requires the following design parameters about the Outside Plant Fiber in order to assess feasibility of the system on a specific fiber route.

- Span length (km)

- Absolute end to end span loss (dB) at 1550 nm

- Fiber loss (dB/km) measured at 1410, 1550, and 1625 nm

- Splice loss (dB, per event) measured at 1410, 1550 and 1625 nm

- Reflection (dB, per event) measured at 1410, 1550 and 1625 nm

- Incremental (psec/km) and total chromatic dispersion (psec) measured from 1520 to 1620 in 5 nm increments

- Dispersion response (psec vs nm.) measured from 1520 to 1620 in 5 nm increments

- Zero-dispersion wavelength (nm) and slope (psec/nm)

- Incremental (psec/root-km) and mean polarization-mode dispersion (psec) measured at 1550 nm

Purpose of determining the OSP parameters   These OSP fiber parameters will be utilized in a LambdaXtreme™ Transport system to:

- Determine the required level of amplification at each node

- Determine the required dispersion compensation module at each node

- Determine the required power setting for the forward Raman pumps (based on the dispersion characteristics of the fiber, span loss, 10G/40G, and connector type)

- Determine the appropriate pulse width for the ULH OTs

- Ensure that the first 20km of the OSP fiber does not have losses that would impact Raman pumping/gain

- Verify Polarization Mode Dispersion of the fiber

The need for measurements

Because these parameters are critical in designing an optimal LambdaXtreme™ Transport system, the customer must conduct Fiber Optic Characterization Measurements on every route on which they plan to deploy a LambdaXtreme™ Transport system. Embedded fiber must adhere strictly to the engineering rules for parameters such as: Optical Loss, Chromatic Dispersion, and Polarization Mode Dispersion. By testing adherence to these specifications, customers can either verify the ability to implement the desired application or identify a problem that must be corrected beforehand.

Lucent Technologies offers a Fiber Optic Characterization Service that measures and analyzes all relevant fiber parameters to verify that the embedded fiber will support the desired application, design and level of performance.

Required FOC information

The Fiber Optic Characterization required information is

- general information (route and span data)

- loss measurements

- Optical Time-Domain Reflectometer (OTDR) measurements

- chromatic dispersion measurements

- Polarization Mode Dispersion (PMD) measurements

General information for FOC service

General FOC information consists of route and span information, as described in . This information must be provided for every span.

Table 7-7   General Information for FOC Service

Parameter	Comments
Route Information	
Route Name	
Connector Family	Specify the connector type as SC, *ST*™, or FC.
Span Information	

Table 7-7   General Information for FOC Service   (continued)

Parameter	Comments
Span Number	This is an integer number for N spans: 1, 2, 3, ...N
A-End Node ID	The ID of the node at the beginning of the span. One of the unique node IDs.
A-Node location (longitude, latitude) or Node Address (Address Line 1, Address Line 2, State, Zip)	
B-End Node ID	The ID of the node at the end of the span. One of the unique IDs.
B-Node location (longitude, latitude) or Node Address (Address Line 1, Address Line 2, State, Zip)	
Patch Through Site Locations (longitude, latitude) or Node Address (Address Line 1, Address Line 2, State, Zip)	
Total Fiber Length	

Loss measurements

Fiber loss measurements must be taken for East-West and West-East fibers in every span. The required measurements are described in Table 7-8, "Fiber Loss Measurements" (7-11).

Table 7-8   Fiber Loss Measurements

Parameter	Comments
Measured Fiber Information	
Fiber Label	This attribute enables us to distinguish the chosen/measured fiber from the rest as well as receive and transmit fibers.

Table 7-8   Fiber Loss Measurements   (continued)

Parameter	Comments
Fiber Type	Fiber type of the span. (Multiple fiber types spliced in a single span are generally not supported. The presence of mixed fiber spans in a given route will make the engineering more complex and will require additional, specific engineering effort.)
Total Span Loss	Measured at 1550 nm.
A Connector Loss	Measured at 1410 nm, 1550 nm, and 1625 nm using OTDR.
B Connector Loss	Measured at 1410 nm, 1550 nm, and 1625 nm using OTDR.
Fiber Loss Coefficient	Measured at 1410 nm, 1550 nm, and 1625 nm. (The fiber loss coefficient at 1410 nm needs to be bidirectional with focus on the first 20 km.)

OTDR measurements

The fibers in a given span may consist of multiple segments spliced together. The OTDR scans need to identify the splice locations and characteristics of the events. Note that the OTDR testing should be done from LambdaXtreme™ Transport equipment Lightguide Cross Connect (LGX) to the other corresponding LambdaXtreme™ Transport equipment LGX.

OTDR measurements must be taken for East-West and West-East fibers in every span. Provide the measurements shown in the list below.

The required OTDR measurements (in dB) are taken at 1410 nm, 1550 nm, and 1625 nm. For every event, the following two measurements are required:

• Splice loss

• Reflection

Chromatic dispersion measurements

Chromatic dispersion measurements are taken for East-West and West-East directions from 1520 nm to 1620 nm (in 5 nm increments) for every span, as described in Table 7-9, "Chromatic Dispersion

Table 7-9   Chromatic Dispersion Measurements

λ (nm)	Dispersion Coefficient (ps/(nm*km))	Dispersion Slope (ps/(nm²/km))	Attenuation Coefficient at given wavelength (dB/km)
1520			
1525			
1530			
1535			
1540			
1545			
1550			
1555			
1560			
1565			
1570			
1575			
1580			
1585			
1590			
1595			
1600			
1605			
1610			
1615			
1620			

In addition to the measurements in the table above, the following two parameters should also be provided:

- zero dispersion wavelength (nm)
- slope at zero dispersion wavelength (ps/(nm²/km))

Polarization Mode Dispersion (PMD) measurements

Polarization mode dispersion measurements are taken for East-West and West-East directions at 1550 nm for every span

- Average (mean) PMD (ps)

- Incremental PMD (ps/root km)

- PMD second order (ps)

- Reference wavelength for PMD measurement (if not at 1550 nm)

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Fiber Optic Characterization Service

Testing The Lucent Fiber Optic Characterization Service includes the following tests:

- Optical Time-Domain Reflectometer (OTDR) testing
- optical loss testing
- Chromatic Dispersion testing
- Polarization Mode Dispersion testing

OTDR testing   OTDR testing is the preliminary step in FOC measurements, which
sets the stage for the next set of measurements. The optical time
domain measurements allow for the determination of span length,
span loss, and fiber event identification with location, loss, and
reflectance data. The optical time domain analysis provides an
examination of the integrity and continuity of the fiber, as well as
verification of the reflection and attenuation behavior. The emphasis is
on obtaining the power loss profile for the first 20 km of the OSP
fiber at each end to identify loss points (e.g. bad splices). This will
ensure that we do not have unexpected losses early on in the span
which would prevent Raman pumps from providing adequate
amplification. This test is a single-ended measurement that is
performed with an optical time-domain reflectometer, in both
directions (reflectance will be different in each direction) and at
wavelengths of 1410, 1550 and 1625 nanometers. This is a Lucent
standard which exceeds the industry standard of one-way testing. But,
in doing so we provide the customer greater flexibility in using the
fiber.

Figure 7-1 Typical OTDR Display

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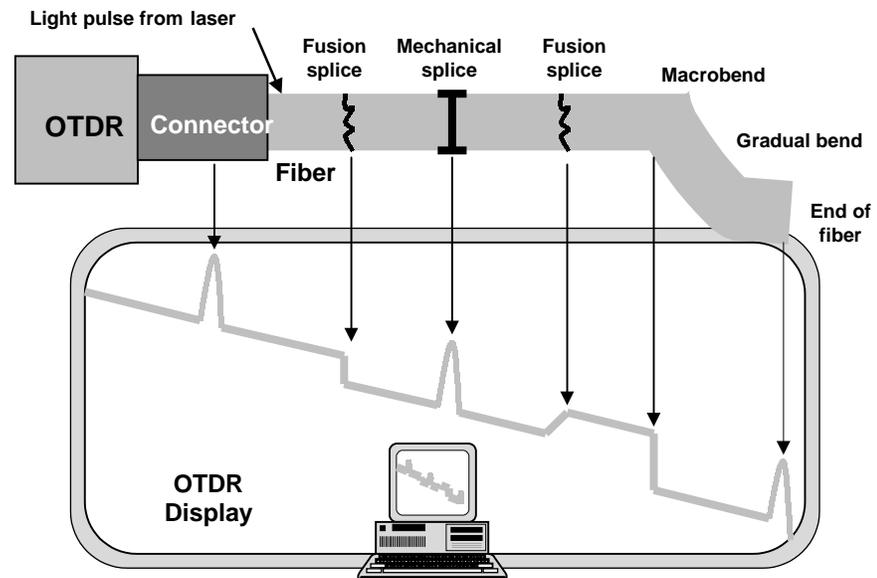
How is OTDR testing conducted?

Using an OTDR, a laser pulse is sent down to each fiber being tested. Most of the light energy reaches the end of the fiber and is reflected back (Fresnel reflection). However, a portion of light is scattered and reflected back toward the OTDR (Rayleigh backscatter). Optical loss and time domain reflection measurements are performed by Lucent engineers in the field using an OTDR. The OTDR's receiver measures the time it takes the light pulse to travel down the fiber and back to the detector and converts time to distance, and detected signals for display on the OTDR's screen.

Optical loss and time domain reflection measurements performed by Lucent Technologies in the field using a state-of-the-art OTDR. This is a very powerful test instrument for complete fiber analysis. It supports characterization of single mode fiber at 1410, 1550 and 1625 nanometers (±10 nm) with a dynamic measurement range of up to 40 dB, and pulse widths from 10 nanoseconds to 20 microseconds on fibers up to 256 kilometers in length. The near-end detection dead zones are typically 3.5 meters (reflective) and 6 meters (non-reflective). To avoid near-end detection dead zones, a known fiber (e.g. of ~1 km in length) is added between the test set and the OSP fiber.

Optical time domain measurements facilitate:

- Locating end of fiber to get accurate span length and span continuity
- measuring average loss (dB/km)
- calculating end to end loss
- locating splices and defects
- measuring splice and defect loss
- measuring splice and defect reflectance
- calculating Optical Return Loss

Optical loss testing

Usually the second FOC measurement is Optical Loss Testing. This is a precise measurement of the absolute Fiber Attenuation in the Span.

Lucent Technologies performs Optical Loss Testing on both directions of the fiber span with a light source at one end and a power meter at the other. The measurement is performed at a single wavelength of 1550 nm for LambdaXtreme™ Transport. Using this data, design engineers determine whether the fiber spans meet the required loss budget specifications.

Chromatic Dispersion (CD) testing

Chromatic dispersion measurements allow for the determination of the pulse spreading characteristics of the fiber. The dispersion analysis provides an examination of the limitations of the fiber in terms of bandwidth, as well as verification of the dispersion budget.

This test is a two-ended unidirectional measurement that is performed with a transmitter and a receiver, across the window of interest (i.e. 1520 nm to 1620 nm).

Lucent Technologies measures Chromatic Dispersion in the field using a fast, accurate, and reliable Chromatic Dispersion Test Set. This instrument conforms to the TIA FOTP-175 dispersion measurement standard. Two fibers are required: one reference fiber for up-link control, and one fiber under test. The system is calibrated on a regular basis by running a reference measurement with the transmitter and receiver in a back-to-back configuration. High accuracy and stability are provided by a unique double-demodulation technique. A 70 MHz modulating frequency is used for determination of amplitude and phase shift at two switched wavelengths.

Dispersion will be measured from 1520 to 1620 nanometers in 5 nm increments. This test will also identify the zero dispersion wavelength and provide attenuation coefficients for each of the measured wavelengths.

Polarization Mode Dispersion (PMD) testing

Polarization Mode Dispersion (PMD) happens because the fiber core is not perfectly circular, particularly in older installations. This causes different polarizations of the signal to travel with different group velocities amounting to closure of the optical eye pattern. PMD testing assesses the extent of polarization mode dispersion on customers' embedded fiber. Lucent engineers perform this test with PMD test sets at both ends of the fiber span (at 1550 nm wavelength). These engineers compare the PMD field measurements to customers' system budget specifications to evaluate whether their networks are capable of transporting higher OC-n data rates and to determine regenerator placement.

PMD is caused by spatial and physical conditions of the actual fiber, which can be induced by handling during fiber installations, such as:

- imperfections in the crystalline structure of the fiber
- manufacturing imperfections in the core shape and internal stresses on the fiber

- external stresses from forces such as bends and twists

- PMD is also impacted by the bit rate and presents more of a problem when your signal speeds increase from 2.5 Gbps to 10 Gbps and beyond

Polarization mode dispersion measurements allow for the determination of the birefringence and polarization mode coupling of the fiber. PMD measurement analysis also provides an examination of the limitations of the fiber in terms of transmission rate, as well as evaluation of the fiber integrity. If the measurements indicate that fiber PMD values exceed the limits of the network design, the network design team is alerted to take appropriate action to deal with the high PMD values.

PMD is tested in the field using a state-of-the-art PMD measurement system. The measurement system implements a single-ended interferometric technique based on the USA TIA proposal for PMD measurement using a Michelson interferometer at the receiver and a polarized light source at the far end. The instrument measures the distribution of differential group delay and computes the mean total and the first order polarization mode dispersion. It also estimates the second order polarization mode dispersion. Dispersion may be measured from 0.065 to 240.0 picoseconds.

Data collection and documentation

As all of these tests are intrusive; fiber lines cannot be carrying traffic at the time of testing. Existing live traffic will need to be rolled onto spare fibers to permit testing. Therefore it is substantially better that fiber characterization be performed well before service is placed on the fiber. Following field-testing, Lucent analyzes and documents all testing results for use in network design and implementation.

Benefits

The Fiber Optic Characterization Service offers the following benefits:

- Optimizes resources

- Optimizes fiber utilization and route capacity capabilities

- Verification of OSP infrastructure and true end to end connectivity

- Optimizes equipment deployments

- Minimizes technical problems during implementation by confirming the fiber can support the desired application

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- Minimizes capital investments for test equipment by providing Lucent personnel and equipment to conduct all fiber testing

- Provides experience and expertise with Lucent's skilled product and network specialists and processes for quick and efficient fiber testing activities

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Installation Services

Overview Lucent Technologies offers Installation Services focused on providing the technical support and resources needed to efficiently and cost-effectively install your network equipment. Lucent Installation Services provide unparalleled network implementation expertise to help install your wireline and wireless networks. We use state-of-the-art tools and technology, and highly skilled technicians to install your equipment and help to ensure the timely and complete implementation of your network solution. By relying on our installation experts, we can rapidly build or expand your network, help manage the complexity of implementing new technologies, reduce operational costs, and help improve your competitive position by enabling your staff to focus on the core aspects of your business rather than focusing on infrastructure details.

Description Within Lucent's overall Installation Services portfolio, Basic Equipment Installation and Site Supplemental Installation are the two services most closely linked to the initial deployment of Lucent's LambdaXtreme™ Transport product into your network.

Basic Equipment Installation

Provides the resources, experience and tools necessary to install the LambdaXtreme™ Transport product into your network. We assemble, cable and wire, and test the LambdaXtreme™ Transport, helping to ensure it is fully functioning as engineered and specified.

Site Supplemental Installation

Enhances the Basic Equipment Installation service by performing supplemental work that is unique to your specific site location, configuration, or working requirements. Includes installation of material other than the main footprint product (e.g., earthquake bracing); provision of services unique to your site (e.g., hauling and hoisting, multi-floor cabling, rental and local purchases) or as may be required by your operations (e.g., overtime to meet your compressed schedules, night work requested by you, abnormal travel expenses, abnormal transportation or warehousing); and any other additional effort or charges associated with your environment.

Benefits   When implementing our Installation Services, Lucent becomes a strategic partner in helping you realize your long-term strategies and achieve your business and technological goals. We combine our state-of-the-art technical background, high-quality processes, expertise in the latest technologies, knowledge of revolutionary equipment breakthroughs, and feature-rich project management tools to get your network up and running - quickly, efficiently and reliably. With Lucent, you can concentrate on your core business, while we apply our years of knowledge and experience to installing your network.

Our Installation Services let you:

- *Rapidly expand your network* —by turning hardware into working systems, with the capability to deploy multiple networks in parallel rollouts

- *Reduce operational expense* —of recruiting, training, and retaining skilled installation personnel

- *Leverage Lucent's resources and expertise* — by utilizing our team of knowledgeable and fully equipped experts that implement projects of any size, anywhere around the world

- *Implement quality assurance* —through our total quality management approach

- *Reduce operational expenses* — by avoiding the purchase of the necessary state-of-the-art tools, test equipment, specialized test software, and spare parts that Lucent Installation Services utilize

- *Ensure high-quality support* —with Lucent's extensive support structure, including proven methods and procedures, mechanized tools, professional training, technical support, and access to Bell Labs

For more information on Installation Services contact your Lucent account representative.

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Engineering Services

Overview   LambdaXtreme™ Transport Worldwide Services offers Engineering Services focused on providing the technical support and resources needed to efficiently and cost-effectively engineer your network equipment. We provide the best, most economical equipment solution by ensuring your network equipment is configured correctly, works as specified, and is ready for installation upon delivery. With our proven, end-to-end solutions and experienced network engineering staff, Lucent Technologies Worldwide Services is the ideal partner to help service providers engineer and implement the technology that supports their business.

Description   Within Lucent's overall Engineering Services portfolio, Site Survey, Product Configuration and Site Engineering are the three services most closely linked to the initial deployment of LambdaXtreme™ Transport into your network; each is described below.

Site Survey

A Site Survey may be required to collect your site requirements needed for proper equipment engineering. If adequate site requirements and records are not available up front, a site survey would be performed to collect information required for configuration of the equipment and integration of the equipment into the site.

Product Configuration

Ensures that the correct footprint hardware is ordered and that the ordered equipment is configured for optimal performance in the network for the customer. Lucent Engineering configures equipment requirements based on inputs from the customer order, completed questionnaires, and/or site survey data. The decisions as to specific equipment needs are based on each component's functionality and capacity, and the application of engineering rules associated with each component.

Site Engineering

Ensures that the correct site material is ordered and that the optimal equipment layout for the installation of the ordered equipment in the customer's site is determined. Site Engineering will be used in assisting the customer with determining the necessary site conditions, layout and equipment required to properly install/integrate the footprint hardware components into a specific location.

Benefits   When implementing our Engineering Services, Lucent becomes a strategic partner in helping you realize your long-term strategies and achieve your business and technological goals. Our Engineering Services portfolio delivers quick, responsive support, with state-of-the-art tools, top technicians and end-to-end services to help you engineer an optimal network solution. Whether you are looking to outsource your total engineering effort or simply supplement basic coverage gaps, our portfolio of services provides the flexible level of support you need. With Lucent, you can concentrate on your core business while we apply our years of knowledge and experience in engineering your equipment solutions.

Our Engineering Services let you:

- *Rapidly expand your network* —by turning products into working systems, with the capability to deploy multiple networks in parallel rollouts

- *Reduce costs* —by determining the most cost-effective network configuration and optimal use of office space when planning and providing an equipment solution

- *Reduce operational expense* —of recruiting, training, and retaining skilled engineering personnel

- *Leverage Lucent's resources and expertise* — by utilizing our team of knowledgeable and fully equipped experts that can plan, design, and implement projects of any size, anywhere around the world

- *Implement quality assurance* —through our total quality management approach and use of ISO-certified processes

- *Provide one–stop shopping* with a globally deployed engineering workforce, saving the time, delays and coordination challenges of dealing with multiple equipment vendors and service providers

- *Keep pace with rapidly changing technology* — by supporting the latest technologies and equipment breakthroughs, including Lucent's and other vendor's products

- *Ensure high-quality support* — with Lucent's extensive support structure, including proven methods and procedures, mechanized tools, professional training, technical support, and access to Bell Labs

- *Maintain customer office record* — keep track of equipment locations and connections

For more information on Engineering Services contact your Lucent account representative.

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Optical Network Integration

Introduction   There is a crucial step necessary to take installed network elements and operations systems and transform them into a network that is fully tested and ready for service. Lucent has an experienced Optical Network Integration Team in place that can provide integration and deployment of networks that are single-city, regional, national, multinational or transcontinental. Optical Network Integration can help ensure that networks are deployed quickly and are revenue ready upon implementation.

Optical Network Integration is delivered following the physical installation of the optical networking equipment. Lucent develops a customized Network Integration Plan that details how the optical network shall be deployed and accepted. The plan will consist of integration test procedures, specific to the network application, details of network design, network diagrams, system-level/site-specific provisioning information, and other data, as required. Lucent engineers and technicians then execute the plan and perform on-site turn-up, integration and acceptance testing of the optical network. All pertinent field results and other support information are reviewed during acceptance and compiled into a Customer Turnover Package.

Network Integration Planning   Network integration planning consists of the areas discussed below.

Network Design Support

Network design verification:

- Latest customer traffic data
- Latest customer network data

Data Communications Network Design

Up front planning & design support of DCN:

- DCN parameter specifications
- Network partitioning rules

Fiber Assignments

Fiber assignments are

- Specified by relay rack/LGX
- Mapped to OTU/OLS from LGX

Network Management Plan

The Network Management plan consists of:

- Management system design & verification
- Alarm Plan testing & monitoring

System Configuration

System Configuration planning is based on:

- circuit packs in network elements
- functional requirements
  - Protocol
  - Bit rates
- network requirements
  - OTs, OAs, spec DCMs
  - Fiber plant
  - Route requirements
  - Maximum number of wavelengths

Local vs. Link vs. Network Level Testing

Integration Test Plan

The Integration Test Plan has the following elements:

- End-to-End Transmission
- Network Management
- Alarm

Network Integration Plan Document Produced

The plan produces an internal document used by engineering teams in the field.

Customer Network Plan

Customer acceptance is obtained before field execution.

Network Integration Plan Execution

Execution of the Network Integration Plan is described in the following paragraphs

Span Loss/Link Loss Measurements Recorded

System Level Provisioning

The steps for system level provisioning are listed below:

1. Initial System provisioning and software set-up

    - Verify software release loaded, Network element type entered

    - Set time, date, alarm reporting, etc.

    - Enter TIDs for network elements

    - Provision terminal type

2. Establish data link connectivity

    - Configure overhead circuit packs

    - Set up first wavelength for OA&M

3. Enable NMS and Remote Administration

    - Enter parameter thresholds for performance monitoring

4. Interconnection

    - Adjust link loss

    - Install/setup Dispersion Compensation Modules

    - Verify supervisory data link interconnection

5. Wavelength Associations

    - Enter wavelength add associations

    - Balance power levels

    - Measure optical signal to noise ratio of received wavelengths

    - Assure more than the minimum allowable level

    - Enter wavelength drop associations for each wavelength

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Customized Test Plan

The Customized Test Plan consists of the following:

- End-to-end Transmission Test
    - BER tests of planned circuit paths
    - Between spans or nodes
    - End to end traffic verification
- Network Management Testing
    - NMS connectivity/functionality of interface and applications
    - Performance monitoring-transmission links
- Alarm Testing
    - Critical, major, and minor alarm on network elements
    - Verify alarms are reported to NOC via NMS
    - Clear alarms on network elements, verify cleared at NOC

Customer Acceptance

Customer acceptance consists of:

- Execution all of tests specified in Test Plan
- Results of all tests recorded in Customer Turnover Package
- Acceptance verified through sign-off

Customer Turnover Package

The Customer Turnover document consists of the following:

- Test procedures, results and measurements
- Optical network drawings:
    - Network Diagrams
    - Per site bay layouts
    - Test circuit diagrams
    - DCN drawings
- Provisioning/interconnection data
- Signed acceptance paperwork
- Support contacts

Cutover of Live Traffic

An orderly cutover of live traffic is effected by

- Coordinating cutover with operations center
- Using per site provided traffic add/drop tables

    - Verify alarm free operation of each circuit/network element to be integrated

    - Verify switch of live traffic to protection if requested

    - Connect circuit/network element being integrated and the network

    - Troubleshoot any problems/issues

    - Release forced switch to protection

    - Verify alarm free operation of the integrated circuit/network element

Optical Network Integration Value

Optical Network Integration delivers value by shortening the interval between deciding to install new optical products and having that network producing revenue. The integration of network elements into a cohesive system - the step that makes the network revenue ready - can be achieved sooner using Lucent's Optical Network Integration. Optical Network Integration field engineers know ONG equipment inside and out and can make real-time changes and adjustments that have bottom-line implications for speed and quality of turn-up. And our experience and record of success means the difference between a network merely running and a network running optimally, with the ability to evolve. Finally, using Optical Network Integration keeps it simple for the customer: one solutions vendor, one solutions integrator.

Optical Network Integration Benefits

Briefly, the benefits of using Optical Network Integration are

- Focus on making money from the network, not deploying it
- Receive revenue ready/generating network that is optimally implemented and applied
- Fast deployment of complex products, networks, technologies and services
- Optimize staff resource utilization

- Simplicity
  - Lucent provides experience and expertise
  - Lucent does the planning and testing
  - Lucent delivers flawless and seamless execution of the NI plan
  - Lucent provides the tools for OLS Integration
  - There is one plan

For planning purposes only   This description of Optical Network Integration is for planning purposes only, and is not intended to modify or supplement any Lucent Technologies scope of work or warranties relating to these services. The publication of information herein does not imply freedom from patent or other protective rights of Lucent Technologies or others.

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Maintenance Services

Description
Maintenance Services is composed of four individual services to support your maintenance needs. The services are

- Remote Technical Support Service (RTS)
- OnLine Customer Support (OLCS)
- On-site Technical Support Service (OTS)
- Repair and Exchange Services (RES)

Remote Technical Support Service (RTS)

The RTS helps clients cost-effectively maximize the availability and performance of their Lucent-deployed systems (including both Lucent and selected third-party equipment) with remote technical support to troubleshoot and resolve system problems.

With this service, remote system engineers troubleshoot and resolve system problems via phone or modem connection, answer questions regarding system problems, and provide software updates to clear faults. If an outage occurs, these remote system engineers provide rapid service restoration.

Support from our expert remote system engineers will:

- Enable trouble tracking, resolution, and restoration
- Answer technical product-related questions and specific feature and function questions
- Provide and assist in applying periodic software maintenance fixes and software updates (subject to the terms, restrictions, and limitations contained in the licenses under which the software was acquired). Provide phone support in applying available software maintenance fixes and software updates provided under product warranty.

Single Point of Contact — provides a Lucent technical support system engineer as a single point-of-contact for information and status with:

- Expert knowledge of client's network
- Proactive consultative support

Service Options — Remote Technical Support is available with two coverage options:

• 24 hours a day, 7 days a week (24x7)

• 8 hours a day (8 am - 5 pm Client local time) 5 days per week (8x5), Monday - Friday, excluding Lucent holidays

OnLine Customer Support (OLCS)

OnLine Customer Support (OLCS) provides technical support using online technologies that gives you access to web information to help resolve technical support requests. OLCS is included when you purchase our Remote Technical Support Services, described above.

On-site Technical Support Service (OTS)

Provides cost-effective support for Lucent products including systems that incorporate selected third-party equipment. Lucent will provide On-site Technical Support to perform on-site troubleshooting and testing at a client's location to resolve equipment issues when a system problem requires on-site intervention. In addition to the OTS Service via Dispatch is our OTS Dedicated Technician Service. This provides experienced technicians to become part of the customers first-line maintenance organization eliminating the need for cost prohibitive in-house self maintenance.

The client has the following service delivery options to select from below:

• Same Day Dispatch, 24x7, 4-hour Response

• Same Day Dispatch, Monday - Friday, 8 am - 5 pm customer local time, 4-business hour Response

• Next Business Day Dispatch, Monday - Friday, 8 am - 5 pm customer local time

Repair and Exchange Services (RES)

Repair and Exchange Services (RES) provide rapid replacement or repair of your defective hardware, eliminating the need for you to purchase and maintain a costly spares inventory. These services can dramatically reduce investment capital and recurring operating expenses while helping to assure maximum network availability.

Contact number   To contact Lucent Maintenance Services, call 1–866–LUCENT8.

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Remote Network Management Services

Services Overview Remote Network Management Services (RNMS) use state-of-the-art tools and technology and highly skilled technicians to provide ongoing remote management of clients' IP, Circuit-switched, Optical, and Wireless networks. Teams of technical experts, located around the world at our Lucent Worldwide Services Knowledge Centers provide a single point of contact to coordinate network management activities. We combine the expertise of our people with the unique Lucent Worldwide Services Network Management System, a set of commercial applications and software tools custom-developed by Bell Labs, to provide a leading-edge, modular remote network management program that can complement clients' existing staff or provide an end-to-end network management solution.

Fault Management Services Fault Management services are focused on providing network troubleshooting and problem resolution of IP, Circuit-switched, Optical, and Wireless networks.

Fault Management Service - IP, Circuit-switched, Optical, and Wireless Networks

A permanent connection to clients' networks allows our Lucent Worldwide Services Knowledge Center to provide year round remote monitoring and real-time problem management of contracted network elements/devices, 24-hours a day. Lucent's expert technicians proactively identify and resolve network failures and fault conditions to minimize future outages, reduce fault numbers, and maximize the service availability of clients' networks. These services are available 24-hours a day, year round or for fold-down coverage supporting after hours or weekend coverage needs.

Fault Management Basic Service

Fault Management Basic service provides remote monitoring and dispatch only functions of contracted switches, mobile switching centers, and network elements/devices. Our expert technicians remotely monitor clients' networks, proactively identify network failures and fault conditions, and then contact the clients' operations or maintenance staff for problem resolution.

For additional information on Fault Management services, call 303–368–2512

Fault Management - Trouble Management Center Service

We provide a toll-free number for either clients' end-users or their help desks to call our Customer Care representatives to report network problems. Our experienced Customer Care service team initiates and manages the trouble ticket process and restoration functions. This service is a valuable addition to the Fault Management Service.

For additional information on the Trouble Management Center, call 720–482–5514.

Configuration Management Services

Lucent Worldwide Services engineers provide remote technical expertise to manage service-provisioning functions for Optical network devices. We provide accurate trunk and line provisioning, test and turn-up functions, translations, and help clients maintain accurate and current documentation of switch software translations.

For additional information on Configuration Management services, call 720–482–5080.

Performance Management Services

Performance Management service provides remote collection and analysis of clients' network performance data for trends and network reliability. We pay special attention to congestion areas and resource utilization to provide clients with the recommendations they need to keep their networks operating at peak efficiency.

For additional information on the Performance Management service, call 720–482–5514.

Escalation Process   The escalation process is described below:

- *Escalation and Resolution of Network Troubles* —The Network Knowledge Center (NKC) will initiate corrective action in response to service affecting alarm conditions based on the most current client's resolution/escalation plan that is kept within the Customer Interface Agreement (CIA) on file at the NKC.

- *For Lucent-provided and contracted NEs* — If the client has a service agreement with Lucent for Remote Technical Support (RTS) maintenance service, the NKC may refer the problem to the RTS organization, if contractually agreed upon (Full Fault Management). To do so, the NKC must have confirmation of client's RTS service agreement or that the NE is still covered by warranty. Current resolution-escalation criteria are documented in the active Client's CIA.

- *For non-Lucent contracted NEs* — The NKC will refer the problem to an appropriate party, as contractually agreed upon (Full Fault Management). To do so, the NKC must have on file a vendor-specific ″Letter of Agency″ signed by the client. Current resolution-escalation criteria are documented in the active Customer Interface Agreement (CIA).

RNMS Benefits   Our Remote Network Management Services enable clients to:

- Enhance reliability through real-time, around-the-clock monitoring for fault conditions, proactive troubleshooting, analysis of performance trends, and implementation of network management recommendations

- Simplify network management through designated remote specialists who are knowledgeable about clients' networks and operations and work with clients' staffs in a true team effort. Customize network management by designing the solution that works best for their businesses. We can support clients' existing teams by taking over the tasks they designate, or provide an end-to-end management solution

- Eliminate capital costs of purchasing and maintaining operating systems and associated hardware

- Dramatically lower expenses for hiring, training, and retaining the technical staff needed for centralized remote network management

- Increase revenues through improved customer satisfaction and loyalty, and faster time-to-market with new services

- Improve end-user satisfaction and reduce operational costs by finding and solving problems before they escalate

Additional information

For additional details on RNMS, see the Service Product Descriptions, Datasheets and Statements of Work at:

http://networkcare.web.lucent.com/sales/mngmt/datasheets_sows.asp

Here you can see an overview of the RNMS as well as the marketing collateral for all the service options offered within the RNMS family.

Detailed Billable Services Description for Optical Networks

For Circuit Switched and Optical Networks:

- Monitoring & Surveillance

- Customer Care / Trouble Management

- Network Performance Management

- Trunk Group Analysis

- Provisioning Management

Statement of Work (SOW) & Deliverables

The combined SOW for all RNMS services as well as individual options for Network Management Services are currently available. Connectivity from the NKC to the Client's contracted network elements/network devices (NE/NDs) is either required or recommended for these services. Review and use the SOW for Lucent RNMS Network Care Knowledge Center Connectivity - NAR. See the website below for more details:

http://networkcare.web.lucent.com/sales/mngmt/spd_ds_sow.asp

Serviceability Evaluation

The Serviceability Engineer (SE) performs a product serviceability assessment and documents this evaluation for those characteristics that require compatibility verification to Lucent platforms. The serviceability results will determine what RNMS services can be delivered against the applicable NE. Configuration Management is supported through a network connection between the remote center managing the configuration and the customer's network.

NMS Platform

The NMS platform includes support for the following:

Network Elements supported

The RNMS portfolio currently addresses NEs from edge to edge of a Client's network.

SNMP NEs

From a Simple Network Management Protocol (SNMP) perspective, this would typically be the last SNMP manageable wide area network (WAN) NE, e.g. router or hub and local area network components such as servers and applications (Performance Management service only). We currently do not have the delivery capability to support another local area network (LAN) NE, specifically PCs.

Non-SNMP NEs

The support for a Non-SNMP NE is addressed on a case-by-case basis.

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Warranty

Terms   The warranty terms are stated in the contract between Lucent and the Customer.

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Documentation Support

How to comment on this document

Send comments about this document to:

Lucent Technologies

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101 Crawfords Corner Road

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FAX: 732-949-5000

Related documentation

The *LambdaXtreme™ Transport Applications and Planning Guide* is part of a set of documents that support the LambdaXtreme™ Transport system. The following documents are included in the set:

Select Code	Document Title
365-575-781R1.1	*LambdaXtreme™ Transport User Operations Guide, Release 1.1*
365-575-782R1.1	*LambdaXtreme™ Transport Installation Manual and System Turn-up Services, Release 1.1*
365-575-783R1.1	*LambdaXtreme™ Transport Alarms, Messages, and Trouble Clearing Guide, Release 1.1*
365-575-797	*LambdaXtreme™ Transport Software Ordering Guide, Release 1.1*
109163642	*LambdaXtreme™ Transport Software Release Description, Release 1.1*
ED-8C861-10	*LambdaXtreme™ Transport Engineering and Ordering Information, Equipment List*
ED-8C861-20	*LambdaXtreme™ Transport Terminating System Interconnect Circuits*

Ordering documents

The LambdaXtreme™ Transport customer documentation can be ordered as individual paper copies or as a set on a CD-ROM. One-time orders include a binder (if applicable) and the document contents for the current issue in effect at the time of the order. Also, placement on the standing order list for all later reissues of the document may be requested. The standing order list for each document provides automatic distribution of all reissues of the document.

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The available LambdaXtreme™ Transport courses are listed in the table below.

Course Number	Course
LW2271	LambdaXtreme™ Transport Applications and Planning—instructor-led
LW2471	LambdaXtreme™ Transport Installation and Testing—instructor-led, hands-on
LW2671	LambdaXtreme™ Transport Operations and Maintenance—instructor-led, hands-on

Schedule and registration For more information or to register for any of these courses, call:

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Altamonte Springs, FL 32701

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8 Technical Specifications

Overview

Purpose   This chapter provides information on the LambdaXtreme™ Transport technical specifications.

Contents

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General System Specifications

Optical connector interfaces
LambdaXtreme™ Transport uses LC connectors for internal connections and Universal Build Out Block (UBOB) connectors for external connections. Optional ST and FC interfaces are also available for external connections.

Transmission medium
LambdaXtreme™ Transport operates with the following types of transmission media:

- LEAF

- TrueWave RS (TW-RS)

- Standard Single-Mode Fiber (SSMF)

- TrueWave Classic

- TrueWave Plus

NEBS Level 3 compliance
LambdaXtreme™ Transport meets the NEBS Level 3 Criteria as defined by Telcordia (Bellcore) Special Report SR-3580, Network Equipment - Building System (NEBS) Criteria Levels, as tested to the corresponding Telcordia GR-63-CORE Network Equipment - Building System (NEBS) Requirements: Physical Protection, and Telcordia GR-1089-CORE Electromagnetic Compatibility and Electrical Safety - Generic Criteria for Network Telecommunications Equipment requirements for ″GR-1089 Type 2″ equipment.

Optical Safety (FDA/CDRH Class I and IEC-60825-1 Class 1M Classification)
LambdaXtreme™ Transport is classified as an FDA/CDRH Class I and an IEC-60825-1 Class 1M laser product and assessed as an IEC-60825-2 Hazard Level 4 system as required in Part 4.1.1 of the IEC-60825-2 Standard.

Operating wavelength
LambdaXtreme™ Transport operates at wavelengths between 1554.537 nm (192.850 THz) and 1607.466 nm (186.500 THz).

Optical reflections tolerance
The Optical Amplifier ports within the LambdaXtreme™ Transport System can tolerate up to -45 dB of reflectance.

Capacity LambdaXtreme™ Transport is capable of carrying either of the following:

- up to 128 wavelengths (channels) at 10 Gbps for a total of 1.28 Tbps

- up to 64 wavelengths (channels) at 40 Gbps for a total of 2.56 Tbps

Transmission standards compliance LambdaXtreme™ Transport meets the single-mode interoffice digital fiber optic systems requirements and objectives as specified in GR 253.

Cable access LambdaXtreme™ Transport uses connectorized cabling that utilizes commercially available connectors. All cables are accessed from the front of the bays.

Low voltage cut-off The low-voltage cut-off for the LambdaXtreme™ Transport System is -39.25V_{DC} ±0.25V_{DC}.

Power specifications This section provides power specifications for the LambdaXtreme™ Transport System.

Refer to Table 8-1, "System and OT Power Specifications" (8-3) for LambdaXtreme™ Transport System and OT Power Specifications.

Table 8-1   System and OT Power Specifications

Description	Specification
Voltage Range	-39V_{DC} to -72V_{DC} (Note 1); -48V_{DC} or -60V_{DC} nominal) (Note 1)
Power Feeders (Bays)	Four -48V_{DC} per bay (A1, A2, B1, B2)
Power Feeders (Repeaters)	Two -48V_{DC} per shelf (A, B)
Current Drain	See Table 8-5, "Current Drains for Bays and Repeaters" (8-10)

Notes:

1. For CE mark compliance, the -60V source must be a SELV (Safety Extra Low Voltage) source. The product is designed to operate over ETSI 300 132-2 operational limits.

Laser Output Power Classifications

Raman Pump and Optical Amplifiers The output power classifications (FDA and IEC) for Raman Pumps and Optical Amplifiers are shown in the table below. In all cases, there are 9μm fibers.

Description	FDA Class/ IEC Class
RP	IV/4
RP (50G/100G)	IV/4
RPG	IV/4
RPG (DCF)	IV/4
OA (VOA)	IIIb/3B
OA (Raman EDFA)	IV/4
OA (DGEF)	IV/4
OA (Raman)	IV/4
OA (PreAmp High Gain) and OA (PreAmp Low Gain)	IIIb/3B
OA (OADM Add), OA (OADM Thru), and OA (OADM LineOut)	IIIb/3B

Physical Dimensions and Specifications

Bay dimensions Refer to Table 8-2, "System Physical Dimensions" (8-5), for the dimensions of each LambdaXtreme™ Transport Bay. Use this table when planning floor space requirements for your system. Note that floor space for equipment is also known as "footprint."

Table 8-2   System Physical Dimensions

Bay Framework	Equipment	Height	Width	Depth
Lucent Seismic	Bay	213.4 cm (7 ft.)	66 cm (26 in)	46 cm (18.0 in)
	Repeater Shelf	99 cm (39 in)	Standard: 59.2 cm (23.3 in) Reduced[1]: 53.5 cm (21.1 in)	45 cm (17.7 in)
Lucent ETSI[2] Seismic Cabinet	Bay	220 cm (86.64 in)	60 cm (23.62 in)	60.0 cm (23.62 in)

Notes:

1. The Repeater is offered with two mounting flanges; the narrower flanges are for those customers who want to install the Repeater in an ETSI bay frame that complies with ETS 300 119-3.

2. The Lucent ETSI bay complies with ETS 300 119-2.

Circuit pack dimensions Each slot in a bay is 30 mm wide; LambdaXtreme™ Transport circuit packs are 1 to 4 slots wide, as shown in Table 8-3, " Circuit Pack Dimensions" (8-5).

Table 8-3   Circuit Pack Dimensions

Circuit Pack	Slots	Width
RP	4	120 mm
RP (50G/100G)	4	120 mm
RPG	4	120 mm
RPG (DCF)	4	120 mm

Table 8-3   Circuit Pack Dimensions   (continued)

Circuit Pack	Slots	Width
OA (Raman)	4	120 mm
OA (Raman EDFA)	4	120 mm
OA (PreAmp High Gain)	4	120 mm
OA (PreAmp Low Gain)	4	120 mm
OA (VOA)	4	120 mm
OA (DGEF)	4	120 mm
OA (OADM LineIn)	4	120 mm
OA (OADM LineOut)	4	120 mm
OA (OADM Add)	3	90 mm
OA (OADM Thru)	2	60 mm
OM (40G 0GHz Offset)	3	90 mm
OM (0GHz Offset)	3	90 mm
OM (100G Offset)	3	90 mm
OM (50GHz Offset)	3	90 mm
OM (150G Offset)	3	90 mm
OM (OADM 0GHz Offset)	4	120 mm
OD (0GHz Offset)	3	90 mm
OD (40G 0GHz Offset)	3	90 mm
OD (100GHz Offset)	3	90 mm
OD (50GHz Offset)	3	90 mm
OD (150GHz Offset)	3	90 mm
OD (OADM 0GHz Offset)	4	120 mm
OT (10G MUX)	2	60 mm
OT (10G ADD-DROP ULH)	2	60 mm
OT (10G ADD-DROP)	1	30 mm
OT (40G ADD-DROP)	3	90 mm
OT (40G THROUGH)	3	90 mm
OT (40G MUX)	3	90 mm
NCTL	1	30 mm
SCTL	1	30 mm

Table 8-3   Circuit Pack Dimensions   (continued)

Circuit Pack	Slots	Width
SUPVY	1	30 mm
OMON (4 port)	1	30 mm
OMON (8 port)	1	30 mm
Blank plate	1	30 mm

Floor loading specifications

Refer to Table 8-4, "System Floor Loading Specifications" (8-7), for LambdaXtreme™ Transport floor loading specifications.

Table 8-4   System Floor Loading Specifications

Framework	Seismic Bay Framework		ETSI Seismic Cabinet	
	Weight (lbs)	Weight/ft^2	Weight (kg)	Weight/m^2
System Bay, End Terminal	510–560	63–70	275–300	360–390
System Bay, OADM	535–565	66–70	290–305	375–395
Line Bay, End Terminal	545–635	67–80	295–335	380–435
Line Bay, OADM	555–595	68–75	300–315	385–410
Extension Bay	555–675	68–85	250–310	385–460
	Standard Lucent Bay		ETSI Bay Format	
Repeater Shelf	165–167	22–23	75–76	110–113
MAX Loading Allowed (GR-63 2.2.5)		114.7		560

Synchronization

Time of day clock A time of day clock is provided on the Network Element Controller (NCTL) circuit pack. Accuracy is 20 ppm. The NCTL will provide 12 hours of power to the real time clock in the event of a power failure.

OSC timing scheme The Optical Supervisory Channel (OSC) uses an asynchronous packet transmission scheme where the clock at the receiving end automatically tracks the clock at the transmitting end. In this manner the OSC does not require provisioned timing modes. Each SUPVY circuit pack uses a 20 ppm local oscillator.

Circuit pack clocks There is no System timing for the transmission circuit packs; each circuit pack has its own clock domain per direction of transmission.

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System Current Drain Definitions

Power consumption   Refer to the following definitions when determining System Current Drains and sizing power components.

Maximum List 1 Use twice this value to size batteries and rectifiers. These values represent the average busy-hour current at normal operating voltages of -48.0 V_{DC}. These values are based on maximum system equipage and circuit pack power dissipations of high temperature and full activity.

Maximum List 2 Use this value to size feeder and fuse. These values represent the peak current under worst case operating conditions. Feeders A2 and B2, and Feeders A1 and B1, are shared feeders, and the values listed here can be realized on any one of the shared feeders. (List 2 assumes that one of the shared feeders has failed.) Maximum current drains occur at -39.0 V_{DC}. These values are based on maximum system equipage and circuit pack power dissipations for high temperature and full activity.

Minimum List 1 These values represent the average busy-hour current at normal operating voltages of -48.0 V_{DC} for minimum system equipage and circuit pack power dissipations for high temperature and full activity.

Minimum List 2 These values represent the peak current under worst case operating conditions. Feeders A2 and B2, and Feeders A1 and B1, are shared feeders and the values listed here can be realized on any one of the shared feeders. (List 2 assumes that one of the shared feeders has failed.) Maximum current drains occur at -39.0 V_{DC}. These values are based on minimum system equipage and circuit pack power dissipations for high temperature and full activity.

Current drains for bays and Repeaters   Refer to Table 8-5, "Current Drains for Bays and Repeaters" (8-10), for the current drains for LambdaXtreme™ Transport Bays and Repeaters.

Table 8-5   Current Drains for Bays and Repeaters

Bay		Feeder	Current Drain (Amps)			
Description	**Shelf #**		**Max List 2 (39V)**	**Min List 2 (39V)**	**Max List 1 (48V)**	**Min List 1 (48V)**
10G ET, System Bay[1]	3/4	A2, B2	31	7	13	3
	1/2	A1, B1	27	23[5]	11	9[5]
10G ET, Line Bay[1]	3/4	A2, B2	35	5	14	2
	1/2	A1, B1	34	15[5]	14	6[5]
40G ET, System Bay[2]	3/4	A2, B2	32	15[6]	13	6[6]
	1/2	A1, B1	27	25[6]	11	10[6]
OADM, System Bay[1]	3/4	A2, B2	30	14[6]	12	6[6]
	1/2	A1, B1	24	20	10	8
OADM, Line Bay[1]	3/4	A2, B2	34	12[6]	14	5[6]
	1/2	A1, B1	24	20	10	8
Extension Bay[3]	3/4	A2, B2	44	5	18	2
	1/2	A1, B1	44	6[7]	18	2[7]
Repeater[4]	1/2	A1, B1	29	23	12	9

Notes:

1.   Assumes worst case OT packs, 10G LH Add/Drop, IR

2.   Assumes worst case OT packs, 40G UHC Add/Drop, IR

3.   Assumes worst case OT packs, 4 x 10G MUX OT

4.   Assumes worst case, Repeater with Extra Gain

5.   Assumes 4 OT packs

6.   Assumes 2 OT packs

7.   Assumes 1 OT pack

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Power Dissipation
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Power dissipation for bays and Repeaters

Refer to Table 8-6, "Power Dissipation for Bays and Repeaters" (8-12), for the power dissipation for LambdaXtreme™ Transport Bays and Repeaters using maximum and minimum number of Circuit Packs (CPs). All values are at $48V_{DC}$.

Table 8-6   Power Dissipation for Bays and Repeaters

Bay/Shelf Type	Power Dissipation (Watts)				Power Density (Watts/sq.ft[1]	
	Max # CPs, 23ºC	Min # CPs, 23ºC	Max # CPs, 50ºC	Min # CPs, 50ºC	Max # CPs, 23ºC	Max # CPs, 50ºC
10G ET, System Bay[2]	1808	699[6]	2286	1151[6]	223	281
10G ET, Line Bay[2]	2355	530[6]	2678	760[6]	290	330
40G ET, System Bay[3]	1802	1125[6]	2282	1533[6]	222	281
OADM, System Bay[2]	1470	812[7]	2088	1326[7]	181	257
OADM, Line Bay[2]	1593	746[7]	2229	1278[7]	196	274
Extension Bay[4]	3122	266[8]	3408	414[8]	384	419
Repeater[5]	546	436	1143	897	67	141

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Notes:

1. Applies to both Seismic and ETSI bays

2. Assumes worst case OT packs, 10G LH Add/Drop, IR

3. Assumes worst case OT packs, 40G UHC Add/Drop, IR

4. Assumes worst case OT packs, 4 x 10G MUX OT

5. Assumes worst case, Repeater with Extra Gain

6. Assumes 4 OT packs

7. Assumes 2 OT packs

8. Assumes 1 OT pack

Power dissipation for circuit packs

Table 8-7, "Power Dissipation for Circuit Packs" (8-13) shows the power dissipation for the LambdaXtreme™ Transport Circuit Packs. All readings are at -48V$_{DC}$.

Table 8-7   Power Dissipation for Circuit Packs

Circuit Pack Name	Power (Watts)	
	Room Temperature (23ºC)	**High Temperature (50ºC)**
OA (VOA)	64	107
OA (DGEF)	66	148
OA (Raman)	41	117
OA (Raman EDFA)	68	155
OA (PreAmp High Gain)	62	130
OA (PreAmp Low Gain)	63	130
OA (OADM Thru)	35	47
OA (OADM Add)	45	96
OA (OADM LineIn)	35	112
OA (OADM LineOut)	64	112
RP	46	149
RP (50G/100G)	46	149
RPG	46	75
RPG (DCF)	55	123
OM (0GHz Offset)	31	41

Table 8-7   Power Dissipation for Circuit Packs   (continued)

Circuit Pack Name	Power (Watts)	
	Room Temperature (23°C)	High Temperature (50°C)
OM (100GHz Offset)	31	41
OM (50GHz Offset)	38	41
OM (150GHz Offset)	33	41
OM (40G 0GHz Offset)	32	41
OM (OADM 0GHz Offset)	38	41
OD (0GHz Offset)	32	37
OD (100GHz Offset)	32	37
OD (50GHz Offset)	32	37
OD (150GHz Offset)	32	37
OD (40G 0GHz Offset)	32	37
OD (OADM 0GHz Offset)	32	37
OT (10G ADD-DROP, SR)	41	43
OT (10G ADD-DROP, IR)	44	46
OT (10G MUX)	63	66
OT (10G ADD-DROP ULH, SR)	58	61
OT (10G ADD-DROP ULH, IR)	58	61
OT (40G MUX)	145	152
OT (40G ADD-DROP)	142	149
OT (40G THROUGH)	95	100
CIO	1	1
NCTL	31	38
SCTL	46	48
SIO	1	1
SUPVY	50	50
OMON (8 Port)	16	16
OMON (4 Port)	16	16
PWR	3	5

Table 8-7   Power Dissipation for Circuit Packs   (continued)

Circuit Pack Name	Power (Watts)	
	Room Temperature (23°C)	**High Temperature (50°C)**
FAN	58	125

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Sizing Feeders and Fuses for Bays/Shelves

Overview   Use the following guidelines to determine the feeder and fuse sizes for each bay. It is recommended to use the maximum feeder and fuse sizes for all bays in order to simplify the engineering.

Guidelines   The *Max List2* current drain for each bay feeder is provided in Table 8-5, "Current Drains for Bays and Repeaters" (8-10) for a minimum voltage condition of -39.0 V_{DC}. This is the minimum voltage for system operations and represents the maximum current conditions for feeders and fuses. Use the *Max List2* current drains provided to determine the feeder and fuse sizes. Table 8-8, "Recommended Fuse/Circuit Breaker Ratings @ BDFB" (8-16) shows the minimum recommended fuse/circuit breaker values based on the type of bay or shelf; values are taken at the Battery Distribution Fuse Board (BDFB).

Table 8-8   Recommended Fuse/Circuit Breaker Ratings @ BDFB

Bay/Shelf Type	Min. Fuse/Circuit Breaker Rating[1]
System Bay	60 Amps
Line Bay	60 Amps
Extension Bay	60 Amps
Repeater Shelf	60 Amps

Notes:

1.   The circuit breaker within the Power Line Filter on each shelf is rated at 50 Amps.

If a minimum voltage other than -39V_{DC} is preferred for calculating feeder and fuse maximum current, then use the following equation to obtain the modified Max List2 current drain. Note that minimum voltage (V_{min}) must always be greater than 39.0V_{DC}.

Equation for modified Max List2 current drain

Max List2 (for V_{min}) = [Max List2 (for -39.0 V_{DC})] X [39.0/V_{min}]

Feeder wire size

The feeder wire must comply with all applicable local and national codes. Size each bay/shelf feeder for *Max List2* current drain for the corresponding bay/shelf.

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Reliability Specifications

Overview　Reliability specifications for LambdaXtreme™ Transport Release 1.1 include estimates of circuit pack failure rates, network element availability, example of system availability for an 8–channel, 10G 1600km LambdaXtreme™ Transport system, and sparing tables.

Circuit pack failure rates　Circuit pack failure rates are based on the Lucent Technologies' Reliability Information Notebook, 7th Edition, Revision 1, October 1999. Refer to Table 8-9, "Circuit Pack FIT Rates" (8-17), for predicted Circuit Pack Failure In Time (FIT) rates. The FIT values are computed based on the Lucent nominal ambient temperature of 40ºC and nominal percentage (25%) of the device's rated electrical stress.

FIT rates are provided to enable customers to stock the recommended number of spares as it is generally expected that circuit packs will fail in time. The FIT rates do not alter any applicable contracts or warranties. Refer to Table Notes 1 through 5 located at the end of the table for additional comments on data summarized in Table 8-9, "Circuit Pack FIT Rates" (8-17).

Table 8-9　Circuit Pack FIT Rates

Circuit Pack Assembly	Steady State FIT	Mean Time Between Failures (months)
SIO	63	21744
CIO	192	7135
NCTL	1015	1350
SCTL	1015	1350
OM 100G Offset (10G & 40G)	1827	750
OM 150G Offset (10G)	1827	750
SUPVY	1859	737
OMON (1x4 — Repeater)	2053	667
OM (50GHz Offset) (10G)	2127	644
OMON (1x8)	2153	636
OD 100G Offset (10G & 40G)	2305	594

Table 8-9   Circuit Pack FIT Rates   (continued)

Circuit Pack Assembly	Steady State FIT	Mean Time Between Failures (months)
OD (150GHz Offset)	2305	594
OD (OADM, 0GHz Offset)	2359	581
OD (0GHz Offset) (10G)	2405	570
OD (40G 0GHz Offset)	2505	547
OD (50GHz Offset) (10G)	2505	547
OM (40G 0GHz Offset)	2727	502
OM (0GHz Offset) (10G)	2927	468
OM (OADM 0GHz Offset)	3380	405
OT 2.5G/10G MUX LH SR (128 λ)	3950	347
OT ADD/DROP ULH IR-2 (128 λ)	5207	263
OT ADD/DROP LH IR-2 (10G) (128 λ)	5876	233
OT ADD/DROP LH SR (10G) (128 λ)	5926	231
OA OADM THRU (10G)	5353	256
OT ADD/DROP ULH SR (10G) (128 λ)	7277	188
OT 40G MUX IR (64 λ)	8990	152
OT 40G MUX VSR (64 λ)	8990	152
RPG Expansion	8394	163
OA OADM LineIn (10G)	9084	151
OA OADM Add (10G)	11773	116
OA (PreAmp Low Gain)	9671	142
OA (PreAmp High Gain)	9609	143
RPG (DCF)	11002	125
RP	10736	128
RP (50G/150G)	10936	125
OA (OADM LineOut)	11875	115
OA (VOA)	13870	99
OA (DGEF)	11705	117

Table 8-9   Circuit Pack FIT Rates   (continued)

Circuit Pack Assembly	Steady State FIT	Mean Time Between Failures (months)
OA (Raman)	12756	107
OA (Raman, EDFA)	13911	98
PWR	84	16308
FAN (single unit)	500	2740

Notes:

1. The circuit pack failure rates included are based on present day estimates of failure rates of individual components. Reliability tests on these devices show significant improvement from the initial estimates, which will be periodically reflected in CP failure rate estimates as appropriate.

2. Transmission of optical signals through LambdaXtreme™ Transport nodes is not always impacted by the failure of individual components on certain circuit packs. Raman pump lasers on amplifiers and Raman pump packs are an example. The failure of an individual pump, which technically results in the failure of the circuit pack it is mounted on, does not necessarily imply a failure of the transmission path (see Note 4 below). Therefore, failure rates of certain circuit packs in the transmission path should not be directly used for estimating availability of individual or a group of wavelength channels. In general, the availability of one or more channels is expected to be significantly better than that represented by cumulative failure rates of the transmission path circuit packs.

3. The number in the parenthesis at the end of OT pack descriptions is the number of OT's with different wavelengths in the same category. For example, OT ADD/DROP LH IR-2 (10G) (128 λ) means that there are 128 kinds (wavelengths) of 10G ADD DROP RZ Short Reach OTs. FIT and MTBF of OTs in the same category expect to be approximately the same. FIT of all circuit packs per Bellcore RPP 6, TR-332 are also available and will be provided upon request.

4. The reliability model of load sharing pumps in the LambdaXtreme™ Transport system was developed based on simulation of transmission that showed that loss of any single pump does not degrade transmission of any channels beyond the acceptance limits of the respective transmission parameters. The availability model, therefore, includes the

following assumptions: 1) Loss of two pumps in RPM-CO will not impact the signal transmission. 2) Loss of one pump in RPM or RPM-DCM will not impact the signal transmission. 3) The probability of a second failure during the repair process (2 hours) is very small and can be neglected without significant influence on prediction accuracy.

5. FIT rates for the OT 40G MUX VSR and OT 40G MUX IR circuit packs are based on target FIT rates for certain optics modules and devices. FIT rates for these two 40G OT packs may have to be modified if, in working with the vendors of these devices, our reliability team obtains FIT rates for these devices which deviate from the target FIT rates.

Transmission path availability

System/node availability varies with system/node configuration. Table 8-10, "LambdaXtreme™ Transport End Terminals Availability Estimate" (8-20) summarizes the availability estimates for LambdaXtreme™ Transport End Terminals. Table 8-11, "LambdaXtreme™ Transport Node Availability Estimates" (8-21) summarizes the availability estimates for LambdaXtreme™ Transport OADM terminals and Repeaters.

Network Element (Node) Availability

Table 8-10   LambdaXtreme™ Transport End Terminals Availability Estimate

	Unit	End Terminal (10G, 8 λ)	End Terminal (10G, 40 λ)	End Terminal (40G, 8 λ)[7]
Node Availability[1]	%	99.987,203	99.954,462	99.987,491
Node Outage[2]	Min-utes per year	67.3	239.4	65.8
Node Channel Availability[3]	%	99.993,129	99.988,833	99.993,227
Node Channel Outage[4]	Min-utes per year	36.1	58.7	35.6

Table 8-10 LambdaXtreme™ Transport End Terminals Availability Estimate (continued)

	Unit	End Terminal (10G, 8 λ)	End Terminal (10G, 40 λ)	End Terminal (40G, 8 λ)[7]
Node MTBF[5]	Hours	13,996	4,255	14,284
Node MTBMA[6]	Hours	11,218	3,807	11,402

Notes:

1. *Node Availability* is referred to as the probability of provisioning required services for all channels through the node.

2. *Node Outage* is node downtime in minutes per year = (1-Node Availability)*(365*24*60*).

3. *Node Channel Availability* is referred to as the probability of provisioning required services for an individual channel.

4. *Node Channel Outage* is node channel downtime in minutes per year = (1-Node Channel Availability)*(365*24*60*).

5. *MTBF* is mean time between failures.

6. *MTBMA* is mean time between maintenance activities.

7. This node contains OT 40G MUX VSR and OT 40G MUX IR circuit packs whose FIT rates are based on target FIT rates for certain optics modules and devices. If, in working with the vendors of these devices, our reliability team obtains FIT rates for these devices which deviate from the target FIT rates, the 40G OT circuit pack FIT rates and the node reliability and availability data will have to be updated.

Table 8-11 LambdaXtreme™ Transport Node Availability Estimates

	Unit	OADM	Basic Repeater	DGEF Repeater
Node Availability[1]	%	99.976, 462	99.996, 329	99.995, 131
Node Outage[2]	Min-utes per year	123.7	19.3[7, 8, 9]	25.6[8, 9, 10]
Node Channel Availability[3]	%	99.982, 388	99.996, 329	99.995, 131

Table 8-11   LambdaXtreme™ Transport Node Availability Estimates   (continued)

	Unit	OADM	Basic Repeater	DGEF Repeater
Node Channel Outage[4]	Min-utes per year	92.6	19.3[7, 8, 9]	25.6[8, 9, 10]
Node MTBF[5]	Hours	7,085	23,613	25,336
Node MTBMA[6]	Hours	5,662	18,212	18,967

Notes:

1. *Node Availability* is referred to as the probability of provisioning required services for all channels through the node.

2. *Node Outage* is node downtime in minutes per year = (1-Node Availability)*(365*24*60*).

3. *Node Channel Availability* is referred to as the probability of provisioning required services for an individual channel.

4. *Node Channel Outage* is node channel downtime in minutes per year = (1-Node Channel Availability)*(365*24*60*).

5. *MTBF* is mean time between failures.

6. *MTBMA* is mean time between maintenance activities.

7. A basic Repeater has 4.3 minutes per year outage time with pre-emptive rerouting planned downtime out of 19.3 minutes per year node total outage time. (Planned downtime can be removed from the node down time if pre-emptive rerouting can be implemented through available channels in other transmission paths of the network.)

8. The reliability model of load sharing pumps in the LambdaXtreme™ Transport system was developed based on simulation of transmission that showed that loss of any single pump does not degrade transmission of any channels beyond the acceptance limits of the respective transmission parameters. The availability model, therefore, includes the following assumptions: 1) Loss of two pumps in RPM-CO will not impact the signal transmission. 2) Loss of one pump in RPM or RPM-DCM will not impact the signal transmission. 3) The probability of a second failure during the repair process (2 hours) is very small and can be neglected without significant influence on prediction accuracy.

9. There are two categories of system outage (downtime): 1) General outage (unplanned downtime) - refers to the failure of component that

will affect transmission of all channels. Mean repair and reinstallation time to restore service is assumed to be two hours. 2) Outage with preemptive rerouting (planned downtime) - refers to repair and reinstallation of component failure that produce an alarm but do not affect transmission of any channel through the system. The failed circuit pack is expected to be repaired within the assumed mean time to repair (MTTR) of 2 hours. Transmission of all channels is modeled as interrupted during the time needed to physically replace the circuit pack. MTTR for this category of repair is reduced to 15 minutes. As noted before, the probability of a second failure during the repair process (2 hours) is considered to be very small and its impact on outage is neglected without significant influence on prediction accuracy.

10. A DGEF Repeater has 3.1 minutes per year outage time with pre-emptive rerouting planned downtime out of 25.6 minutes per year node total outage time. (Planned downtime can be removed from the node down time if pre-emptive rerouting can be implemented through available channels in other transmission paths of the network.)

System availability

Availability of transmission path through an 8-channel, 10G, 1600km system is estimated as shown in <u>Table 8-12, "LambdaXtreme™ Transport System Availability Example" (8-23)</u>. The configuration includes 2 End Terminals, 13 Repeaters, and 2 DGEF Repeaters.

Also note the following concerning Transport System Outage

- Transport System Outage has 65 minutes per year outage time with pre-emptive rerouting (planned downtime) out of 436 minutes per year of transport system outage time.

- Transport System Outage has 371 minutes per year general outage time (unplanned downtime) out of 436 minutes per year of transport system outage time.

Table 8-12   LambdaXtreme™ Transport System Availability Example

Reliability Metrics	Unit	Estimate
Transport System Availability[1]	%	99.916,958
Transport System Outage[2]	Minutes per year	436
Transport System Channel Availability[3]	%	99.928,811

**Table 8-12   LambdaXtreme™ Transport System Availability
          Example   (continued)**

Reliability Metrics	Unit	Estimate
Transport System Outage[4]	Hours/ year	4.95
Transport System MTBF[5]	Hours	1,297
Transport System MTBMA[6]	Hours	1,013

Notes:

1. ***Transport System Availability*** is equal to the steady-state probability that a customer can access and use any of the two-way transmission path or individual transmission channels. (Telcordia GR-418–Core, Issue 2).

2. ***Transport System Outage*** is transport system downtime in minutes per year = (1-Transport System Availability)*(365*24*60*).

3. ***Transport System Channel Availability*** is estimated by the long fraction of time that an individual channel can be expected to perform normally. (Telcordia GR-418–Core, Issue 2).

4. ***Transport System Channel Outage*** is the transport system channel downtime in minutes per year = (1-Transport System Channel Availability)*(365*24*60*).

5. ***MTBF*** is mean time between failures.

6. ***MTBMA*** is mean time between maintenance activities.

Sparing for field replaceable units Refer to Table Notes 1 and 2, located at the end of this section, for comments on data summarized in Tables F-1 and F-2, below.

Table F-1. Recommended Circuit Pack Assembly Unit Sparing Levels – (Assumes a 30 Day Lead[1] Time)

Complex CP Assembly Name	Complex CP Assembly Code	Number of Circuit Packs in Service to be Covered by the Spares[2]															
		1	5	10	15	20	25	30	40	50	65	80	100	150	200	300	500
System Input/Output	WWAD04	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
Controller Input/Output	WWAD01	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3
Network Element Controller	WWAD02	1	1	1	1	1	1	2	2	2	3	3	3	3	3	4	4
Shelf Controller	WWAD03	1	1	1	1	1	1	2	2	2	3	3	3	3	3	4	4
Optical Multiplexer 100GHz offset (10G & 40G)	WWAC03	1	1	1	1	2	2	2	3	3	3	3	3	4	4	4	5
Optical Multiplexer 150 GHz offset (10G)	WWAC04	1	1	1	1	2	2	2	3	3	3	3	3	4	4	4	5
Optical Supervisory Channel Controller	WAD05	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	5
Optical Monitor (1:4)	WWAD08	1	1	1	2	2	2	2	3	3	3	3	3	4	4	5	5
Optical Multiplexer 50GHz offset (10G)	WWAC02	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Monitor (1:8)	WWAD06	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 100GHz offset (10G&40G)	WWAB03	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 150GHz offset (10G)	WWAB04	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 0GHz offset OADM	WWAB21	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 0GHz (10G)	WWAB01	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 0GHz offset (40G)	WWAB11	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Demultiplexer 50GHz offset (10G)	WWAB02	1	1	1	2	2	2	3	3	3	3	3	3	4	4	5	6
Optical Multiplexer 0GHz offset (40G)	WWAC11	1	1	1	2	2	3	3	3	3	3	3	4	4	4	5	6
Optical Multiplexer 0GHz offset (10G)	WWAC01	1	1	2	2	2	3	3	3	3	3	3	4	4	4	5	6
Optical Multiplexer 0GHz offset OADM	WWAC21	1	1	2	2	3	3	3	3	3	3	4	4	4	5	5	7
10G MUX RZ SR OT (128)	WWBDXXXX	1	1	2	2	3	3	3	3	3	3	4	4	4	5	6	7

Complex CP Assembly Name	Complex CP Assembly Code	Number of Circuit Packs in Service to be Covered by the Spares[2]														
		1	5	10	15	20	25	30	40	50	65	80	100	150	200	300	500
10G ADD DROP SOL IR OT (128)	WWBFXXXX	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
10G ADD DROP RZ IR OT (128)	WWBBXXXX	1	2	2	3	3	3	3	3	4	4	4	4	5	6	7	9
10G ADD DROP RZ VSR OT (128)	WWBAXXXX	1	2	2	3	3	3	3	3	4	4	4	4	5	6	7	9
Optical Amplifier (OADM, Thru)	WWAA34	1	1	2	3	3	3	3	3	3	4	4	4	5	6	7	8
10G ADD DROP SOL VSR OT (128)	WWBEXXXX	1	2	3	3	3	3	3	4	4	4	4	5	6	6	7	10
40G MUX OT IR (64)	WWBJXXXX	1	2	3	3	3	3	4	4	4	5	5	5	6	7	9	12
40G MUX OT VSR (64)	WWBNXXXX	1	2	3	3	3	3	4	4	4	5	5	5	6	7	9	12
Raman Pump Expansion	WWAF03	1	2	3	3	3	3	3	4	4	4	5	5	6	7	8	10
Optical Amplifier (OADM,Line-In)	WWAA04	1	2	3	3	3	3	4	4	4	4	5	5	6	7	8	11
Optical Amplifier (OADM, Add)	WWAA24	1	2	3	3	3	4	4	4	4	5	5	6	7	8	9	13
Optical Amplifier EDFA Low Gain Preamp	WWAA02	1	2	3	3	3	3	4	4	4	5	5	5	6	7	9	11
Optical Amplifier EDFA High Gain Preamp	WWAA03	1	2	3	3	3	3	4	4	4	5	5	5	6	7	9	11
Raman Pump Expansion DCF	WWAF04	1	2	3	3	3	4	4	4	4	5	5	6	7	8	9	12
Raman Pump OSP	WWAF01	1	2	3	3	3	3	4	4	4	5	5	6	7	7	9	12
Raman Pump OSP with Splitter	WWAF02	1	1	1	1	1	1	2	2	2	3	3	3	3	3	4	4
Optical Amplifier (OADM, Line-Out)	WWAA14	1	2	3	3	3	4	4	4	4	5	5	6	7	8	10	13
Optical Amplifier EDFA with VOA	WWAA01	1	3	3	3	4	4	4	4	5	5	6	6	7	8	10	14
Optical Amplifier Line Amp with DGEF	WWAA07	1	2	3	3	3	4	4	4	4	5	5	6	7	8	9	12
Optical Amplifier Line Amp with Raman	WWAA05	1	3	3	3	3	4	4	4	5	5	5	6	7	8	10	13
Optical Amplifier Line Amp with RAMAN & EDFA	WWAA06	1	3	3	3	4	4	4	4	5	5	6	6	7	8	10	14
Six Fan Tray Assembly		1	1	2	2	2	3	3	3	3	3	3	4	4	4	5	6
Power Filter	WWAD07	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2

Table F-2. Recommended Circuit Pack Assembly Unit Sparing Levels – (Assumes a 60 Day Lead[1] Time)

Complex CP Assembly Name	Complex CP Assembly Code	Number of Circuit Packs in Service to be Covered by the Spares[2]															
		1	5	10	15	20	25	30	40	50	65	80	100	150	200	300	500
System Input/Output	WWAD04	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Controller Input/Output	WWAD01	1	1	1	1	1	1	1	1	1	1	2	2	2	3	3	3
Network Element Controller	WWAD02	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	5
Shelf Controller	WWAD03	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	5
Optical Multiplexer 100GHz offset (10G & 40G)	WWAC03	1	1	2	2	3	3	3	3	3	3	4	4	4	5	6	7
Optical Multiplexer 150 GHz offset (10G)	WWAC04	1	1	2	2	3	3	3	3	3	3	4	4	4	5	6	7
Optical Supervisory Channel Controller	WAD05	1	1	2	2	3	3	3	3	3	3	4	4	4	5	6	7
Optical Monitor (1:4)	WWAD08	1	1	2	2	3	3	3	3	3	3	4	4	5	5	6	7
Optical Multiplexer 50GHz offset (10G)	WWAC02	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	7
Optical Monitor (1:8)	WWAD06	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	7
Optical Demultiplexer 100GHz offset (10G&40G)	WWAB03	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Demultiplexer 150GHz offset (10G)	WWAB04	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Demultiplexer 0GHz offset OADM	WWAB21	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Demultiplexer 0GHz (10G)	WWAB01	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Demultiplexer 0GHz offset (40G)	WWAB11	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Demultiplexer 50GHz offset (10G)	WWAB02	1	1	2	3	3	3	3	3	3	4	4	4	5	5	6	8
Optical Multiplexer 0GHz offset (40G)	WWAC11	1	1	2	3	3	3	3	3	4	4	4	4	5	6	7	8
Optical Multiplexer 0GHz offset (10G)	WWAC01	1	2	2	3	3	3	3	3	4	4	4	4	5	6	7	9
Optical Multiplexer 0GHz offset OADM	WWAC21	1	2	3	3	3	3	3	4	4	4	4	5	5	6	7	9
10G MUX RZ SR OT (128)	WWBDXXXX	1	2	3	3	3	3	3	4	4	4	5	5	6	6	8	10

Complex CP Assembly Name	Complex CP Assembly Code	Number of Circuit Packs in Service to be Covered by the Spares[2]														
		1	5	10	15	20	25	30	40	50	65	80	100	150	200	300	500
10G ADD DROP SOL IR OT (128)	WWBFXXXX	1	2	3	3	3	3	4	4	4	5	5	5	6	7	9	12
10G ADD DROP RZ IR OT (128)	WWBBXXXX	1	2	3	3	3	4	4	4	4	5	5	6	7	8	9	12
10G ADD DROP RZ VSR OT (128)	WWBAXXXX	1	2	3	3	3	4	4	4	4	5	5	6	7	8	10	13
Optical Amplifier (OADM, Thru)	WWAA34	1	2	3	3	3	3	4	4	4	5	5	6	7	7	9	12
10G ADD DROP SOL VSR OT (128)	WWBEXXXX	1	3	3	3	4	4	4	4	5	5	6	6	7	9	11	14
40G MUX OT IR (64)	WWBJXXXX	1	3	3	4	4	4	5	5	5	6	7	7	9	10	13	18
40G MUX OT VSR (64)	WWBNXXXX	1	3	3	4	4	4	5	5	5	6	7	7	9	10	13	18
Raman Pump Expansion	WWAF03	1	3	3	3	4	4	4	5	5	6	6	7	8	9	11	15
Optical Amplifier (OADM,Line-In)	WWAA04	1	3	3	4	4	4	4	5	5	6	6	7	8	10	12	16
Optical Amplifier (OADM, Add)	WWAA24	1	3	3	4	4	4	5	5	6	6	7	8	9	11	14	19
Optical Amplifier EDFA Low Gain Preamp	WWAA02	1	3	3	4	4	4	4	5	5	6	6	7	9	10	12	17
Optical Amplifier EDFA High Gain Preamp	WWAA03	1	3	3	4	4	4	4	5	5	6	6	7	9	10	12	17
Raman Pump Expansion DCF	WWAF04	1	3	3	4	4	4	5	5	6	6	7	8	9	11	13	18
Raman Pump OSP	WWAF01	1	3	3	4	4	4	5	5	6	6	7	7	9	10	13	18
Raman Pump OSP with Splitter	WWAF02	1	3	3	4	4	4	5	5	6	6	7	7	9	11	13	18
Optical Amplifier (OADM, Line-Out)	WWAA14	1	3	3	4	4	4	5	5	6	6	7	8	10	11	14	19
Optical Amplifier EDFA with VOA	WWAA01	1	3	4	4	4	5	5	6	6	7	8	8	10	12	15	21
Optical Amplifier Line Amp with DGEF	WWAA07	1	3	3	4	4	4	5	5	6	6	7	8	9	11	14	19
Optical Amplifier Line Amp with Raman	WWAA05	1	3	3	4	4	5	5	5	6	7	7	8	10	12	15	20
Optical Amplifier Line Amp with RAMAN & EDFA	WWAA06	1	3	4	4	4	5	5	6	6	7	8	8	10	12	15	21
Six Fan Tray Assembly		1	2	2	3	3	3	3	3	4	4	4	4	5	6	7	9
Power Filter	WWAD07	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3

Notes for sparing levels

1. In the context of sparing, lead time, also known as circuit pack repair turnaround time, is defined as the elapsed time from when a circuit pack is known to fail at a given service location to when a repaired pack (or new replacement pack) arrives at the location were the spares are stocked. Lead time, as used herein, does not pertain to the delivery intervals from the submission of a purchase order, as that term may be used under any applicable contract. Furthermore, lead time should not be confused with mean time to repair (typically, 0.5 to 4 hours), which is the time elapsed from when a circuit pack or unit is known to fail in service to when a spare circuit pack or unit is placed in service to replace the failed item. It is the customer's responsibility to maintain the recommended sparing levels at all times. The need to maintain recommended sparing levels implies that a replacement spare must be ordered immediately upon the detection of a pack failing in service. In addition, lead times and FIT rates specified here are assumptions for purposes of maintaining adequate sparing levels only, and they do not change the terms of any applicable contracts, including ordering terms, lead times, delivery provisions, or any applicable warranties that may be in effect.

2. Estimated spares are based on steady-state failure rates shown in Table 8-9, "Circuit Pack FIT Rates" (8-17).

Scheduled maintenance

Change air filters every 6 months.

☐

Glossary

NUMERICS

3R (Reshaping, Reamplification, Retiming) Functionality

When a signal is converted from optical to electrical, optical translators reshape, reamplify, and retime the electrical signal. The electrical signal is then converted back to optical.

10/100 BASE-T

A twisted-pair cable version of an IEEE 802.3 network.

100BASE-TX

A 100-Mbps Ethernet implementation over Category 5 twisted-pair cabling. In other words, this is a 100 megabit-per-second local area network known by the generic name of Fast Ethernet operating over twisted copper cable. This technology is becoming very popular and cost-effective. It is designed to integrate with existing networks with minimal disruption.

A   ACO (Alarm Cut-Off)

A push-button switch on the indicator strip that can be used to retire an audible office alarm.

AID (Access Identifier)

AIDs identify an entity or a range of entities within a NE in a TL1 message (for example, a port or list of ports). See also TL1. This field is optional.

AIM (Alarm Indication Message)

A message sent from a one NE to another NE to indicate that it has received a signal so degraded that it raised an alarm.

AIS (Alarm Indication Signal)

A signal sent downstream by a NE to indicate that its incoming signal has failed.

Alarm

External notification or display of a failure condition. The indication of a failure towards an external system interface or via audible or visible indicators.

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Alarm List
A status report that lists active alarms on the NE.

Alarm Log
A history of the setting and clearing of system alarms on the NE.

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.

Angular Misalignment
Loss at a connector due to misaligned fiber end face angles.

Anomaly
Any deviation from normal behavior. Anomalies do not result in any consequent actions, but are contributors to defects and performance monitoring counts.

ANSI (American National Standards Institute)
A United States standards body that accredits standards for programming languages, communications and networking; it is the U.S. representative in the International Organization for Standardization (ISO).

APC (Angle Polished Connector)
An 5″-15″ angle on the connector tip for the minimum possible back reflection.

Apparatus Code
ASCII name assigned by the manufacturer to identify a particular circuit pack by pack type and number.

APR (Automatic Power Reduction)
The lowering of the laser power to a limit that fits into class 1 category for handling fiber cables. APR replaces the full power off feature known as ALS (automatic laser shutdown) or APSD (automatic power shutdown).

AR (Antireflection coating)
A thin, dielectric or metallic film applied to an optical surface to reduce its reflection and thereby, increase its transmission.

ASE (Amplified Spontaneous Emission)
An optical noise generated in an erbium-doped fiber amplifier (EDFA) with and without signal input power.

ASTM (American Society for Testing and Materials)

A non-profit industry wide organization that publishes standards, methods of test, recommended practices, definitions and other related material.

Asynchronous

Data that is transmitted without an associated clock signal.

ATAG (Autonomously generated correlation TAG)

An autonomous TL1 message (event) counter used to detect lost events.

ATM (Asynchronous Transfer Mode)

A digital transmission switching format, containing 5 bytes of header information followed by 48 data bytes. Part of the B-ISDN standard.

Attenuation

The decrease in signal strength along a fiber optic waveguide caused by absorption and scattering. Attenuation is usually expressed in dB/km.

Attenuator

In optical systems, a passive device that reduces the amplitude of a signal without distorting the waveform.

Auto-Provisioning

Configuration of system parts without pre-provisioning. When a part is plugged into the system it is accepted with its default configuration.

Automatic Protection Switch

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

Autonomous Messages

Messages sent to the CIT to notify it of state changes in the system. These messages are initiated by the system. They are not responses to a CIT-initiated command.
Examples of Autonomous Messages include alarms, events (non-alarmed condition), notification of connections that are added or deleted, and changes in the node database.

B   Backscattering

The return of a portion of scattered light to the input end of a fiber; the scattering of light in the direction opposite to its original propagation.

Bay

A mechanical facility to mount shelves and other equipment for system configurations. Bays can be accessed from the front side or front and rear side. It is made of aluminum or steel and is attached to the wall or ceiling. Equipment cabling is laid in or attached to the Bay. Also known

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as rack.

BCM (Board Controller Module)

A small module (printed wiring board plus components) that plugs into almost every circuit pack (other than the NCTL, SCTL, and SUPVY) to supply the processor, memory and intra-NE communications capabilities needed to operate the pack in the system.

Beamsplitter

An optical device, such as a partially reflecting mirror, that splits a beam of light into two or more beams. Used in fiber optics for directional couplers.

Bend Radius

The smallest radius an optical fiber or fiber cable can bend before increased attenuation or breakage occurs.

Bending Loss

Attenuation caused by high-order modes radiating from the outside of a fiber optic waveguide, which occur when the fiber is bent around a small radius. See also macrobending, microbending.

BER (Bit Error Rate)

BER measures how accurately a bit stream is transmitted through a system. It measures how many bits are received in error compared to how many are sent.

Birefringent

When the refractive index differs in light of different polarizations.

C **Cable Assembly**

A cable that is connector terminated and ready for installation.

Cable Plant

The cable plant consists of all the optical elements including fiber connectors, splices, etc. between a transmitter and a receiver.

CCITT (Consultative Committee for the International Telephone and Telegraph)

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).

CDS (Complementary Double Shelf)

The double shelf used in an Extension Bay; two per bay.

CE (Conformite Europeenne)

The CE Mark is a European proof of conformity and is also described as "passport" that allows manufacturers and exporters to circulate products freely within the EU. The letters "CE" indicate that the manufacturer has satisfied all assessment procedures specified by law for its product.

Center Wavelength

In a laser, the nominal value central operating wavelength. It is the wavelength defined by a peak mode measurement where the effective optical power resides. In a LED, the average of the two wavelengths measured at the half amplitude points of the power spectrum.

Channel

A communications path or the signal sent over that path.

Chirp

In laser diodes, the shift of the laser's central wavelength during single pulse duration due to laser instability.

Chromatic Dispersion

The speed at which an optical pulse travels depends on the fiber wavelength. This is caused by several factors including material dispersion, waveguide dispersion and profile dispersion. The net effect is that if an optical pulse contains multiple wavelengths (colors), then the different colors travel at different speeds and arrive at different times, smearing the received optical signal.

CIO (Controller Input/Output) Circuit Pack

CIO indicates Ethernet port status.

CIT (Craft Interface Terminal)

The terminal used as the local interface between humans and an NE. It is used to issue commands to the local system or, by way of a remote login, to another system on the same fiber as the local system.

CL (Coupling Ratio/Loss)

The ratio/loss of optical power from one output port to the total output power, expressed as a percent.

Cladding

The material that surrounds the core of an optical fiber which has a lower index of refraction compared to that of the core. The lower index of refraction causes the transmitted light to travel down the core.

CLEI (Common Language Equipment Identifier)

For circuit packs in domestic markets, this is assigned by Telecordia and is 10 bytes (characters) long. The CLEI is mapped to the ECI (Equipment Code Identifier) in the customer database. For

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international market, the CLEI is assigned by CClib and is 9 characters long.

Connector
A mechanical or optical device that provides a demountable connection between two fibers or a fiber and a source or detector.

Connector Plug
A device used to terminate an optical conductor cable.

Connector Receptacle
The fixed or stationary half of a connection that is mounted on a panel/bulkhead. Receptacles mate with plugs.

Connector Variation
The maximum value in dB of the difference in insertion loss between mating optical connectors (for example, with re-mating, temperature cycling, etc.). Also called optical connector variation.

Core
The central portion of the fiber that transmits light. It is composed of material with a higher index of refraction than the cladding.

Coupler
An optical device that combines or splits power from optical fibers.

CR (Coupling Ratio/Loss)
The ratio/loss of optical power from one output port to the total output power, expressed as a percent. For a 1 x 2 WDM or coupler with output powers O1 and O2, and Oi representing both output powers.

CRC (Cyclic Redundancy Check)
A method to detect skipped bits in a byte stream.

CSA (Canadian Standards Association)
A non-profit independent organization which operates a listing services for electrical and electronic materials and equipment. It is the body that establishes telephone equipment (and other) standards of use in Canada. At least in part, CSA is the Canadian counterpart of the Underwriters Laboratories. CSA also is heavily involved in the development of the ISO standards on quality and Environmental Management.

CSMA/CD (Carrier Sense Multiple Access with Collision Detection)
A control technique for getting onto and off a LAN. All devices attached to the network listen for transmissions in progress (that is, carrier sense) before starting to transmit (multiple access). If two or more begin transmitting at the same time and their transmissions crash into each other, each backs off (collision detection) for a different amount of time (determined by an algorithm) before again attempting to transmit.

CTAG (Correlation Tag)
The CTAG of a TL1 command is repeated in the associated response and allows an operator to find matches.

Current SW Generic (Current Software Generic)
The software and data that the NE is currently using. It is loaded on to the active partition of the FMM.

CW (Continuous Wave)
The constant optical output from an optical source when it is turned on, but not modulated with a signal.

D **DAR (Deutscher AkkreditierungsRat)**
The German Accreditation Council (DAR) is a working group established by the Federal Government, the Ministries of the Federal German States and the German industry. DAR coordinates the activities in the area of accreditation and recognition of testing and calibration laboratories, certification and inspection bodies in Germany; runs a central registration of German accreditations and recognitions granted; and represents German interests in national, European and international organizations dealing with general questions of accreditation and recognition.

Dark Current
The flow of electricity through the diode in a photodiode when no light is present.

DCC (Data Communication Channel)
A portion of the SDH/SONET signal that contains alarm, surveillance, and performance information.

DCF (Dispersion Compensating Fiber)
DCF is a special fiber with a negative chromatic dispersion coefficient used to compensate the positive chromatic dispersion of the transmission fiber in the third optical window.

DCM (Dispersion Compensation Module)
Spooled fiber used to control excess dispersion found in certain fiber types at pre- and post-amplification.

DCN (Data Communication Network)
DCN supports communications between NEs and the NMS.

DCS (Digital Cross-Connect System)
A system that has multiple input and output streams, and can interconnect a signal from any input to any output.

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DEMUX or DMX (Demultiplexer)

A module that separates two or more signals previously combined by compatible multiplexing equipment.

Detector

An opto-electric transducer used in fiber optics to convert optical power to electrical current. Usually referred to as a photodiode.

DGEF (Dynamic Gain Equalization Filter)

A filter that equalizes the gain of an optical signal

DHCP (Dynamic Host Control Protocol)

DHCP enables PCs and workstations to get temporary or permanent IP addresses from the server.

DIN (Deutsche Industrie Norm)

DIN is the German Institute for Standardization in Berlin. Since 1975 it has been recognized by the German government as the national standards body and represents German interests at international and European level.

Directional Coupler

A coupling device for separately sampling (through a known coupling loss) either the forward (incident) or the backward (reflected) wave in a transmission line.

Dispersion

The temporal spreading of a light signal in an optical waveguide caused by light signals traveling at different speeds through a fiber either due to modal or chromatic effects.

Distortion

The difference in value between two measurements of a signal (transmitted and received.)

DL (Data Link)

The communication links used for data transmission from a source to a destination.

DSA (Directory System Agent)

A DSA is an operating system application process that provides the Directory functionality.

DSF (Dispersion-Shifted Fiber)

Standard single-mode fibers exhibit optimum attenuation performance at 1550 nm and optimum bandwidth at 1300 nm.

DTE (Data Terminal Equipment)

DTE is part of a broader grouping of equipment known as customer premises equipment which includes voice, data, and end terminals.

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Duplex Cable

A two-fiber cable suitable for duplex transmission.

Duplex Transmission

Transmission in both directions, either one direction at a time (half-duplex) or both directions simultaneously (full-duplex).

DWDM (Dense Wavelength Division Multiplexing)

Transmitting two or more signals of different wavelengths simultaneously over a single fiber.

E   E-LEAF (Enhanced -Large Effective Area Fiber)

A fiber type manufactured by Corning.

EDC (Error Detection Code)

Code construction that provides a way to protect, correct data from errors, and maintain the data integrity.

EDCV (Error Detection Code Violation)

An EDCV occurs when the calculated checksum over a signal does not match the received checksum.

EDFA (Erbium-Doped Fiber Amplifier)

Optical fibers doped with the rare earth element erbium which can amplify light in the 1550 nm region when pumped by an external light source.

EEPROM (Electrical Erasable and Programmable Read-Only Memory)

Kind of non-volatile memory. Often used to store inventory data.

EMI (Electromagnetic Interference)

High-energy, electrically induced magnetic fields that cause data corruption in cables passing through the fields.

EML (Externally Modulated Laser)

When laser is modulated using a Mach-Zehnder modulator.

EMR (Electromagnetic Radiation)

Radiation made up of oscillating electric and magnetic fields and propagated with the speed of light. Includes gamma radiation, X-rays, ultraviolet, visible and infrared radiation, and radar and radio waves.

EMS (Element Management System)

Element management systems, for example, OCI or SNMS, which are either directly attached to a NE or remotely by using the DCN.

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Engineering Rules

A set of rules that determine the system configuration possibilities based on fiber type, OA, rate and number of wavelengths. These rules determine the maximum loss per span that can be tolerated, the maximum distance between spans allowed and the maximum number of spans that can be supported.

EOL (End-Of-Life)

EOL defines the status or values at the end of the guaranteed lifetime. EOL is reached when the wear-out failure rate dominates the component failure rate.

Error Recovery

The intent to recover from a detected error, such as inconsistent state or configuration information. See also Operational Recovery.

ES-IS (End System to Intermediate System Protocol)

An ISO OSI network layer protocol (ISO 9542) for End Systems (alias hosts) communicating to Intermediate Systems (alias routers) that dynamically builds the relevant network routing databases (administrative protocol).

ESD (Electro-Static Discharge)

Static electrical energy potentially harmful to circuit packs and humans.

ET (End Terminal)

Optical equipment that terminates optical line signals.

ETSI (European Telecommunications Standards Institute)

Located in Sophia-Antipolis in France, ETSI is the European counterpart to ANSI. Its task is to pave the way for telecommunications integration in the European community as part of the single European market program. It establishes telecommunication standards for the European community.

External Modulation

Modulation of a light source by an external device that acts like an electronic shutter.

Extinction Ratio

The ratio of the low, or OFF optical power level (Pl) to the high, or ON optical power level (Ph).

Eye Pattern

Also called eye diagram. The proper function of a digital system can be quantitatively described by its BER, or qualitatively by its eye pattern. The ″openness″ of the eye relates to the BER that can be achieved.

F   **Fabric**

The part of an optical system that is responsible for switching voice, data or video from one place to another

Failure

A failure is declared when a fault cause persists for a certain period of time.

Failure Rate

The number of failures of a device per unit of time.

Fall Time

The time required for the trailing edge of a pulse to fall from 90% to 10% of its amplitude; the time required for a component to produce such a result. Typically measured between the 80% and 20% points or alternately the 90% and 10% points. Also called turn-off time.

Far-End Crosstalk

Crosstalk which travels along a circuit in the same direction as the signals in the circuit.

FAS (Frame Alignment Signal)

A sequence at the beginning of an SDH/SONET frame that detects the frame start.

FC (Fiber Optic Connector)

A threaded optical connector (originated in Japan), good for single-mode or multimode fiber and applications requiring low back reflection.

FC/PC

A special curved polish on the connector for very low back reflection.

FCC (Federal Communications Commission)

The U.S. federal regulatory agency responsible for the regulation of interstate and international communications by radio, television, wire, satellite and cable.

FDDI (Fiber Distributed Data Interface)

A 100 Mbps fiber optic LAN.

FE (Far End)

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

FEBE (Far End Block Error)

A maintenance signal transmitted in the physical overhead indicating that a bit error has been detected at the physical layer at the far end of the link.

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FEC (Forward Error Correction)

A method to correct bit errors in a transmission signal. Additional information is put into the data signal to allow the correction of bit errors. There is no acknowledge information in the back direction.

Ferrule

A rigid tube that confines or holds a fiber as part of a connector assembly.

Fiber Optic Attenuator

A component installed in a fiber optic transmission system that reduces the power in the optical signal. It is often used to limit the optical power received by the photo detector to within the limits of the optical receiver.

Fiber Optic Cable

A cable containing one or more optical fibers.

Fiber Optic Link

A transmitter, receiver, and cable assembly that can transmit information between two points.

Fiber Optic Span

An optical fiber/cable terminated at both ends which may include devices that add, subtract, or attenuate optical signals.

FIT (Failure In Time)

A unit of failure rate in reliability analysis. One FIT is equivalent to one failure per one billion operating hours.

FIT Rate

Number of device failures in one billion device hours.

FMM (FlashDisk Memory Module)

A nonvolatile memory device used to store the installation software generic or the NE database.

Fresnel Reflection

A reflection of light that occurs at the air-glass interface at the ends of an optical fiber.

Fused Fiber

A bundle of fibers fused together so they maintain a fixed alignment with respect to each other in a rigid rod.

Fusion Splicer

An instrument that permanently bonds two fibers together by heating and fusing them.

G   Gain

The increase in power and magnitude of a signal.

GNE (Gateway Network Element)

A system node that has a physical attachment to the management system to support the access of the remote NE. The number of remote NEs a GNE can serve is specified in terms of the number of OSI stack associations the GNE can support without running out of local resources.

GPIO (General Purpose Input/Output)

GPIO provides a flexible way of interfacing a wide range of peripheral devices with a computer. Among the interface methods GPIO uses are the configurable data sense and handshaking (signals used between a computer and a peripheral to inform each other when either is ready to receive or transmit data).

Grooming

Consolidating or segregating traffic for efficiency.

Ground Loop Noise

Noise that results when equipment is grounded at points having different potentials thereby creating an unintended current path. The dielectric properties of optical fiber provide electrical isolation that eliminates ground loops.

H   HDDS (High Density Double Shelf)

The double shelf used in Line Bays; two per bay.

I   ICEA (Insulated Cable Engineers Association)

ICEA (previously IPCEA) is a professional organization dedicated to developing cable standards for the electric power, control, and telecommunications industries.

IDI (Initial Domain Identifier)

Part of the NSAP, the IDI defines the country code of the registration authority responsible for the allocation and assignment of the NSAP address.

IEC (International Electrotechnical Commission)

The international standards and conformity assessment body for all fields of electrotechnology, including electricity and electronics.

IEEE (Institute of Electrical and Electronic Engineers)

The IEEE helps advance global prosperity by promoting the engineering process of creating, developing, integrating, sharing, and applying knowledge about electrical and information technologies and sciences for the benefit of humanity and the profession.

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IMF (Infant Mortality Factor)

The ratio of the first year failure rate to the steady-state failure rate.

Index of Refraction

Also refractive index. The ratio of the velocity of light in free space to the velocity of light in a fiber material. Symbolized by n and is greater than or equal to one.

Index-Matching Gel

A gel with an index of refraction nearly equal to that of the fiber's core. This gel is used to reduce Fresnel reflection at fiber ends.

Insertion Loss

The loss of power that results from inserting a component, such as a connector or splice, into a previously continuous path.

Intrinsic Losses

Splice losses arising from differences in the fibers being spliced.

IR (Intermediate Reach)

Optical sections from a few kilometers (km) to approximately 15 km.

Irradiance

The amount of power per unit area.

ISO (International Standards Organization)

A United Nations agency concerned with international standardization in a broad range of industrial and technical field.

ITU (International Telecommunication Union)

A United Nations telecommunications established to provide standardized communications procedures and practices including frequency allocation and radio regulations on a worldwide basis.

J   Jacket

The outer, protective covering of the cable.

Jitter

Small and rapid variations in the timing of a waveform due to noise, changes in component characteristics, supply voltages, imperfect synchronizing circuits, and so forth.

Jumper

A short fiber optic cable with connectors on both ends.

L   **L-Band (Long Band)**
A dispersion-shifted fiber range of 1570 to 1610 nm, where a wide range of wavelengths are possible with low loss. L-Band doubles the number of wavelengths best suited in DWDM applications and uses newer, more expensive optical amplifiers. In LambdaXtreme™ Transport, the L-Band is widened and referred to as an Extended L-Band.

LAN (Local Area Network)
1. A communication link between two or more points within a small geographic area, such as between buildings. 2. A data network which has a size of normally up to 10 km. Important LANs are Ethernet, Token Ring, Token Bus and FDDI.

LAPD (Link Access Protocol on D-channel)
A special protocol of the OSI Data Link Layer, which provides the functional and procedural means to establish, maintain, and release data link connections for NEs. For NE-NE communications over the DCC, Layer 2 services are provided by LAPD.

Launch Fiber
An optical fiber used to couple and condition light from an optical source into an optical fiber Often the launch fiber is used to create an equilibrium mode distribution in multimode fiber. Also called launching fiber.

LBC (Laser Bias Current)
Current that runs through the laser to make it work. LBC is monitored by performance monitoring. If the current goes beyond a certain threshold, it means that the circuit pack must be replaced.

LBO (Line Build Out)
Attenuation used to simulate a load.

LC (Lucent Connector)
A small-form-factor (SFF) design based on a proven 1.25 mm ceramic ferrule. This connector uses RJ-style latching. It facilitates high-speed applications with lower power requirements due to lower insertion loss (0.1 dB typical) and higher return loss (55 dB single mode).

LD (Laser Diode)
A semiconductor that emits coherent light when forward biased.

LEAF (Large Effective Area Fiber)
A type of fiber manufactured by Corning.

LED (Light-emitting diode)
Diodes which translate electrical current into light. Made out of semiconductor material like Gallium-Arsenide; a semiconductor that emits incoherent light when forward biased.

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LGX (Lightguide Cross-Connect)

(Lucent product family) Fiber termination shelves and hardware used for interconnecting fiber cables, jumpers and closures that connect the switching systems to the transmission equipment.

LH (Long Haul)

A 10 Gbps application for transmission of 128 channels, giving a capacity of 1.28 Tbps and a reach of up to 2000 km. Payload (per channel) can be one OC192/STM-64 or four OC48/STM-16 signals.

LID (Link ID Protocol)

A Lucent proprietary protocol for exchange of neighbor information over a DCC link. LID makes use of LAPD (OSI) or PPP (IP).

Interchannel Isolation

The ability to prevent undesired optical energy from appearing in one signal path as a result of coupling from another signal path.

LOF (Loss of Frame)

Loss of frame is detected when the OOF anomaly persists for a certain time.

Loose-Tube

A type of fiber optic cable construction where the fiber is contained within a loose tube in the cable jacket.

LOS (Loss of Signal)

When the optical input power falls below a certain threshold.

Loss

The amount of a signal's power, expressed in dB, that is lost in connectors, splices, or fiber defects.

LR (Long Reach)

A standard for optics, concerning transmitters and receivers in a system and ensuring that transmission can be maintained for long distances (tens of kilometers). This standard constrains the output power of the transmitter and the sensitivity of the receiver for long-haul applications (up to 80 km) without the need for regeneration.

M   Macrobending

In a fiber, all macroscopic deviations of the fiber axis from a straight line.

MAN (Metropolitan Area Network)

A network covering an area larger than a local area network. A wide area network (two or more local area networks), that covers a metropolitan area.

Margin
The allowance for attenuation in addition to that explicitly accounted for in system design.

MAS (Multiplex Alignment Signal)
A byte in the 40G overhead which checks if the four-bit multiplexed 10G data streams are demultiplexed correctly. It has a value of 10100101 in the first 10G data stream, and 01011010 in the other 10G data streams.

MDI (Miscellaneous Discrete Inputs)
System input ports used to supervise external equipment in the office, for example, doors, fire alarm, and so forth.

MDO (Miscellaneous Discrete Outputs)
System binary output ports used to control external equipment in the office, for example, light, and so forth.

Mechanical Splice
An optical fiber splice accomplished by fixtures or materials, rather than by thermal fusion.

Microbending
Minute but severe bends in fiber that result in light displacement and increased loss.

Modulation
The process by which the characteristic of one wave (the carrier) is modified by another wave (the signal). Examples include amplitude modulation (AM), frequency modulation (FM), and pulse-coded modulation (PCM).

MPI (Multipath Interference)
Signal reflections and delayed signal images that interfere with the proper signal path. MPI is caused by reflections from dirty/damaged connectors, and return loss of the jumpers/patch cords. MPI may cause severe system degradation.

MS (Multiplex Section)
A multiplex section is a maintenance entity between two MS TT functions.

MTBF (Mean Time Between Failures)
The expected time between failures, usually expressed in hours.

MTTR (Mean Time To Repair)
The average time that it takes until a failure is repaired, usually expressed in hours.

Multimode Fiber
An optical fiber that has a core large enough to propagate more than one mode of light The typical diameter is 62.5 micrometers.

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Multiplexing

The process by which two or more signals are transmitted over a single communications channel. Examples include time-division multiplexing and wavelength-division multiplexing.

MUX (Multiplexer)

A device that combines two or more signals into a single output.

N   Navis Optical Element Management System (OEMS)

Navis OEMS is an element management system that provides networks with operational functions such as configuration management, fault management, performance management, and security management.

NCTL (Network Element Controller)

The NCTL provides control and user interfaces at the NE level.

NE (Network Element)

Processor controlled entities of a telecommunications network that primarily provide switching and transport network functions and contain network operations functions.

Near Infrared

The part of the infrared near the visible spectrum, typically 700 nm to 1500 nm or 2000 nm.

Near-End Crosstalk

The optical power reflected from one or more input ports, back to another input port. Also known as isolation directivity.

NEBS (Network Equipment Building Systems)

Developed by Telcordia, these are standards that vendors must adhere to if they want to sell equipment to the Regional Bell Operating Companies (RBOCs) and the Competitive Local Exchange Carriers (CLECs).

NEC (National Electric Code)

A standard governing the use of electrical wire, cable and fixtures installed in buildings; developed by the NEC Committee of the American National Standards Institute (ANSI), and sponsored by the National Fire Protection Association (NFPA).

NEMA (National Electrical Manufacturers Association)

NEMA, created in the fall of 1926 by the merger of the Electric Power Club and the Associated Manufacturers of Electrical Supplies, provides a forum for the standardization of electrical equipment, enabling consumers to select from a range of safe, effective, and compatible electrical products.

NFPA (National Fire Protection Association)

A not-for-profit organization which works with U.S. Congress and federal agencies to promote the adoption and use of fire protection codes and standards, and to promote a uniform national approach to fighting the problem of fires.

NIM (Non-intrusive Monitor)

A kind of sink termination point function which does not touch SDH/SONET signals but monitors quality of service.

NSAP (Network Service Access Point)

The access point where the Network Layer Services are available to network service users.

NVM (Non-Volatile Memory)

NVM denotes memory which survives a shut-down or power-down of the system such as a hard disk, floppy or tape. Xtreme uses a PCMCIA card for NVM.

NZDSF (Non-Zero Dispersion Shifted Fiber)

Fiber that was designed to introduce a small amount of dispersion without the zero point crossing being in the WDM passband. With this type of fiber you can eliminate, or at least greatly reduce the degradation due to four wave mixing, a distortion mechanism that requires the spectral components to be phase matched along the fiber. Examples are the TrueWave fiber from Lucent and the LS fiber from Corning.

O   OA (Optical Amplifier)

A device that amplifies an input optical signal without converting it into electrical form. The best OAs developed are optical fibers doped with the rare earth element, erbium.

OADM (Optical Add Drop Multiplexer) Terminal

A terminal capable of adding and dropping lower-rate signals from a higher- rate multiplexed signal without completely demultiplexing the signal.

OBA (Optical Booster Amplifier)

An optical amplifier with high output power.

OC-n (Optical Carrier-level n)

A carrier rate specified in the SONET standard.

OCWR (Optical Continuous Wave Reflectometer)

An instrument used to characterize a fiber optic link where an unmodulated signal is transmitted through the link, and the resulting light scattered and reflected back to the input is measured.

OD (Optical Demultiplexer)

ODs extract individual wavelengths from the DWDM optical that is generated using an Optical Multiplexer (OM).

OGC (Optic Gate Controller)

The controller of an Optic Gate module. Its tasks are to control the components of the module and connect it to a circuit pack.

OLS (Optical Line System)

A lightwave transmission system that can multiplex up 8, 16, 80 or more wavelengths, transmit the resulting multiplexed signal, and then demultiplex the signal at the other end.

OM (Optical Multiplexer)

The process by which two or more wavelengths are combined onto a single fiber.

OMON (Optical MONitor)

The OMON circuit pack scans the entire DWDM spectrum to provide Optical Spectrum Analysis (OSA) for up to 4 or 8 selected locations in an NE.

OMS (Optical Multiplex Section)

A layer in the Xtreme transmission hierarchy.

OOF (Out of Frame)

State in which the frame alignment sequence of an SDH/SONET frame has not been found for several consecutive frames.

OOS (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.

Operational Recovery

A recovery with the intent to perform an operation, such as to activate new software version.

Optical Channel

An optical wavelength band for WDM optical communications.

Optical Channel Spacing

The wavelength separation between adjacent WDM channels.

Optical Channel Width

The optical wavelength range of a channel.

Optical Isolator

A component used to block out reflected and unwanted light. Used in laser modules, for example. Also called an isolator.

Optical Link Loss Budget

The range of optical loss over which a fiber optic link will operate and meet all specifications. The loss is relative to the transmitter output power.

Optical Path Power Penalty

The additional loss budget required to account for degradations due to reflections, and the combined effects of dispersion resulting from intersymbol interference, mode-partition noise, and laser chirp.

Optical Power Meter

An instrument that measures the amount of optical power present at the end of a fiber or cable.

Orderwire

A section of the supervisory signal that is used for communication between sites.

ORL (Optical Return Loss)

The ratio (expressed in units of dB) of optical power reflected by a component or an assembly to the optical power incident on a component port when that component or assembly is introduced into a link or system.

OSA (Optical Spectrum Analyzer)

Optoelectronic device that resolves the incident light into individual wavelengths and display power vs. wavelength. Usually these are based on diffraction-grating.

OSC (Optical Supervisory Channel)

See SUPVY/SU (Supervisory Channel).

OSI (Open System Interconnection)

The internationally accepted grouping of standards for communication between different systems made by different vendors.

OSNR (Optical Signal to Noise Ratio)

The ratio between the optical power of the data signal and the power of the optical noise signal.

OT (Optical Translators)

OTs do frequency adaptation between LambdaXtreme™ Transport equipment and external equipment that are not optically compatible with LambdaXtreme. OTs also provide 3R functionality (retiming, reshaping, reamplification); and, perform fault management and performance monitoring (Non-intrusive Monitoring) on the SONET/SDH and WaveWrapper signal.

OTDR (Optical Time Domain Reflectometer)

An instrument that locates faults in optical fibers or infers attenuation by backscattered light measurements.

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OXC (Optical Cross-connect)
Devices that can switch optical signals between different optical fibers, without the need for conversion to electrical signals.

P   Passive Branching Device
A device which divides an optical input into two or more optical outputs.

PCMCIA (Personal Computer Miniature Communications International Association)
An international standards body and trade association that establishes standards for Integrated Circuit cards and promotes interchangeability among mobile computers where ruggedness, low power, and small size were critical.
PCMCIA publishes the PC Card standard which contains all of the physical, electrical and software specifications for the PC card technology. .

PCMCIA Adapter (Personal Computer Miniature Communications International Association) Adapter
A slot on the Network controller or PC where the flash disk is inserted.

PD (Photodetector)
An optoelectronic transducer such as a PIN photodiode or avalanche photodiode.

PDU (Protocol Data Unit)
PDUs are used for the information exchange between equal protocol layers.

Peak Power Output
The output power averaged over that cycle of an electromagnetic wave having the maximum peak value that can occur under any combination of signals transmitted.

Photodiode
A device that converts optical energy to electrical energy.

PID (Password Identification)
A word or character string recognized by automatic means that permits a user access to protected storage, files, or input or output devices.

Pigtail
A short optical fiber permanently attached to a source, detector or other fiber optic device.

Plastic Clad Silica
Also called hard clad silica (HCS). A step-index fiber with a glass core and plastic or polymer cladding instead of glass.

Plenum

The air handling space between walls, under structural floors, and above drop ceilings, which can be used to route intrabuilding cabling.

Plenum Cable

A cable that has flammability and smoke characteristics which allow it to be routed in a plenum area without being enclosed in a conduit.

PLL (Phase Locked Loop)

An electronic circuit that controls an oscillator so that it maintains a constant phase angle relative to a reference signal.

PM (Performance Monitoring)

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

PMD (Polarization Mode Dispersion)

PMD is an inherent property of all optical media. It is caused by the difference in the propagation velocities of light in the orthogonal principal polarization states of the transmission medium. The net effect is that if an optical pulse contains both polarization components, then the different polarization components travel at different speeds and arrive at different times, smearing the received optical signal.

pN_EBC (Near-end Errored Block Count)

Every second the number of near-end errored blocks (N_Bs) within that second is counted as the Near-end Errored Block Count (pN_EBC). This counter is used to determine the degraded defect and as an input for the performance monitoring process.

Point-to-Point Transmission

The transmission between two designated stations.

Polarization

The direction of the electric field in the lightwave.

PPP/IP (Point-to-Point Protocol/Internet Protocol)

A protocol used by a computer to connect to the Internet via a dial up telephone line and modem.

Pre-Provisioning

The capability to provision a slot before installing a circuit pack.

Previous SW Generic (Previous Software Generic)

The previous SW generic is the software and data on the alternate partition to the currently executed SW/data of the PCMCIA card. It might be installed and activated per user command. After installation previous and current SW generic are exchanged.

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Provisioning
Placing and configuring hardware and software required to activate a telecommunications service for a customer. If the equipment is in place, provisioning may consist of creating or modifying a customer record in a database to activate the services.

Pulse Spreading
The dispersion of an optical signal as it propagates through an optical fiber.

Pump laser
A laser used in an optical fiber amplifier.

Q   QoS (Quality of Service)
A set of performance parameters that characterize the transmission quality over a given virtual connection.

R   Raman Amplification
A technique in which high-power laser light is sent into the outside plant fiber (OSP) transforming part of the fiber itself into an amplifier.

Rayleigh Scattering
The scattering of light that results from small inhomogeneties of material density or composition.

RBOC (Regional Bell Operating Company)
One of the seven regional holding companies formed after the AT&T divestiture. These companies included Ameritech, Bell Atlantic, BellSouth, NYNEX, Pacific Telesis, Southwestern Bell, and U.S. West. Later on, Bell Atlantic and NYNEX merged and became Verizon; Ameritech, Pacific Telesis and Southwestern Bell merged and became SBC; and U.S. West was renamed Quest.

RDI (Remote Defect Indication)
RDI signals convey the defect status of the trail signal at the trail destination (that is, at trail termination sink function) back to the trail origin (that is, trail termination source function). This mechanism allows alignment of the near-end and far-end performance monitoring processes.

Receiver
A terminal device that includes a detector and signal processing electronics. It functions as an optical-to-electrical converter.

Receiver Overload
The maximum acceptable value of average received power for an acceptable BER or performance.

Receiver Sensitivity

The minimum acceptable value of received power needed to achieve an acceptable BER or performance. It takes into account power penalties caused by use of a transmitter with worst-case values of extinction ratio, jitter, pulse rise and fall times, optical return loss, receiver connector degradations, and measurement tolerances.

Refractive Index

A property of optical materials that relates to the speed of light in the material.

Refractive Index Gradient

The change in refractive index with distance from the axis of an optical fiber.

Refractive Index Profile

The description of the value of the refractive index as a function of distance from the optical axis along an optical fiber diameter

Regenerator

A repeater, designed for digital transmission, in which digital signals are amplified, reshaped, retimed, and retransmitted. For optical transmission, a device that receives an optical signal, converts it to electrical, regenerates the signal, converts it to optical, then transmits it.

REI (Remote Error Indication)

REI signals contain either the exact or truncated number of error detection code violations detected in the trail signal at the trail termination sink. This information is conveyed to the trail termination source. REI allows alignment of the near-end and far-end performance monitoring processes. Examples of REI signals are the FEBE bits in SDH signals.

Repeater

A receiver and transmitter set designed to amplify attenuated signals. Used to extend operating range.

Responsivity

The ratio of a photodetectors electrical output to its optical input in Amperes/Watt.

Ribbon Cables

Cables in which many fibers are embedded in a plastic material in parallel, forming a flat ribbon-like structure.

Rise Time

The time taken to make a transition from one state to another, usually measured between the 10% and 90% completion points of the transition. Alternatively the rise time may be specified at the 20% and 80% amplitudes. Shorter or faster rise times require more bandwidth in a transmission channel.

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Riser Cables
High-strength cables used in vertical shafts between floors in multi-story buildings.

RJ (Random Jitter)
Random jitter is due to thermal noise and may be modeled as a Gaussian process. The peak-to-peak value of RJ is of a probabilistic nature, and thus any specific value requires an associated probability.

RM (Registration Manager)
The Registration Manager is an application process that initiates the Registration Request Protocol, and communicates the DSA address and Name-prefix information to the Registration Agent.

RP (Raman Pump)
In LambdaXtreme Transport, RPs provide amplification/gain in the outside plant fiber by supplying a counterpropagating signal. The amplification is provided by ″pumping″ high-intensity wavelengths (that are lower than the signal wavelength) into the fiber that carries the incoming DWDM signal. (Also see RPG).

RPG (Growth Raman Pump)
In LambdaXtreme Transport, RPGs provide amplification/gain in the outside plant fiber and internally in the Dispersion Compensation Module. RPGs provide copropagating wavelengths to the outside plant fiber at the output DWDM signal and counterpropagating wavelengths to the incoming DWDM signal and to the Dispersion Compensation Module. RPGs are optional; they are used for channels above 188.45 THz. (Also see RP).

S   SC (Subscription channel connector.)
A push-pull type of optical connector that originated in Japan. Some of its features are high packing density, low loss, low backreflection, and low cost.

Scattering
The change of direction of light rays or photons after striking small particles. It may also be regarded as the diffusion of a light beam caused by the inhomogeneity of the transmitting material.

SCOT (Software Control of Transmission)
The software architecture and algorithms for control of transmissions in LambdaXtreme Transport. Software control includes the following areas: startup, transient control, APR and APR recover, single node failure in a network, adding/deleting channels, and adding the expansion pump pack (RPG).

SCTL (Shelf Controller)
SCTL provides control at the double shelf backplane level (half of a bay).

SDH (Synchronous Digital Hierarchy)

A family of digital transmission rates from 51.84 Mb/s to 9.953 Gb/s that allows the interconnection of transmission products around the world.

SEC (SDH Equipment Clock)

A timing device (equipment) used to synchronize network equipment that operates according to the principles governed by SDH.

Shelf

A shelf is a mechanical facility that is in general a housing for circuit packs. Shelves are housed in Bays.

Simplex

Single element (for example, a simplex connector is a single-fiber connector).

Simplex Cable

A term sometimes used for a single-fiber cable.

Simplex Transmission

Transmission in one direction only.

SIO (System Input/Output) Circuit Pack

SIO CP connects the NCTL to the SCTLs, provides the main interface to the system, provides LAN interfaces, provides orderwire interfaces, and provides performance monitoring interfaces.

SNMS (Sub-Network Management System)

See Navis OEMS.

Soliton Pulse

An optical pulse having a shape and power level designed to take advantage of nonlinear effects in an optical fiber waveguide, for the purpose of essentially negating dispersion over long distances. The result is that the pulse retains its original shape as it travels.

SONET (Synchronous Optical Network)

A North-American standard developed by Bell-Labs for the optical long distance networks.

Span

Fiber link between NEs that may be unidirectional or bidirectional, depending upon network design.

Span Loss

Loss (in dB) of optical power due to the span transmission medium (includes fiber loss and splice losses).

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Spectral Width
A measure of the extent of a spectrum. For a source, the width of wavelengths contained in the output at one half of the wavelength of peak power. Typical spectral widths are 50 to 160 nm for an LED and 0.1-5 nm for a laser diode.

Splice
A permanent connection of two optical fibers through fusion or mechanical means.

Splitting Ratio
The ratio of power emerging from two output ports of a coupler.

SPOT (Synchronous Partial Overhead Transparency)
Overhead bytes of SDH/SONET transmission signals which are sent together with payload although they are mapped into higher rate signals. The transparency feature is often used in combination with fiber shortage solutions.

SR (Short Reach)
Optical sections of 2 km or less.

SRS (Simulated Raman Scattering)
a broadband effect where power is transferred from a low wavelength channel to a higher-wavelength channel. The short wavelength source acts like a ″pump″.

SSMF (Standard single-mode fiber)
This is the most common type of fiber deployed. This fiber was designed to provide zero chromatic dispersion at 1310 nm, to support the early long-haul transmission systems operating at this wavelength. It has a chromatic dispersion of at most 20 ps/(nm*km) in the 1550 nm wavelength range and usually around 17 ps/(nm*km).

ST (Straight tip connector)
Popular fiber optic connector that uses a bayonet style coupling rather than a screw-on coupling.

Step-Index Fiber
Fiber that has a uniform index of refraction throughout the core.

Strength Member
The part of a fiber optic cable composed of aramid yarn, steel strands, or fiberglass filaments that increase the tensile strength of the cable.

SUPVY Pack (Supervisory Pack)
SUPVY circuit pack is a low-speed transmission pack that facilitates communication between LambdaXtreme NEs.

SUPVY/SUP (Supervisory Channels)

SUPVY/SUP supports the following communications: node-to-node, interworking, client LAN, and orderwire communication.

SW Generic (Software Generic)

The whole software and (static) data associated with a particular NE release. See also current and previous SW generic.

Synchronous

A data signal that is sent along with a clock signal.

T   T-Carrier

Generic designator for any of several digitally multiplexed telecommunications carrier systems.

Tap

The entry point into a system module

Tap Loss

In a fiber optic coupler, the ratio of power at the tap port to the power at the input port.

Tap Port

In a coupler where the splitting ratio between output ports is not equal, the output port containing the lesser power

TBOS (Telemetry Byte Oriented Serial) Protocol

A protocol used for transmitting alarms, status, and control points between a NE and the operating system.

TC (Tandem Connection)

An arbitrary series of contiguous link connections and/or subnetwork connections.

TCA (Threshold-Crossing Alert)

A condition set when a counter exceeds a user-selected high or low threshold. A TCA does not generate an alarm but is available on demand through the CIT.

TCP/IP (Transmission Control Protocol/Internet Protocol)

A suite of several networking protocols developed for the Internet that provides communication across interconnected networks, between computers with diverse hardware architectures and various operating systems. Some examples are FTP, SMTP, SNMP, and so forth.

TD (Transmit Degrade)

Indicates that the transmitted signal has degraded to a level where a certain threshold of error code violations is exceeded.

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TDC (Tunable Dispersion Compensator)

A device which has negative chromatic dispersion where the amount of dispersion can be adjusted. It is used for compensation of the chromatic dispersion of the transmission fibers.

Thermal Noise

Noise resulting from thermally induced random fluctuation in the receiver load resistance current.

Throughput Loss

In a fiber optic coupler, the ratio of power at the throughput port to the power at the input port.

TID (Target Identifier)

A provisionable parameter used to identify a NE within a TL1 command.

TL1 (Transaction Language 1)

TL1 is an OS/NE machine-to-machine language. TL1 messages are expressed as ASCII strings. TL1 messages and syntax are defined by Telcordia requirements.

TrueWave® Fiber

Non–zero dispersion-shifted fiber manufactured by Lucent Technologies.

TSD (Trail Signal Degrade)

The TSD signal (generated by a trail termination sink function) informs the next function(s) of the "signal degrade" condition of the associated data signal.

TSF (Trail Signal Fail)

The TSF signal (generated by a trail termination sink function) informs the next downstream function(s) of the "signal fail" condition of the associated data signal (which contains, due to that "signal fail" condition, the all-ONEs (AIS) pattern).

TT (Trail Termination)

An atomic function within a layer that generates, adds, and monitors information concerning the integrity and supervision of adapted information.

U   UART (Universal Asynchronous Receiver and Transmitter)

A receiver/transmitter that converts incoming serial data from a port into parallel form.

UFEC (Ultra Forward Error Correction)

An improved method to correct bit errors in a transmission signal. Additional information is put into the data signal to allow the correction of bit errors. There is no acknowledge information in the back direction.

UHC (Ultra High Capacity)

A 40G application for transmission of 64 channels for a capacity of 2.56 Tbps and a reach of up to 1000 km. Payload (per channel) can be one OC768/STM-256 or four OC192/STM-64 signals.

UID (User Identification)

A CIT user code that comprises one to ten alphanumeric, case-sensitive characters. UID identifies a user when he/she logs into a system.

ULH (Ultra Long Haul)

A 10 Gbps application for transmission of 128 channels giving a capacity of 1.28 Tbps and a reach of 2000–4000 km. Payload (per channel) can be one OC192/STM-64 or four OC48/STM-16 signals.

UNITE (UNIversal high speed TDM Equipment for multi-services)

A 10G/40G platform.

V **VOA (Variable Optical Attenuator)**

VOA correct the signal strength differences that occur in the transmission line.

VSR (Very Short Reach)

VSR is a SONET/SDH interface that provides a low-cost solution interconnection of less than 300 meters between routers, switches and DWDM systems.

W **WAN (Wide Area Network)**

A network whose elements are separated by long distances.

Waveguide

A material medium that confines and guides a propagating electromagnetic wave.

Waveguide Couplers

A coupler in which light is transferred between planar waveguides.

Waveguide Dispersion

The part of chromatic dispersion arising from the different speeds light travels in the core and cladding of a single-mode fiber (that is, from the fiber's waveguide structure).

Wavelength

The distance between points of corresponding phase of two consecutive cycles of a wave. The wavelength, is related to the propagation velocity, and the frequency.

Wavelength Growth

A type of growth in which all eight wavelengths are added to a single line before more lines are added.

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WaveWrapper

WaveWrapper provides network management functions such as optical-layer performance monitoring, error correction and ring protection on a per-wavelength basis.

WDM (Wavelength-Division Multiplexing)

Sending several signals through one fiber with different wavelengths of light.

WGR (Waveguide Grating Router)

Device used to take a mix of wavelengths and separate into the component wavelengths

WTR time (Wait To Restore time)

The WTR time ensures that a previous failed synchronization source is only again considered as available by the selection process if it is fault free for a certain time.

X   XT Crosstalk X-talk

Undesired coupling from a circuit, part of a circuit, or channel to another.

Y   Y Coupler

A variation on the tee coupler in which input light is split between two channels (planar waveguide) that branch out like a Y.

Z   Zero DSF (Zero Dispersion Shifted Fiber)

DSF where the zero dispersion point is shifted from 1310nm to 1550 nm. It is best suited for applications involving single channel transmission at 1550 nm, providing the benefits of zero dispersion as well as taking advantage of the lower attenuation wavelength.

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