OptiX BWS 1600G
Backbone DWDM Optical Transmission System
Technical Description

V100R003

OptiX BWS 1600G
Backbone DWDM Optical Transmission System
Technical Description

BOM	31026769
Date	June 30, 2006
Document Version	T2-040269-20060630-C-1.32

Huawei Technologies Co., Ltd. provides customers with comprehensive technical support and service. Please feel free to contact our local office or company headquarters.

Huawei Technologies Co., Ltd.

Address: Administration Building, Huawei Technologies Co., Ltd.,
Bantian, Longgang District, Shenzhen, P. R. China

Postal Code: 518129

Website: http://www.huawei.com

Email: support@huawei.com

Contents

Figures

Tables

About This Document

Purpose

This document describes the functions, features, specifications and network application of the equipment. This document provides both introductory information and detailed interface parameters.

Intended Audience

The intended audiences of this document are:

- Policy planning
- Installation and commissioning engineer
- NM configuration engineer
- Technical support engineer

Organisation

This document consists of following chapters and is organised as follows.

Chapter	Description
Chapter 1 Overview	This chapter describes the market target and the features of the OptiX BWS 1600G product, and it also introduces the classification of six system types of the OptiX BWS 1600G products.
Chapter 2 Product Description	This chapter describes the mechanical structure, boards and the software architecture of the OptiX BWS 1600G product.
Chapter 3 System Configuration	This chapter describes NE composition and NE configuration of the product.

Chapter	Description
Chapter 4 Networking and System Applications	This chapter describes the NE architecture, system configuration and network application. In this chapter, some system functions are also introduced, such as ALC, APE, IPA and OAMS.
Chapter 5 Protection	This chapter describes the protection mechanism of the OptiX BWS 1600G products, including power protection, service protection, clock protection and the protection of network management information channel.
Chapter 6 Technical Specifications	This chapter describes the technical specifications and indices of the functional units.
Appendix A Measures in DWDM Network Designing	This chapter describes the measures in DWDM network designing.
Appendix B Technology Introduction	This chapter describes some advanced technologies, such as FEC, SuperWDM and Raman amplification.
Appendix C Glossary	This chapter describes the glossary mentioned in this manual.
Appendix D Abbreviations and Acronyms	This chapter describes the abbreviations and acronyms mentioned in this manual.

Conventions

Symbol Conventions

Symbol	Description
Warning	A warning notice with this symbol indicates high voltage could result in harm to person.
Warning	A warning notice with this symbol indicates strong laser beam could result in personal injury.
Warning	A warning notice with this symbol indicates a risk of personal injury.
Caution	A caution notice with this symbol indicates a risk to equipment damage or loss of data.
Caution	A caution notice with this symbol indicates the equipment is static-sensitive.
Important Note	An important note notice with this symbol helps you avoid an undesirable situation or indicates important supplementary information.

Symbol	Description
🕮 Note	A note notice with this symbol indicates additional, helpful, non-critical information.

General Conventions

Convention	Description
Boldface	Names of files, directories, folders, and users are in **boldface**. For example, log in as user **root**.
Italic	Book titles are in *italics*.
`Courier New`	Terminal display is in `Courier New`.

Update History

Updates between document versions are cumulative. Therefore, the latest document version contains all updates made to previous versions.

Updates in Document Version T2-040269-20060630-C-1.32

Fix some bugs in version 1.31.

The specifications of the system and the board have been updated.

The description of the AP8, AS8, LQS, OCU, OCUS, RPL board.

Updates in Document Version T2-040269-20060115-C-1.31

Fix some bugs in version 1.30.

Updates in Document Version T2-040269-20051210-C-1.30

Add the FDG, LOG, LOGS and DWC boards and the related features in this version.

Documentation Set Guide

Documentation Set

This document provides a documentation map to guide you through the documentation set supplied with your OptiX BWS 1600G equipment or T2000 software package. The document can be used as the starting point for reading your user documentation. For the details of the T2000, see the documentation set for the T2000, including printed documents, online help or CD-ROM.

Documentation for OptiX BWS 1600G

- Installation Guide
- Commissioning Guide
- Configuration Guide
- Routine Maintenance
- Troubleshooting
- Quick Reference Guide
- Technical Description
- Hardware Description
- Alarms and Performance Events Reference
- Compliance and Safety Manual

Documentation for OptiX iManager T2000

- Installation Guide
- High Availability System Installation Guide
- Administrator Guide
- Operator Guide for WDM
- T2000-LCT User Guide
- System Description for WDM
- Online Help
- Northbound CORBA Interface Developer Guide

Documentation for OptiX BWS 1600G

This document package contains documents that introduce the theory, functionality, features, and specifications of the product. In addition, these documents provide procedure guides for project planning, hardware installation, commissioning, service configuration, routine maintenance, and troubleshooting.

The following list provides the short introduction to each document that is supplied with your package.

- Installation Guide

This document provides guides to install the hardware. This document describes the hardware installation procedure, cable routing and related installation specifications for the equipment.

- Commissioning Guide

This document provides guides to practice the commissioning and testing operations after hardware installation. This document describes the preparation, methods and procedures for the station commissioning and the network commissioning.

- Configuration Guide

This document provides guides to configure the services on the T2000 after network commissioning is complete. This document describes how to configure optical network element, service protection, IPA, APE and ALC.

- Routine Maintenance

This document provides guides to practice routine maintenance. This document describes the detailed routine maintenance activities and precautions, including hardware maintenance items and equipment maintenance items on the T2000.

- Troubleshooting

This document provides guides to operate the troubleshooting. This document describes the basic thoughts and operations of troubleshooting. In this document, procedures detailing board replacing methods are included.

- Quick Reference Guide

This document provides guides for field engineers to conduct on-site maintenance. This document describes basic operational and maintenance information covering the majority of day to day activities that will be carried out at a network element.

- Technical Description

This document describes the functions, features, specifications and network application of the equipment. This document provides both introductory information and detailed interface parameters.

- Hardware Description

This document describes hardware architecture and composition of the equipment, including boards, cables, interfaces, as well as their functions and parameters.

- Alarms and Performance Events Reference

This document lists alarms and performance events generated by the equipment. It also provides ways of handling alarms and performance events to clear the faults or failures.

- Compliance and Safety Manual

The Compliance and Safety Manual provides compliance and safety information.

Documentation for OptiX iManager T2000

This document package contains procedure guides for T2000 installation, operation, and equipment maintenance through T2000.

- Installation Guide

This document provides guides to install the T2000 software system. This document describes the installation procedure of database, client and server of the T2000 software system.

- High Availability System Installation Guide

This document provides guides to install, to operate and maintain the High Availability System. Detailed procedures, normal operations, and common faults are given. Three types of user documents are available for the Sun Cluster, Watchman, Veritas depending on the requirement of project.

- Administrator Guide

This document provides guides to manage and maintain the T2000. Normal operations and common faults are given.

- Operator Guide for WDM

This document provides guides to monitor, configure, maintain, and manage a piece of equipment through the T2000.

- T2000-LCT User Guide

This document is shipped with the OptiX iManager T2000-LCT. This document provides guides to install the T2000-LCT, to manage and maintain a piece of equipment through the T2000-LCT.

- System Description for WDM

This document describes the position, functional characteristics, system architecture and networking mode of the T2000, appended with standards that the T2000 complies with, abbreviations and performance indexes.

- Online Help

This document provides guides to use the T2000. This document describes the functionality, menu and interface parameters of the T2000 and how to monitor, configure, maintain and manage a piece of equipment through the T2000.

- Northbound CORBA Interface Developer Guide

This document provides guides to use the T2000CORBA interface. Functions, features, installation and maintenance information are given.

Use Phases

See the following table to use desired documents according to the phases and user profiles.

Document Name	Intended Audience			
	Planning	**Installation & Commissioning**	**Configuration**	**Maintenance**
Installation Guide	I&C, T&S	-	-	F, I&C
Commissioning Guide	-	I&C	NM-R	F, I&C
T2000 Installation Guide Note 1	-	I&C, T&S	NM-C	-
T2000 HA System Installation Guide Note 1 Note 2	-	I&C, T&S	NM-C	-
Configuration Guide	P	-	NM-C, T&S	NM-R
T2000 Operation Guide for WDM Note 1	-	I&C	NM-C, T&S	NM-R, T&S, O
T2000- LCT User Guide Note 1	-	I&C	NM-C, T&S	NM-R, T&S, O
T2000 On-line Help Note 1 Note 3	-	-	NM-C, T&S	NM-R, T&S, O
Quick Reference Guide	-	-	-	F
Routine Maintenance	-	-	-	NM-R, F, T&S, O
Troubleshooting	-	-	-	NM-R, T&S, O
Alarms and Performance Events Reference	-	-	-	NM-R, T&S, O
Technical Description	P	I&C	NM-C	T&S
Hardware Description	P	I&C	NM-C	T&S, O, F
T2000 System Description for WDM Note 1	P	I&C	NM-C, O	T&S

Document Name	Intended Audience			
	Planning	Installation & Commissioning	Configuration	Maintenance
Compliance and Safety Manual	-	T&S	-	T&S

F: Field engineer P: Policy planning

O: Operation engineer I&C: Installation and commissioning engineer

T&S: Technical support engineer NM-R: NM real time engineer

B: Build and acceptance engineer NM-C: NM configuration engineer

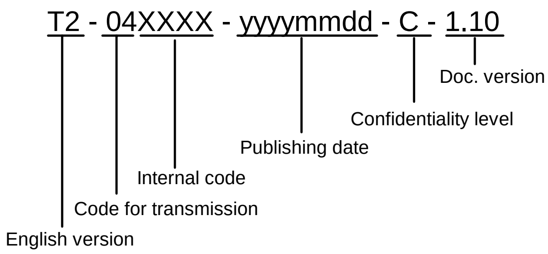
Note 1: These documents are for NM and should be delivered with the NM software.

Note 2: The Optical iManager T2000 HA System User Guide should be delivered with the user documentation of the Sun Cluster, Watchman or Veritas depending on the project.

Note 3: The OptiX iManager T2000 on-line help is integrated in the system, providing comprehensive operation guide.

Version Control

The documentation version is displayed as:



If the version is updated, then the last **Doc. version** 1.10 will be changed to 1.11, and the **Publishing date** will be updated.

Safety Information

For safety and warning information, see *OptiX BWS 1600G Backbone DWDM Optical Transmission System Compliance and Safety Manual* shipped with the product. This document lists EMC and other safety standards that the OptiX BWS 1600G complies with, and provides safety precautions that should be followed during the installation and maintenance of the OptiX BWS 1600G.

Distribution

The documentation set for the OptiX BWS 1600G is shipped with the hardware product, in printed and CD-ROM.

The documentation set for the NM is shipped with the OptiX iManager T2000, including printed document, online help and CD-ROM.

Feedback on Documentation

Your suggestions and comments are welcome. Please email us at support@huawei.com.

1 Overview

1.1 Introduction to the OptiX BWS 1600G

The OptiX BWS 1600G Backbone DWDM Optical Transmission System, the OptiX BWS 1600G for short, is a large capacity and long haul backbone transmission product. It is designed in line with the present conditions and the future development of optical networks, with inherited flexible configuration and good compatibility of OptiX series.

With the modular design that enables rich configurations and flexible protection features, the OptiX BWS 1600G plays a leading role in a transmission network. The access capacity of an optical fibre can be smoothly expanded from 10 Gbit/s to 1600 Gbit/s (160 × 10 Gbit/s). During the expansion, there is no need to shut off the equipment or interrupt the service. Just insert new hardware or add new nodes.

The OptiX BWS 1600G system can be deployed in point-to-point, linear and ring networks. Being a backbone layer of the network, it connects main cities to carry heavy traffic of optical switching equipment, metropolitan area network (MAN) DWDM equipment, SDH equipment or router. That is providing large capacity transmission channel for services and network outlets. The position of an OptiX BWS 1600G system in a network is shown in Figure 1-1.

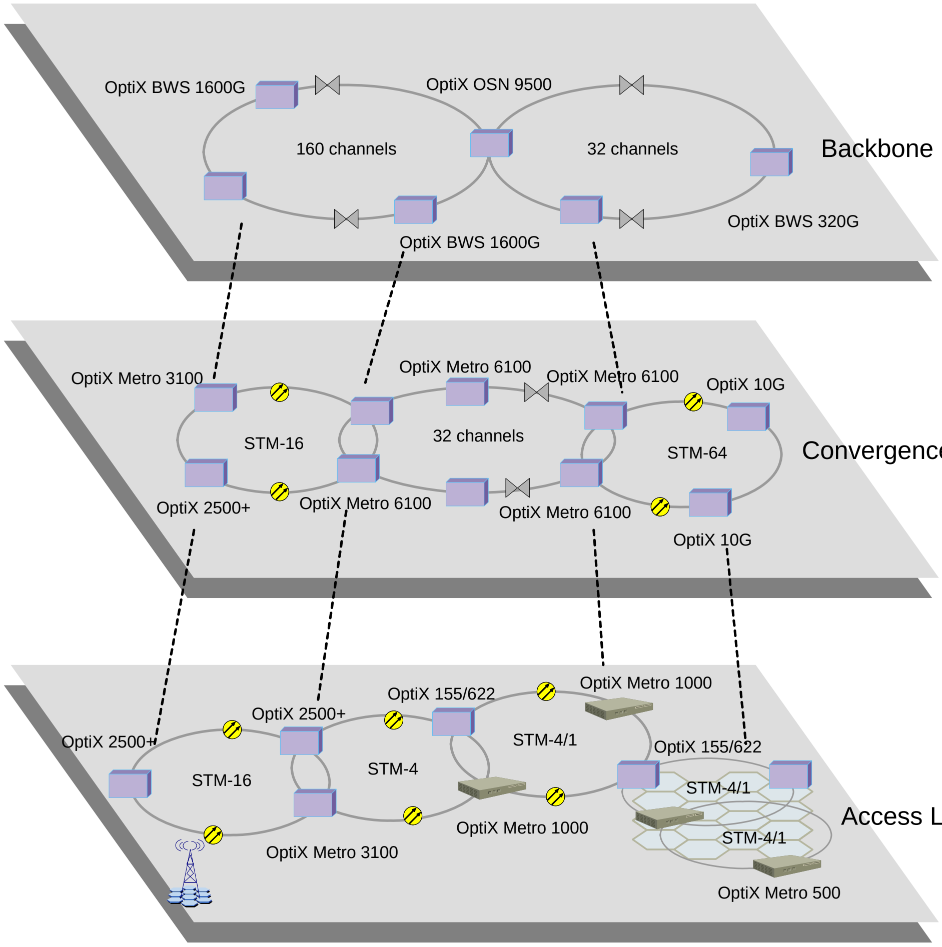


Figure 1-1 OptiX BWS 1600G in a transmission network

The OptiX BWS 1600G transmits the unidirectional services over a single fibre, that is, a bi-directional transmission is achieved by two optical fibres, of which one is for transmitting and the other for receiving.

The OptiX BWS 1600G is highly reliable in performance and flexible in networking by using:

- Reliable multiplexer/demultiplexer
- Erbium-doped optical fibre amplifier
- Raman amplifier
- Channel equalisation technology
- SuperWDM technology
- Dispersion compensation technology
- Universal and centralised network management system

Figure 1-2 shows the appearance of the OptiX BWS 1600G cabinet.

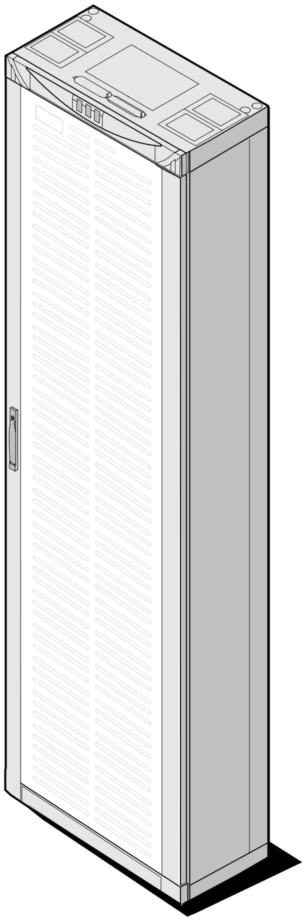


Figure 1-2 Appearance of the OptiX BWS 1600G

1.2 Types of the OptiX BWS 1600G

Classification of System Types

To meet the requirements of different areas, users and investing environments, the OptiX BWS 1600G is available in six types:

- OptiX BWS 1600G-I
- OptiX BWS 1600G-II
- OptiX BWS 1600G-III
- OptiX BWS 1600G-IV
- OptiX BWS 1600G-V
- OptiX BWS 1600G-VI

In later sections, the OptiX BWS 1600G-I is referred to as the type I system for short, and other types are the type II, type III, type IV, type V and type VI systems. If there is no type identity, for example, the OptiX BWS 1600G, it refers to all system types.

Characteristics of Each System Type

Table 1-1 shows the characteristics of the six system types.

Table 1-1 Characteristics of system types

Type / Item	I	II		III	IV	V	VI	
Maximum capacity (Gbit/s)	1600	800		400	400	100	400	100
Working wavelength band	C-band and L-band	C-EVEN and L-ODD (Note 1)	C-band	C-EVEN (Note 1)	L-ODD (Note 1)	C-EVEN (Note 1)	C-EVEN (Note 1)	
Channel spacing (GHz)	50	100	50	100	100	100	100	200
Maximum number of channels	160	80	80	40	40	40	40	10
Maximum accessing rate (Gbit/s)	10	10	10	10	10	2.5	10	
Transmission distance without REG (km) (Note 2)	360	560	1600/1120 (Note 5)	2000 (Note 3)	400	640	200/230 (Note 7)	
Per-channel output power of amplifier (dBm)	1	4	4/1 (Note 6)	4/1/0 (Note 4)	1	4	12	17
Fibre type	G.652/G.655	G.652/G.655	G.652/G.655	G.652/G.653/G.655	G.653	G.652/G.655	G.652/G.655	
Clock protection function	Supported	Supported	Not supported	Not supported	Not supported	Not supported	Not supported	

Type / Item	I	II		III	IV	V	VI
Accessing service type	SDH/SONET/POS/GE/10GE	SDH/SONET/POS/GE/10GE	SDH/SONET/POS/GE/10GE/arbitrary service at a rate of 34 Mbit/s – 2.5 Gbit/s	SDH/SONET/POS/GE/10GE/arbitrary service at a rate of 34 Mbit/s – 2.5 Gbit/s	SDH/SONET/POS/GE/10GE	SDH/SONET/POS/GE/arbitrary service at a rate of 34 Mbit/s – 2.5 Gbit/s	SDH/SONET/POS/GE/10GE/arbitrary service at a rate of 34 Mbit/s – 2.5 Gbit/s
Maximum numbers of add/drop channels(Note 8)	160	80	80	40	40	40	NA
Dispersion compensation	Required	Required	Required	Required	Required	Not required	Required

Note 1: C-EVEN indicates even channels (40 channels in total) in C-band and the L-ODD indicates odd channels (40 channels in total) in L-band.
Note 2: The data in the above table is for system without adopting the Raman amplification technology. If the technology is adopted, the longer transmission distance without any REG will be supported. Here the distance is computed out with an attenuation coefficient of 0.275 dB/km.
Note 3: With technologies such as FEC, SuperWDM and optical equilibrium being applied, the transmission distance without any REG reaches up to 2000 km in the type III systems.
Note 4: Per-channel output optical power of the optical amplifier in the type III system is 4 dBm on G.652/G.655 fibre, and 1 dBm or 0 dBm on G.653 fibre.
Note 5: The data is for particular fibre and line code. The distance of 1600 km is for G.652 fibre with return to zero (RZ) encoding and 1120 km for G.655 fibre with RZ encoding.
Note 6: The type II C800G system provides two types of amplifiers. The output optical power of one type is 23 dBm, and that of the other type is 20 dBm.
Note 7: The 200 km refers to the LHP system and 230 km refers to ROPA system with a fiber attenuation coefficient of 0.275 dB/km.
Note 8: The maximum numbers of add/drop channels refer to the channels added/dropped in OADM stations by back to back OTMs. Besides, with the dynamic wavelength control (DWC) board, the system can block or pass through channels of any wavelengths. The channels are added/dropped dynamically. This is how the OptiX 1600G forms a dynamic ROADM that can be restructured.

By system channel spacing, the OptiX BWS 1600G system can be divided into three categories: 50 GHz channel spacing system, 100 GHz channel spacing system and 200 GHz channel spacing system. Refer to Table 1-1.

1.3 Features

Huge Transmission Capacity

- Transmission capacity of the type I system can be upgraded up to 1600 Gbit/s by adding modules of 400 Gbit/s capacity. In a module of 400 Gbit/s capacity, the capacity can get increments with 10 Gbit/s.
- Transmission capacity of the type II system can be upgraded from 400 Gbit/s to 800 Gbit/s. In a module of 400 Gbit/s capacity, the capacity can get increments with 10 Gbit/s.
- Maximum transmission capacity of the type III/IV system is 400 Gbit/s. In a module of 400 Gbit/s capacity, the capacity can get increments with 10 Gbit/s.
- Maximum transmission capacity of the type V system is 40 $\times$ 2.5 Gbit/s. In the module, the capacity can get increments with 2.5 Gbit/s.
- The type VI system, a long hop application, is classified as 10-channel system and 40-channel system. In the module, the capacity can get increments with 2.5 Gbit/s or 10 Gbit/s.

Long Haul Transmission

- When forward error correction (FEC) technology is used, the system allows an attenuation of 10 $\times$ 22 dB for transmission without REG.
- When technologies such as FEC, SuperWDM and optical equilibrium are used, the system allows an attenuation of 25 $\times$ 22 dB for transmission without an REG.
- When FEC and optical amplification technologies are used, the system allows an attenuation of 56 dB in long hop application. Upon this result, the remote optical pumping amplifier (ROPA) technology can extend long hop transmission up to 64 dB attenuation.

Abundant Service Access

The OptiX BWS 1600G accesses the following service types:

- Standard SDH: STM-1/4/16/64
- Standard synchronous optical network (SONET): OC-3/12/48/192
- Standard SDH concatenated payload: VC-4-4c/16c/64c
- Standard SONET concatenated payload: STS-3c/12c/48c/192c
- ETHERNET: Gigabit Ethernet (GE), 10GE
- Other service: Services at the rate ranging from 34 Mbit/s to 2.5 Gbit/s, such as enterprise system connection (ESCON), fibre connection (FICON), fibre channel (FC), fibre distributed data interface (FDDI) and PDH (34 Mbit/s, 45 Mbit/s or 140 Mbit/s)

The type I and type IV systems only access SDH, SONET, GE, 10GE, FC100 and POS services at 2.5 Gbit/s and 10 Gbit/s.

The type II, type III, and type VI systems access all the services listed above.

The type V system can access the services only at 2.5 Gbit/s and below.

Supervisory Channel and Clock Transmission Channels

The optical supervisory channel (OSC) mainly carries orderwire and network management information. The OptiX BWS 1600G transmits supervisory signals at 1510 nm or 1625 nm, with the rate of 2.048 Mbit/s.

The electric supervisory channel (ESC) does not demand the configuration of optical supervisory channel units. In this mode, the optical transponder unit (OTU) multiplexes the supervisory information into the service channel for transmission.

The OptiX BWS 1600G also provides three clock transmission channels with high quality in each transmission direction, each at a rate of 2.048 Mbit/s. The three channels are embedded into the OSC.

Integrated System and Open System Compatibility

There are two types of DWDM systems: integrated DWDM system and open DWDM system. The open DWDM system is configured with OTUs to convert non-standard wavelengths into ITU-T G.694.1-compliant wavelength. The integrated DWDM system does not need the OTUs when its client side equipment (for example, SDH equipment) has ITU-T G.694.1-compliant optical transmitter interfaces. The OptiX BWS 1600G achieves the combination of open and integrated systems.

Centralised Intelligent Network Management

The OptiX BWS 1600G can be managed by the centralised NM due to its excellent interconnectivity with other Huawei products.

1.4 Characteristics

1.4.1 Service Characteristics

Low-Speed Service Aggregation

The OptiX BWS 1600G supports the aggregation of low-speed services. It can:

- Multiplex two channels of GE signals into one channel of STM-16 signal.
- Multiplex two channels of GE signals into one channel of OTU1 signal.
- Multiplex eight channels of FC100 signals into one channel of OTU2 signal.
- Multiplex eight channels of GE signals into one channel of OTU2 signal.
- Multiplex four channels of STM-16 signals into one channel of OTU2 signal.
- Multiplex four channels of FC200 signals into one channel of OTU2 signal.

High-quality Clock Transmission

The OptiX BWS 1600G offers a new solution for the transmission of synchronous clock. Its optical supervisory channel provides three clock transmission channels operating at 2.048 Mbit/s. The clock signals can be added/dropped or just pass through at any station.

Scalable Optical Add/Drop and Multiplexing Technology

The OptiX BWS 1600G system can add/drop 32 channels at most by cascading optical add/drop multiplexing boards.

1.4.2 Technical Characteristics

Forward Error Correction

The OTU uses FEC and AFEC (advanced FEC) technologies to:

- Decrease the requirements on the receiver optical signal-to-noise ratio (OSNR), to stretch the span of optical amplification sections or optical regeneration sections.
- Decrease the bit error ratio (BER) in the line transmission, to improve the quality of service (QoS) of DWDM networks.

AFEC is a new error correction technique that adopts two-level encoding. It has increase in encoding gain, and can equally distribute burst errors. AFEC is more powerful than FEC.

Tunable Wavelengths

The OptiX BWS 1600G supports tunable wavelengths. It adopts 10 Gbit/s and 2.5 Gbit/s OTUs that support tunable wavelengths, such as the LWF and the LWC1. The 10 Gbit/s OTU supports tunable wavelengths in up to 80 channels with 50 GHz spacing. The 2.5 Gbit/s OTU supports tunable wavelengths in up to 40 channels with 100 GHz spacing. Besides function as service boards, the tunable wavelength OTUs also function as spare parts to substitute OTUs of different wavelengths. This reduces the amount of OTUs and lowers the cost.

Mature EDFA Technology

The OptiX BWS 1600G uses mature erbium-doped fibre amplifier (EDFA) technology for the amplification of C-band and L-band signals, and the implement of long haul transmission without REG. EDFA adopts gain locking technology and transient control technology to make the gain of each channel independent of the number of channels. Bit error bursts in the existing channels are also avoided during adding or dropping channels.

Advanced Raman Amplification Technology

Besides the EDFA amplification, the system also supports Raman fibre amplification. The hybrid application of the Raman and EDFA achieves broad gain bandwidth and low system noise, and reduces the interference of non-linearity on the system, which thus greatly stretches the transmission distance.

Unique SuperWDM Technology

By using the RZ encoding and unique phase modulation technology, the OptiX BWS 1600G is able to effectively suppress the non-linear impairments in transmission and improve the noise tolerance capability. With the SuperWDM technology, the OptiX BWS 1600G achieves ultra long haul application in the absence of Raman amplifiers.

Jitter Suppression

Due to advanced jitter suppression and clock extraction technology is adopted, the jitter performance of the OptiX BWS 1600G is better than the requirements defined by ITU-T Recommendations related to DWDM. OTUs of the system also check B1 and B2 bit errors, and extract J0 bytes. Thus when accessing the SDH equipment, the system can quickly detect whether the bit error occurred to the SDH section or the optical path. This function is of critical importance when the OptiX BWS 1600G system accesses the SDH equipment of different vendors.

1.4.3 Intelligent Adjustment

Automatic Level Control

The system applies automatic level control (ALC) function to control the power along the link, thereby ensuring the normal laser level in the optical fibre. The ALC function keeps the optical signal at normal level and prevents the input and the output power of the downstream optical amplifiers from declining. This improves the quality of the transmission signals.

Intelligent Power Adjustment

The intelligent power adjustment (IPA) protects the human body from the exposure to the laser, which can be emitted from an open interface or fibre cracks. If there is a leakage of optical power, the system will reduce the power to that lower than the safe threshold.

Automatic Power Equilibrium

In long haul transmission, the non-flatness of per-channel OSNR at the receiving end becomes a serious issue. With the automatic power equilibrium (APE) function, the OptiX BWS 1600G can automatically adjust the launched optical power of each channel, thus achieving power equilibrium at the receiving end and improving the OSNR. The APE is well suited for the applications with many spans.

Intelligent Environment Temperature Monitoring System

The OptiX BWS 1600G is designed with intelligent system for environment temperature monitoring, reporting and alarming. This ensures the normal running of the system under a stable temperature.

1.4.4 Automatic Monitoring

Optical Fibre Line Automatic Monitoring Function

The OptiX BWS 1600G offers an optical fibre line automatic monitoring system (OAMS) to alert the aging of a fibre, alarm the fibre fault and locate the fault. The OAMS is a built-in system, which is optional for ordering.

In-Service Optical Performance Monitoring

There are optical monitoring interfaces on multiplexer/demultiplexer, optical amplifier, and so on. Optical spectrum analyser or multi-wavelength meter can be connected to these monitoring interfaces, to measure performance parameters at reference points while not interrupting the service.

These monitoring interfaces can also connect to built-in optical multi-channel spectrum analyser unit (MCA) by using optical fibres. With the help of an MCA, optical spectral features including the optical power, central wavelength and OSNR can be observed from a network management system (NM).

1.4.5 Reliabilty

Perfect Protection Mechanism

The OptiX BWS 1600G provides a perfect protection mechanism, including optical channel protection, optical line protection and equipment level unit protection.

The system clock is protected by the 1+1 backup of clock units.

Automatic Laser Shutdown

For an OTU, if ALS is enabled, the OTU board will shut down the laser on the WDM side to avoid the laser injury to the human body when there is no optical power received on the client side.

Also, when there is no optical power received on the line side, the OTU board will shut down the laser on the client side to avoid the laser injury to the human body.

But if ESC is performed, ALS function must be disabled because the supervisory information has been multiplexed into the transmitting channel by the OTU boards.

For more details, refer to section 2.3.2 "Configuring the WDM Interface Attributes of a Board" in *OptiX BWS 1 600G Configuration Guide*.

Reliable Power Backup

The power supply system of the OptiX BWS 1600G is fed with two DC inputs (for mutual backup). The power supply of key units is protected by 1+1 hot backup. The power of OTU boards is protected by a common protection power feed.

Perfect Optical Fibre Management Function

The OptiX BWS 1600G fully considers the demands for fibre management. Various cabling channels and fibre storage units are available to ease the fibre management in the cabinet and between the cabinets.

1.5 Network Management System

Huawei NM is able to manage not only DWDM equipment, but also the entire OptiX family members including SDH and Metro equipment. In compliance with ITU-T, NM offers rich network maintenance functions. It can manage the fault, performance, configuration, security, maintenance and test of the entire OptiX network. It also provides the end-to-end management function according to the requirements of users. It improves the quality of network services, reduces the maintenance cost and ensures the rational use of network resources.

NM with friendly Man-Machine interfaces, powerful and state-of-the-art functionality, is used in OptiX BWS 1600G system. Its object-oriented design allows the user to enable or disable any service according to the physical network.

In an OptiX BWS 1600G network, NM provides many functions, such as:

- End-to-end channel (wavelength) management
- Wavelength resource statistical analysis
- Terminal simulation program
- Alarm management
- Performance management
- System management
- Equipment maintenance and management

2 Product Description

The hardware of the OptiX BWS 1600G includes:

- Cabinet
- Subrack
- Power box
- Fan tray assembly
- DCM frame
- HUB frame

The cabinet can hold subracks that are installed with different boards to form different equipment types.

2.1 Cabinet

2.1.1 Overview

Table 2-1 lists the full configuration of ETSI 300 mm cabinets of different heights. When the cabinet is not fully configured, configure the work subracks from bottom to top.

Table 2-1 Full configuration of 300 mm deep cabinets of different heights

Cabinet height	Amount of power boxes	Amount of subracks	Amount of DCM frames	Amount of HUB frames
1.8 m	1	2	1	1
2.0 m	1	2	1	1
2.2 m	1	3	1	1
2.6 m	1	3	2	1

A power box is mounted at the top of an OptiX BWS 1600G cabinet. The OptiX BWS 1600G is powered with –48 V DC or –60 V DC. Two power supplies are provided as mutual backup to each other. It also provides 16-channel external alarm input interfaces and 4-channel cabinet alarm output interfaces, easing the management of the equipment.

The OptiX BWS 1600G cabinet has the following features:

- The cabinet leaves much space for routing and managing optical fibers.
- Two movable side doors are installed at both sides of the cabinet. Each side door can move in or move out along the top and bottom slide rails.
- Air vents are provided at the front door of the subrack, the rear door and upper enclosure frame of the cabinet to ensure heat dissipation.

For the structure of the cabinet, see Chapter 1 "Cabinet" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

2.1.2 Specifications

Table 2-2 Specification of the cabinet

	Height (mm)	Width (mm)	Depth (mm)	Weight (kg)	Maximum system power consumption (W)
Type 1	2600	600	300	78 (Note1)	2000 (Note2)
Type 2	2200	600	300	69 (Note1)	2000 (Note2)
Type 3	2000	600	300	64 (Note1)	1300 (Note2)
Type 4	1800	600	300	58 (Note1)	1300 (Note2)

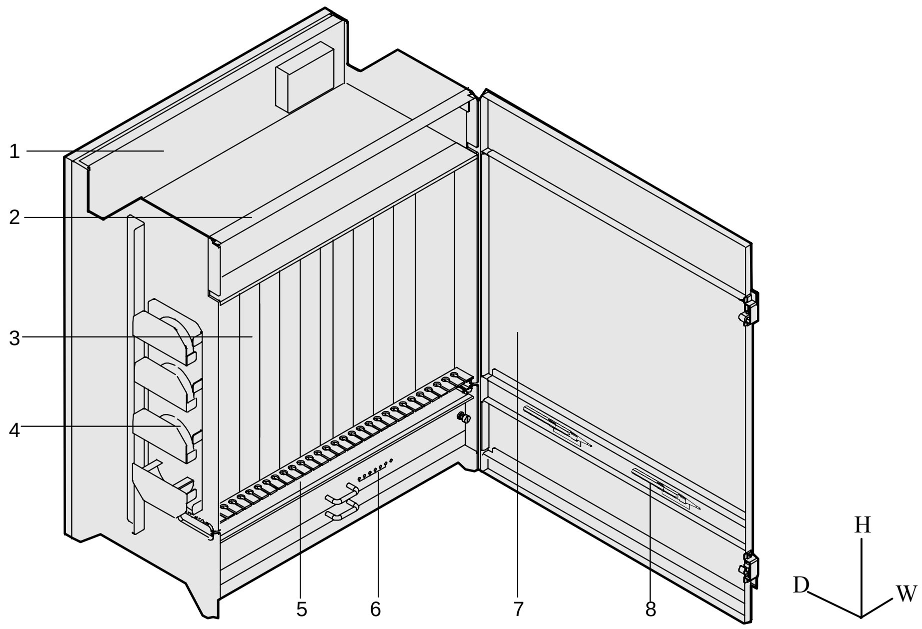
Note1: The value including the weight of the power box and the empty cabinet.

Note2: The value is measured when the cabinet is fully loaded.

2.2 Subrack

2.2.1 Structure

The OptiX BWS 1600G subrack is divided into four areas. The upper part is the interface area where all kinds of electrical signals are accessed. The middle part is the board area where DWDM boards are installed and the lower part comprise the fibre cabling area & fan tray assembly area. The structure of the subrack is shown in Figure 2-1.



1. Interface area	2. Beam	3. Board area	4. Fiber spool
5. Fiber laying area	6. Fan tray assembly	7. Subrack front door	8. Hook

Figure 2-1 OptiX BWS 1600G subrack

- Interface area

All external interfaces are located in this area, including the interfaces for subrack power supply, NM, orderwire telephone, and so on.

The interface area also works as a heat dissipation outlet of the subrack. A beam (a solid metal sheet) is placed at the top of subrack to fix the orderwire phone.

- Board area

Totally 13 board slots are available, numbered IU1, IU2, IU3, … IU13 from left to right when you face the front surface of the subrack. Slot IU7 is for the SCC/SCE board and is 24 mm wide. Other slots are 38 mm wide. All optical ports are located on these front panels. Most optical ports are of LC/PC type while the "LINE", "EXT" and "OUT" optical ports on the front panel of the Raman amplifier unit and "OUT" port of the HBA board are of LSH/APC type.

- Fibre cabling area

All the optical fibres from the optical ports are routed to this area. These optical fibres then come out of this area and reach the corresponding side of the subrack. There are fibre spools at the two sides of the subrack, allowing good management over the optical fibres.

Mechanical variable optical attenuator (VOA) is installed here.

- Fan tray assembly

This area contains a fan tray and an air filter. The air filter is fixed beneath the fan tray. The fans and the air filter ensure that the equipment works in a dust-free and normal temperature environment.

- Front door

The front door is intended for equipment protection and EMC. The inner side of the front door is equipped with hooks to hold the screws for adjusting the mechanical VOA.

- Fibre spools

They are used to coil the slack of the optical fibre.

2.2.2 Specifications

Table 2-3 Specifications of the subrack

Item	Parameter
Dimensions	625 mm (H) x 495 mm (W) x 291 mm (D)
Weight	18 kg (with the backplane but with not boards and fan tray assembly)
Maximum system power consumption (fully loaded)	650 W

For more details, see Chapter 3 "Subrack" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

2.3 Functional Units

This section describes the basic functional units (boards) of the OptiX BWS 1600G system. According to their functions, the boards can be categorized as:

- Optical transponder unit
- Optical multiplexer/demultiplexer and add/drop multiplexer
- Optical amplifier unit
- Optical supervisory channel and timing transporting unit
- Performance monitoring and adjustment unit
- Optical fibre automatic monitoring unit (optional, not depicted in Figure 2-2)
- Protection unit (optional, not depicted in Figure 2-2)
- System control and communication unit (not depicted in Figure 2-2)

Figure 2-2 shows the positions of the boards in the system, illustrating only the unidirectional signal flow.

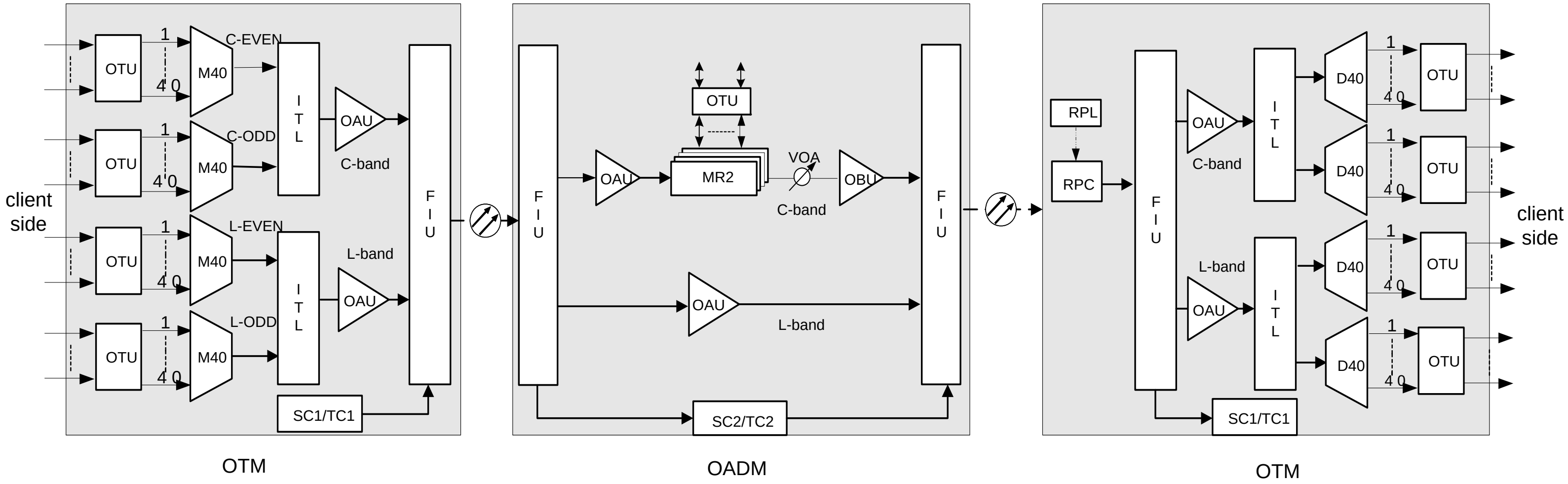


Figure 2-2 Positions of the boards in the system

2.3.1 Optical Transponder Unit

Table 2-4 Board name and category of the optical transponder unit

Service type	Board	Board description
10Gbit/s optical transponder unit	E2LWF	STM-64 transmit-receive line wavelength conversion unit with FEC function
	E3LWF	STM-64 transmit-receive line wavelength conversion unit with AFEC function
	E2LWFS	STM-64 transmit-receive line wavelength conversion unit with FEC function (Super WDM)
	E3LWFS	STM-64 transmit-receive line wavelength conversion unit with AFEC function (Super WDM)
	LRF	STM-64 line regenerating wavelength conversion unit with FEC function
	LRFS	STM-64 line regenerating wavelength conversion unit with FEC function (Super WDM)
	TMR	10.71G line regenerating wavelength conversion board with AFEC and G.709
	TMRS	10.71G line regenerating wavelength conversion board with AFEC and G.709 (Super WDM)
	LBE	Transmit-receive line wavelength conversion board for 10GE (LAN)
	LBES	Transmit-receive line wavelength conversion board for 10GE (LAN) (Super WDM)
10Gbit/s convergent optical transponder unit	TMX	4-channel STM-16 asynchronous MUX OTU-2 wavelength conversion board
	TMXS	4-channel STM-16 asynchronous MUX OTU-2 wavelength conversion board (Super WDM)
	LOG	8-port Gigabit Ethernet multiplex optical wavelength conversion board
	LOGS	8-port Gigabit Ethernet multiplex optical wavelength conversion board (Super WDM)
2.5Gbit/s and lower optical transponder unit	LWC1	STM-16 line wavelength conversion unit (compliant with G.709)
	TRC1	STM-16 optical transmitting regenerator (compliant with G.709)
	LWM	Multi-rate optical wavelength conversion board
	LWMR	Multi-rate optical wavelength conversion relay board
	LWX	Arbitrary bit rate wavelength conversion unit
	LWXR	Arbitrary bit rate regenerating board

Service type	Board	Board description
2.5Gbit/s convergent optical transponder unit	LDG	2 x Gigabit Ethernet unit
	FDG	2-port Gigabit Ethernet wavelength conversion board With FEC

The following table briefs the application and functions of the above boards. For more details, see Chapter 6 "Optical Transponder Unit" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

Table 2-5 Application and description of wavelength conversion units (10 Gbit/s)

Board name	Application	Function	Regenerating board
E2LWF (Note 1)	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: FEC	The LWF board is an STM-64 transmit-receive line wavelength conversion unit with FEC. In the transmit direction (towards DWDM), the LWF board converts the STM-64 client signal into the G.694.1-compliant DWDM signal of the standard wavelength. In the receive direction, the LWF restores the G.694.1-compliant DWDM signal of the standard wavelength to the STM-64 client signal. The signal encoding and decoding is compliant with ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	LRF
E2LWFS	Channel spacing: 50 GHz or 100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: FEC	The function, encoding/decoding and overhead processing are the same as that of the E2LWF. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	LRFS

Board name	Application	Function	Regenerating board
LRF	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: FEC	Achieves the 3R functions (reshaping, retiming and regeneration) for the FEC encoding signal with the rate of 10 Gbit/s. Signal wavelengths input or output by the board are all G.694.1-compliant DWDM wavelengths. The signal encoding and decoding is compliant with ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	LRF
LRFS	Channel spacing: 50 GHz/100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: FEC	The function, encoding/decoding and overhead processing are the same as that of the LRF. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	LRFS
E3LWF	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: AFEC	The LWF board is an STM-64 transmit-receive line wavelength conversion unit with AFEC. In the transmit direction (towards DWDM), the LWF board converts the STM-64 client signal into the G.694.1-compliant DWDM signal of the standard wavelength. In the receive direction, the LWF restores the G.694.1-compliant DWDM signal of the standard wavelength to the STM-64 client signal. The signal encoding and decoding is compliant with ITU-T G.975.1, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TMR

Board name	Application	Function	Regenerating board
E3LWFS	Channel spacing: 50 GHz or 100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: AFEC	The function, encoding/decoding and overhead processing are the same as that of the E3LWF. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	TMRS
LBE	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: AFEC	The LBE board is a 10 GE-LAN transmit-receive wavelength conversion unit with AFEC. In the transmit direction, the LBE board converts the 10GE-LAN signal into the 10.71 Gbit/s G.694.1-compliant DWDM signal of the standard wavelength. In the receive direction, the LBE restores the G.694.1-compliant DWDM signal of the standard wavelength to the 10 GE-LAN client signal. The signal encoding and decoding adopts Huawei's own AFEC encoding established on ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TMR
LBES	Channel spacing: 50 GHz or 100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: AFEC	The function, encoding/decoding and overhead processing are the same as that of the LBE. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	TMRS

Note 1: E2 and E3 in the brackets before the board name are hardware versions.

Table 2-6 Application and description of wavelength conversion units (2.5 Gbit/s or lower)

Board name	Application	Functions	Regenerating board
LWC1	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: FEC	Accesses STM-16 optical signal compliant with ITU-T G.957 on the client side. Converts the signal into OTU1 optical signal and outputs DWDM standard wavelength compliant with ITU-T G.694.1. The reverse process is similar. The signal encoding and decoding is compliant with ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TRC1
TRC1	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: FEC	Used in an REG station to regenerate corresponding optical signals. The signal encoding and decoding is compliant with ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TRC1
LWM	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: does not support	Converts the signal with the rate of STM-1/OC-3, STM-4/OC-12 or STM-16/OC-48 into the optical one with the G.694.1-comliant DWDM standard wavelength. Supports service conversion in SDH/SONET and all kinds of cascading formats. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	LWMR

Board name	Application	Functions	Regenerating board
LWX	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: does not support	Converts the optical signal with the arbitrary rate (34 Mbit/s-2.7 Gbit/s) within the 1280 nm–1565 nm wavelength range into the optical one with the G.694.1-compliant standard wavelength. Is able to access the PDH (34 Mbit/s, 45 Mbit/s or 140 Mbit/s), ESCON (200 Mbit/s) and FC (1.06 Gbit/s) services. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	LWXR

Table 2-7 Application and description of convergent optical wavelength conversion units

Board name	Application	Functions	Regenerating board
TMX	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: AFEC	In the transmit direction, the TMX board multiplexes four STM-16 signals from different sources into G.709-compliant OTU2 signal. Then, this signal is converted into the optical signal with ITU-T G.694.1-compliant standard wavelength. In the receive direction, it performs the reverse. The signal encoding and decoding is compliant with ITU-T G.975.1, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TMR
TMXS	Channel spacing: 50 GHz or 100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: AFEC	The function, encoding/decoding and overhead processing are the same as that of the TMX. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	TMRS

Board name	Application	Functions	Regenerating board
LOG	Channel spacing: 50 GHz or 100 GHz Line code: NRZ Applied to type I, II, III, IV, VI systems FEC mode: AFEC	Converges four channels of FC200 services, eight channels of GE services or eight channels of FC100 services into the STM-64/OC-192 optical signal, and then converts it into the ITU-T G.694.1-compliant standard wavelength. In the receive direction, the board achieves the reverse. The signal encoding and decoding is compliant with ITU-T G.975.1, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TMR
LOGS	Channel spacing: 50 GHz or 100 GHz Line code: CRZ Applied to type II, III, VI systems FEC mode: AFEC	The function, encoding/decoding and overhead processing are the same as that of the LOG. It does not support wavelength adjustment for the transmitted optical signal on the DWDM side. Supports SuperWDM technology.	TMRS
LDG	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: does not support	Multiplexes two GE signals into an STM-16 signal. In the transmit direction, the board converts two IEEE 802.3z-compliant GE signals into the optical signal with the G.694.1-compliant DWDM standard wavelength through conversion, decapsulation and multiplexing. In the receive direction, it restores two IEEE 802.3z-compliant GE signals and sends them to the Gigabit router or other GE devices in the reverse process. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	LWMR

Board name	Application	Functions	Regenerating board
FDG	Channel spacing: 100 GHz Line code: NRZ Applied to type II, III, V, VI systems FEC mode: FEC	Multiplexes two GE signals into an OTU1 signal with FEC. In the transmit direction, the board converts two IEEE 802.3z-compliant GE signals into the optical signal with the G.694.1-compliant DWDM standard wavelength through conversion, decapsulation and multiplexing. In the receive direction, it restores two IEEE 802.3z-compliant GE signals and sends them to the gigabit router or other GE devices in the reverse process. The signal encoding and decoding is compliant with ITU-T G.975, supporting G.709-compliant overhead processing. Supports wavelength adjustment for the transmitted optical signal on the DWDM side. It does not support SuperWDM technology.	TRC1

2.3.2 Optical Multiplexer/Demultiplexer and Add/Drop Multiplexer

The optical multiplexing/demultiplexing related boards of the OptiX BWS 1600G system include:

Table 2-8 Board name and category of the Optical Multiplexer/Demultiplexer and Add/Drop Multiplexer unit

Service type	Board	Board description
Optical multiplexer/demultiplexer and add/drop multiplexer unit	M40	40-channel optical multiplexer
	D40	40-channel optical demultiplexer
	V40	40-channel optical multiplexer with VOA
	FIU	Fiber interface unit
	ITL	Interleaver unit
	MR2	2-channel optical add/drop unit
	DWC	Dynamic wavelength add/drop control unit

Table 2-9 briefs the application and functions of the above boards. For more details, see Chapter 7 "Optical Multiplexer, Demultiplexer, Add and Drop Unit" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

Table 2-9 Application and description of the optical multiplexer/demultiplexer/add/drop multiplexer

Board name	Application	Functions
M40	There are four types of boards corresponding to four wavebands: M40 (C-EVEN), M40 (C-ODD), M40 (L-EVEN) and M40 (L-ODD) Applied to all types of systems.	At the transmit end, the M40 multiplexes 40 optical signals from OTUs into a single fibre for transmission. That is, it has the function of multiplexing 40 channels. Provides the online monitoring of optical interfaces to monitor the spectrum of the main optical path without interrupting the traffic.
D40	There are four types of boards corresponding to four wavebands: D40 (C-EVEN), D40 (C-ODD), D40 (L-EVEN) and D40 (L-ODD) Applied to all types of systems.	At the receive end, the D40 demultiplexes the main path optical signal transmitted over a single fibre into 40 optical signals of different wavelengths and sends them to the corresponding OTUs. Provides the online monitoring of optical interfaces to monitor the spectrum of the main optical path without interrupting the traffic.
V40	There are two types of boards corresponding to two wavebands: V40 (C-EVEN), V40 (C-ODD) Applied to type I, II, III, V and VI systems.	At the transmit end, the V40 adjusts the optical input power of the 40 channels and multiplexes these channels into a single fibre for transmission. Provides the online monitoring of optical interfaces to monitor the spectrum of the main optical path without interrupting the traffic.

Board name	Application	Functions
FIU	There are four types of boards corresponding to different systems: FIU-01: Supports the C-band, L-band, supervisory channel multiplexer and demultiplexer; applied to type I and II systems. FIU-02: Supports the C-band, L-band, supervisory channel multiplexer and demultiplexer, and clock protection; applied to type I and II systems. FIU-03: Supports the C-band, supervisory channel multiplexer and demultiplexer; applied to type III and V systems. FIU-04: Supports the L-band, supervisory channel multiplexer and demultiplexer; applied to type IV system. FIU-06: Supports the C-band, supervisory channel multiplexer and demultiplexer; applied to high power situation such as type VI system.	The FIU multiplexes or demultiplexes the signals over the main channel and the optical supervisory channel. In the transmit direction, the FIU accesses the optical supervisory signal. In the receive direction, it extracts the optical supervisory signals. Provides the online monitoring of optical interfaces to monitor the spectrum of the main optical path without interrupting the traffic.
ITL	There are two types of boards corresponding to different wavebands: ITL-C and ITL-L. Applied to type I system.	The ITL board achieves the mutual conversion between the DWDM system with the 100 GHz channel spacing and that with the 50 GHz channel spacing.
MR2	Applied to all types of systems except type IV and type VI.	The MR2 board adds/drops two channels of services with the fixed wavelength in the OADM.
DWC	Applied to all types of systems except type IV and type VI.	The DWC board adds/drops any channel of services in the OADM.

2.3.3 Optical Amplifier

The EDFA is an essential component of the system. It is used to compensate for signal attenuation caused by optical components and optical fibres so as to extend the signal transmission distance.

The OptiX BWS 1600G system also adopts the Raman amplification technology. The combination of EDFA and Raman amplifier can reduce the system noise and effectively suppress the deterioration of OSNR, thereby optimising the system performance.

The optical amplifier boards include the following:

Table 2-10 Board name and category of the Optical amplifier unit

Service type	Board	Board description
Optical amplifier unit	OAU	Optical amplifier unit
	OBU	Optical booster unit
	OPU	Optical preamplifier unit
	HBA	High-power optical booster amplifier unit
	RPC	Raman pump amplifier unit for C-band
	RPA	Raman pump amplifier unit for C-band and L-band

Table 2-11 and Table 2-12 brief the application and functions of the EDFA unit and the Raman amplifier unit. For more details, see Chapter 8 "Optical Amplifier Unit" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

Table 2-11 Application and description of the EDFA units

Board name	Application	Functions
OAU	The E2 version provides one type of OAU board: OAU-LG (See Note 1) OAU-LG is used for amplifying L-band optical signals. The E3 version provides three types of OAUs: OAUC01, OAUC03, and OAUC05 to amplify signals in C-band Applied to all types of systems.	The OAU board can amplify the input optical signal, compensate for the fibre loss, and increase the receive-end sensitivity budget. The OAU board uses the automatic gain control technique to realise the gain locking function.
OBU	The OBU has also two hardware versions: E2OBU and E3OBU. One type of the E2OBU is available: OBU-L. OBU-L is used for amplifying L-band optical signals. The E3OBU is of two specifications, mainly applying to C-band system: OBUC03 and OBUC05. Applied to all types of systems.	The OBU board can amplify the optical signal power. The OBU board uses the automatic gain control technique to realise the gain locking function.
OPU	Used alone or together with the OBU. Applied to the C-band Applied to type III, V and VI systems.	Features small noise figure, used to improve the receiver sensitivity budget. Uses the automatic gain control technique for gain locking.

Board name	Application	Functions
HBA	Applied to the transmitter of the OTM station in long hop (LHP) application. Applied to the C-band. Applied to type VI system.	Amplifies the optical signal to high-power in the transmit direction to meet the requirements for LHP application.

Table 2-12 Application and description of the Raman amplifier units

<table>
<tr><th>Board name</th><th>Application</th><th>Functions</th></tr>
<tr><td>RPC</td><td>RPC is the Raman pump amplifier unit for C-band.
Always used together with the EDFA.
Applied to type I, II, III and VI systems.</td><td rowspan="2">Used at the receive end of the DWDM system, it amplifies signals during transmission by sending high-power pump light to the transmission fibre.
Raman pump amplifier units realise long-haul, broad bandwidth, low noise, and distributed online optical signal amplification.
These units can automatically lock the pump power, receive the SCC command to switch on/off the pump source, separate the signal light, report performances and alarms, and protect the pump laser.</td></tr>
<tr><td>RPA</td><td>RPA is the Raman pump amplifier unit for C-band and L-band.
Always used together with the EDFA.
Applied to type I, II and IV systems.</td></tr>
</table>

2.3.4 Optical Supervisory Channel and Timing Transporting Unit

The optical supervisory unit implements overhead processing and transport. The optical supervisory and timing transporting unit implements overhead processing and timing transport.

Table 2-13 Board name and category of the optical supervisory channel unit

Service type	Board	Board description
optical supervisory channel unit	SC1	Unidirectional optical supervisory channel
	SC2	Bidirectional optical supervisory channel
	TC1	Unidirectional optical supervisory and timing transporting unit
	TC2	Bidirectional optical supervisory and timing transporting unit

Table 2-14 briefs the application and functions of the above boards. For more details, see Chapter 12 "Optical Supervisory Units and System Control and Communication Unit" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description.*

Table 2-14 Application and description of optical supervisory channel/timing transporting units

Board name	Application	Functions
SC1	The SC1 is used in OTM. Applied to all types of systems.	Processes one channel of optical supervisory signal, receives and sends optical supervisory signal in OTM. The carrier wavelength of the optical supervisory channel is 1510 nm or 1625 nm.
SC2	The SC2 is used in OLA, OADM, REG, and OEQ. Applied to all types of systems.	Receives and sends bi-directional optical supervisory channel signals. The carrier wavelength of the optical supervisory channel is 1510 nm or 1625 nm.
TC1	The TC1 is used in OTM. Applied to all types of systems.	Receives and sends one optical supervisory channel signal and three channels of 2 Mbit/s clock signals. The carrier wavelength of the optical supervisory channel is 1510 nm or 1625 nm.
TC2	The TC2 is used in OLA, OADM, REG and OEQ. Applied to all types of systems.	Receives and sends bi-directional optical supervisory channel signals and three channels of 2 Mbit/s clock signals. The carrier wavelength of the optical supervisory channel is 1510 nm/1625 nm.

2.3.5 Performance Monitoring and Adjustment Unit

The performance monitoring and adjustment unit is used to monitor the optical spectrum characteristics and optical power, and to adjust the optical power and dispersion. It includes:

Table 2-15 Board name and category of the performance monitoring and adjustment unit

Service type	Board	Board name
performance monitoring and adjustment unit	MCA	Multi-channel spectrum analyzer unit
	VOA	Variable optical attenuator unit
	VA4	4-channel variable optical attenuator unit
	DGE	Dynamic gain equalizer unit
	DSE	Dispersion slop equilibrium unit
	GFU	Gain flatness unit

Table 2-16 briefs the application and functions of the above boards. For more details, see Chapter 9 "Performance Detection and Adjustment Units" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description.*

Table 2-16 Application and description of performance monitoring & adjustment units

Board and module name	Application	Functions
MCA	There are two types of MCA available: MCA-8: on-line monitoring of eight optical channels. MCA-4: on-line monitoring of four optical channels. Applied to all types of systems.	Provides the built-in on-line monitoring and spectrum analysis function to online monitor such parameters as the central wavelength, optical power, and OSNR of the optical signals at 8/4 different points of the system.
VOA	Adjusts the optical power of the line signal. Applied to all types of systems.	Adjusts the optical power of one optical channel according to the command from the SCC.
VA4	Used in the OADM system to adjust the power of the add/drop channel optical signal, ensuring power equalization for the main path signal. Applied to all types of systems.	Adjusts the optical power of four optical channels according to the command from the SCC.

Board and module name	Application	Functions
DGE	Applied to the optical equilibrium (OEQ) station. Applied to type II, III system.	Equalises the optical power of all channels by adjusting its own insertion loss spectrum.
DSE	There are two types of DSE boards: DSE-I and DSE-II. Applied to type II, III system.	Provides the dispersion slope compensation optical interface, used together with the dispersion compensation module (combination of DCMs), for dispersion equalization and compensation.
GFU	Used together with the optical amplifier unit (E2OAU), raman amplifier or ROP amplifier. Applied to type II and III systems.	Uses the gain flattening filter (GFF) for static compensation on uneven gains caused by optical amplifier and amplifier concatenation.

2.3.6 Optical Fibre Automatic Monitoring Unit

The optical fibre automatic monitoring unit monitors a fibre (cable) automatically. It provides features such as fibre aging pre-warning, fibre link alarming and initial fibre fault locating. It includes:

Table 2-17 Board name and category of the optical fibre automatic monitoring unit

Service type	Board	Board description
optical fibre automatic monitoring unit	FMU	Fiber monitoring unit
	MWA	Monitoring wavelength access unit
	MWF	Monitoring wavelength filtering unit

The embedded OAMS is an optional function. You can order it as required in practice. The structure of an embedded OAMS system is shown in Figure 2-3.

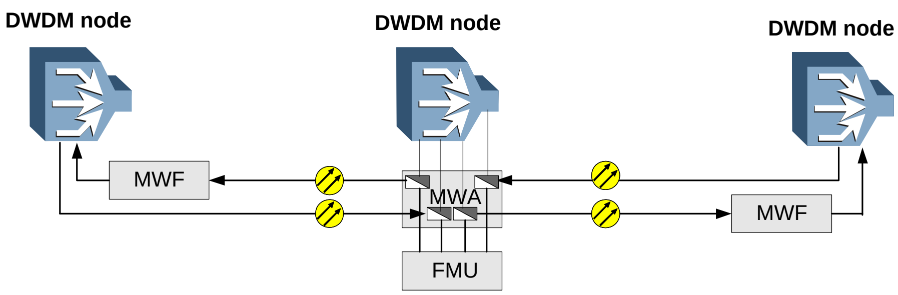


Figure 2-3 Structure of the embedded OAMS application (online monitoring)

Table 2-18 briefs the application and functions of the boards involved in the OAMS. For more details, see Chapter 10 "Optical Fibre Automatic Monitoring Units" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description*.

Table 2-18 Application and description of the fibre Automatic Monitoring System

Board name	Application	Functions
FMU	Applied to the embedded OAMS as its core unit. Applied to all types of systems.	Measures the time domain reflection of four fibres.
MWA	Applied to the embedded OAMS, including two types: MWA-I: Accesses two channels of monitoring optical signals. MWA-II: Accesses four channels of monitoring optical signals. Applied to all types of systems.	During the online monitoring, it multiplexes the service signal of the DWDM system and the test signal wavelength.
MWF	Applied to the embedded OAMS, including two types: MWF-I: Filters out two channels of monitoring optical signals. MWF-II: Filters out four channels of monitoring optical signals. Applied to all types of systems.	In online monitoring, it filters out the test signal wavelength to eliminate its effect on the transmission system. Used when the service signal and the test signal are co-directional.

2.3.7 Protection Unit

The protection unit helps to realise optical line protection, 1+1 optical channel protection, inter-board 1+1 optical channel protection, 1:N (N≤8) channel protection and OTU secondary power backup. It includes:

Table 2-19 Board name and category of the protection unit

Service type	Board	Board name
protection unit	OLP	Optical line protection unit
	OCP	Optical channel protection unit
	SCS	Sync optical channel separator unit
	PBU	Power backup unit

Table 2-20 briefs the application and functions of the above boards. For more details, see Chapter 11 "Optical Protection Units" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description.*

Table 2-20 Application and description of protection units

Board name	Application	Functions
OLP	For line protection, located between the FIU and the line. (OLP01) For inter-subrack 1+1 optical channel protection, located between the client-side device and the OUT. (OLP03) Applied to all types of systems.	Divides the optical signal into two parts at the transmit end, and receives them selectively at the receive end according to the optical power. Uses the OLP board for optical line protection. Able to automatically switch the traffic to the standby fibre when the performance of the active fibre degrades. Realize inter-subrack 1+1 optical channel protection. The signals automatically switch to protection channel when the working channel degrades.
OCP	Located between the client equipment and the OTU. Applied to type I, II, III, IV and VI systems.	Helps to realise the 1:N (N≤8) channel protection.
SCS	Located between the client equipment and the OTU. Applied to all types of systems.	Achieves dual-fed for optical signals. Helps to realise the 1+1 channel protection. Is able to automatically switch the traffic to the standby fibre when the signal quality in the active fibre degrades.
PBU	Serves as the secondary power backup unit of the OTU. Applied to all types of systems.	Achieves centralized protection for the power supplies of the OTU boards in the same subrack, and supports the 3.3 V, 5 V and –5.2 V power supplies on the two OTU boards simultaneously when power fails.

2.3.8 System Control and Communication Unit

The system control and communication unit (SCC) is the control centre of the entire system, which enables equipment management and the communications between equipments. It includes the SCC and SCE.

Table 2-21 Board name and category of the system control and communication unit

Service type	Board	Board name
protection unit	SCC	System control and communication unit
	SCE	System control and communication unit for extended subrack

Table 2-22 briefs the application and functions of the SCC and SCE. For more details, see Chapter 12 "Optical Supervisory Units and System Control and

Communication Unit" in *OptiX BWS 1600G Backbone DWDM Optical Transmission System Hardware Description.*

Table 2-22 Application and description of the SCC and SCE

Board name	Application	Functions
SCC	Applied to every NE. Applied to all types of systems.	Accomplishes NE management, overhead processing and the communication between equipments, and provides the interface between the 1600G system and the NM. It is the control centre of the entire OptiX BWS 1600G.
SCE	Applied to the extended subrack. Applied to all types of systems.	Supports the same functions as the SCC except the overhead processing.

2.4 System Software Architecture

The software system of the OptiX BWS 1600G is a modular structure. Mainly the whole software is distributed in three modules, including board software, NE software and NM system, residing respectively on the functional boards, SCC, and NM computer.

Hierarchical structure ensures that it is highly reliable and efficient. Each layer performs specific functions and provides service for the upper layer. The OptiX BWS 1600G system software architecture is shown in Figure 2-4. In the diagram, all modules are NE software except "Network Management System" and "Board Software".

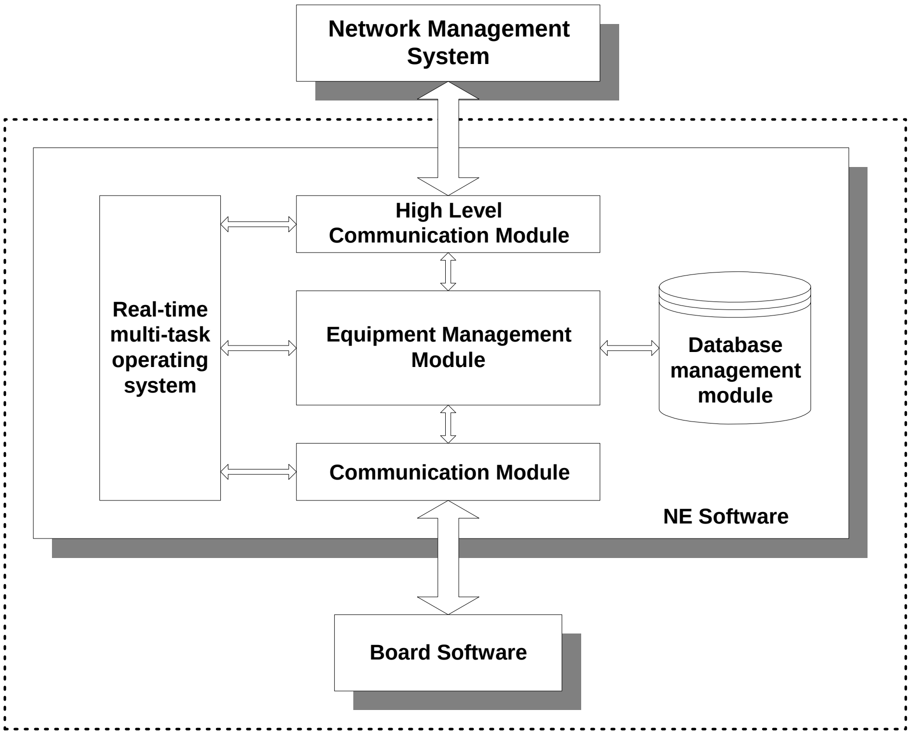


Figure 2-4 Software architecture of the OptiX BWS 1600G

2.4.1 Communication Protocols

Qx Interface

The Qx interface connects MD, QA and NE equipment through the local communication network (LCN). At present, the QA is provided by network element management layer. MD and OS are provided by the network management layer. They are connected with each other via the Qx interface. According to the ITU-T Recommendations, the Qx interface provided by the type I system is developed on the basis of transport control protocol/internet protocol (TCP/IP) connectionless network service (CLNS1) protocol stack.

2.4.2 Working Principles

The functions and implementation of different layers of the system software are discussed in the following text.

Board Software

The board software runs on each board, managing, monitoring and controlling the operation of the board. It receives the command issued from the NE software and reports the board status to the NE software through performance events and alarm.

The specific functions include:

- Alarm management

- Performance management
- Configuration management
- Communication management

It directly controls the functional circuits in corresponding boards and implements ITU-T compliant specific functions of the NE.

NE Software

NE software manages, monitors and controls the board operations in NE. It also assists the NM system to facilitate the centralized management over DWDM network. According to ITU-T Recommendation M.3010, NE software is on the unit management layer of the telecom management network, performing the functions: network element function (NEF), partial mediation function (MF) and OS function at network unit layer. Data communication function (DCF) provides communication channel between NE and other components (including NM and other NEs).

- Real-time multi-task operating system

Real-time multi-task operating system of NE software is responsible for managing public resources and support application programmes. It isolates the application programmes from the processor and provides an application programme execution environment, which is independent from the processor hardware.

- Communication module

Communication is the interface module between NE software and board software. According to the corresponding communication protocol, communication function between NE software and board software is implemented for information exchange and equipment maintenance. Via low level communication, board maintenance and operation commands from the NE software are sent to the boards. On the other hand, the corresponding board state and alarm and performance events are reported to the NE software.

- Equipment management module

Equipment management module is the kernel of the NE software for implementing network element management. It includes administrator and client. Administrator can send network management operation commands and receive events. Client can respond to the network management operation commands sent by the administrator, implement operations to the managed object, and send up events according to state change of the managed object.

- High level Communication module

The communication module exchanges management information between network management system and network element and among NEs. It consists of network communication module, serial communication module and ECC communication module.

- Database management module

The database management module is an effective part of the NE software. It includes two independent parts: data and programme. The data are organized in the form of database and consist of network, alarm, and performance and equipment bases. The programme implements management and accesses to the data in the database.

Network Management System

Huawei network management system OptiX iManager, not only provides DWDM equipment management, but it also handles the entire OptiX family members including SDH and Metro equipment. In compliance with ITU-T Recommendation, it is a network management system integrating standard management information model and object-oriented management technology. It exchanges information with NE software through the high level communication module to monitor and manage the network equipment.

The NM software runs on a workstation or PC, managing the equipment and the transmission network to help to operate, maintain and manage the transmission equipment. The management functions of the NM software include:

- Alarm management: collect, prompt, filter, browse, acknowledge, check, clear, and statistics in real time; fulfill alarm insertion, alarm correlation analysis and fault diagnosis.
- Performance management: set performance monitoring; browse, analyze and print performance data; forecast medium-term and long-term performance; and reset performance register.
- Configuration management: configure and manage interfaces, clocks, services, trails, subnets and time.
- Security management: NM user management, NE user management, NE login management, NE login lockout, NE setting lockout and local craft terminal (LCT) access control of the equipment.

Maintenance management: provide loopback, board resetting, automatic laser shutdown (ALS) and optical fiber power detection, and collect equipment data to help the maintenance personnel in troubleshooting.

3 System Configuration

The OptiX BWS 1600G offers five types of NEs:

- OTM: Optical Terminal Multiplexer
- OLA: Optical Line Amplifier
- OADM: Optical Add/Drop Multiplexer
- REG: Regenerator
- OEQ: Optical Equalizer

Each NE type can operate at 160 channels at most.

3.1 OTM

3.1.1 Signal Flow

The OTM is a terminating station of the DWDM network. An OTM is divided into the transmit end and the receive end.

At the transmit end, the OTM receives optical signals from multiple client equipment (for example, SDH equipment), and converts these signals, multiplexes, amplifies and sends them on a single optical fibre.

At the receive end, the OTM demultiplexes the signals into individual channels and distributes them to the corresponding client equipment.

An OTM consists of:

- Optical transponder unit (OTU)
- Optical multiplexer (OM)
- Optical demultiplexer (OD)
- Optical amplifier (OA)
- Raman pump amplifier unit (RPU)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)

- Dispersion compensation module (DCM)
- Multi-channel spectrum analyser unit (MCA)
- System control & communication unit (SCC)
- Power backup unit (PBU)

Figure 3-1 shows the OTM signal flow.

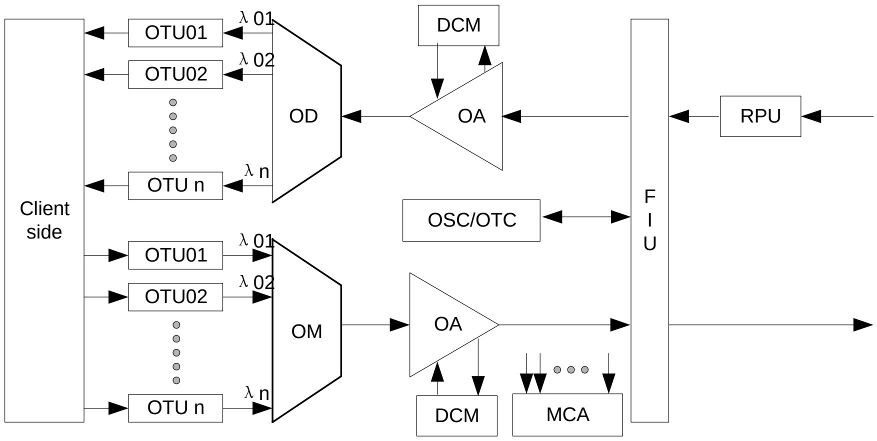


Figure 3-1 OTM signal flow

At the transmit end, up to 160 client-side signals are received at OTU boards, where these signals are converted into standard DWDM signals in compliance with ITU-T G.694.1.

The OM multiplexes these signals and sends them to the OA for amplification. Meanwhile, the DCM implements dispersion compensation. Finally, the amplified main path signal and supervisory signal are multiplexed, through the FIU, and are sent to the optical fibre for transmission.

At the receive end, the RPU (optional), a low-noise pump amplifier, amplifies the received main path signal. Then the main path signal is separated into supervisory signal and service signal. After amplification and dispersion compensation, the service signal is sent to the OD and demultiplexed by the OD. The supervisory signal is directly processed by the OSC or OTC.

The OM, OD and OA provide optical performance monitoring port, through which the MCA is accessed for monitoring the central wavelength, optical power and OSNR of multiple channels of optical signals.

The integrated OTM can work without OTU at the transmit end, so 160 channels of signals can be directly multiplexed into DWDM main optical path.

3.1.2 Structure

For the OTM of the six system types (see Chapter 1 "Overview" for the classification of system types), each functional unit and the board(s) contained are shown in Table 3-1.

For the functions of these boards, see Chapter 2 "Product Description".

Table 3-1 Functional units and the boards contained (six system types)

System \ Unit		OTU	OM	OD	OA	OSC/OTC	FIU
I		LWF, TMX, LBE, LOG	M40+ITL, V40+ITL	D40+ITL	OAU, OBU, OPU	SC1, TC1	FIU-01, FIU-02
II	C + L 800 G	LWF, TMX, LBE, LOG	M40, V40	D40	OAU, OBU, OPU	SC1, TC1	FIU-01, FIU-02
	C 800G	All OTUs	M40+ITL, V40+ITL	D40+ITL	OAU, OBU, OPU	SC1, TC1	FIU-03
III		All OTUs	M40, V40	D40	OAU, OBU, OPU	SC1, TC1	FIU-03
IV		LWF	M40, V40	D40	OAU, OBU, OPU	SC1, TC1	FIU-04
V		LWC1, LDG, FDG, LWM, LWX	M40, V40	D40	OAU, OBU, OPU	SC1, TC1	FIU-03
VI		All OTUs	M40, V40	D40	Transmit end: HBA Receive end: OPU+OAU	SC1, TC1	FIU-06

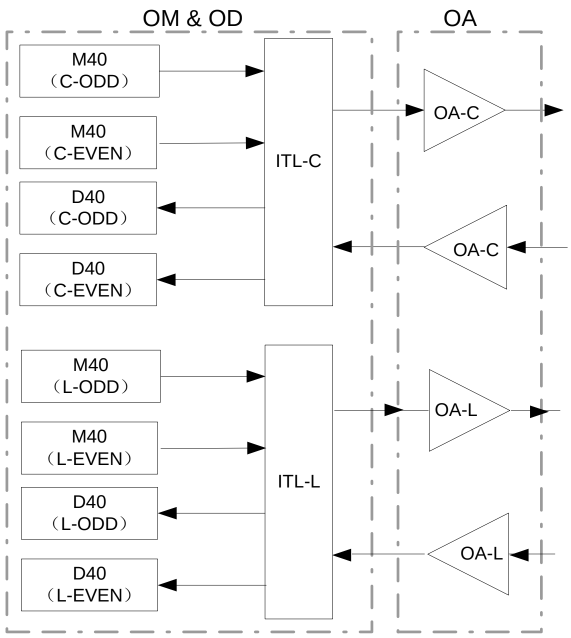
Type I System

The type I system (1600G capacity) uses four 400 Gbit/s modules together to access 160 channels. Refer to Table 3-2.

Table 3-2 Distribution of 160 channels

Group	Frequency range (THz)	Wavelength range (nm)	Channel spacing (GHz)
C-EVEN	192.10–196.00	1529.16–1560.61	100
C-ODD	192.15–196.05		100
L-EVEN	186.95–190.85	1570.42–1603.57	100
L-ODD	187.00–190.90		100

The structure of the OM, OD and OA of the type I system is shown in Figure 3-2. Each of them has different specifications to process signals of different bands. For example, the M40 (C-ODD) multiplexes signals of C-ODD channels, while the M40 (C-EVEN) multiplexes signals of C-EVEN channels.



ITL-C: C-band interleaver
OA-C: C-band optical amplifier unit
M40: 40-channel multiplexing unit
ITL-L: L-band interleaver
OA-L:L-band optical amplifier unit
D40: 40-channel demultiplexing unit

Figure 3-2 Structure of the OM, OD and OA of the type I system

The four 400 Gbit/s optical modules multiplex optical signals of each band and send the multiplexed signal to the ITL-C and ITL-L, where the multiplexed signals are multiplexed again into 80-channel multiplexed signal in C-band and 80-channel multiplexed signal in L-band, with channel spacing of 50 GHz. After amplification and dispersion compensation, the signals of two bands, together with the optical supervisory signal or optical supervisory signal & clock signal, are sent to the optical fibre for transmission.

Note

The channel spacing within each group is 100 GHz, that is the channel spacing at each multiplexer/demultiplexer is 100 GHz. But the spacing between two adjacent channels, for example channel 1 and channel 2, is 50 GHz. Therefore, the interleaver can be used to realise 50 GHz channel spacing for the 1600G transmission system.

For example, the frequencies of a multiplexed signal are 192.1 THz, 192.2 THz …196.0 THz, totally 40 channels, and those of another multiplexed signal are 192.15 THz, 192.25 THz …196.05 THz, totally 40 channels. After passing through the interleaver, the output frequencies change to 192.1 THz, 192.15 THz, 192.2 THz, 192.25 THz…196.05 THZ, with channel spacing of 50 GHz. In this way, the interleaver multiplexes or demultiplexes odd channels and even channels.

Type II System

The type II system can be realised in two ways:

- C+L 800G
- C 800G

The channel spacing of the C+L 800G system is 100 GHz, and that of the C 800G system is 50 GHz. The structure of the OM, OD, and OA of the type II system is similar to that of the type I system. The OM, OD and OA of the C+L 800G system operate at C-EVEN and L-ODD bands, and those of the C 800G system operate at C-EVEN and C-ODD. See Figure 3-3.

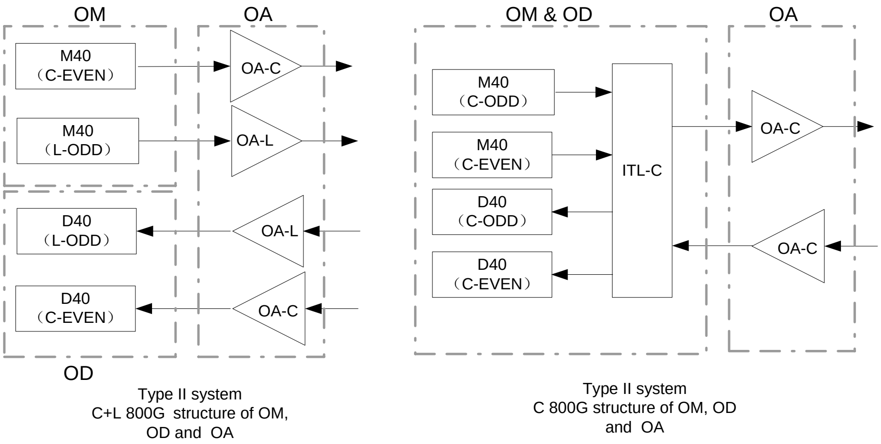


Figure 3-3 Structure of OM, OD, OA of the type II system

Type III, IV, V and VI Systems

The structure of the OM, OD, and OA of the type III, V, and VI systems is similar to that of the type I system, operating at C-EVEN band only. The type IV system operates at L-ODD band only.

The structure of the OM, OD and OA of the type III, IV, V, and VI systems is shown in Figure 3-4.

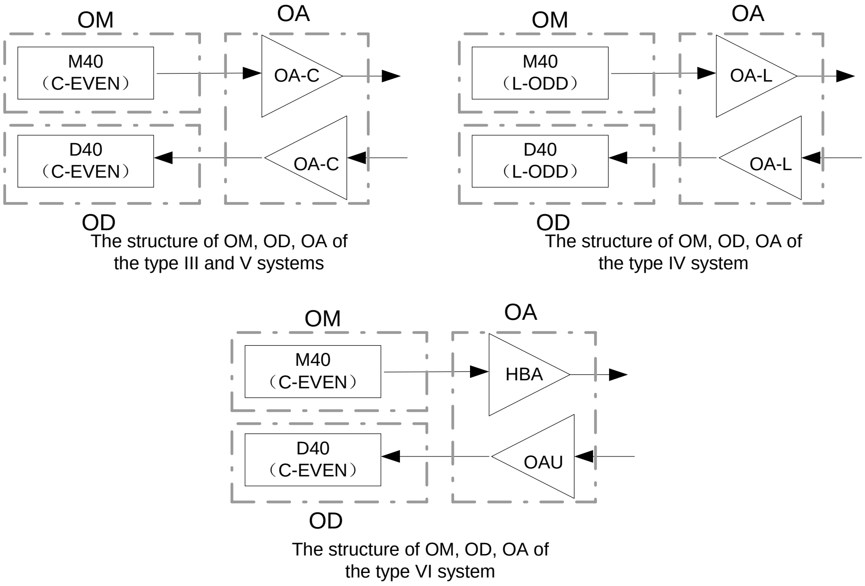


Figure 3-4 Structure of OM, OD, OA of the type III, IV, V and VI systems

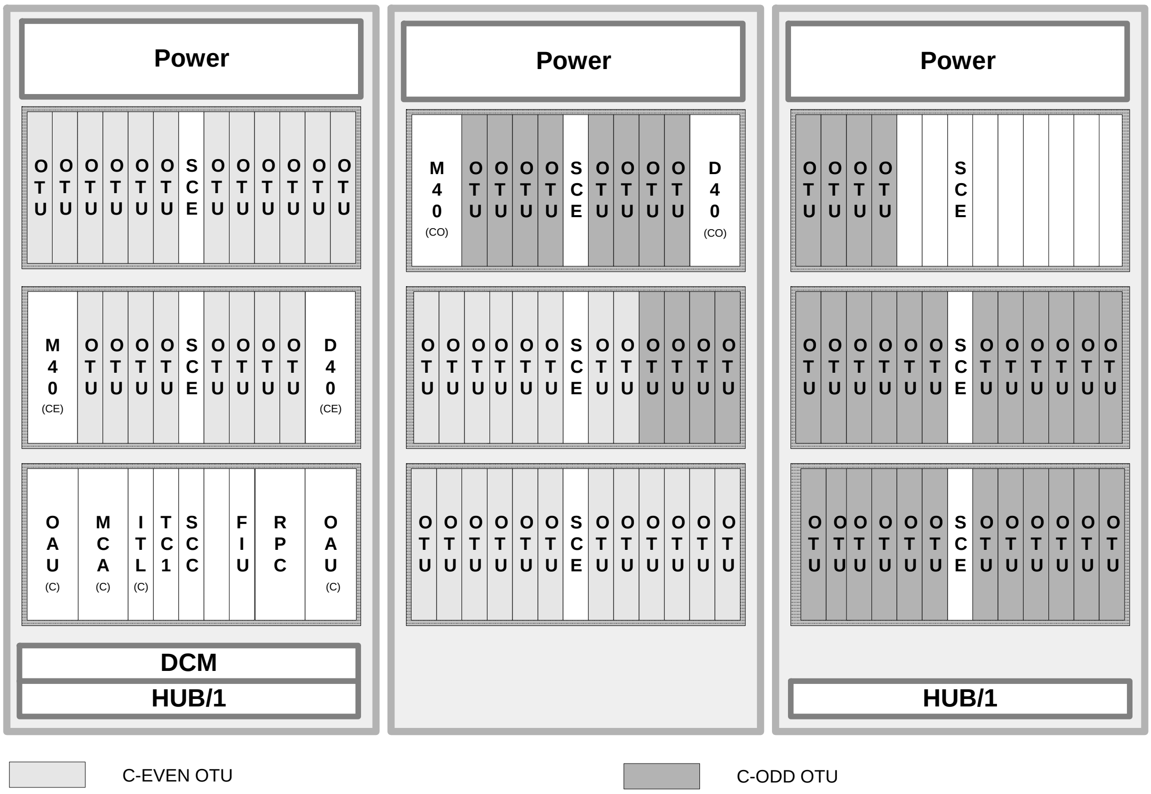
3.1.3 Typical Configuration

Type I System

In full configuration, an open OTM of the type I system needs six cabinets and 17 subracks, while an integrated OTM needs two cabinets and six subracks.

The configuration of OTM is based on the system capacity and upgrading mode. Typically, the type I system adopts the smooth expansion by adding the C-EVEN module, C-ODD module, L-EVEN module, and then L-ODD module. Each module has a maximum capacity of 400 Gbit/s (40 channels) and smooth expansion from 1 channel to 40 channels can be enabled within each module.

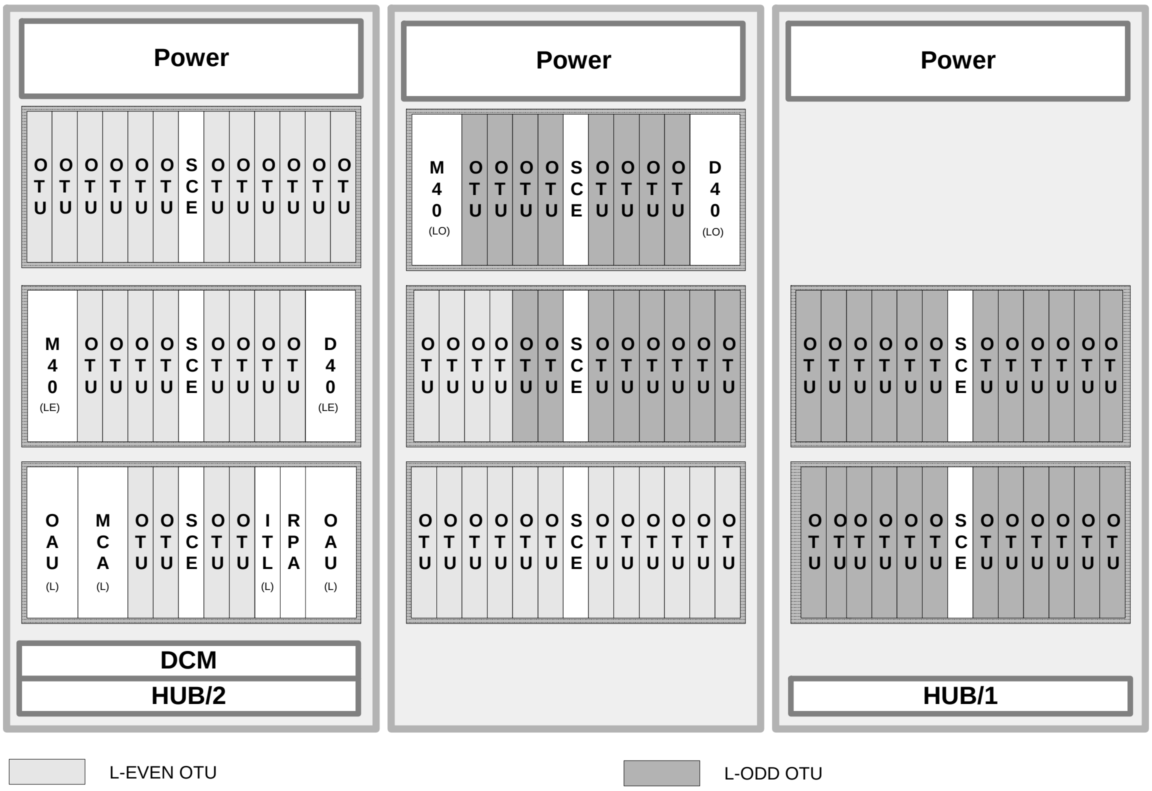
Figure 3-5 shows the typical C-band 800 Gbit/s OTM configuration and Figure 3-6 shows the typical L-band 800 Gbit/s OTM configuration.



CE: C-band EVEN CO: C-band ODD C: C-band

Note: All plug-in OTUs belong to C-band. HUB/1 indicates one 8-port HUB is configured in the HUB frame

Figure 3-5 Configuration of the C-band 800 Gbit/s OTM (type I system)



LE: L-band EVEN LO: L-band ODD L: L-band

Note: All plug-in OTUs belong to L-band. HUB/1 indicates one 8-port HUB is configured in the HUB frame, and HUB/2 indicates two 8-port HUBs are configured in the HUB frame.

Figure 3-6 Configuration of the L-band 800 Gbit/s OTM (type I system)

Note

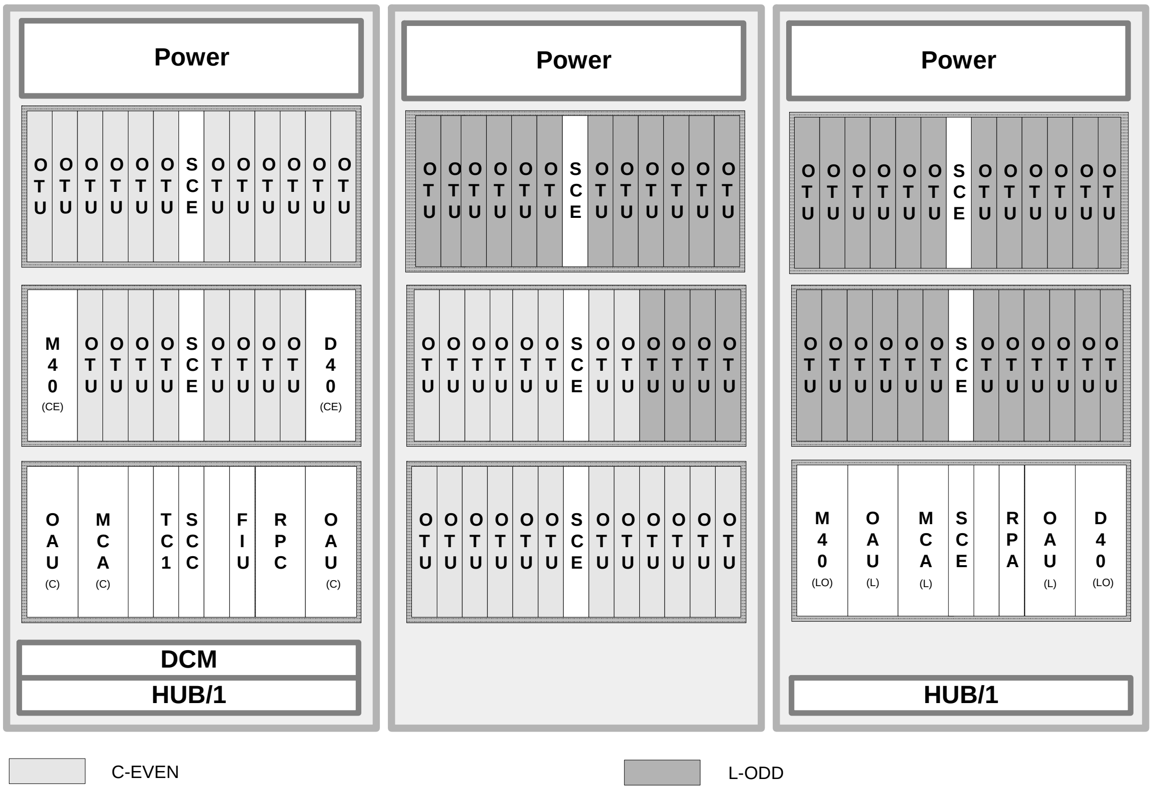
If the system provides the line protection function, the OLP01 board needs to be configured. In this case, the Raman amplifier unit cannot be used.

If OTUs need centralised power protection, a PBU board must be configured in slot 1 of the subrack holding OTUs and all OTUs are placed from left to right.

Type II System

The type II system supports C+L 800G and C 800G.

The configuration of C+L OTM can be upgraded from the initial C-band 400G to C+L 800G. See Figure 3-7.



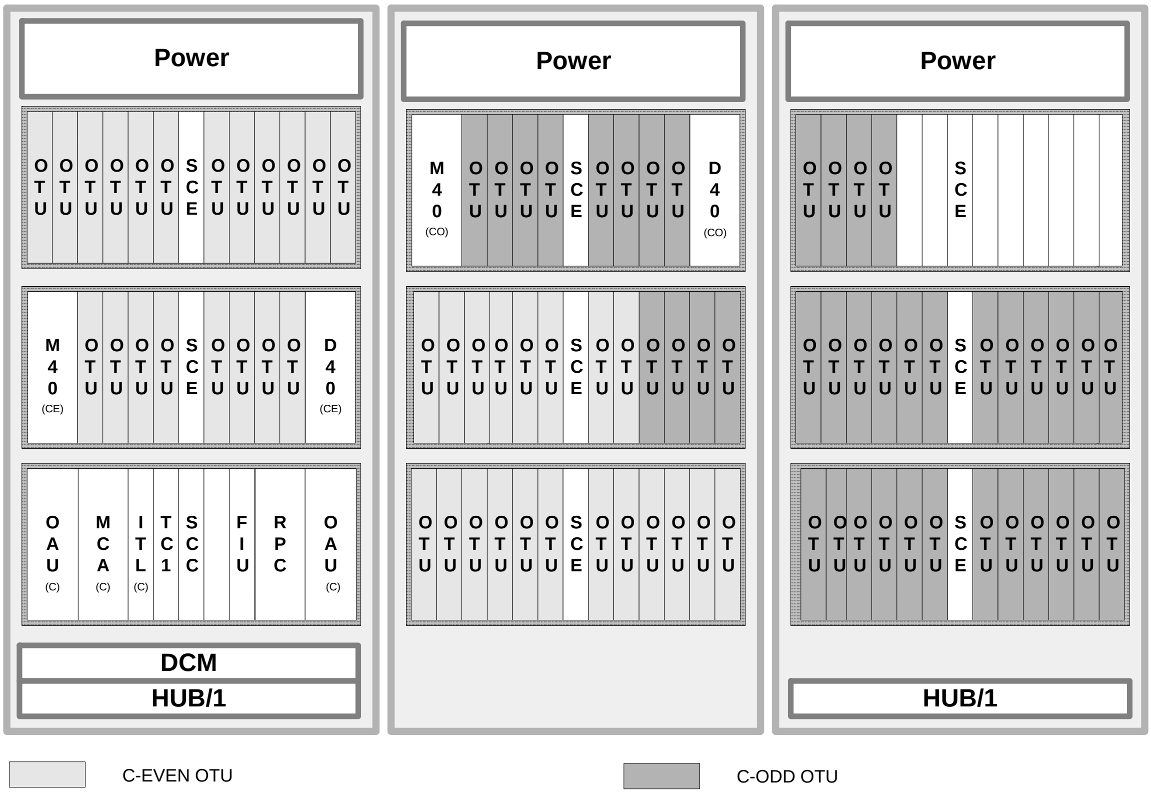
CE: C-band EVEN LO: L-band ODD L: L-band
C: C-band

Note: OTUs are either in C-EVEN or L-ODD band. HUB/1 indicates one 8-port HUB is configured in the HUB frame.

Figure 3-7 Configuration of the C+L 800 Gbit/s OTM (type II system)

If OTUs need centralised power protection, a PBU board must be installed in slot 1 of the subrack holding OTUs.

C band OTM supports service expansion form 1 to 80 channels. The typical configuration of the C band 800G OTM is shown in Figure 3-8.



CE: C-band EVEN CO: C-band ODD C: C-band

Figure 3-8 Configuration of the C band 800 Gbit/s OTM (type II system)

Type III, IV and V Systems

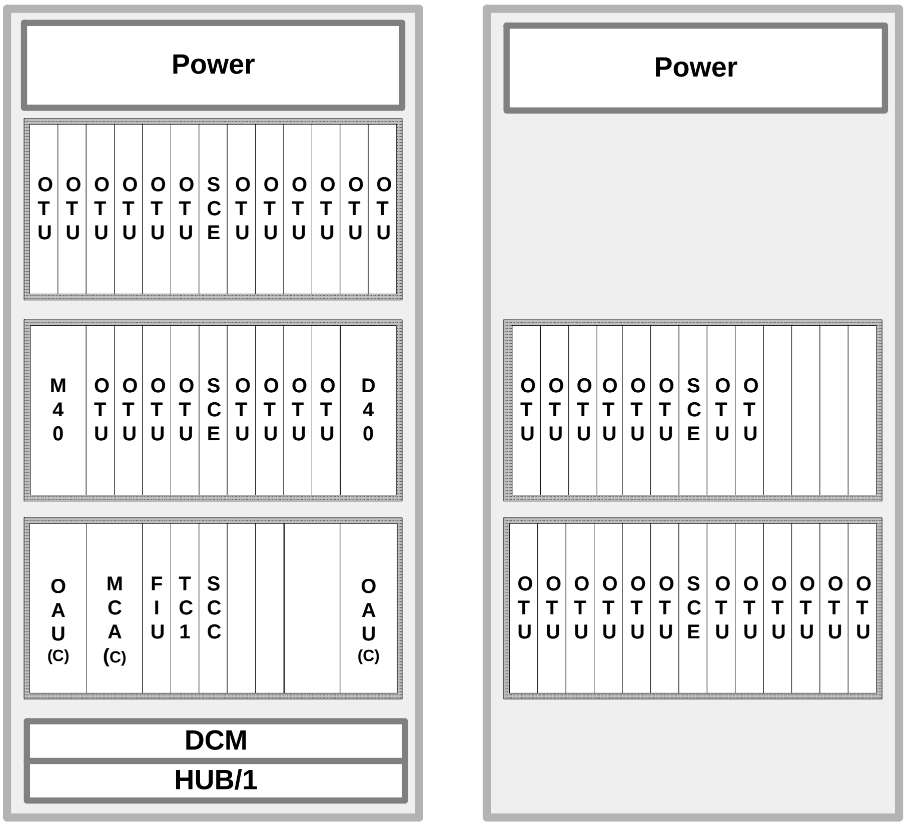
Figure 3-9 shows the configuration of the OTM of the type III system (C-EVEN 400 Gbit/s).

The configuration of the L-ODD 400G OTM of the type IV system is similar to that of the type III system, except the boards are in L-ODD band.

The configuration of the C-EVEN OTM of the type V system is similar to that of the type III system, but the OTU it uses is no more than 2.5 Gbit/s and no DCM is needed.

If the system provides the line protection function, the OLP01 board needs to be configured. In this case, the Raman amplifier unit cannot be used.

If OTUs need centralised power protection, a PBU board must be installed in slot 1 of the subrack holding OTUs.

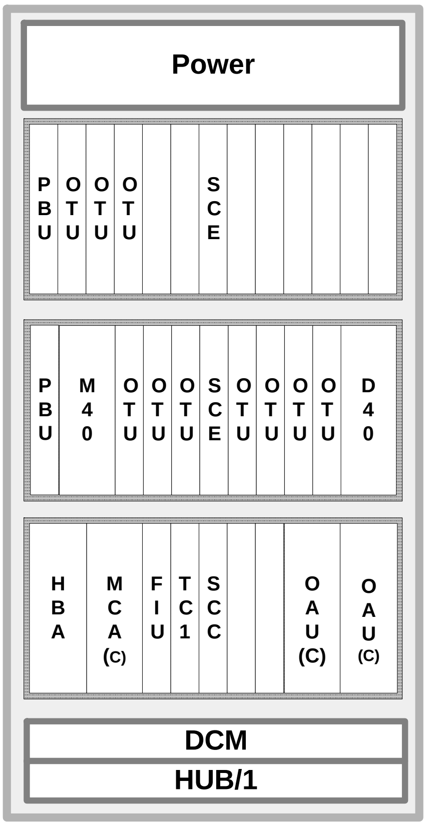


Note: All OTUs belong to C-EVEN band. The "(C)" indicates the C band.

Figure 3-9 Configuration of the 400 Gbit/s OTM (type III system)

Type VI System

Being an LHP, the type VI system provides 10-channel and 40-channel application, which has similar configuration, except the number of OTUs. Figure 3-10 shows the configuration of the 10-channel system.



Note: All OTUs belong to C-EVEN band. The "(C)" indicates the C band.

Figure 3-10 Configuration of the 10-channel OTM (type VI system)

The OTM of the type VI system is configured with a high booster amplifier (HBA) at the transmit end and two optical amplifier units (OAU) at the receive end.

3.1.4 Configuration Principle

Configuration of M40, V40 and VA4

- In an open system, if the output power of the OTU boards is not adjustable, the number of optical channels is more than 16, and there is a need for power equalization, use the V40. If the number of optical channels is less than 16, and there is a need for power equalization, install one M40 along with several VA4s.
- In an integrated system, if there is a need for power equalization, install the V40.
- In a hybrid system, if the output power of the OTU boards is not adjustable, the number of optical channels is more than 16, and there is a need for power equalization, the M40 is replaced by a V40 of corresponding band. If the number of optical channels is less than 16, and there is a need for power equalization, install one M40 along with several VA4s.
- If there is no need for power equalization, install the M40.

Configuration of OTU

- When installing the OTU, first configure the C-EVEN module, and then C-ODD, L-EVEN and L-ODD modules, from the bottom subrack to top subrack and left to right in the subrack.

Configuration of SCC/SCE

- Generally, the SCC board is required in the subrack with the SC1, SC2, TC1 or TC2 installed. The SCE is installed in other subracks.

Configuration of Amplifier Unit

- Amplifier units of the transmit and receive ends are installed in the leftmost slots or rightmost slots.

Configuration of Supervisory Channel and Timing Transporting Unit

- If clock transmission is required, use the TC1 or TC2. Otherwise use the SC1 or SC2. Note that the TC1 or TC2 cannot be used with the SC1 or SC2.
- If clock protection is required, install the TC1 or TC2 in both slot 6 and slot 8. Otherwise slot 6 is preferential.

Configuration of Protection Group

- In 1:8 OTU protection, all the boards in a protection group, including the working OTU boards, the protection OTU and the OCP, should be installed in one subrack. One subrack can accommodate one protection group only.
- The OLP01 is used for the purpose of optical line protection. It is not used with the Raman amplifier unit.
- When you configure the inter-subrack 1+1 protection, the working OTU, the protection OTU and the OLP03 can be configured in different subracks. The OLP03 supports protection against subrack power failure. In this case, the protection OTU and the OLP03 should not be in the same subrack.

3.2 OLA

3.2.1 Signal Flow

The OLA amplifies bidirectional optical signals and compensates for the fiber link attenuation to extend the transmission distance without regeneration.

The OLA consists of:

- Optical amplifier (OA)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Dispersion compensation module (DCM)
- System control & communication unit (SCC)

The OLA flow signal is shown in Figure 3-11.

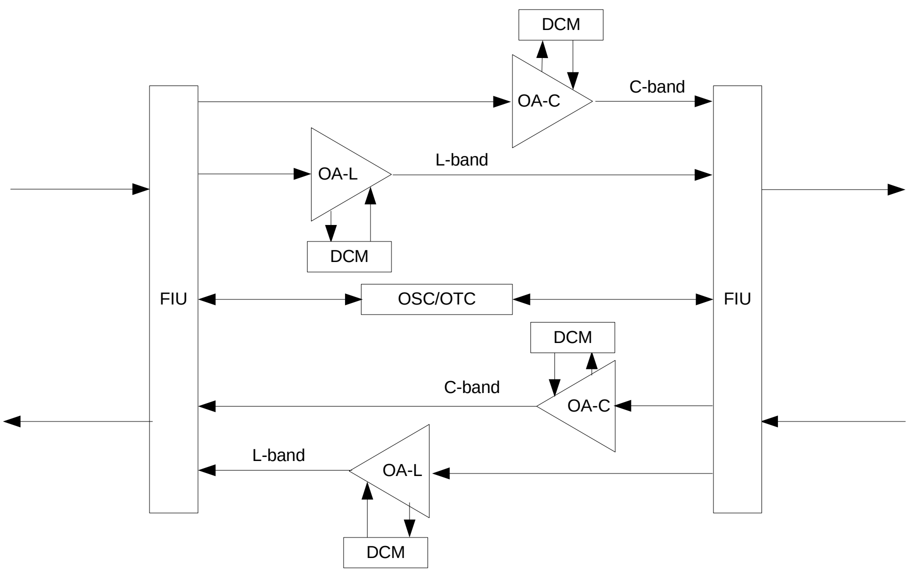


Figure 3-11 OLA signal flow

At the receive end, the FIU separates the line optical signals into service signals and supervisory signal.

Then all the service signals are sent to the OA, where these signals are amplified according to C-band and L-band. Meanwhile, the DCM implements the dispersion compensation to the service signals. Optical supervisory signals are sent to the OSC (OTC) for overhead processing (overhead and network clock).

At the transmit end, the amplified service signals and supervisory signal are sent, through the FIU, to the optical fibre for transmission.

3.2.2 Structure

For the OLA of the six system types, each functional unit and the board(s) contained are shown in Table 3-3.

For the functions of these boards, see Chapter 2 "Product Description".

Table 3-3 Functional unit and the boards contained (five system types)

Unit / System	OA	OSC/OTC	FIU
I	OAU, OBU, OPU	SC2, TC2	FIU-01, FIU-02
II	OAU, OBU, OPU	SC2, TC2	FIU-01, FIU-02
II (C 800G)	OAU, OBU, OPU	SC2, TC2	FIU-03
III	OAU, OBU, OPU	SC2, TC2	FIU-03
IV	OAU, OBU, OPU	SC2, TC2	FIU-04
V	OAU, OBU, OPU	SC2, TC2	FIU-03

- The OLA of the type I system adopts the optical amplifier of C-band and L-band for amplifying service signals of C-band and L-band.
- The C+L 800G OLA of the type II system adopts the optical amplifier of C-band and L-band for amplifying service signals of C-band and L-band . The C band 800G OLA adopts the optical amplifier of C-band for amplifying service signals of C-band.
- The OLA of the type III and V system adopts the optical amplifier of C-band for amplifying service signals of C-band.
- The OLA of the type IV system adopts the optical amplifier of L-band for amplifying service signals of L-band.
- The type VI system is a long hop system with no need for the OLA.

3.2.3 Typical Configuration

In full configuration, the OLA only needs one cabinet. In engineering configuration, whether to use OAU, OBU, OPU or the combination of them is dependent on the actual line loss and power budget.

Type I System

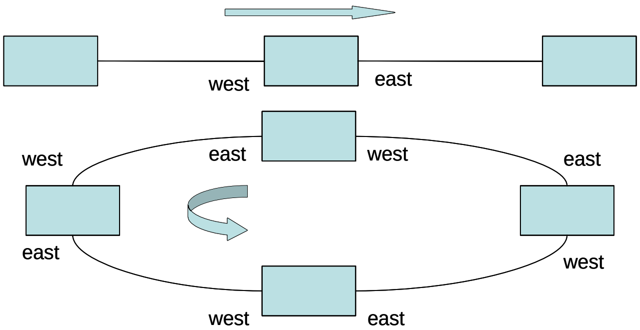
The OLA equipment achieves the bidirectional main path optical signal amplification in C-band and L-band. In each direction, two optical amplifiers are needed, which amplify optical signals in C-band and L-band respectively. The configuration is shown in Figure 3-12.

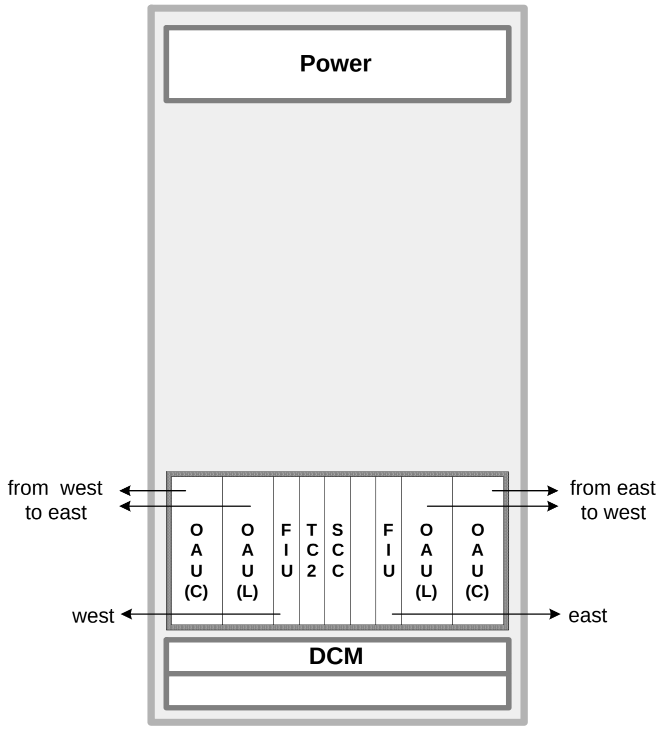
Note

In DWDM equipment, the definition about west and east is:

1. In a chain network, left is west and right is east.

2. In a ring network, the counter-clockwise (outer ring) is the primary ring, in the direction from west to east.





Note: The "(L)" indicates the L band. The "(C)" indicates the C band.

Figure 3-12 Configuration of the C+L band OLA (type I and II systems)

If the system needs a Raman amplifier unit, configure two RPA boards in the new middle subrack. If the system needs to configure the optical line protection, configure two OLP boards in the new middle subrack. Note that RPA and OLP can not be configured at the same time.

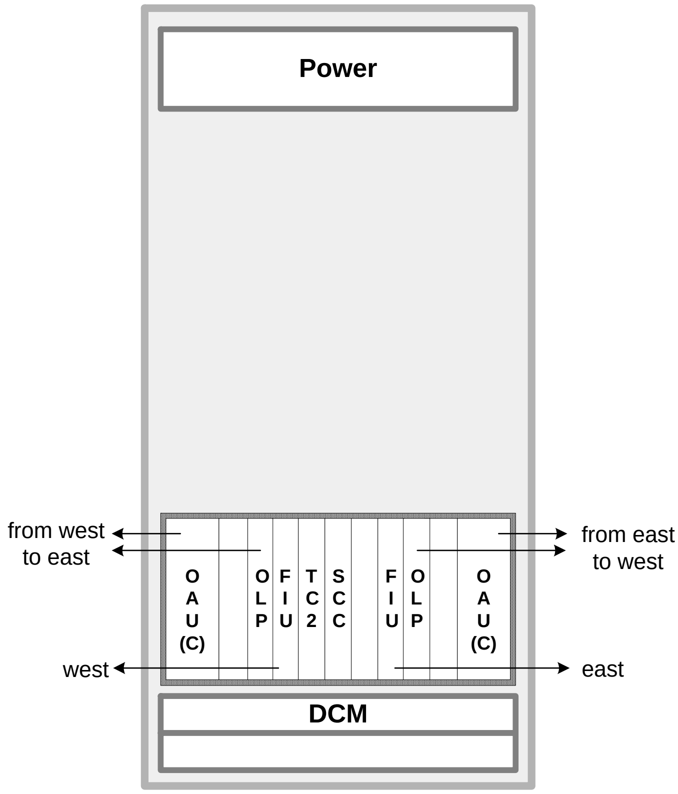
Type II System

The type II system supports C+L 800G and C 800G.

The C+L band OLA amplifies the signals on the main bidirectional path of C band and L band. In each direction, two optical amplifiers are needed for amplifying optical signals of C band and L band respectively. See Figure 3-12. The C band OLA amplifies the optical signals on the main bidirectional path of C band. In each direction, one optical amplifier is needed. See Figure 3-13.

Type III and V Systems

The OLA equipment achieves the bidirectional main path optical signal amplification in C-band, and each direction needs one optical amplifier. The configuration is shown in Figure 3-13.



Note: The "(C)" indicates the C band.

Figure 3-13 Configuration of the C band OLA (type III and V systems)

The case shown in Figure 3-13 is configured with optical line protection, which can be disabled by removing the OLP01 board. If the system needs a Raman amplifier unit, configure two RPC boards in the lower subrack. Note that the Raman amplification function and line protection function are exclusive.

Usually, the type V system does not need the DCM unit.

Type IV System

The configuration of the type IV system is similar to that of the type III system, except that the OA units of the type IV system are used in L-band.

3.2.4 Configuration Principle

Configuration of Amplifier Unit

- If the OAU, OBU and Raman amplifier unit are to be configured from west to east, install them at the left side (slot 1 or 3) of the subrack. If they are to be configured from east to west, install them at the right side (slot 12 or 10) of the subrack.
- If the power budget of the system is not adequate, the OBU can be used besides OAU. Install the OBU in slot 3 (from west to east) or slot 10 (from east to west).

- The OBU is preferential than the Raman amplifier unit when installed in the slots above mentioned. Raman amplifier units can also be installed in other idle slots.

Configuration of SCC/SCE

- Generally, the SCC is installed in the subrack with the SC1/SC2/TC1/TC2 installed. The SCE is installed on other subracks.

Configuration of Optical Supervisory Channel and Timing Transporting Unit

- If clock transmission is required, use the TC2. Otherwise use the SC2. Note that the TC2 cannot be used with SC2.
- If clock protection is required, install the TC2 in both slot 6 and slot 8. Otherwise slot 6 is preferred.

Configuration of Protection Group

The OLP01 is used for the purpose of optical line protection, but not used with the Raman amplifier unit.

3.3 OADM

3.3.1 Signal Flow

The OADM is used to add/drop channels to/from the main path locally while passing other channels transparently.

The OptiX BWS 1600G has three types of OADM equipment: serial OADM, parallel OADM and re-configurable OADM (ROADM). Serial OADM can be configured by concatenating MR2 boards, while parallel OADM is formed by back-to-back OTMs. ROADM can be configured with DWC board. They are applied to type I to type V systems. The type VI system is a long hop system with no need for the OADM equipment.

Serial OADM

It consists of:

- Optical add/drop multiplexer (OADM)
- Optical transponder unit (OTU)
- Optical amplifier (OA)
- Raman pump amplifier unit (RPU)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Dispersion compensation module (DCM)
- Multi-channel spectrum analyser unit (MCA)

- System control & communication unit (SCC)
- Power backup unit (PBU)

Figure 3-14 shows the signal flow of the serial OADM.

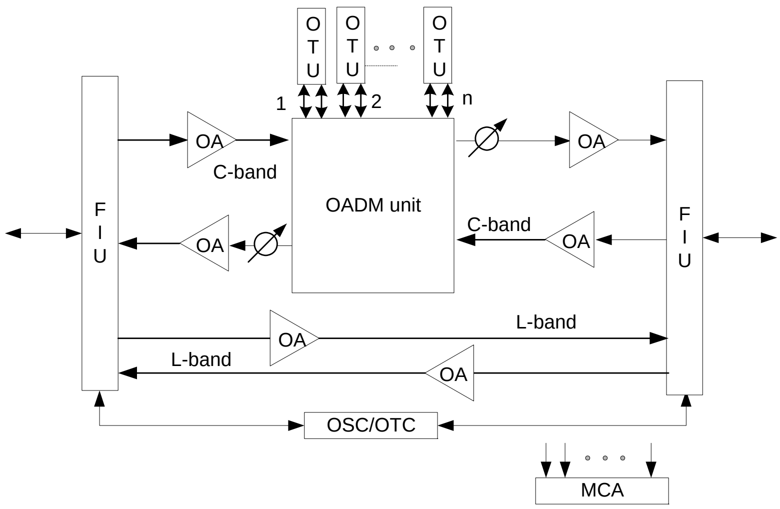


Figure 3-14 Signal flow of the serial OADM

The OADM unit in Figure 3-14 is formed by the MR2, and can support full add/drop at C-band.

At the receive end, the RPU (optional), a low-noise pump amplifier, amplifies line optical signals. The FIU demultiplexes the line optical signals into service signals and supervisory signal.

The supervisory signal is sent to the OSC or OTC for processing. The C-band service signals are added/dropped some channels in the OADM. Note that the service signals may need to be amplified before they enter or after they go out of the OADM unit. The L-band service signals are also amplified through the OA. Finally, C-band and L-band service signals are combined with supervisory signal and sent to the optical fibre.

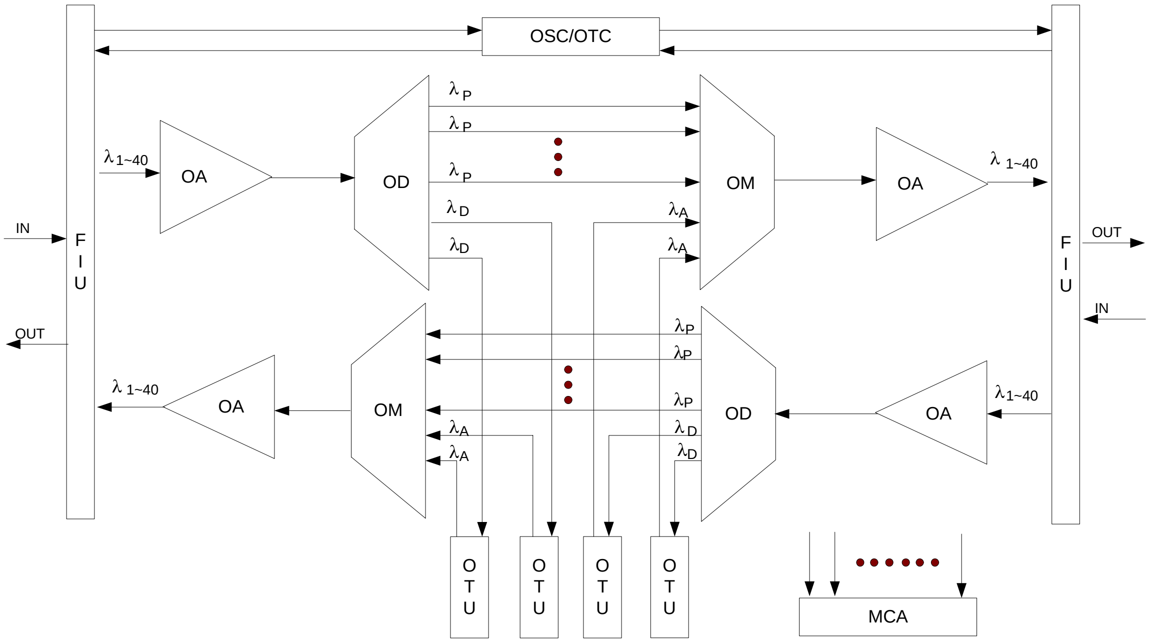
Parallel OADM

It consists of:

- Optical transponder unit (OTU)
- Optical multiplexer (OM)
- Optical demultiplexer (OD)
- Optical amplifier (OA)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Dispersion compensation module (DCM)

- Multi-channel spectrum analyser unit (MCA)
- System control & communication unit (SCC)
- Power backup unit (PBU)

Figure 3-15 shows the signal flow of the parallel OADM (the 40-channel system is taken as an example)



λP: Pass-through channel λA: Added channel λD: Dropped channel

Figure 3-15 Signal flow of the parallel OADM

The parallel OADM is formed by back-to-back OTMs. The parallel OADM can add/drop channels through the OD (D40) and the OM (M40) while regenerating or passing through other channels.

When more than 32 add/drop channels are required in one station, the parallel OADM is usually used. In addition, it can be upgraded to 160 channels as needed.

ROADM

The ROADM consists of functional units as follows:

- Optical add/drop multiplexer (OADM)
- Optical transponder unit (OTU)
- Optical multiplexer (OM)
- Optical demultiplexer (OD)
- Optical amplifier (OA)
- Optical supervisory channel (OSC)
- Fiber interface unit (FIU)
- Dispersion compensation module (DCM)

- Multi-channel spectrum analyzer unit (MCA)
- System control and communication unit (SCC)
- OTU power backup unit (PBU)

Figure 3-16 shows the signal flow of the ROADM. (40-channel system for example)

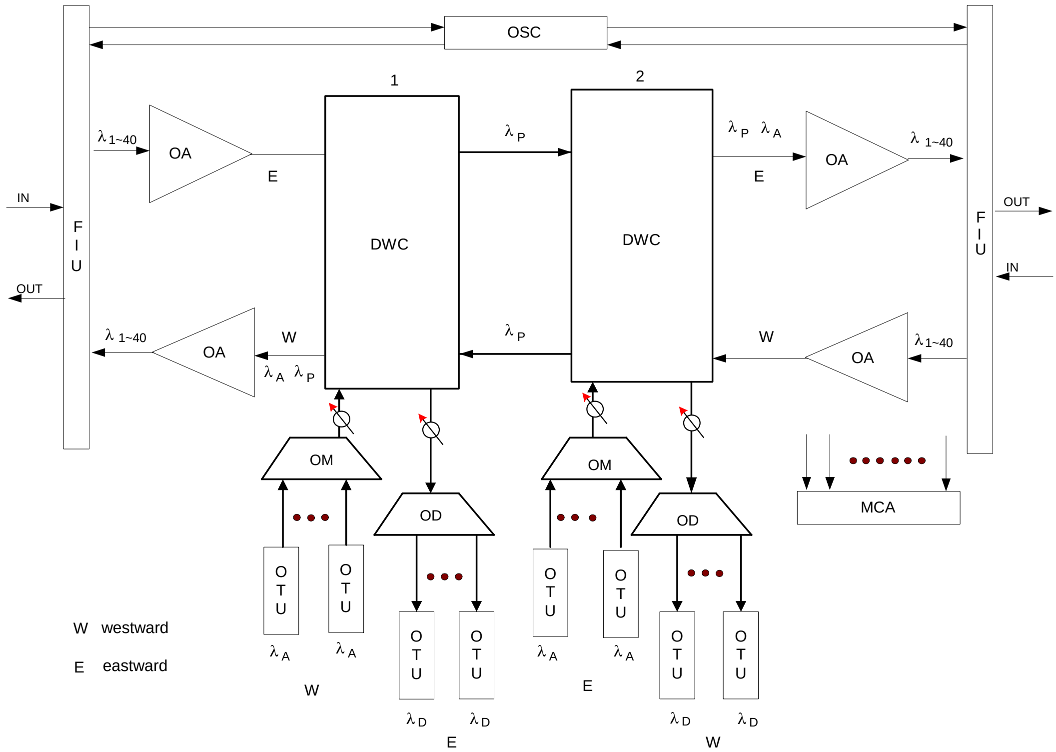


Figure 3-16 Signal flow of the ROADM

The ROADM adds and drops any channel of the C-band in both directions by two cascaded DWCs.

From west to east, the No.1 DWC divides the signals into two same groups of multi-wave signals. One is to pass through and another is to be dropped.

The optical demultiplexer (OD) connect with No.1 DWC demultiplexes signals to be dropped into single channels.

Channels to pass through enter the No.1 DWC. Then channels to be dropped are blocked. Those to pass through directly pass through.

Channels to be added are multiplex by the optical multiplexer (OM) of fixed wavelength (connect with No.2 DWC). Then the signals enter the No.2 DWC and are multiplexed with the passing through multi-wave signals. Finally, the multiplexed signals enter the amplifier and reach the line end.

Signals from east to west are the same.

3.3.2 Structure

The parallel OADMs and ROADM of the five system types (type I to type V) are constructed in the similar way. Here only serial OADM is introduced.

For the serial OADM of the five system types, each functional unit and the board(s) contained are shown in Table 3-4.

For the functions of these boards, see Chapter 2 "Product Description".

Table 3-4 Functional units and the boards contained (five system types)

Unit / System	OTU	OADM	OA	OSC/OTC	FIU
I	LWF, TMX, LBE, LOG	ITL+MR2	OAU, OBU, OPU	SC2, TC2	FIU-01, FIU-02
II (C+L 800G)	LWF, TMX, LBE, LOG	MR2	OAU, OBU, OPU	SC2, TC2	FIU-01, FIU-02
II (C 800G)	All OTUs	ITL+MR2	OAU, OBU, OPU	SC2, TC2	FIU-03
III	All OTUs	MR2	OAU, OBU, OPU,	SC2, TC2	FIU-03
IV	LWF, TMX, LBE, LOG	MR2	OAU, OBU, OPU	SC2, TC2	FIU-05
V	LWC1, LDG, FDG, LWM, LWX	MR2	OAU, OBU, OPU	SC2, TC2	FIU-03

Type I System

The structure of the serial OADM of the type I system is shown in Figure 3-17 .

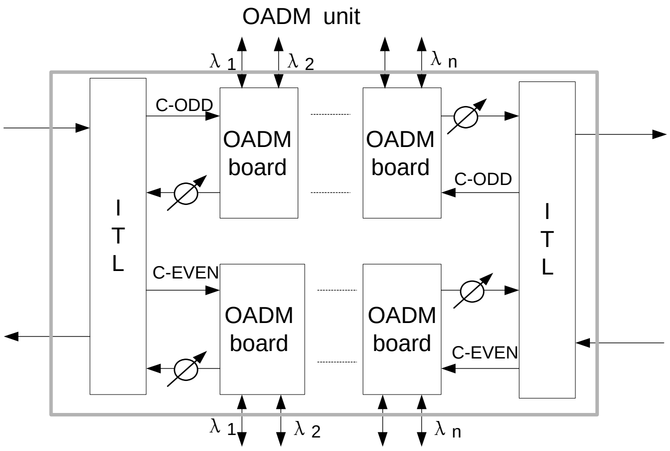


Figure 3-17 Structure of the OADM in type I system

In Figure 3-17, the OADM includes the ITL, which divides the service signals into odd channels and even channels. Up to 16 odd channels and 16 even channels can be added/dropped in C band, so the OADM can add/drop up to 32 channels locally.

Type II System

The type II system supports C+L 800G and C 800G.

The C+L OADM does not include ITL. It supports full add/drop by cascading OADM units. The OADM of C band is the same as that of the type I system. It can add/drop up to 32 channels.

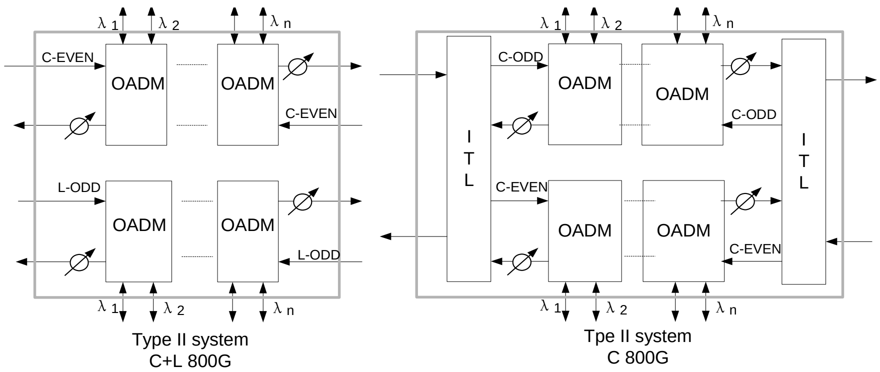


Figure 3-18 Structure of the OADM in type II system

Type III, IV and V Systems

The OADM of the type III system does not include the ITL. It can support full add/drop by cascading OADMs. See Figure 3-19.

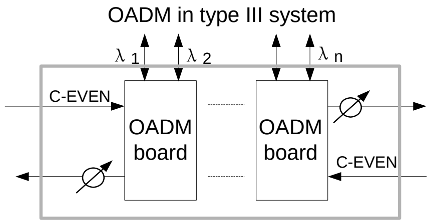


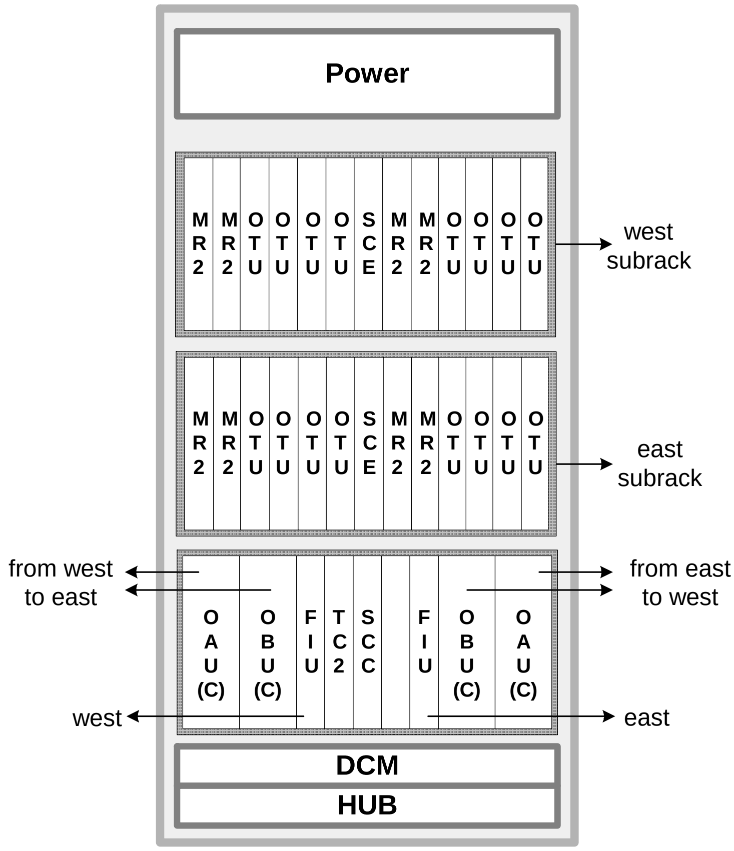
Figure 3-19 Structure of the OADM in type III system

The OADM of the type IV and V systems does not include the ITL either. They add/drop up to 16 channels by cascading MR2 boards.

3.3.3 Typical Configuration

Serial OADM

Taking the type III system as an example, 16 channel services can be added/dropped at OADM (eight in east and eight in west), and other wavelengths pass through. The configuration is shown in Figure 3-20.



Note: The "(C)" indicates the C band.

Figure 3-20 Configuration of the C-band serial OADM equipment (type III system)

If the system needs the Raman amplifier unit, the RPU is installed in the new subrack. If the system needs the optical line protection, two OLP boards are installed in the new subrack and cabinet.

If OTUs need centralised power protection, a PBU board must be configured in slot 1 of each subrack holding OTUs. And all OTU boards are placed from left to right after the PBU.

The configurations of OADM of other systems are similar to that of the type III system. For the type I system, the ITL board and L-band OAU must be added.

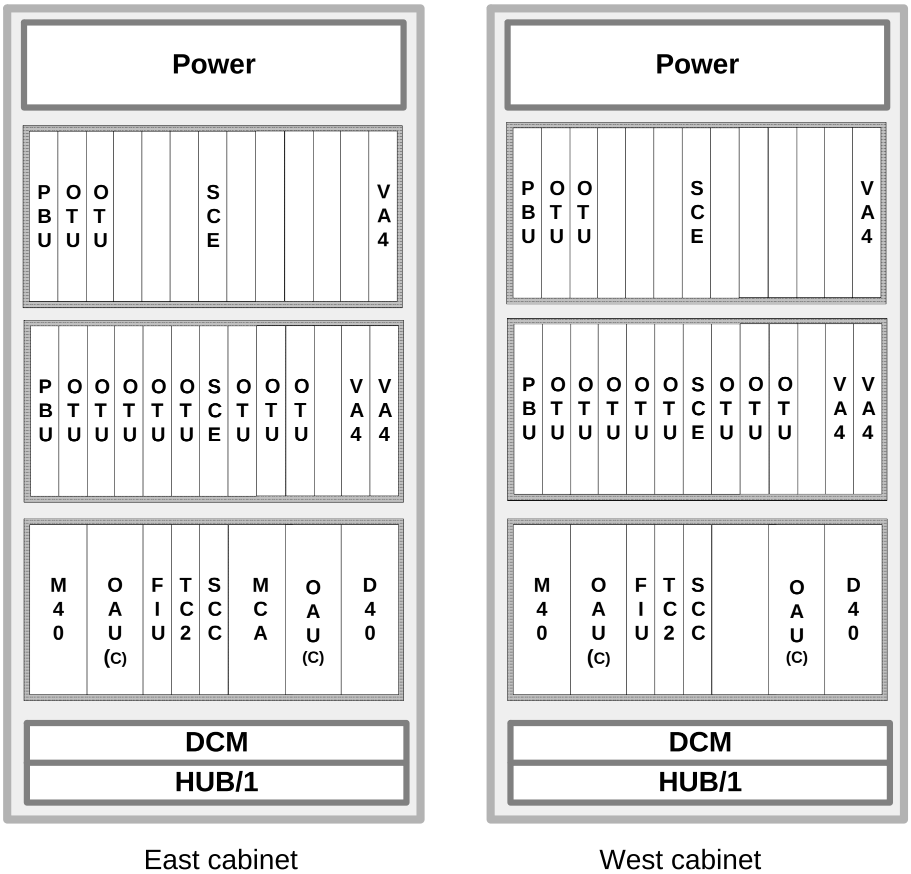
For the type II system, the L-band OAU must be added for C+L 800G and the ITL board added for C 800G.

For the type IV system, the L-band OAU and OADM unit must be added.

For the type V system, the DCM is not needed.

Parallel OADM

Take the type III system as an example. 20 channels of services can be added/dropped at OADM (10 in east and 10 in west), and other wavelengths pass through. The configuration is shown in Figure 3-21.



Note: The "(C)" indicates the C band.

Figure 3-21 Configuration of the C-band parallel OADM equipment (type III system)

3.3.4 Configuration Principle

Configuration of Amplifier Unit

- C or L below the OAU, OBU, MCA, and ITL indicates their working bands.
- If the OAU is to be used with the Raman amplifier unit, install the OAU-CR/OAU-LR. Otherwise, use the OAU-CG/OAU-LG. and the SSE3OAU C-series OAUs.
- If the OAU, OBU, Raman amplifier unit and ITL are to be configured from west to east, install them at the left side of the subrack. If they are to be configured from east to west, install them at the right side of the subrack.

Configuration of OTU

- When installing the OTU, first configure the C-EVEN module, and then C-ODD module.
- If the number of MR2 boards exceeds 4, east MR2 boards are installed in one subrack and west MR2 boards in another. If the number is no more than 4, east MR2 boards are installed in right slots and west MR2 boards in left slots of the same subrack.

Configuration of SCC/SCE

- Generally, the SCC board is required on the subrack with the SC1, SC2, TC1 or TC2 installed. The SCE is installed on other subracks.

Configuration of Optical Supervisory Channel and Timing Transporting Unit

- If clock transmission is required, use the TC2. Otherwise use the SC2. Note that the TC2 cannot be used with the SC2.
- If clock protection is required, install the TC2 in both slot 6 and slot 8. Otherwise slot 6 is preferred.

Configuration of Protection Group

The OLP01 is used for the purpose of optical line protection. It is exclusive with the Raman amplifier unit in the configuration.

3.4 REG

3.4.1 Signal Flow

We have already discussed that the OLA can extend the optical transmission distance without regeneration. However, when the distance is longer, such factors as dispersion, optical noise, non-linear effect, or PMD will affect the transmission performance. In this case, we need to regenerate the original signals. An REG implements the 3R function, that is, reshaping, re-timing and regenerating, to improve the signal quality and extend the transmission distance.

An REG station contains:

- Optical transponder unit (OTU)
- Optical multiplexer (OM)
- Optical demultiplexer (OD)
- Optical amplifier (OA)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Multi-channel spectrum analyser unit (MCA)
- System control & communication unit (SCC)
- Power backup unit (PBU)

Figure 3-22 shows the block diagram of the REG signal flow.

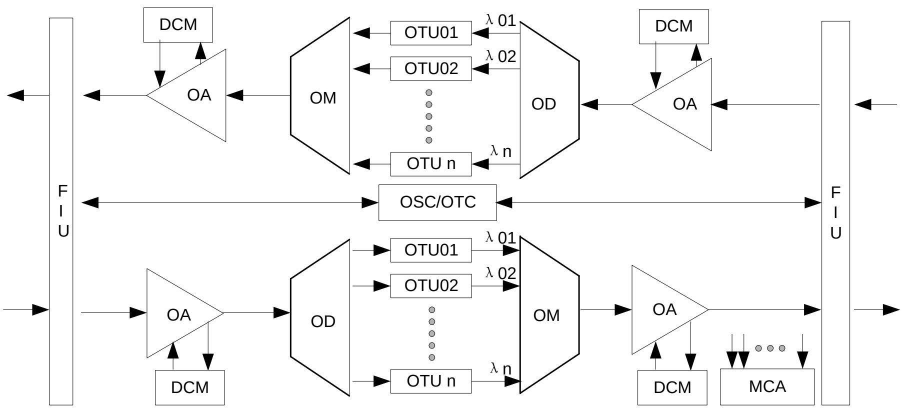


Figure 3-22 REG signal flow

The signal flow of the REG is similar to that of back-to-back OTMs, except that no signal is added/dropped. Signals are regenerated through the regenerating OTU.

3.4.2 Structure

For the REG of the six system types, each functional unit and the board(s) contained are shown in Table 3-1.

The structure of the OM, OD, and OA of the six system types is the same as that of the OTM equipment, as shown in Figure 3-2 and Figure 3-3.

3.4.3 Typical Configuration

The configuration of the REG is basically equivalent to that of two back-to-back OTMs, following the same configuration rule.

Difference:

The REG needs to be configured with a bidirectional OSC/OTC or a pair of OSCs/OTCs for backup.

The REG needs to be configured with two FIU boards.

The REG needs the regenerating OTU.

The configuration of the REG of 20-channel application in type III system is the same as that shown in Figure 3-21.

3.4.4 Configuration Principle

The configuration principle of the REG is the same as that of the OTM.

3.5 OEQ

3.5.1 Signal Flow

In the extra long haul (ELH) application, as the transmission distance without the regenerator is much longer than that in the long haul application, the following problems may occur.

Accumulation of non flatness of optical amplifier gain spectrum and fibre attenuation spectrum causes disequilibrium of both the optical power and signal-to-noise ratio at the receive end.

The dispersion slope of DCM does not match with optical fibres completely, so all wavelengths cannot be compensated completely, and the dispersion at the receive end fails to meet the requirement of the system.

To better realise optical power equalization and dispersion compensation, the OEQ is used in the ELH application. Currently, the type II and II systems can realise ELH transmission.

The OEQ equipment consists of the optical power equaliser and the dispersion equaliser.

(1) Optical power equaliser

It consists of:

- Optical power equaliser (OPE)
- Optical amplifier (OA)

- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Multi-channel spectrum analyser unit (MCA)
- System control & communication unit (SCC)

Figure 3-23 shows the signal flow of the optical power equaliser.

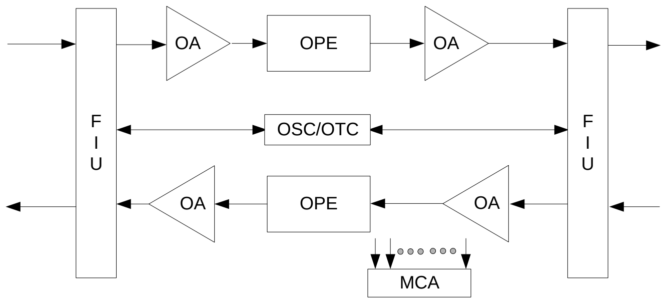


Figure 3-23 Signal flow of optical power equaliser.

(2) Dispersion equaliser

It consists of:

- Dispersion equaliser (DE)
- Optical amplifier (OA)
- Optical supervisory channel unit or supervisory channel and timing transporting unit (OSC/OTC)
- Fibre interface unit (FIU)
- Dispersion compensation module (DCM)
- Multi-channel spectrum analyser unit (MCA)
- System control & communication unit (SCC)

Figure 3-24 shows the signal flow of dispersion equaliser.

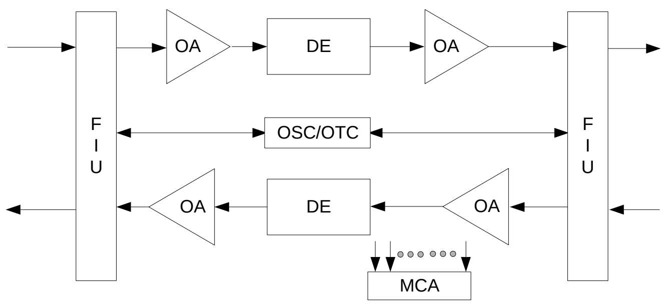


Figure 3-24 The signal flow of dispersion equaliser

The dispersion equaliser and the optical power equaliser can be placed in the same station.

The dispersion equaliser is often placed at the receive end of the OTM for dispersion equalization, as shown in Figure 3-25 . It is recommended to place it at the receive end of the last station in the optical multiplexing section.

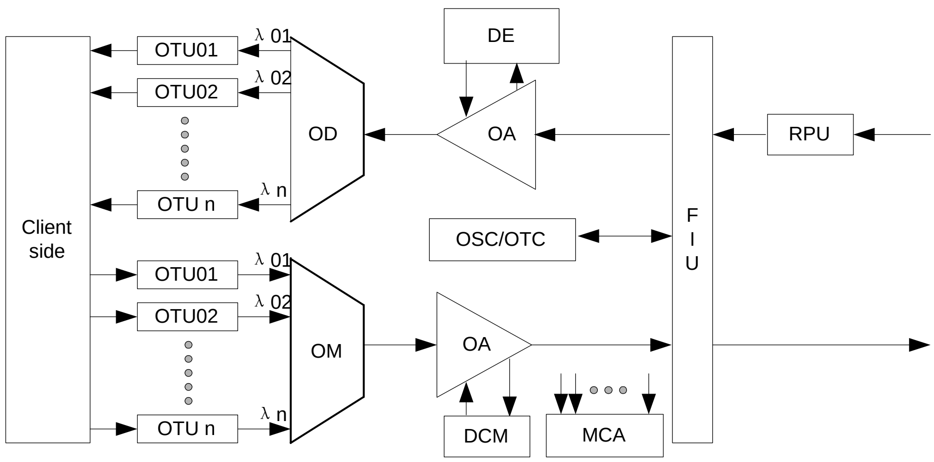
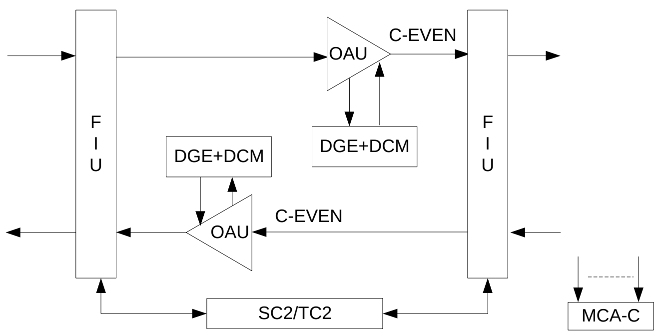


Figure 3-25 Signal flow of dispersion equaliser in OTM

3.5.2 Structure

- Optical power equaliser

Two solutions are available: use of the dynamic gain equaliser unit (DGE) and use of the VMUX unit, as shown in Figure 3-26 and Figure 3-27.



DGE: Dynamic gain equaliser unit
OAU: Optical amplifier unit
DCM: Dispersion compensation module
FIU: Fibre interface unit
SC2: Bidirectional optical supervising channel unit

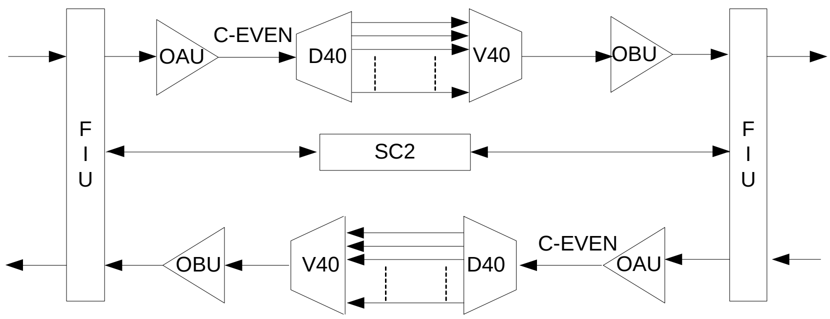
Figure 3-26 Optical power equalization through the DGE

As shown in Figure 3-26, the optical power equaliser unit consists of the DGE and DCM. The DGE realises optical power equilibrium of each channel by adjusting insertion loss spectrum of the DGE board. The DCM is used to realise dispersion compensation of the system.

This solution has all the functions of the OLA. In addition, optical power equilibrium is implemented to make the multiplexed signals meet the requirement for optical power flatness, and to extend the transmission distance without regeneration.

Note

For DGE solution, note whether the power margin of the OAU meets the insertion loss requirement of the DCM and the DGE. If the margin cannot meet the requirement, OAU+OBU should be adopted. DCM and DGE are placed between two amplifiers.



V40: 40-channel multiplexing unit with VOA
OBU: Optical booster unit
SC2: Bidirectional optical supervisory channel unit
D40: 40-channel demultiplexing unit
FIU: Fibre interface unit
OAU: Optical amplifier unit

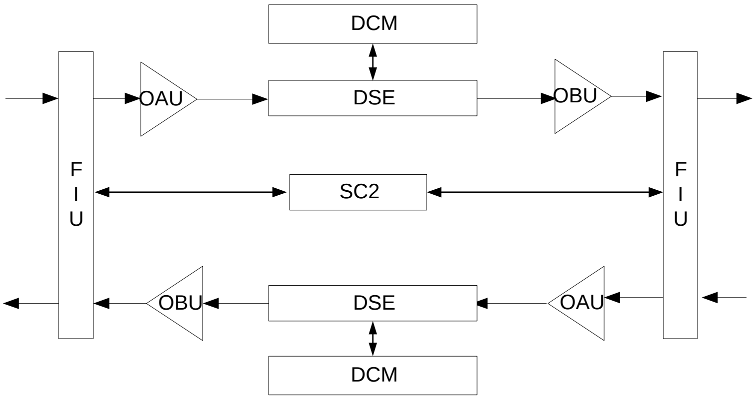
Figure 3-27 Optical power equalization through the VMUX (the V40 board)

In Figure 3-27, the VMUX is adopted. The V40 is used as the VMUX unit to adjust optical power of each channel, so as to equalize optical power.

The user can select one of the solutions according to the actual requirement.

- Dispersion equaliser

The dispersion equaliser realises equalised compensation of dispersion for multiplexed signals, as shown in Figure 3-28.



DSE: Dispersion slope equaliser unit
OBU: Optical booster unit
FIU: Fibre interface u nit
OAU: Optical amplifier unit
SC2: Bidirectional optical supervising channel unit
DCM: Dispersion compensation module

Figure 3-28 Composition of dispersion equaliser

Through the dispersion slope equaliser (DSE), the system sends the multiplexed signals to the DCM for equalised compensation for dispersion.

Note

In ultra-long haul transmission, the configuration of the optical equaliser should follow the principles below.

1. In the case of "8 ≤ number of optical amplification sections ≤ 12", and without configuration of the OEQ, the VMUX must be configured at the transmit end for equalisation.

2. In the case of "number of optical amplification sections ≥ 12", the OEQ must be configured. The subsequent optical amplification sections will be configured differently according to OEQ solution.

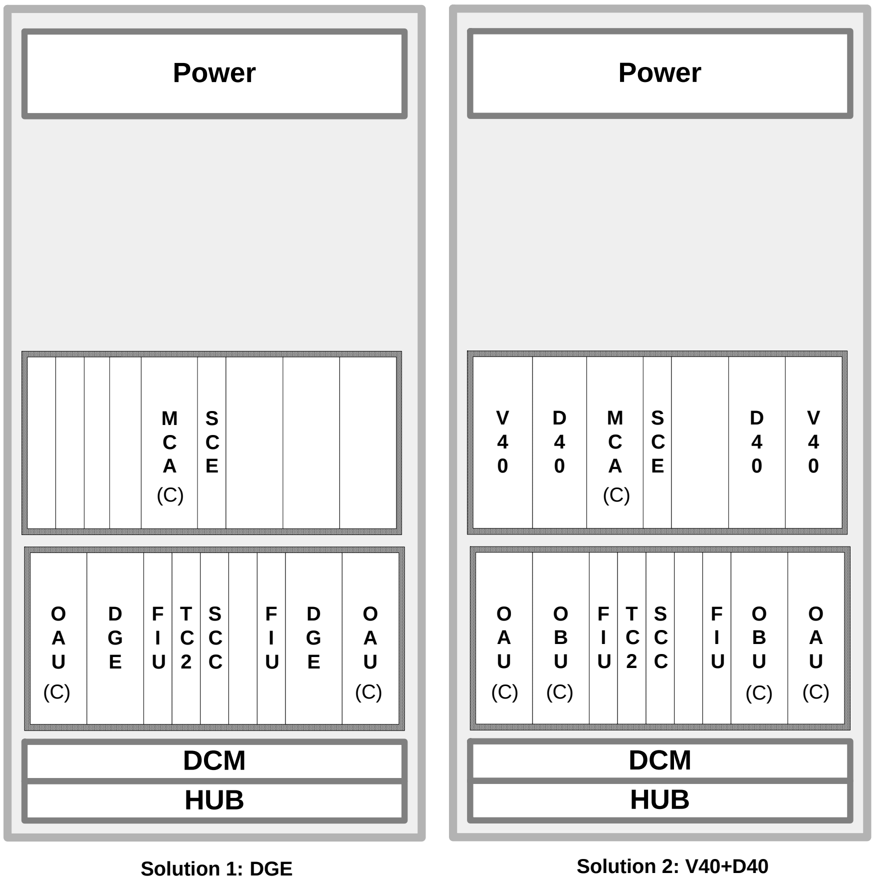
(a) D40+V40 solution: An OEQ is added when 8 optical amplification sections are added.

(b) DGE solution: An OEQ is added when 5 optical amplification sections are added.

If the optical fibre length of multiplexing section is equal to or greater than 1000 km, a dispersion equaliser is required.

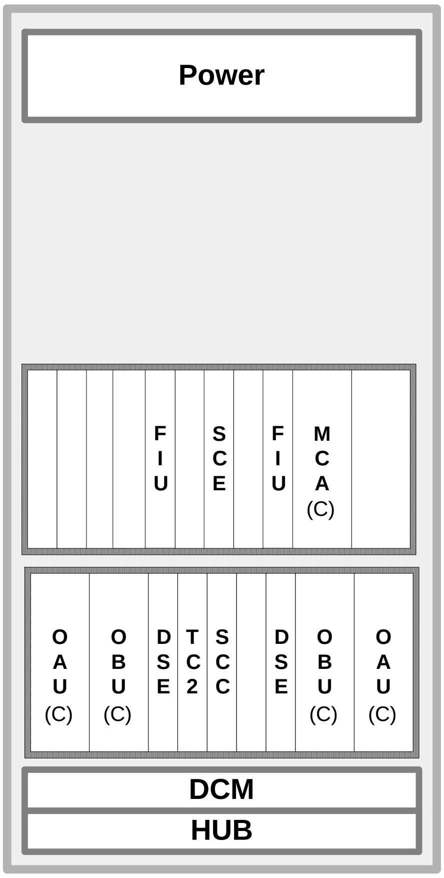
3.5.3 Typical Configuration

Figure 3-29 shows the configuration of the optical equaliser in the type III system. Figure 3-30 shows the configuration of the dispersion equaliser in the type III system.



Note: The "(C)" indicates the C band.

Figure 3-29 Configuration of OEQ



Note: The "(C)" indicates the C band.

Figure 3-30 Configuration of dispersion equaliser

3.5.4 Configuration Principle

The configuration principle of the OEQ is the same as that of the OLA.

The OEQ (DGE and DSE) is inserted following "west on the left and right on the east".

4 Networking and System Applications

4.1 Networking and Applications

As shown in Figure 4-1, the OptiX BWS 1600G can be used in point-to-point network, chain network and ring network, all of which can realize long haul, ultra long haul, or ultra long haul and long hop application under different system configurations and technologies.

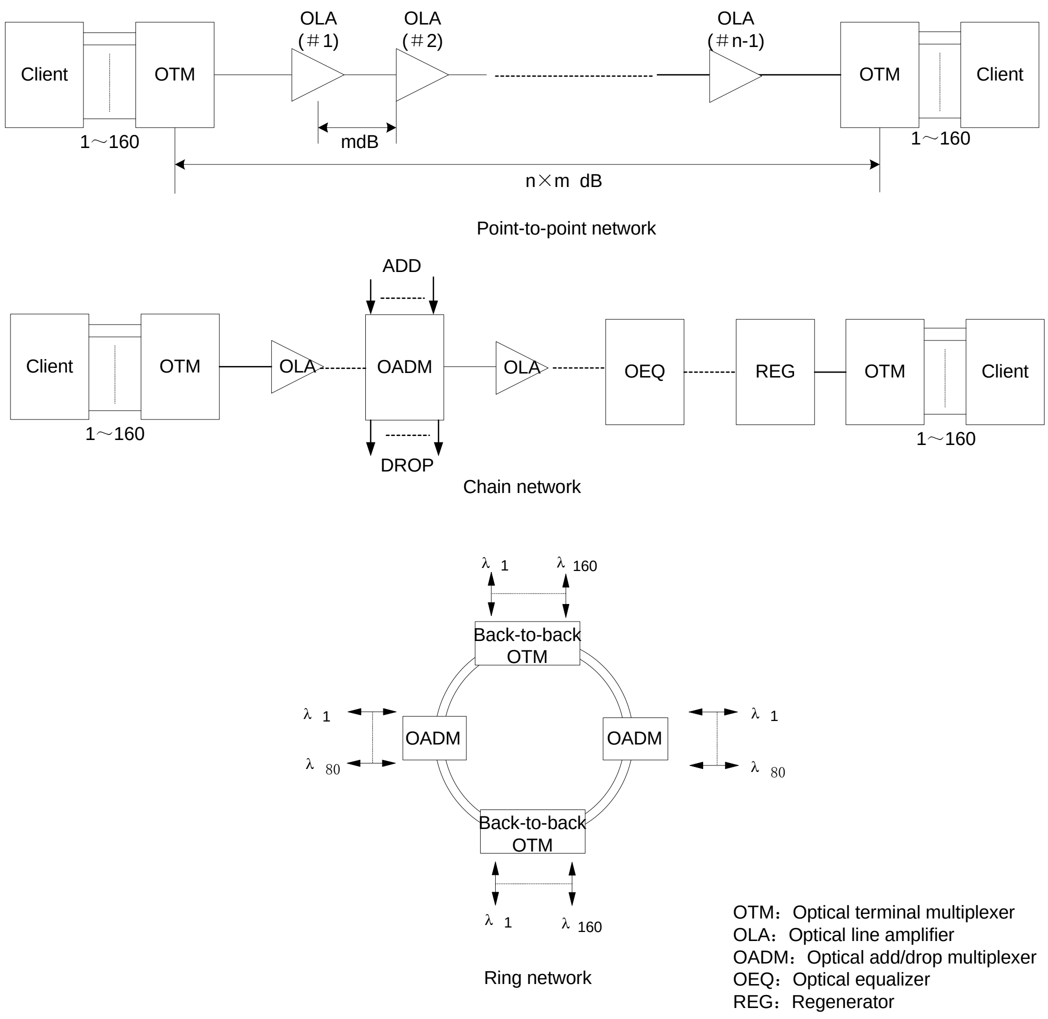


Figure 4-1 OptiX BWS 1600G networking diagram

- Point-to-point

The point-to-point network, composed of OTM and OLA, is the most prevalent networking mode adopted by the OptiX BWS 1600G.

- Chain

The chain network is frequently used in a national DWDM backbone network that is of high capacity and long distance. A chain network may comprise OTM, OLA, OADM, REG and OEQ, and can be regarded as the extension of a point-to-point network.

- Ring

The ring network is largely used in regional networks. It may comprise OADMs or back-to-back OTMs depending on the practical situation. In practice, one OADM in the DWDM ring network may be composed of back-to-back OTMs to remove the accumulated noise caused by the amplifier.

4.1.1 Type I system

The type I system, adopting non return to zero (NRZ) encoding, is applied in G.652 or G.655 optical fibers. Table 4-1 shows its networking capability.

Table 4-1 Networking capability of the type I system (160-channel, NRZ)

Classification	Specification	Typical distance
With FEC	1 × 28 dB	1 × 101 km (101 km)
	2 × 24 dB	2 × 87 km (174 km)
	5 × 20 dB	5 × 72 km (360 km)

The span attenuation is the actual attenuation of fibers, not including the loss of any optical components.

Note

In section 4.1 , the span attenuation is the actual attenuation of the fiber, that is, the difference between the output optical power of the local station and the input optical power of the downstream station, not including the attenuation of the FIU board.

In section 4.1 , the typical distances in the networking specification are calculated on condition that the fiber attenuation coefficient is 0.275 dB/km.

The Raman amplifier can suppress OSNR from deteriorating to support more spans, and to transmit signals longer. With Raman amplification, the type I system supports a transmission distance of 640 km without a regenerator.

If the type I system uses out-band AFEC, it can support longer transmission without REG.

4.1.2 Type II system

The type II system supports C+L 800G and C 800G.

C+L 800G

The C+L 800G system, adopting NRZ encoding, is applied in G.652 or G.655 optical fibers. Table 4-2 shows its networking capability.

Table 4-2 Networking capability of type II system (C+L 80-channel, NRZ)

Classification	Specification	Typical distance
With FEC Without Raman amplification	1 × 32 dB	1 × 116 km (116 km)
	4 × 25 dB	4 × 90 km (360 km)
	7 × 22 dB	7 × 80 km (560 km)

C 800G

The C 800G system, adopting NRZ encoding and CRZ encoding (SuperWDM technology), supports G.652 and G.655 fibers. Table 4-3 shows its networking capability.

Table 4-3 Networking capability of type II system (C, 80-channel)

Classification	Specification	Typical distance
G.652 (with FEC)	1 × 32 dB	1 × 116 km (116 km)
	5 × 25 dB	5 × 90 km (450 km)
	8 × 22 dB	8 × 80 km (640 km)
G.652 (with FEC and Super CRZ)	1 × 36 dB	1 × 130 km (130 km)
	10 × 25 dB	10 × 90 km (900 km)
	20 × 22 dB	20 × 80 km (1600 km)
G.655 (with FEC)	1 × 30 dB	1 × 109 km (109 km)
	3 × 25 dB	3 × 90 km (270 km)
	6 × 22 dB	6 × 80 km (480 km)
G.655 (with FEC and Super CRZ)	1 × 32 dB	1 × 116 km (116 km)
	6 × 25 dB	6 × 90 km (540 km)
	14 × 22 dB	14 × 80 km (1120 km)

4.1.3 Type III system

The type III system, adopting NRZ encoding, is applied in G.652 or G.655 optical fibers. Table 4-4 shows its networking capability.

Table 4-4 Networking capability of type III system (40-channel, NRZ)

Classification	Specification	Typical distance
With FEC Without Raman amplification	1 × 34 dB	127 km (127 km)
	5 × 27 dB	5 × 98 km (490 km)
	10 × 22 dB	10 × 80 km (800 km)

Table 4-5 shows the networking capability of the system when it adopts SuperWDM technology (CRZ encoding) and is applied in G.652 optical fibers.

Table 4-5 Networking capability of type III system (40-channel, SuperWDM)

Classification	Specification	Typical distance
With FEC Without Raman	10 × 27 dB	10 × 98 km (980 km)
	25 × 22 dB	25 × 80 km (2000 km)

In ultra-long distance transmission, non-flatness of optical power and dispersion will occur to each channel. If there are more than 12 optical amplification spans, the system should be equipped with the OEQ. If the distance of the fiber in multiplex section exceeds 1000 km, the system should be equipped with dispersion equalization equipment.

If the system adopts Raman amplification or AFEC, the system performance will be improved, thus enhancing the transmission capability over single hop.

The specifications listed in Table 4-4 and Table 4-5 show the application of type III in G.652 and G.655 optical fibers. For G.653, the proper wavelengths and input optical power should be selected in C-band to avoid the mixing of four wavelengths. Table 4-6 shows the application of type III system in G.653 optical fibers.

Table 4-6 Networking capability of type III system (G.653 optical fiber)

Classification	Specification	Typical distance
With FEC 12-wavelength system	1 × 32 dB	1 × 116 km (116 km)
	3 × 27 dB	3 × 98 km (294 km)
	6 × 23 dB	6 × 83 km (498 km)
With FEC 8-wavelength system	1 × 33 dB	1 × 120 km (120 km)
	3 × 28 dB	3 × 100 km (300 km)
	8 × 20 dB	8 × 70 km (560 km)

4.1.4 Type IV system

The type IV system, adopting L-band signal, is specially used in G.653 optical fibers.

This system adopts NRZ encoding. Its networking capability is shown in Table 4-7.

Table 4-7 Networking capability of type IV system (40-channel, L band)

Classification	Specification	Typical distance
With FEC	1 × 30 dB	1 × 109 km (109 km)
	3 × 25 dB	3 × 90 km (270 km)
	5 × 22 dB	5 × 80 km (400 km)

If the system adopts the Raman amplifier, the noise will be greatly reduced, thus realizing longer transmission without a regenerator.

4.1.5 Type V system

The type V system, adopting NRZ encoding, is applied in G.652 or G.655 optical fibers. Table 4-8 shows its networking capability.

Table 4-8 Networking capability of type V system (40-channel, NRZ)

Classification	Specification	Typical distance
With FEC	1 × 39 dB	1 × 140 km (140 km)
	6 × 27 dB	6 × 98 km (588 km)
	8 × 22 dB	8 × 80 km (640 km)

The type V system can realize transmission of 640 km without using the REG and any dispersion compensation component. Generally, the type V system does not need Raman amplification.

4.1.6 Type VI system

The type VI system is an LHP (Long Hop) system, applied in G.652 or G.655 optical fibers. Its networking capability is shown in Table 4-9.

Table 4-9 Networking capability of type VI system (NRZ)

Application / Classification	Single wavelength rate: 10 Gbit/s				Single wavelength rate: 2.5 Gbit/s	
	10-wavelength		40-wavelength		10-wavelength	40-wavelength
OSNR requirement	20 dB	18 dB	20 dB	18 dB	15 dB	15 dB
HBA + FEC + Raman	50 dB	53 dB	43 dB	46 dB	56 dB	49 dB

Note: The OSNR in the table is the requirement at the point MPI-R. The OSNR requirements are typical values.

Table 4-10 System transmission specifications of type VI system with ROPA

Equipment / Sub-System	Single wavelength: 10 Gbit/s				Single wavelength: 2.5 Gbit/s	
	10-wavelength		40-wavelength		10-wavelength	40-wavelength
	NRZ	CRZ	NRZ	CRZ		
ROPA+LHP. R001	-	60 dB	-	51 dB	64 dB	55 dB
ROPA+LHP, G.652 fibre in the line	61 dB	65 dB	51 dB	54 dB	65 dB	57 dB
ROPA+LHP, R002 with G.655(LEAF) fibre in the line	61 dB	64 dB	51 dB	54 dB	65 dB	57 dB

Notes: Table 4-10 lists the basic specifications. If other specifications are required, contact Huawei Technologies Co. Ltd. (hereinafter referred to as Huawei).

The LHP system is point-to-point OTM configuration without any optical or electrical regeneration.

If the SuperWDM technology is used, the transmission distance can be extended.

4.2 System Functions

4.2.1 Automatic Level Control

Function Description

In a DWDM system, optical fiber aging, optical connector aging or human factors might lead to the abnormal attenuation of transmission lines.

In case the attenuation on a line segment increases, all input and output power will be reduced on all downstream amplifiers. The system OSNR will get worse. At the same time, the received optical power will also be reduced. Receiving performance will be greatly affected. The closer the attenuated segment is to the transmit end, the more influence on OSNR there will be, as shown in Figure 4-2.

If the automatic level control (ALC) function is activated, this effect can be minimized. As the attenuation on a line segment is increased, the input power on the amplifier will be reduced. But due to ALC, the output power as well as the input and output powers of other downstream amplifiers will not be changed. Hence there will be much less influence on OSNR. The optical power received by the receiver will not be changed.

Figure 4-3 shows the power changes on optical line amplification regenerators in the gain control and the power control modes in case of abnormal attenuation on optical fiber lines.

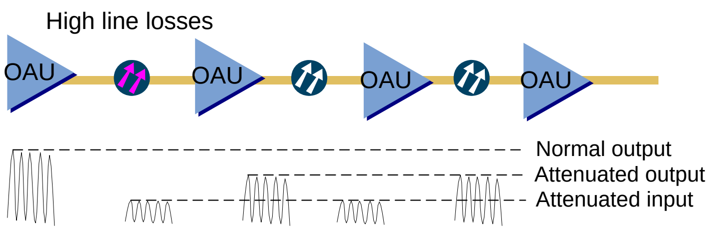


Figure 4-2 System power when ALC is not activated

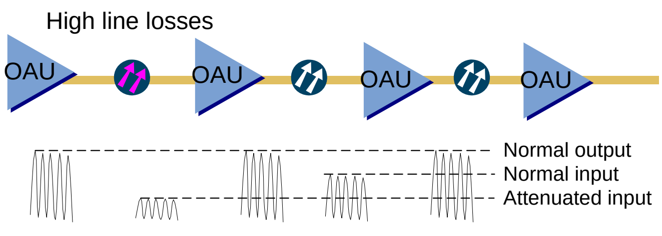


Figure 4-3 System power when ALC is activated

In normal working, two elements might cause the input power change in the optical amplifier:

- The addition/reduction of access channels (multiple channels might be added or dropped at the same time)

In order not to affect the normal working of other channels, the system should quickly respond to the change. The system works in the gain control mode.

- The abnormal attenuation in the physical media

ALC determine the adjustment of the variable optical attenuator according to the channel amount and output power.

The redundancy design of the system permits the abnormal line attenuation adjustment. If the attenuation is within the limit, the adjustment process will take several minutes.

It ensures the normal working of the system.

ALC is realized through channel amount detection and reference power.

Channel Amount Detection

Prerequisite: One MCA needs to be configured on the ALC link.

Realization:

The optical amplifier works in automatic gain control (AGC) mode and realizes ALC function with MCA. The MCA analyzes the amount of working channels. Based on the amount of channels and the output power, the optical amplifier determines the working status and adjusts attenuation to keep the output power stable (the power of a single channel remains unchanged).

Reference Power Detection

Prerequisite: The output optical power of the first node on the ALC link is taken as a reference value.

Realization: The optical amplifier works in AGC mode, by activating the detection of the output optical power of the optical amplifier at the first node to determine further actions. Compare the detecting result with the information reported before the ALC command is trigged. If they are consistent, deliver the ALC adjustment command formally to adjust attenuation and to keep the output optical power stable. (The power of a single channel remains unchanged.)

Involved Boards

Boards of the following types are involved in the ALC.

- Detection board

The MCA is included.

The detection board detects signals of all channels at the receive end.

In channel amount mode, the board provides the system with the wavelength amount of the network.

- Optical amplifier board

The OAU and the OBU are included.

When the ALC is enabled, the output power of optical amplifier boards is detected to check if the link is abnormal.

- Attenuation adjusting board

The OAU, VOA, and the VA4 are included. They adjust the line attenuation.

The OAU is an optical amplifier board but can function as an adjusting board because of its VOA.

- Supervisory channel board

The SC1/TC1 and the SC2/TC2 are included.

The supervisory channel board provides supervisory channel connection and the physical channel to transmit protocol frames.

- SCC board

The SCC functions as the executive board for the ALC function.

- Ethernet port

The Ethernet port provides inter-subrack communication. When the link in L-band is configured, the ALC protocol frames are transmitted in the protocol transmission channel of C-band. This is because the L-band has no protocol transmission channel. The protocols need to be transmitted between subracks of the C-band and of the L-band.

The Ethernet interface is used for inter-subrack connection. In subracks, only the "Ethernet 2" interface is available for protocol transmission.

4.2.2 Intelligent Power Adjustment

Function Description

The OptiX BWS 1600G system provides the intelligent power adjustment (IPA) function.

In case the optical power signals on one or more segments of the active optical path are lost, the system can detect the loss of optical signals on the link and instantly reduce the optical power of the amplifier before the loss to a safety level.

If there are raman amplifiers in the link, it will be shut down also.

When the optical signals are restored to normal, the optical amplifier will work again. The loss of optical signals might be caused by fiber cut, equipment deterioration, or connector disconnections.

Note

In the DWDM system, the IPA function is started only when optical signals of the active optical path are lost.

When this function is executed, only the lasers on the main path are shut down. No operation will be implemented on the optical supervisory channel. Hence the functions of all optical supervisory channels are not affected.

Fiber Break Detection

There are three methods used to detect the fiber break to achieve the IPA function.

- Detect the LOS of the optical amplifier unit
- Detect the signals of the Auxiliary detection unit (OSC/OTU)
- Detect the LOS of the raman amplifier unit (RPC)

Through a combination of the three methods, the fiber break can be judged more correctly.

Following is the logic of problem handling.

- If all the configured detection items meet the fiber break condition at the same time, initiate the shut down process of the IPA.
- If one of the detection conditions recovers to normality, initiate the recovery process of the IPA.

Configuration Precaution

- When the amplifiers are configured as detection unit independently, IPA must only be configured at the first site and the last site of the link. When there is a fiber break, the amplifier at the first site and the last site of the link will be shut down.
- To fulfill the IPA function and judge the fiber break more correctly, detection unit and auxiliary detection unit must be configured at the same time. IPA must be configured at every site. When there is a fiber break, the amplifier before and after the fiber break will be shut down.

4.2.3 Automatic Power Equilibrium

Function Description

The automatic power equilibrium (APE) function can automatically adjust optical power of each channel at the transmit end. This is to optimize the OSNR at the receive end.

In a DWDM system, the variety of the optical fiber condition in the running of the system may change the flatness of a channel's power from that in the commissioning, and degrade the Optical Signal Noise Ratio (OSNR) of signals at the receive end, as shown in Figure 4-4.

With the Automatic Power pre-Equilibrium (APE) function provided by the system, you can enable the system to automatically adjust the optical power of the transmit end of each channel to keep the flatness of the optical power of the receive end close to that in the commissioning and to maintain the OSNR, as shown in Figure 4-5.

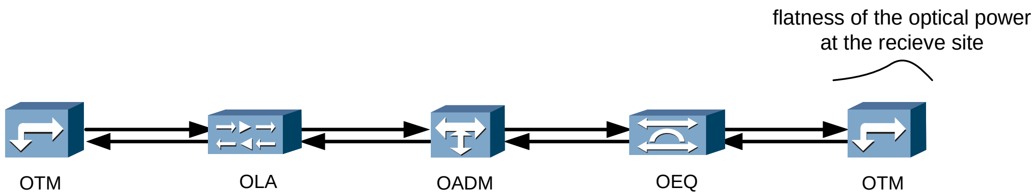


Figure 4-4 Flatness of the optical power at the receive end when APE is not activate

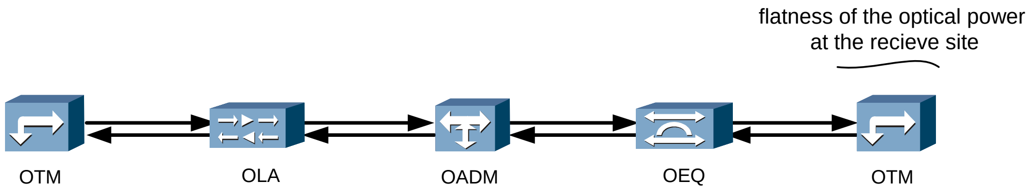


Figure 4-5 Flatness of the optical power at the receive end when APE is activate

The application of the APE streamlines the operation of the DWDM system commissioning and subsequent network maintenance for the operator.

The design of starting regulation manually facilitates the operator to determine whether to adjust the optical power according to the network actual status.

In following example, the APE function is realized by the MCA, V40, SC1 and SCC.

The networking is shown in Figure 4-6.

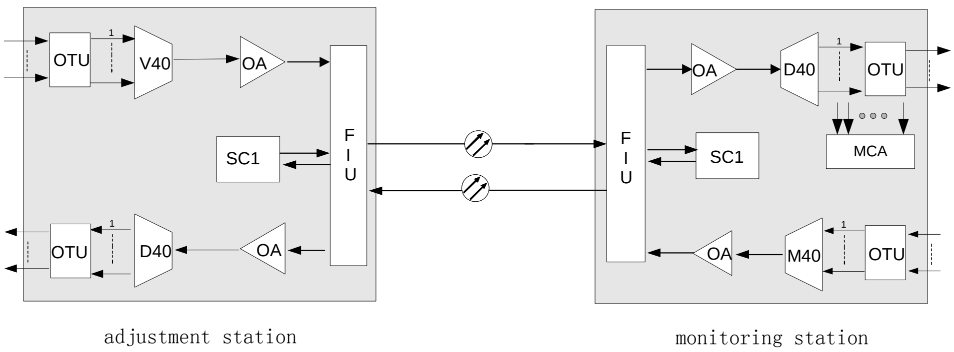


Figure 4-6 Networking for APE function

The normal function of APE requires the coordination between the service boards and the SCC board, and the participation of the user.

As shown in Figure 4-6, for power equilibrium, each channel power at the transmit end can be adjusted according to the per channel power measured by the MCA at the receive end. The APE brings convenience to DWDM system tests in deployment and subsequent network maintenance. The APE function mode can also be set to allow users to decide whether to adjust the optical power.

Implementation Principles

To implement the APE, follow the steps below:

- During the commissioning, apply manual adjustment on the adjustment unit to restore each channel.
- After the commissioning, save the power curve of the receive end as the standard power curve.
- Detect optical power of every channel received by the detection unit (such as MCA) through the optical port at the receive end.
- According to the detected optical power of every channel, adjusts the attenuation rate of the according channel of the adjust unit (such as V40) at the transmit end, so as to maintain the optical signal-to-noise ratio (OSNR) of every channel at the receive end by keeping the flatness of the optical power of every channel.

📖 **Note**

During the running of the equipment, the MCA analyzes the data scanned in a spectral scanning period, which is set in the MCA configuration and is not provided in the APE.

If the power offset exceeds the threshold configured, the system will report the event of optical power unbalance and the user determine whether to adjust it according to the network condition.

Involved Boards

The APE functions through service board and the SCC board. The APE involves board s of the following types:

- Detection board

It detects the signal power of the channels at the receive end and reports APE uneven event.

The MCA functions as the detection board in the system.

- Adjustment board

It is the adjusting entity of the APE and adjusts the attenuation of channels.

The V40 or the DGE functions as the adjustment board in the system.

- Supervisory channel board

It provides the supervisory channel and the physical channel for protocol frame transmission.

The SC1/TC1 or the SC2/TC2 functions as the supervisory channel board.

- System control and communication board

It is the executive entity of the APE.

The SCC functions as the system control and communication board.

Configuration principle

- APE is optional and configured on the users' requirement.
- For the APE function, it is required that the OTM station at the transmit end should be configured with the V40 or the OEQ station should be configured with DGE and MCA, and the OTM station at the receive end should be configured with the MCA. Moreover, since DWDM is a dual-fiber bidirectional system, an MCA should be configured at the both ends of a multiplex section.
- The optical power adjustment is realized in two ways. The V40 adjusts the optical power of the corresponding channel at the transmit end. The DGE of optical equilibrium (OEQ) station adjusts the optical power of the corresponding channels. The optical measurement is realized by using the MCA in OEQ or OTM station.
- To implement the APE function by the DGE board on the OEQ station, when configure the DGE board in T2000. It is required to select the DGE board in the "*Power Regulating Subrack of EVEN wavelength*" and "*Power Regulating Unit of EVEN wavelength*" drop-down lists of the "*Create APE Pair*"tab.
- To realize the APE function, it is required to install the MCA and OSC unit (SC1/SC2/TC1/TC2) in one subrack. If not, the network port ETHERNET 2 of two subracks should be interconnected.
- To realize the APE function, it is required to install the V40 and OSC unit (SC1/SC2/TC1/TC2) in one subrack. If not, the network port ETHERNET 2 of two subracks should be interconnected.

Precautions of the configuration

- Here we define a station as an adjustment station where optical power is adjusted and define a station as a monitoring station where optical power is measured by the MCA.
- To start the APE function, the V40 or DGE of the adjustment station and one of optical interfaces of the MCA of the monitoring station should be first configured as an APE function pair, and enable APE function.

- There is a dedicated APE protocol byte in the overhead frame of the supervisory signal, which is used to transmit APE related information.
- Since an OADM station may exist between the adjustment station and the monitoring station, all the wavelengths detected in monitoring station may not be adjusted by V40 or DGE in the adjustment station. As a result, the wavelengths with APE function activated should be specified by NM.

4.2.4 Clock Transmission

The OptiX BWS 1600G offers a new solution for the transmission of synchronous clock. Its optical supervisory channel provides three clock transmission channels operating at 2 Mbit/s.

In each network element, upstream clock can be transparently transmitted, or sent to local BITS clock receiving equipment, or it can work in the combination of both. The detailed configuration plan should be designed by the network planning engineer according to the actual requirements and needs. In network design, not only the DWDM system but also the local digital synchronous clock network shall be taken into account.

Clock transmission in an OptiX network is explained in the following example and Figure 4-7.

Terminal-A is transmitting the clock. Along the East channel, optical amplifier-1 passes the clocks (CLK) channel transparently, i.e. no clock is added or dropped, while optical amplifier-2 can add or drop one CLK channel to/from the main path. Terminal-B terminates the East CLK.

Similarly, Terminal-B is transmitting the CLK on West channel. Where at amplifier-2 the CLK signal channel is dropped locally and meanwhile passed transparently to the down stream. Optical amplifier-1 can add and drop the one CLK channel to/from the main path. Finally the CLK is terminated at Terminal-A.

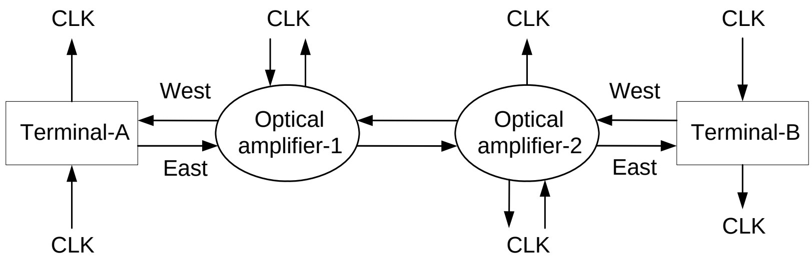


Figure 4-7 Schematic diagram of clock transmission

In the OptiX BWS 1600G system, clock transmission can be set to protection mode or non-protection mode. In clock protection mode, two carrier wavelengths are used, with 1510 nm for normal channel and 1625 nm for protected channel.

A summary of clock transmission is given below.

- In the case that there is no clock being added/dropped at intermediate station, the system supports 3-channel clock transmission at East and West directions respectively, no matter in clock protection mode or clock non-protection mode.

- In the case that there is clock being added/dropped at intermediate station, the intermediate station supports at most 3 clock channels in clock non-protection mode. The clock channels may come from both East and West directions.
- In the case that there is clock being added/dropped at intermediate station, the intermediate station supports at most 3 clock channels in clock non-protection mode. The clock channels must come from only one direction (East or West).

4.2.5 Optical Fiber Line Automatic Monitoring

The OptiX BWS 1600G provides the OAMS (Optical fiber line Automatic Monitoring System) to alert fiber aging, fiber alarm, and locate the fault. The OAMS realizes the monitoring on the fiber link.

As an embedded system, OAMS is optional depending on the requirement of users.

Monitor and Test

- OAMS provides two monitoring modes

On-line (light fiber) monitoring: To monitor and test a working optical fiber (cable). In this case, the wavelength of test signal is 1310 nm.

Standby fiber (dark fiber) monitoring: To monitor and test a standby optical fiber (cable). In this case, the wavelength of test signal is 1550 nm.

- OAMS provides two test modes

Unidirectional test: To monitor and test a span with unidirectional test signal.

In this case, two adjacent spans share an independent remote test unit (RTU), so the RTU number is greatly reduced and OAMS cost decreases accordingly.

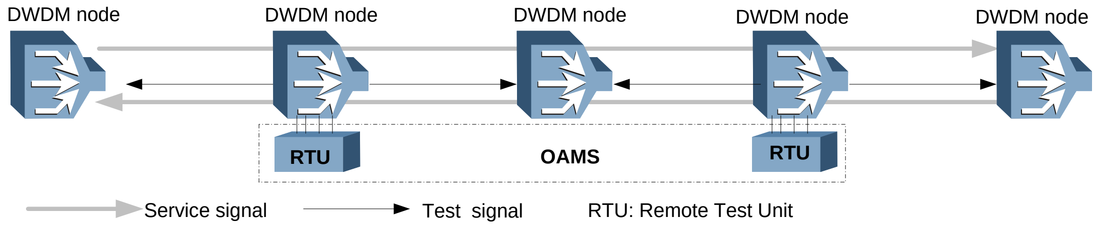


Figure 4-8 Unidirectional test diagram

Due to the limitation of dynamic test range of the built-in optical time domain reflectometer (OTDR), the unidirectional test fails when measuring a long span of much attenuation. Here the monitoring and test can be implemented from both ends of the span by two OTDR modules.

Bidirectional test: To monitor and test a span with bidirectional test signals.

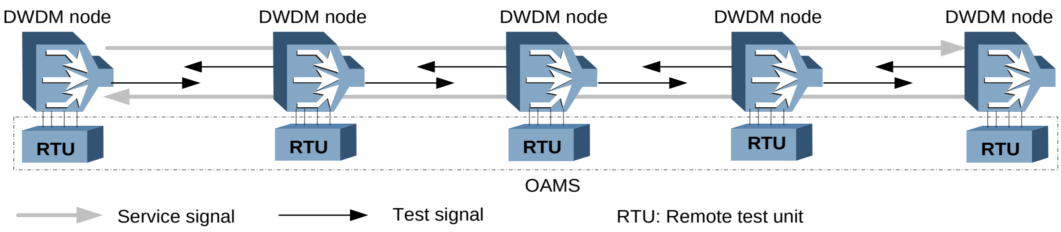


Figure 4-9 Bidirectional test diagram

In the bidirectional test, configure a RTU module at each end of a span, and the two RTUs will report their test results to NM for combination, and then the performance parameter of this span will be obtained by analyzing and processing the test results.

System Architecture

The OAMS structure of online monitoring differs with that of standby fiber monitoring.

- Online monitoring

The RTU shown in Figure 4-8 and Figure 4-9 consists of three boards and their functions are listed in Table 4-11.

Table 4-11 Introduction of boards in embedded OAMS

Board	Name	Function
FMU	Fiber Measure Unit Board	It is the core of OAMS to implement the time-domain reflection measurement of fibers. It can measure four lines of fibers.
MWA	Measure Wavelength Access Board	In online monitoring, it is used to multiplex the service signal of DWDM system with the test signal.
MWF	Measure Wavelength Filter Board	In online monitoring, it is used to filter the wavelength of test signals, to eliminate the effect to the transmission system. The board is used only when the service signal and the test signal are in the same direction.

The embedded OAMS system comprises of FMU, MWA and MWF, as shown in Figure 4-10.

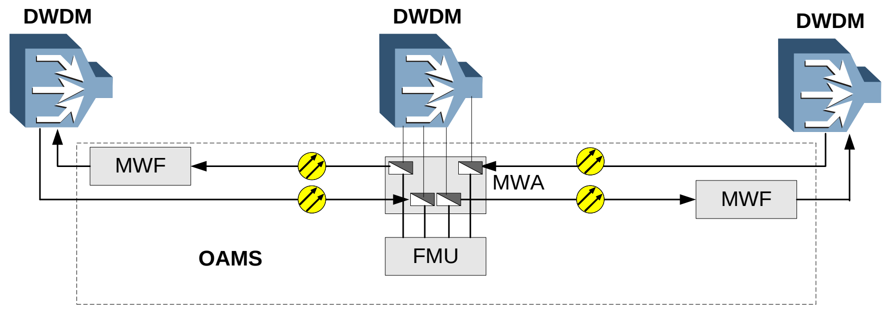


Figure 4-10 Embedded OAMS architecture (online monitoring)

In the Figure 4-10, the DWDM node can be OTM, OLA, OADM, OEQ or REG. The OTDR module in FMU emits the optical test pulse, and receives, collects, processes and reports the reflection signal, thus monitoring the running status of the fiber in real time. FMU can monitor at most four lines of optical fibers.

The coupler on MWA multiplexes the service signal and test signal in one fiber for transmission. When the test signal and service signal are transmitted in the same direction, the filter on MWF can filter the test signal at the receive node to eliminate the effect to the system.

The structure and configuration of OAMS vary with network specifications. The figure here only shows the OAMS of unidirectional test.

- Standby fiber monitoring

Compared with online monitoring, standby fiber monitoring is easier to be implemented, that is, directly access the test wavelength (1550 nm) into the standby fiber for test, as shown in Figure 4-11.

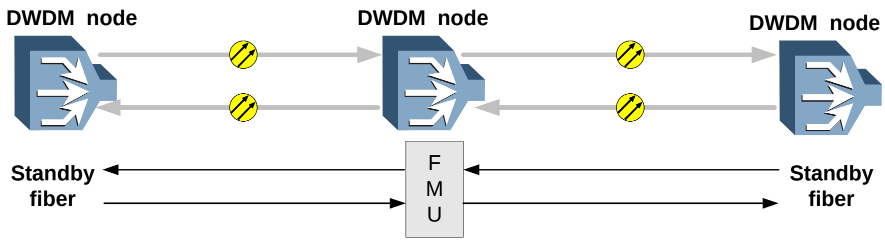


Figure 4-11 Embedded OAMS architecture (standby fiber monitoring)

The performance monitoring and test to the standby fiber can be achieved by using FMU board, NE software and NM. The structure and configuration of OAMS vary with network specifications. Figure 4-11 only shows the OAMS of unidirectional test.

Configuration Plan

The Raman amplification and optical fiber attenuation will affect the embedded OAMS to some extent. Table 4-12 lists the OAMS applications with and without Raman amplification.

Table 4-12 Applications of embedded OAMS

System type	Fiber attenuation	Supported monitoring
With Raman amplification	NA	Standby fiber monitoring
Without Raman amplification	≤45 dB	Standby fiber monitoring and online monitoring
	>45 dB	Standby fiber monitoring (Note)

Note: The 1310nm test signal is of great attenuation in fiber, resulting in limited monitoring distance, so the spans more than 45dB are only provided with standby fiber monitoring.

Table 4-13 lists the configuration of OAMS in various system specifications of the OptiX BWS 1600G under different monitoring modes.

Table 4-13 OAMS configuration specification

Monitoring mode	System specification	Span attenuation (dB)	Monitoring signal wavelength (nm)	OTDR dynamic test range (dB)	Optical fiber length[Note1] (km)	Test mode
Online monitoring	Long distance transmission	22	1310	42	80	Unidirectional test
		28		42	100	Time-shared bidirectional test
		33		42	120	Time-shared bidirectional test
	LHP	38–45		42	138–163	Time-shared bidirectional test
Standby fiber monitoring	Long distance transmission	22	1550	40	80	Unidirectional test
		28		40	100	Unidirectional test
		33		40	120	Time-shared bidirectional test
	LHP	38–45		40	138–163	Time-shared bidirectional test
		45–56		40	163–200	Time-shared bidirectional test

Note1: The optical fiber length is calculated on condition that the attenuation coefficient is 0.275 dB/km.

System Function

- On-line monitoring of optical power of fiber link

Query the input and output optical power of the optical fiber link between nodes, that is, the output optical power of one station and the input optical power of the next station. Obtain the attenuation over the link between two adjacent nodes through the NM and compare the result with the pre-set data. Take the difference of the optical power as the trigger to enable the test. When the difference exceeds the pre-set value or the threshold set by the user through NM, the OAMS will be enabled to test the performance of optical fiber link.

- Multiple test modes

The system provides two ways to test fibers according to the priority.

On-demand test: Generate through NM manually, select and control a RTU to test a certain fiber in the monitored optical fiber line.

Periodical test: Conventional test, namely the test is started upon the previously arranged conditions are satisfied. The equipment will report the result as an event to NM after the test.

The test requirement of higher priority can stop that of lower priority to start a new test queue.

- Analysis of test events

Besides the test function, the OAMS system also provides analysis of the test result and then reports the corresponding test curve and event list to NM.

- Fiber alarm

The equipment reports alarms depending on the analysis of the test curve. The alarms fall into three levels.

Critical alarm: Burst of event over 5 dB, including fiber break. The terminal shows red and gives audible and visible prompt.

Major alarm: The difference between the attenuation of the whole path and the acceptance value (or original data) is no less than 3 dB; or the attenuation increase event (new or not) is no less than 2 dB. The terminal shows pink and gives visible prompt.

Minor alarm: The difference between the attenuation of the whole path and the acceptance value (or original data) is no less than 1 dB, while less than 3 dB; or the attenuation increase event (new or not) is no less than 1 dB. This alarm will be report to NM and recorded as an exception for future query, but will not give prompt.

📖 **Note**

Event: The event in OAMS refers to the physical circumstances showing the status of the optical fiber line during OTDR test. It comprises reflection event and non-reflection event. The fiber reflection events include connector, mechanical connection point and optical fiber end, and so on. While the non-reflection events include optical fiber fusion point, fiber break, bending or macrobend.

5 Protection

5.1 Power protection

5.1.1 DC Input Protection

The power supply system supports two –48 V/–60 V DC power inputs for mutual backup. Therefore, the equipment keeps running normally in case either of the two DC inputs is faulty.

5.1.2 Secondary Power Protection

Non OTU boards adopt two power modules for 1+1 power hot backup, to avoid system breakdown by the damage of one power module.

5.1.3 Centralised Power Protection for OTUs

The system uses power backup unit (PBU) to provide centralised power protection for the secondary power of all OTUs on each subrack, including:

- +3.3 V power supply of the OTU
- +5 V power supply of the OTU
- –5.2 V power supply of the OTU

When detecting the power of the OTU fails (under/over-voltage), the system switches to the PBU for power supply in 600μs. The PBU can supply power for two OTUs at the same time.

The PBU is inserted in slot 1, providing power backup for all OTUs in the subrack, as shown in Figure 5-1.

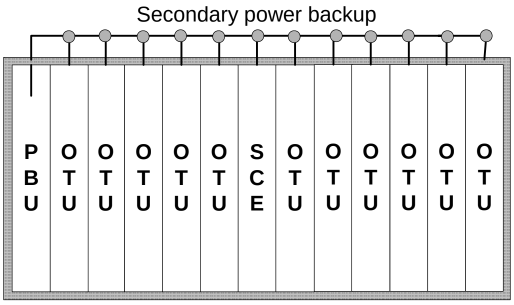


Figure 5-1 Centralised power protection for OTUs

5.2 Service Protection

5.2.1 1+1 Line Protection

The OptiX BWS 1600G provides protection for the lines at the optical layer through the dual-fed signal selection function of the OLP01. The protection mechanism is shown in Figure 5-2.

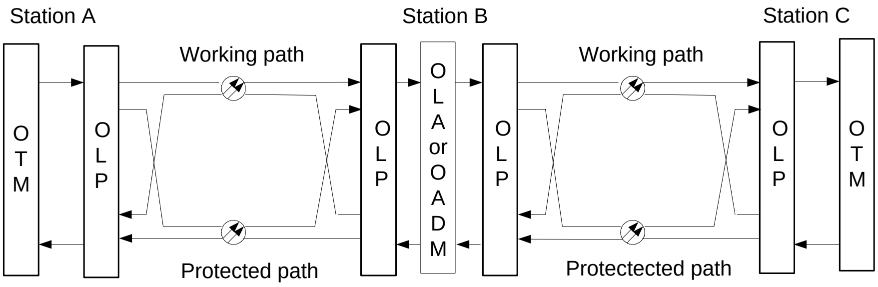


Figure 5-2 1+1 line protection

As shown in Figure 5-2, two optical fibres in an optical cable are used as a bidirectional working path, and other two optical fibres from the other optical cable are used as the protection path. Normally, the working path carries the traffic. In case of any anomaly on the working path, for example, the working optical cable is broken or the performance becomes deteriorated, the traffic will automatically switch to the protection path through the OLP01.

Moreover, the protection path is monitored in real time. When any problem occurs on the protection path, the equipment can detect the fault and handle it in time.

Therefore, with the help of the OLP01, the DWDM equipment protects the transmission line on the optical layer level, improving the network performance.

5.2.2 Optical Channel Protection

1+1 Optical Channel Protection

In a ring network, each wavelength can adopt optical channel protection, as shown in Figure 5-3.

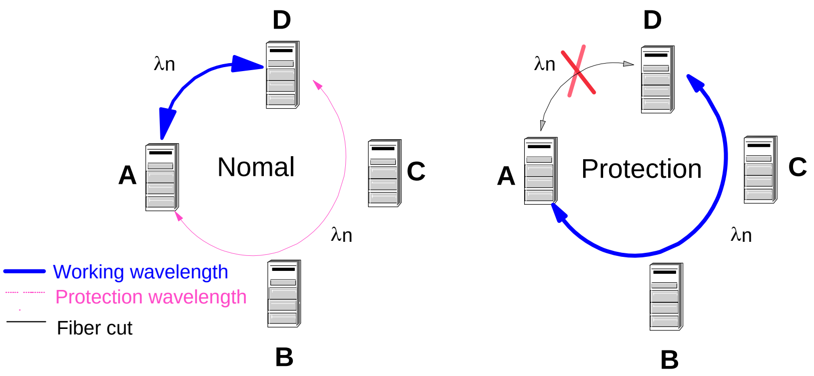


Figure 5-3 Schematic diagram of optical channel protection

The advantages of optical channel protection are fast switching and no need for protection switching protocol.

- Inter-OTU 1+1 optical channel protection

For a protected wavelength, the SCS board at the transmit end separates the incoming client side services into two channels, and sends them to the working OTU and protection OTU. Another SCS board at the receive end combines the services from the working OTU and the protection OTU, and sends them to the client side. Figure 5-4 shows the mechanism.

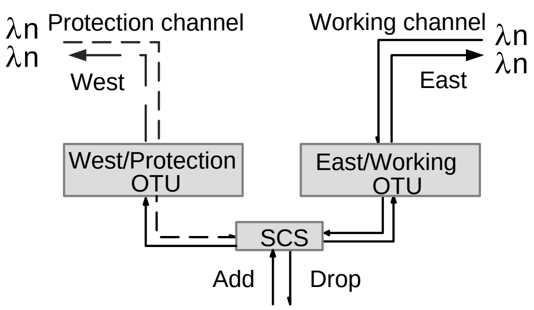


Figure 5-4 Inter-OTU 1+1 optical channel protection

In normal conditions, the services on the working channel will be received and further processed, while the services in the protection channel will be terminated. That is, optical signals are output from the working channel at the receive end and the client side optical transmitter of the protection channel is shut down.

If the LOS alarm is detected on the working channel, the services on the protection channel will be received and processed while the services on the working channel will be terminated. That is, optical signals are output from the protection channel and the client-side optical transmitter at the receive end is shut down.

You can select protection or non-protection for every service channel. If protection is required, the number of OTU boards should be doubled and a certain number of SCS boards are required. See Chapter 11 "Protection Units" in *OptiX BWS 1600G Backbone DWDM Optical Transmission Hardware Description* for details on the SCS.

This optical channel protection is usually used in ring networks.

Note

To realise 1+1 optical channel protection, it is required to set channel protection pair on the NM.

- Client-side optical channel protection

Client-side protection is only applicable to OTUs with convergence function, such as LDG, FDG, TMX, TMXS, LOG and LOGS.

The SCS can split or couple two optical signals. As shown in Figure 5-5, after receiving two client optical signals, the SCS splits each signal into two channels and then sends them to the working and protection OTUs. After convergence and wavelength conversion, the signals are sent to the line for transmission.

When a client signal received by the working OTU is faulty, only this signal is switched. No switching is performed on the WDM side. That is, the working OTU in the opposite end will shut down the client-side transmitting laser corresponding to this failed channel and the protection OTU in the opposite end will turn on the corresponding client-side transmitting laser. Other normal signals are still transmitted through the working OTU.

The client-side protection can be seen as a subset of 1+1 OTU inter-board protection. When protection switching occurs, only part of client-side services are switched to the protection OTU, no need for switching all services.

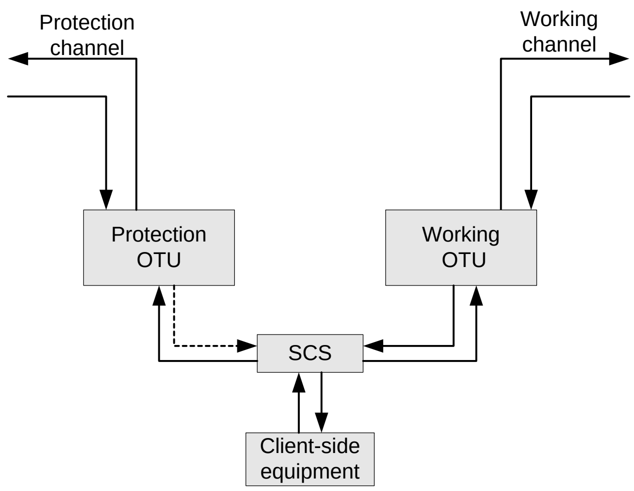


Figure 5-5 Client-side optical channel protection

- Inter-subrack 1+1 optical channel protection

Inter-subrack optical channel protection allows more flexible configuration of boards. The working OTU and the protection OTU may reside in different subracks.

On the transmit side, an OLP03 board divides the incoming client signals and feeds the signals into the working OTU and the protection OTU. Then the two OTUs send the signals over a working channel and a protection channel respectively, as shown in Figure 5-6.

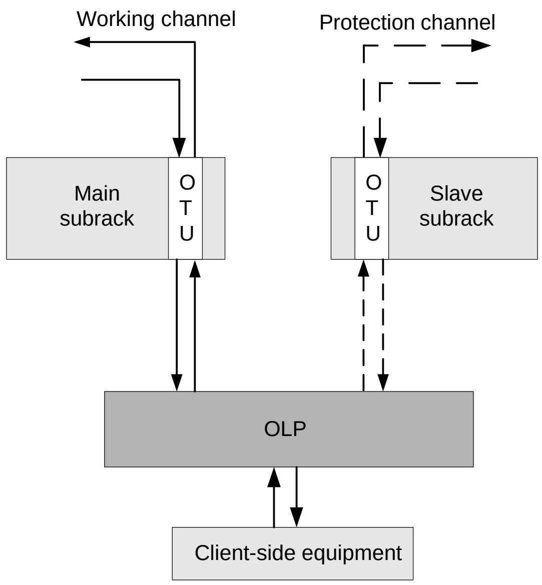


Figure 5-6 Inter-subrack 1+1 optical channel protection

On the receive side, both the working OTU and the protection OTU receive the optical signals and send the signals to the OLP03 board. The OLP03 board selects to receive signals from the working OTU and further sends the signals to client-side equipment.

Once the working channel is faulty, the working OTU shuts down its client-side transmitter. Accordingly the OLP03 board switches to receive signals from the protection OTU. When the working channel recovers, the protection OTU pair can be restored after the switching. And the OLP03 board switches back to receive signals from the working OTU, or continues to receive signals from the original protection OTU according to the pre-configuration.

Note

- If the GE service boards (like LDG, FDG, LOG and LOGS) are configured with the inter-subrack 1+1 optical channel protection, it is forbidden to enable **Auto-Negotiation** for the working boards and protection boards on the transmit and receive ends.
- Channel switching of the OLP03 is according to the optical power of the channel. Thus make sure that the difference of optical interface power between the working channel and the protection channel is less than 3 dm.
- In the configuration of inter-subrack 1+1 protection, the working OTU, protection OTU and OLP03 board can be configured in different subracks. The OLP03 board can still provide protection in case the power of the subrack is off. Then, the protection OTU and OLP03 board cannot be configured in the same subrack.

1:N (N ≤ 8) OTU Protection

Key services can be protected by backing up the OTU board, as shown in Figure 5-7.

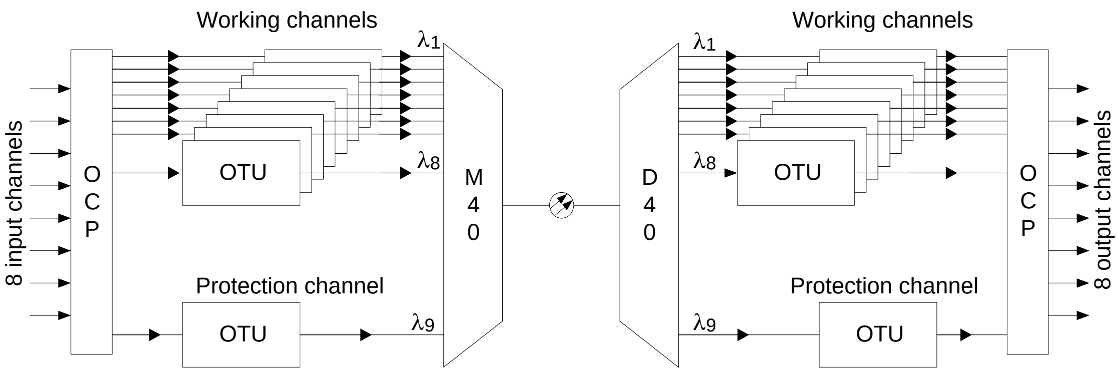


Figure 5-7 Schematic diagram of 1:N (N≤8) OTU protection

As shown in Figure 5-7, wavelengths λ_1 to λ_8 are used as working channels while wavelength λ_9 is used as the protection channel. During normal working, the protection wavelength carries no service. When any OTU with working wavelength $\lambda_1 - \lambda_8$ becomes faulty, the service of the faulty OTU is switched to the standby OTU. That is to say, the traffic will shift to λ_9 through the optical switch at the transmit end, and is further sent to the protected client equipment. If multiple OTUs are faulty, the system will protect the service with the highest priority level. If two working channels have the same priority, the channel with a smaller number is to be switched first.

The advantage is that one dedicated OTU protects the service of N (N≤8) working OTU boards and switches the service at both the transmit and receive ends. The APS protocol is used for service switching. Stable switching mechanism ensures high system performance and saves your investment.

📖 **Note**

1. N (N ≤ 8) working OTU boards and one standby OTU form one protection group. But in such a protection group, each OTU and the OCP board must be plugged in the same subrack.

2. To realise 1:N (N ≤ 8) OTU protection, it is required to set protection pair on the NM.

Currently, the OTUs that support 1:N (N ≤ 8) OTU protection include:

- LWF/LWFS
- LWC1
- LBE/LBES

The 1:8 OTU protection is applied in any networking structure.

5.3 Clock Protection

The clock is the heartbeat of any transmission equipment. For smooth system running, OptiX BWS 1600G system provides equipment/network level protection for the clock channel. The system supports two different clock protection modes: one is dual-fed and dual-receiving, and the other is dual-fed signal selection.

In the first protection mode, clock selection is performed by the customer's external BITS system. The protection is shown in Figure 5-8.

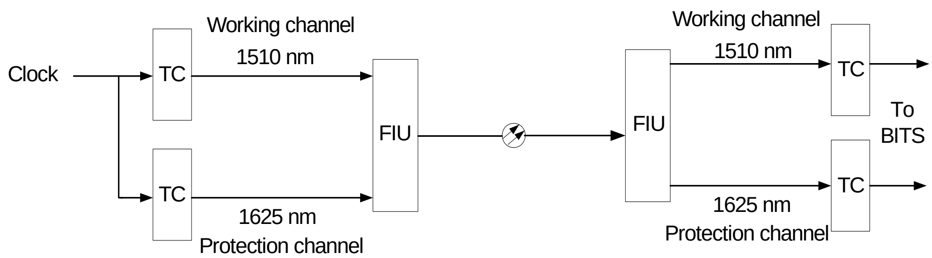


Figure 5-8 Schematic diagram of clock channel protection (dual-fed and dual-receiving)

In the second mode, clock selection is made inside the equipment and single-channel clock is output, as shown in Figure 5-9.

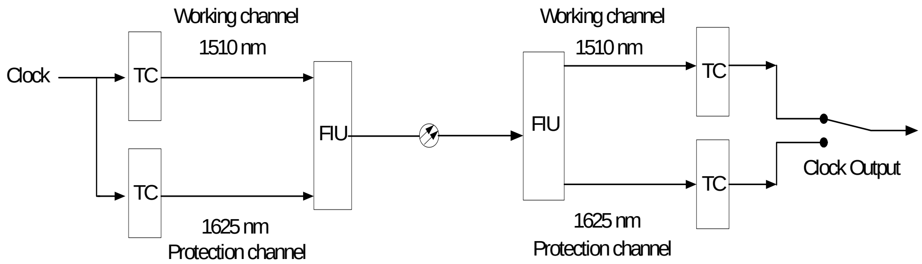


Figure 5-9 Schematic diagram of clock channel protection (dual-fed signal selection)

The TC1 (unidirectional optical supervisory channel and timing transporting unit) is used in the OTM and supports three input/output clocks locally.

The TC2 (bidirectional optical supervisory channel and timing transporting unit) supports six clocks output locally and three clocks input to the system. It is used in the OLA, OADM and REG.

To provide 1+1 clock redundancy, two TC1 or TC2 boards are used, working at 1510 nm (active) and 1625 nm (standby). Two TC boards must be plugged in slot 6 and slot 8 on the subrack at the same time (the board in slot 8 is the backup for the board in slot 6). When only one TC board is used, the clock protection function cannot be activated.

The transmission of up to 3 clocks in the west direction and 3 clocks in the east direction is supported.

The clock is protected only from one direction, that is, either from the east direction or from the west direction.

The clock transmission protection mechanism of the OptiX BWS 1600G system is discussed below.

(1) The intermediate station does not add/drop clock signals

If there is no intermediate site in bidirectional configuration, the transmission of 3 clock signals in both directions can be supported. However, the system supports only unidirectional protection of three clock signals. As shown in Figure 5-10, the networking is the same as the point-to-point clock transmission system.

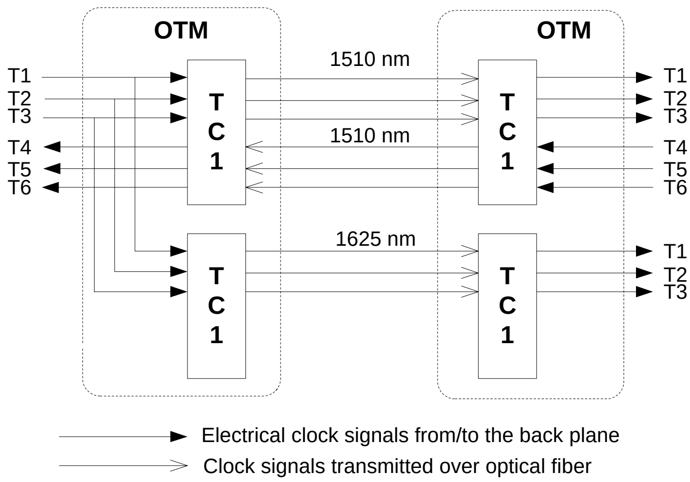


Figure 5-10 Configuration of the system with clock protection function but without add/drop of clock signals at intermediate stations

(2) The intermediate station adds/drops clock signals

If there are clock signals added/dropped in the intermediate stations, the system supports bidirectional transmission of three clocks. However, the system supports only unidirectional protection of three clock signals. Figure 5-11 shows the clock signal configuration at an intermediate station. Figure 5-10 shows the clock signal configuration at the terminal station. The terminal station supports the transmission of up to three clocks in two directions.

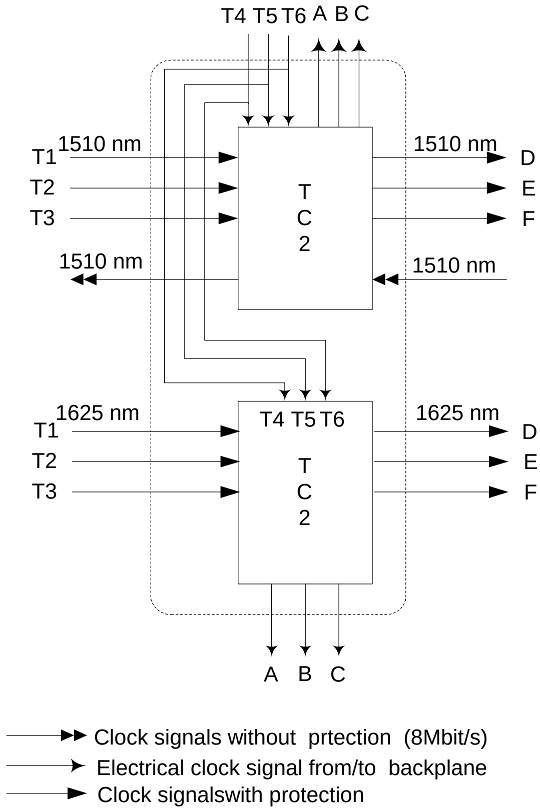


Figure 5-11 Configuration of the intermediate station with clock protection function and with the add/drop of clock signals

---

📖 **Note**

1. The clock protection switching takes one channel of clock as the switching unit.

2. To realise the clock protection function of the network clock, it is required to set the clock protection group on the NM.

5.4 Network Management Channel

5.4.1 Protection of Network Management Information Channel

In DWDM systems, network management information is transmitted over an optical supervisory channel, which shares the same physical channel with the main path. It is obvious that, any anomaly or failure on the main path will affect the supervisory channel. Therefore, a backup supervisory channel must be provided.

In a ring network, when fibre cut occurs in a certain direction, network management information is automatically switched to the optical supervisory channel in the other direction of the ring, as shown in Figure 5-12, not affecting the management of the whole network.

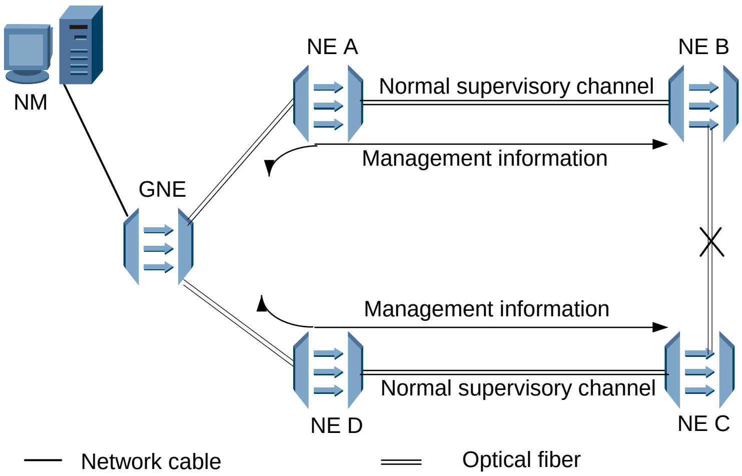


Figure 5-12 Network management protection in ring network (a certain section fails)

With data communication network (DCN), the OptiX BWS 1600G can also provide network management information channel. The user can choose ways to use the channel according to the networking and spanning. In point-to-point networking and chain networking, when both the fiber transmission and the supervisory channel fail, the network goes unmanageable. This can be avoided by the network management information channel in DCN mode. The system NE can provide network management information channel by the DCN.

To set up a DCN network management channel, access the DCN between the two NEs through a router. With initial configuration, network management information is transmitted over the normal supervisory channel when the network is normal. See Figure 5-13.

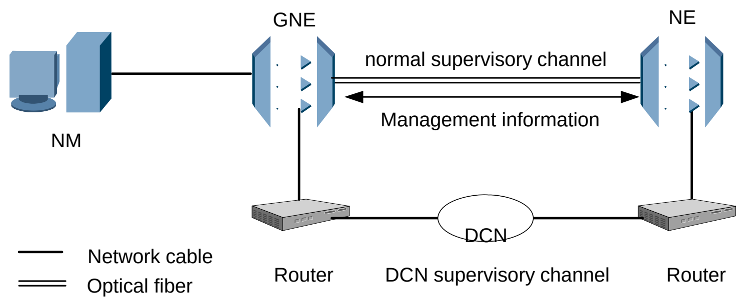


Figure 5-13 Network management through the normal supervisory channel

Upon the failure of the normal supervisory channel, network elements automatically switch the management information to the DCN supervisory channel to guarantee the supervisory and operation on the entire network, as illustrated in Figure 5-14.

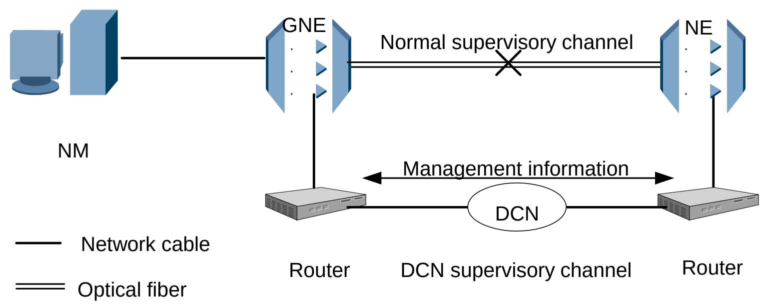


Figure 5-14 Network management through the DCN supervisory channel

It is important to select different routes for the DCN supervisory channel and normal channel during network planning. Otherwise the backup function will not take effective.

5.4.2 Interconnection of Network Management Channel

The OptiX BWS 1600G provides various data interfaces (for example Ethernet interface) for the interconnection of network management channels among different DWDM networks, or between a DWDM network and an SDH network, as shown in Figure 5-15. It enables unified management of different transmission equipment.

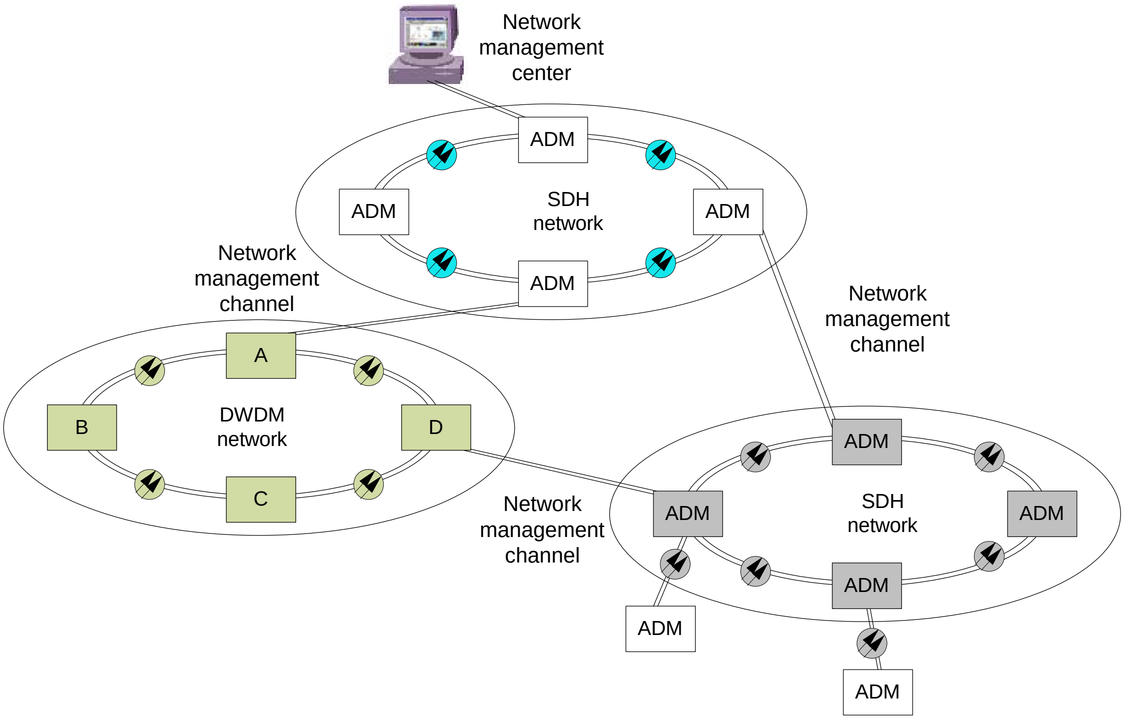


Figure 5-15 Supervision over OptiX transmission network

6 Technical Specifications

6.1 Optical Interfaces

The optical interfaces on the client end comply with ITU-T G.957 and G.691.

STM–64 optical interface: I-64.1, I–64.2, S–64.2b, Se-64.2a, Le-64.2

STM–16 optical interface: I–16, S–16.1, L-16.1, L–16.2

STM–4 optical interface: I–4, S–4.1, L–4.2

STM–1 optical interface: I–1, S–1.1, L–1.2

GE: 1000BASE-SX, 1000BASE-LX

10GE: 10G BASE-LR, 10G BASE-ER

ESCON: ANSI X3.230, X3.296

Laser safety: In compliance with ITU-T Recommendation G.664.

Fibre connector: LC/PC, SC/FC, FC/PC, ESH/APC

6.2 Power Supply

Input voltage: –48 V DC or –60 V DC

Voltage range: –38.4 V to –57.6 V DC or –48.0 V to –72.0 V DC

6.3 Parameters of Mechanical Structure

Table 6-1 Parameters of cabinet and subrack

		Height (mm)	Width (mm)	Depth (mm)	Weight (kg)
T63 Cabinet	Type 1	2200	600	300	69
	Type 2	2600	600	300	78
	Type 3	1800	600	300	58
	Type 4	2000	600	300	64
Subrack		625	495	291	18 (Note 1)

Note 1: It is the weight of an empty subrack with no boards or fan box installed.

6.4 Nominal Power Consumption, Weight and Slots of Boards

Table 6-2 lists the nominal power consumption, weight, and slots of the boards in an OptiX BWS 1600G system. The power consumption in the list is the value when the board works normally in normal temperature (25°C) and high temperature (55°C).

Table 6-2 Power consumption, weight and slots of boards

Board	Maximum power consumption at 25^{0}C (W)	Maximum power consumption at 55^{0}C (W)	Weight (kg)	Slots occupied
E3LWF	27.1	29.8	1.4	1
E2LWF	32.9	36.2	1.6	1
E3LWFS	40.0	44.0	1.4	1
E2LWFS	41.7	45.8	1.7	1
TMX	42.0	46.2	1.8	2
TMXS	46.4	51.0	1.8	2
LWC1	21.5	23.6	1.1	1
LDG	29.5	33.0	1.0	1
FDG	34.5	38.0	1.0	1
LBE	31.6	34.8	1.4	1
LBES	44.3	48.7	1.7	1
LWX	27.0	29.7	1.0	1

Board	Maximum power consumption at 25^0C (W)	Maximum power consumption at 55^0C (W)	Weight (kg)	Slots occupied
LWM	27.0	29.7	1.0	1
TMR	22.3	24.5	1.3	1
TMRS	35.0	38.5	1.3	1
TRC1	21.5	23.0	1.0	1
M40 / D40	20.0	22.0	1.6	2
V40	46.0	50.6	2.2	2
MR2	7.0	7.7	1.1	2
DWC	16.0	17.6	0.9	2
ITL	30.0	33.0	2.0	1
FIU	4.3	4.8	0.9	1
E2OAU	42.0	70.0	2.4	2
E3OAU	30.0	50.0	2.4	2
E3OBU	23.0	30.0	2.2	2
E2OBU	35.0	50.0	2.2	2
OPU	20.0	22.0	2.0	2
HBA	24.0	26.4	2.6	2
RPC	70.0	77.0	4.2	2
RPA	90.0	99.0	4.2	2
MCA	7.0	7.7	1.7	2
VA4	10.0	11.0	1.5	2
VOA	6.5	7.2	0.8	1
DGE	20.0	22.0	2.4	2
DSE	4.3	4.8	0.9	1
GFU	4.3	4.8	0.9	1
TC1	8.5	9.4	0.9	1
TC2	11.5	12.7	1.1	1
SC1	4.0	4.4	0.9	1
SC2	7.0	7.7	1.0	1
SCC / SCE	10.5	11.5	0.8	1

Board	Maximum power consumption at 25⁰C (W)	Maximum power consumption at 55⁰C (W)	Weight (kg)	Slots occupied
OCP	8.0	8.8	1.7	2
OLP	7.0	7.7	0.8	1
SCS	4.3	4.7	0.7	1
PBU	145.0	159.5	1.0	1

6.5 Environment Specifications

The OptiX BWS 1600G can work normally for a long time in the following environment.

Table 6-3 Environment specifications

Item	Parameter
Altitude	≤ 4000 m
Air pressure	70–106 kPa
Temperature	0°C–40°C
Relative Humidity	10%–90%
Antiseismic performance	Standing earthquake of Richter scale 7–9

6.6 Main Optical Path

The following is a typical DWDM network diagram. Read it through, because in the following sections we will use the reference points in Figure 6-1.

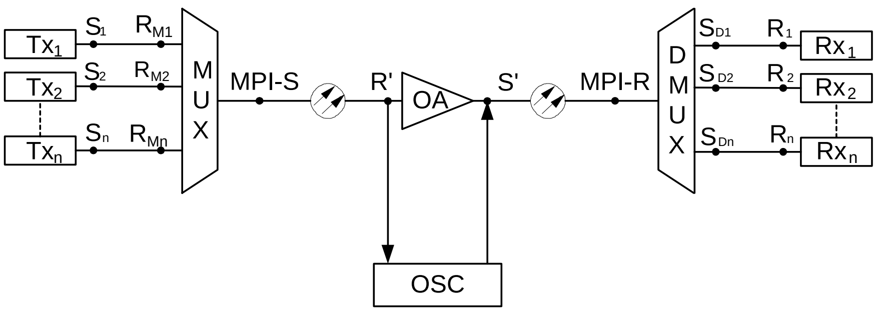


Figure 6-1 Typical DWDM network diagram

The characteristic of the optical interface at points MPI-S or S' and MPI-R or R' as well as the main optical path parameters are shown in the following tables. In this section, the span specifications are provided when FEC technology is adopted and the Raman technology is not used.

6.6.1 Type I System

Table 6-4 Main optical path parameters of the OptiX BWS 1600G-I system (G.652/G.655 fibre)

Item		**Unit**	**Performance Parameter**		
Span of line		-	5 × 20 dB	2 × 24 dB	1 × 28 dB
Number of channels		-	160	160	160
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
Optical interface at points MPI-S and S’					
Channel output power (output end of amplifiers)	Average	dBm	+1.0	+1.0	+1.0
	Maximum	dBm	+3.0	+3.0	+3.0
	Minimum	dBm	–3.0	–3.0	–3.0
Maximum total output power		dBm	+20.0	+20.0	+20.0
Maximum output loss at points S and S’ (FIU insertion loss)		dB	+1.5	+1.5	+1.5
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (MPI-S - MPI-R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	7500/2250 (Note 1)	3600/1080 (Note 1)	2100/630 (Note 1)
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Optical interface at points MPI-R and R’					
Channel input power (input end of amplifier)	Average	dBm	–22	–26	–31
	Maximum	dBm	–18	–22	–29
	Minimum	dBm	–26	–30	–33
Maximum total input power (input end of amplifier)		dBm	–3	–7	–12
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	8	8	6

Item	Unit	Performance Parameter		
Input loss at points MPI-R and R' (FIU insertion loss)	dB	≤ 1.5	≤ 1.5	≤ 1.5
Maximum insertion loss of ITL at the point MPI-R	dB	3	3	3

Note 1: The value before "/" is for the G.652 fibre, and the value after "/" is for the G.655 fibre.

6.6.2 Type II System

Table 6-5 Main optical path parameters of the OptiX BWS 1600G-II system (C+L, G.652 fibre)

Item		Unit	Performance parameter		
Span of line		-	7 × 22 dB	4 × 25 dB	1 × 32 dB
Number of channels		-	80	80	80
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
Optical interface at points MPI-S and S'					
Channel output power (output end of amplifier)	Average	dBm	+4.0	+4.0	+4.0
	Maximum	dBm	+7.0	+7.0	+7.0
	Minimum	dBm	+1.0	+1.0	+1.0
Maximum total output power		dBm	+20.0	+20.0	+20.0
Maximum output loss at points S and S' (FIU insertion loss)		dB	+1.5	+1.5	+1.5
Maximum channel power difference at point MPI-S (C band and L band are independent)		dB	6	6	6
Optical path (MPI-S – MPI-R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	11200	7600	2400
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Minimum return loss		dB	24	24	24
Optical interface at points MPI-R and R'					

Item		Unit	Performance parameter		
Channel input power (input end of amplifier)	Average	dBm	–21	–24	–31
	Maximum	dBm	–17	–20	–28
	Minimum	dBm	–25	–28	–34
Maximum total input power (input end of amplifier)		dBm	–5	–8	–15
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	8	8	6
Input loss at points MPI-R and R’ (FIU insertion loss)		dB	≤1.5	≤1.5	≤1.5

Table 6-6 Main optical path parameters of the OptiX BWS 1600G-II (C, G.652 fibre)

Item		Unit	Performance parameter		
Span of line		NRZ	8 × 22 dB	5 × 25 dB	1 × 32 dB
		CRZ	20 × 22 dB	10 × 25 dB	1 × 36 dB
Number of channels		-	80	80	80
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
Optical interface at points MPI-S and S’					
Channel output power (output end of amplifier)	Average	dBm	+3(NRZ)	+3(NRZ)	+3(NRZ)
			+4(CRZ)	+4(CRZ)	+4(CRZ)
	Maximum	dBm	+8	+7	+7
	Minimum	dBm	0	+1	+1
Maximum total output power		dBm	22(NRZ)	22(NRZ)	22(NRZ)
			23(CRZ)	23(CRZ)	23(CRZ)
Maximum output loss at points S and S’ (FIU insertion loss)		dB	≤ 1.0	≤ 1.0	≤ 1.0
Maximum insertion loss of ITL at the point MPI-S		dB	3	3	3
Maximum channel power difference at point MPI-S		dB	8	6	6

Item		Unit	Performance parameter		
Optical path (MPI - S - MPI - R)					
Maximum optical path penalty		dB	≤ 2	≤ 2	≤ 2
Maximum dispersion		ps/nm	12800 (NRZ)	9500 (NRZ)	2400 (NRZ)
			32000 (CRZ)	19000 (CRZ)	2800 (CRZ)
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15 (NRZ)	15 (NRZ)	15 (NRZ)
			18 (CRZ)	18 (CRZ)	18 (CRZ)
Optical interface at points MPI-R and R’					
Channel input power (input end of amplifier)	Average	dBm	–21 (NRZ)	–24 (NRZ)	–31 [Note 1] (NRZ)
			–20 (CRZ)	–23 (CRZ)	–34 [Note 2] (CRZ)
	Maximum	dBm	–17 (NRZ)	–20 (NRZ)	–28 (NRZ)
			–16 (CRZ)	–19 (CRZ)	–31 (CRZ)
	Minimum	dBm	–25 (NRZ)	–28 (NRZ)	–32 (NRZ)
			–24 (CRZ)	–27 (CRZ)	–37 (CRZ)
Maximum total input power (input end of amplifier)		dBm	–2 (NRZ)	–5 (NRZ)	–12 (NRZ)
			–1 (CRZ)	–4 (CRZ)	–15 (CRZ)
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20 (NRZ)	20 (NRZ)	20 (NRZ)
			17 (CRZ)	17 (CRZ))	17 (CRZ)
Maximum channel power difference at point MPI-R		dB	8	8	6
Input loss at points MPI-R and R’ (FIU insertion loss)		dB	≤ 1.0	≤ 1.0	≤ 1.0
Maximum insertion loss of ITL at the point R		dB	3.0	3.0	3.0

Note 1: The number of working wavelengths should be not less than 2.
Note 2: The number of working wavelengths should be not less than 6.

Table 6-7 Main optical path parameters of the OptiX BWS 1600G-II (C, G.655 fibre)

Item	Unit	Performance parameter		
Span of line	NRZ	6 × 22 dB	3 × 25 dB	1 × 30 dB
	CRZ	14 × 22 dB	6 × 25 dB	1 × 32 dB

Item		Unit	Performance parameter		
Number of channels		-	80	80	80
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
Optical interface at points MPI-S and S’					
Channel output power (output end of amplifier)	Average	dBm	+1	+1	+1
	Maximum	dBm	+5	+4	+4
	Minimum	dBm	–3	–2	–2
Maximum total output power		dBm	20	20	20
Maximum output loss at points S and S’ (FIU insertion loss)		dB	≤ 1.0	≤ 1.0	≤ 1.0
Maximum channel power difference at point MPI-S		dB	8	6	6
Optical path (MPI - S - MPI - R)					
Maximum optical path penalty		dB	≤2	≤2	≤2
Maximum dispersion		ps/nm	2880 (NRZ)	1710 (NRZ)	660 (NRZ)
			6720 (CRZ)	3420 (CRZ)	720 (CRZ)
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15(NRZ)	15(NRZ)	15(NRZ)
			18(CRZ)	18(CRZ)	18(CRZ)
Optical interface at points MPI-R and R’					
Channel input power (input end of amplifier)	Average	dBm	–23	–26	–31 (NRZ) Note 1
					–33 (CRZ) Note 2
	Maximum	dBm	–19	–23	–28 (NRZ)
					–30 (CRZ)
	Minimum	dBm	–27	–29	–34 (NRZ)
					–36 (CRZ)
Channel input power (input end of amplifier)		dBm	–4	–7	–12 (NRZ)
					–14 (CRZ)
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20 (NRZ)	20 (NRZ)	20 (NRZ)
			17 (CRZ)	17 (CRZ))	17 (CRZ)
Maximum channel power difference at point MPI-R		dB	8	6	6

Item	Unit	Performance parameter		
Input loss at points MPI-R and R' (FIU insertion loss)	dB	≤ 1.0	≤ 1.0	≤ 1.0

Note 1: The number of working wavelengths should be not less than 2.
Note 2: The number of working wavelengths should be not less than 6.

6.6.3 Type III System

Table 6-8 Main optical path parameters of the OptiX BWS 1600G-III system (G.652/G.655 fibre)

Item		Unit	Performance parameter		
Span of line			10 × 22 dB	5 × 27 dB	1 × 34 dB
Number of channels			40	40	40
Maximum bit rate of channel			STM–64	STM–64	STM–64
Optical interface at points MPI-S and S'					
Channel output power (output end of amplifier)	Average	dBm	+4.0	+4.0	+4.0
	Maximum	dBm	+7.0	+7.0	+7.0
	Minimum	dBm	+1.0	+1.0	+1.0
Maximum total output power		dBm	+20.0	+20.0	+20.0
Maximum output loss at points S and S' (FIU insertion loss)		dB	+1	+1	+1
maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (MPI - S - MPI - R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion (Note 1)		ps/nm	16000/4800	10000/3000	2500/750
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Minimum return loss		dB	24	24	24
Optical interface at points MPI-R and R'					
Channel input power (input end of amplifier)	Average	dBm	–20	–25	–32 (Note 2)
	Maximum	dBm	–16	–21	–29
	Minimum	dBm	–24	–29	–35

Item	Unit	Performance parameter		
Maximum total input power (input end of amplifier)	dBm	–4	–9	–16
Minimum channel optical signal-to-noise ratio at point MPI-R	dB	20	20	20
Maximum channel power difference at point MPI-R	dB	8	8	6
Input loss at points MPI-R and R’ (FIU insertion loss)	dB	≤1	≤1	≤1

Note 1: The value before "/" is for the G.652 fibre, and the value after "/" is for the G.655 fibre.
Note 2: The number of working wavelengths should be not less than 2.

Table 6-9 Main optical path parameters of the OptiX BWS 1600G-III ELH transmission system (G.652/G.655 fibre, SuperWDM)

Item		Unit	Performance parameter	
Span of line		-	25 × 22 dB	10 × 27 dB
Number of channels		-	40	40
Maximum bit rate of channel		-	STM–64	STM–64
Optical interface at points MPI-S and S’				
Channel output power (output end of amplifier)	Average	dBm	+4.0	+4.0
	Maximum	dBm	+7.0	+7.0
	Minimum	dBm	+1.0	+1.0
Maximum total output power		dBm	+20.0	+20.0
Maximum output loss at points S and S’ (FIU insertion loss)		dB	+1	+1
Maximum channel power difference at point MPI-S		dB	6	6
Optical path (MPI - S - MPI - R)				
Maximum optical path penalty		dB	2	2
Maximum dispersion (Note 1)		ps/nm	40000/12000	20000/6000
Maximum discrete reflectance		dB	–27	–27
Maximum differential group delay (DGD)		ps	18	18
Minimum return loss		dB	24	24
Optical interface at points MPI-R and R’				

Item		Unit	Performance parameter	
Channel input power (input end of amplifier)	Average	dBm	–20	–25
	Maximum	dBm	–16	–21
	Minimum	dBm	–24	–29
Maximum total input power (input end of amplifier)		dBm	–4	–9
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	17	17
Maximum channel power difference at point MPI-R		dB	8	8
Input loss at points MPI-R and R' (FIU insertion loss)		dB	≤1	≤1

Note 1: The value before "/"is for the G.652 fibre, the value after "/"is for the G.655 fibre.

The specifications in Table 6-9 are provided when SuperWDM technology is adopted.

Table 6-10 Main optical path parameters of the OptiX BWS 1600G-III 8-channel system (G.653 fibre)

Item		Unit	Specifications		
Number of spans and attenuation		-	8 x 20 dB	3 x 28 dB	1 x 33 dB
Number of channels		-	8	8	8
Maximum bit rate of per channel		-	STM-64	STM-64	STM-64
System wavelength		THz	192.1,192.3,192.6,193.0,195.1,195.5,195.8,196.0		
Optical interface parameters at points MPI-S and S'					
Channel output power (Note 1)	Average	dBm	+1.0	+1.0	+1.0
	Maximum	dBm	+2.0	+2.0	+2.0
	Minimum	dBm	–4.0	–4.0	–4.0
Maximum total output power		dBm	+11.0	+11.0	+11.0
Maximum insertion loss at S and S' (FIU)		dB	1.0	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (from MPI-S to MPI-R)					
Maximum optical path penalty		dB	2	2	2

Item		Unit	Specifications		
Maximum dispersion		ps/nm	0	0	0
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Minimum return loss		dB	24	24	24
Optical interface parameters at points MPI-R AND R’					
Channel input power	Average	dBm	–19	–27	–32
	Maximum	dBm	–15	–23	–29
	Minimum	dBm	–23	–31	–35
Maximum total input power (input end of amplifier)		dBm	–9	–17	–22
Minimum optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	8	8	6
Maximum insertion loss at MPI-R and MPI-R’ (FIU)		dB	1.0	1.0	1.0

Note 1: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.
Note 2: The split-band dispersion compensation is needed when the transmission distance exceeds 300km on G.653 fibre for C band signal.

Table 6-11 Main optical path parameters of the OptiX BWS 1600G-III 8-channel system (G.653 fibre, SuperWDM)

Item		Unit	Specifications		
Number of spans and attenuation		-	8 x 25 dB	3 x 30 dB	1 x 36 dB
Number of channels		-	8	8	8
Maximum bit rate of per channel		-	STM-64	STM-64	STM-64
System wavelength		THz	192.1,192.3,192.6,193.0,195.1,195.5,195.8,196.0		
Optical interface parameters at points MPI-S and S’					
Channel output power (Note 1)	Average	dBm	+1.0	+1.0	+1.0
	Maximum	dBm	+4.0	+4.0	+4.0
	Minimum	dBm	–2.0	–2.0	–2.0
Maximum total output power		dBm	+11.0	+11.0	+11.0

Item		Unit	Specifications		
Maximum insertion loss at S and S' (FIU)		dB	1.0	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (from MPI-S to MPI-R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	0	0	0
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	18	18	18
Minimum return loss		dB	24	24	24
Optical interface parameters at points MPI-R AND R'					
Channel input power	Average	dBm	–24	–29	–35
	Maximum	dBm	–20	–25	–31
	Minimum	dBm	–26	–31	–37
Maximum total input power (input end of amplifier)		dBm	–14	–19	–25
Minimum optical signal-to-noise ratio at point MPI-R		dB	17	17	17
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	6	6	6
Maximum insertion loss at MPI-R and MPI-R' (FIU)		dB	1.0	1.0	1.0

Note 1: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.
Note 2: The split-band dispersion compensation is needed when the transmission distance exceeds 300 km on G.653 fibre for C band signal.

Dispersion compensation is needed when the transmission distance exceeds 300 km on G.653 fibre for C band signal.

Table 6-12 Main optical path parameters of the OptiX BWS 1600G-III 12-channel system (G.653 fibre)

Item	Unit	Performance parameter		
Span of line	-	6 × 23 dB	3 × 27 dB	1 × 32 dB
Number of channels	-	12	12	12

Item		Unit	Performance parameter		
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
System wavelength		THz	192.1, 192.3, 192.4, 192.6, 192.7, 193.0, 195.1, 195.4, 195.5, 195.7, 195.8, 196.0		
Optical interface at points MPI-S and S’					
Channel output power (Note 1)	Average	dBm	0	0	0
	Maximum	dBm	+1.0	+1.0	+1.0
	Minimum	dBm	–3.0	–3.0	–3.0
Maximum total output power		dBm	+11.0	+11.0	+11.0
Maximum insertion loss at S and S’ (FIU)		dB	1.0	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (MPI - S - MPI - R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	0	0	0
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Minimum return loss		dB	24	24	24
Optical interface at points MPI-R and R’					
Channel input power (input end of amplifier)	Average	dBm	–23	–27	–32
	Maximum	dBm	–19	–24	–29
	Minimum	dBm	–27	–30	–35
Maximum total input power (input end of amplifier)		dBm	–12	–16	–21
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	8	6	6
Input loss at points MPI-R and R’ (FIU insertion loss)		dB	≤1	≤1	≤1

Note 1: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.

Table 6-13 Main optical path parameters of the OptiX BWS 1600G-III 12-channel system (G.653 fibre, SuperWDM)

Item		Unit	Specifications		
Number of spans and attenuation		-	8 x 24 dB	3 x 29 dB	1 x 35 dB
Number of channels		-	12	12	12
Maximum bit rate of per channel		-	STM–64	STM–64	STM–64
System wavelength		THz	192.1,192.3,192.4,192.6,192.7,193.0,195.1,195.4, 195.5,195.7,195.8,196.0		
Optical interface parameters at points MPI-S and S'					
Channel output power (Note 1)	Average	dBm	0	0	0
	Maximum	dBm	+3.0	+3.0	+3.0
	Minimum	dBm	–3.0	–3.0	–3.0
Maximum total output power		dBm	+11.0	+11.0	+11.0
Maximum insertion loss at S and S' (FIU)		dB	1.0	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (from MPI-S to MPI-R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	0	0	0
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	18	18	18
Minimum return loss		dB	24	24	24
Optical interface parameters at points MPI-R and R'					
Channel input power	Average	dBm	–24	–29	–35
	Maximum	dBm	–21	–26	–32
	Minimum	dBm	–27	–32	–38
Maximum total input power (input end of amplifier)		dBm	–13	–18	–24
Minimum optical signal-to-noise ratio at point MPI-R		dB	17	17	17
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	6	6	6

Item	Unit	Specifications		
Maximum insertion loss at MPI-R and MPI-R' (FIU)	dB	1.0	1.0	1.0

Note 1: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.

Dispersion compensation is needed when the transmission distance exceeds 300 km on G.653 fibre for C band signal.

Table 6-14 Main optical path parameters of the OptiX BWS 1600G-III 16-channel system (G.653 fibre, SuperWDM)

Item		Unit	Specifications	
Number of spans and attenuation		-	7x22 dB	5x25 dB
Number of channels		-	16	16
Maximum bit rate of per channel		-	STM–64	STM–64
System wavelength		THz	192.1, 192.2, 192.3, 192.4, 192.6, 192.7, 193.0, 193.1, 195.0, 195.1, 195.4, 195.5, 195.7, 195.8, 195.9, 196.0	
Optical interface parameters at points MPI-S and S'				
Channel output power (Note)	Average	dBm	–1.0	–1.0
	Maximum	dBm	+2.0	+2.0
	Minimum	dBm	–4.0	–4.0
Maximum total output power		dBm	+11.0	+11.0
Maximum insertion loss at S and S' (FIU)		dB	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6
Optical path (from MPI-S to MPI-R)				
Maximum dispersion		ps/nm	0	0
Maximum discrete reflectance		dB	–27	–27
Maximum differential group delay (DGD)		ps	18	18
Minimum return loss		dB	24	24
Optical interface parameters at points MPI-R and R'				
Channel input power	Average	dBm	–23	–26
	Maximum	dBm	–20	–23
	Minimum	dBm	–26	–29

Item	Unit	Specifications	
Maximum total input power (input end of amplifier)	dBm	–11	–14
Minimum optical signal-to-noise ratio at point MPI-R	dB	17	17
Cross-talk	dB	20	20
Maximum channel power difference at point MPI-R	dB	6	6
Maximum insertion loss at MPI-R and MPI-R' (FIU)	dB	1.0	1.0

Note: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.

6.6.4 Type IV System

Table 6-15 Main optical path parameters of the OptiX BWS 1600G-IV system (G.653 fibre, L band)

Item		Unit	Performance parameter		
Span of line		-	5 × 22 dB	3 × 25 dB	1 × 30 dB
Number of channels		-	40	40	40
Maximum bit rate of channel		-	STM–64	STM–64	STM–64
Optical interface at points MPI-S and S'(Note 1)					
Channel output power (Note 2)	Average	dBm	+1.0	+1.0	+1.0
	Maximum	dBm	+2.0	+2.0	+2.0
	Minimum	dBm	–4.0	–4.0	–4.0
Maximum total output power		dBm	+17.0	+17.0	+17.0
Maximum insertion loss at S and S' (FIU)		dB	1.0	1.0	1.0
Maximum channel power difference at point MPI-S		dB	6	6	6
Optical path (MPI - S - MPI –R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	1600	1080	440
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	15	15	15
Minimum return loss		dB	24	24	24

Item		Unit	Performance parameter		
Optical interface at points MPI-R and R'					
Channel input power (input end of amplifier)	Average	dBm	–21	–24	–29
	Maximum	dBm	–18	–21	–26
	Minimum	dBm	–24	–27	–32
Maximum total input power (input end of amplifier)		dBm	–5	–8	–13
Minimum channel optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	6	6	6
Input loss at points MPI-R and R' (FIU insertion loss)		dB	≤1	≤1	≤1

Note 1: The pre-equilibrium should be performed to the optical power input into the transmit end.
Note 2: The channel output power is the input optical power of the system at point S, including FIU loss at the transmit end.

6.6.5 Type V System

Table 6-16 Main optical path parameters of the OptiX BWS 1600G-V system (G.652/G.655 fibre)

Item		Unit	Performance parameter		
Span of line			8 × 22 dB	6 × 27 dB	1 × 39 dB
Number of channels			40	40	40
Maximum bit rate of channel			STM–16	STM–16	STM–16
Optical interface at points MPI-S AND S'					
Channel output power (output end of amplifier)	Average	dBm	+4.0	+4.0	+4.0
	Maximum	dBm	+7.0	+7.0	+7.0
	Minimum	dBm	+1.0	+1.0	+1.0
Maximum total output power		dBm	+20.0	+20.0	+20.0
Maximum output loss at points S and S' (FIU insertion loss)		dB	+1	+1	+1
Channel signal-to-noise ratio at point MPI-S		dB	> 35	> 35	> 35
Maximum channel power difference at point MPI-S		dB	6	6	4

Item		Unit	Performance parameter		
Optical path (MPI - S - MPI –R)					
Maximum optical path penalty		dB	2	2	2
Maximum dispersion		ps/nm	12800/3840	12000/3600	3000/900
Maximum discrete reflectance		dB	–27	–27	–27
Maximum differential group delay (DGD)		ps	40	40	40
Minimum return loss		dB	24	24	24
Optical interface at points MPI-R and R'					
Channel input power (input end of amplifier)	Average	dBm	–20	–25	–37 (Note 1)
	Maximum	dBm	–16	–21	–34
	Minimum	dBm	–24	–39	–40
Maximum total input power (input end of amplifier)		dBm	–4	–9	–20
minimum channel optical signal-to-noise ratio at point MPI-R		dB	20	20	20
Cross-talk		dB	20	20	20
Maximum channel power difference at point MPI-R		dB	8	8	6
Input loss at points MPI-R and R' (FIU insertion loss)		dB	≤1	≤1	≤1

Note 1: The number of working wavelengths should be not less than 8.

6.6.6 Type VI System

Table 6-17 System transmission specifications

Equipment / Sub-System	Single wavelength: 10 Gbit/s				Single wavelength: 2.5 Gbit/s	
	10-wavelength		40-wavelength		10-wavelength	40-wavelength
	NRZ	CRZ	NRZ	CRZ		
ROPA+LHP. R001	-	60 dB	-	51 dB	64 dB	55 dB
ROPA+LHP, G.652 fibre in the line	61 dB	65 dB	51 dB	54 dB	65 dB	57 dB
ROPA+LHP, R002 with G.655(LEAF) fibre in the line	61 dB	64 dB	51 dB	54 dB	65 dB	57 dB

Notes: Table 6-17 lists the basic specifications. If other specifications are required, please contact Huawei Technologies.

Note

Among the main optical path parameters of all types of systems mentioned above, the values in the "Minimum optical signal-to-noise ratio at point MPI-R" row refer to the typical OSNR values in a given networking. The actual OSNR values may be different from the values in the table because of various factors.

6.7 Optical Amplifier

6.7.1 OAU

The OptiX BWS 1600G system has two kinds of OAUs according to their hardware versions. They are E2OAU and E3OAU. Their parameters will be detailed in this section.

The E2OAU has one type: OAU-LG. The specific parameters are shown in Table 6-18.

Table 6-18 Parameters of OAU-LG for L-band

Item		Unit	Performance parameter		
			23 dB	28 dB	33 dB
Working wavelength range		nm	1570.42–1603.57	1570.42–1603.57	1570.42–1603.57
Total input power range		dBm	–32 to –3	–32 to –8	–32 to –13
Single channel input power range	32 channels	dBm	–32 to –18	–32 to –23	–32 to –28
	40 channels	dBm	–32 to –19	–32 to –24	–32 to –29
	80 channels	dBm	–32 to –22	–32 to –27	–32
Noise figure (NF)	PA	dB	< 5.5	< 5.5	< 5.5
	BA	dB	< 6	< 6	< 6
Input reflectance		dB	< –40	< –40	< –40
Output reflectance		dB	< –40	< –40	< –40
Pump leakage at input end		dBm	< –30	< –30	< –30
Maximum reflectance tolerable at input end		dB	–27	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27	–27
Maximum total output power		dBm	20	20	20
Gain response time to add/drop the channel		ms	< 10	< 10	< 10

Item	Unit	Performance parameter		
		23 dB	28 dB	33 dB
Channel gain	dB	21–26	26–31	31–36
Gain flatness	dB	≤ 2	≤ 2	≤ 2
Multi-channel gain tilt	dB/dB	≤ 2	≤ 2	≤ 2
Polarization dependent loss (PDL)	dB	≤0.5	≤0.5	≤0.5

The OAUC01, OAUC03 and OAUC05 of E3OAU are used in:

- C 800G system (OptiX BWS 1600G type II)
- C 400G system (OptiX BWS 1600G type III)
- C 100G system (OptiX BWS 1600G type V, for 2.5 Gbit/s services)
- The long hop transmission system (OptiX BWS 1600G type VI)

Table 6-19 shows the specifications of the OAUC01, Table 6-20 shows that of the OAUC03, and Table 6-21 shows that of the OAUC05.

Table 6-19 Parameters of OAUC01 for C band

Item		Unit	80 channels performance parameter		
Application code			20 dB	26 dB	31 dB
Working wavelength range		nm	1529.16–1560.61	1529.16–1560.61	1529.16–1560.61
Total input power range		dBm	–32 to 0	–32 to –6	–32 to –11
Single channel input power range	32 channels	dBm	–32 to –15	–32 to –21	–32 to –26
	40 channels	dBm	–32 to –16	–32 to –22	–32 to –27
	80 channels	dBm	–32 to –19	–32 to –25	–32 to –30
Noise figure (NF)		dB	<9 (Note 1)	<7 (Note 1)	<6 (Note 1)
Output reflectance		dB	<–40	<–40	<–40
Input reflectance		dB	<–40	<–40	<–40
Pump leakage at input end		dBm	<–30	<–30	<–30
Maximum reflectance tolerable at input end		dB	–27	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27	–27
Maximum total output power		dBm	20	20	20

Item	Unit	80 channels performance parameter		
Gain response time to add/drop the channel	ms	<10	<10	<10
Maximum channel gain	dB	20–23	23–29	29–31
Gain flatness	dB	≤2	≤2	≤2
Multi-channel gain tilt	dB/dB	≤2	≤2	≤2
Polarization dependent loss (PDL)	dB	≤0.5	≤0.5	≤0.5

Note 1: The value for noise figure is varying with the gain which can be tunable, only the typical value is given here.
Note 2: As for E3OAUC01 amplifier, the total gain is 33 dB. The internal insertion loss ranges from 2 dB to 13 dB, and thus the gain varies from 20 to 31.

Table 6-20 Parameters of OAUC03 for C band

Item		Unit	80 channels performance parameter		
Application code		-	24 dB	29 dB	36 dB
Working wavelength range		nm	1529.16–1560.61	1529.16–1560.61	1529.16–1560.61
Total input power range		dBm	–32 to –4	–32 to –9	–32 to –16
Single channel input power range	32 channels	dBm	–32 to –19	–32 to –24	–32 to –31
	40 channels	dBm	–32 to –20	–32 to –25	–32
	80 channels	dBm	–32 to –23	–32 to –28	–32
Noise figure (NF)		dB	<7 (Note 1)	<6 (Note 1)	<6 (Note 1)
Output reflectance		dB	<–40	<–40	<–40
Input reflectance		dB	<–40	<–40	<–40
Pump leakage at input end		dBm	<–30	<–30	<–30
Maximum reflectance tolerable at input end		dB	–27	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27	–27
Maximum total output power		dBm	20	20	20
Gain response time to add/drop the channel		ms	<10	<10	<10
Maximum channel gain		dB	24–28	28–30	30–36
Gain flatness		dB	≤2	≤2	≤2
Multi-channel gain tilt		dB/dB	≤2	≤2	≤2

Item	Unit	80 channels performance parameter		
Polarization dependent loss (PDL)	dB	≤0.5	≤0.5	≤0.5

Note 1: The value for noise figure is varying with the gain which can be tunable, only the typical value is given here.
Note 2: As for E3OAUC03 amplifier, the total gain is 38 dB. The internal insertion loss is 2-14 dB, thus the gain varies from 24 to 36.

Table 6-21 Parameters of OAUC05 for C band

Item		Unit	80 channels performance parameter		
Application code		-	23 dB	30 dB	34 dB
Working wavelength range		nm	1529.16–1560.61	1529.16–1560.61	1529.16–1560.61
Total input power range		dBm	–32 to 0	–32 to –7	–32 to –11
Single channel input power range	32 channels	dBm	–32 to –15	–32 to –22	–32 to –26
	40 channels	dBm	–32 to –16	–32 to –23	–32 to –27
	80 channels	dBm	–32 to –19	–32 to –26	–32 to –30
Noise figure (NF)		dB	<9 (Note 1)	<7 (Note 1)	<6 (Note 1)
Output reflectance		dB	<–40	<–40	<–40
Input reflectance		dB	<–40	<–40	<–40
Pump leakage at input end		dBm	<–30	<–30	<–30
Maximum reflectance tolerable at input end		dB	–27	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27	–27
Maximum total output power		dBm	23	23	23
Gain response time to add/drop the channel		ms	<10	<10	<10
Maximum channel gain		dB	23–26	26–33	33–34
Gain flatness		dB	≤2	≤2	≤2
Multi-channel gain tilt		dB/dB	≤2	≤2	≤2
Polarization dependent loss (PDL)		dB	≤0.5	≤0.5	≤0.5

Note 1: The value for noise figure is varying with the gain which can be tunable, only the typical value is given here.

6.7.2 OBU

The OptiX BWS 1600G system has two kinds of OBUs according to their hardware versions. They are E2OBU and E3OBU. Their parameters will be detailed in this section respectively.

Table 6-22 shows the parameters of E2OBU.

Table 6-22 Parameters of OBU-L for L-band (for E2OBU)

Item		Unit	Performance parameter	
Application			OBU03	OBU05
Working wavelength range		nm	1570.42–1603.57	1570.42–1603.57
Total input power		dBm	–22 to –3	–22 to 0
Single channel input power range	32 channels	dBm	–22 to –18	-
	40 channels	dBm	–22 to –19	–22 to –16
	80 channels	dBm	–22	–22 to –19
Noise figure (NF)		dB	<6	<7.5
Input reflectance		dB	< –40	< –40
Output reflectance		dB	< –40	< –40
Pump leakage at input end		dBm	< –30	< –30
Maximum reflectance tolerable at input end		dB	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27
Maximum total output power		dBm	20	23
Gain response time to add/drop the channel		ms	< 10	< 10
Channel gain		dB	23	23
Channel gain range			21 to 26	21 to 25
Gain flatness		dB	≤ 2	≤ 2
Multi-channel gain tilt		dB/dB	≤ 2	≤ 2
Polarization dependent loss (PDL)		dB	≤ 0.5	≤ 0.5

Note: In performance parameters column, the parameters before the slash "/" are for C band, and those after the slash "/" are for L band.

Table 6-23shows the parameters of E3OBU.

Table 6-23 Parameters of OBUC03 and OBUC05

Item		Unit	Performance parameter	
Application code			OBUC03	OBUC05
Working wavelength range		nm	1529.16–1560.61	1529.16–1560.61
Total input power		dBm	–24 to –3	–24 to 0
Single channel input power range	32 channels	dBm	–24 to –18	–24 to –15
	40 channels	dBm	–24 to –19	–24 to –16
	80 channels	dBm	–22	–24 to –19
Noise figure (NF)		dB	< 6	< 7
Input reflectance		dB	< –40	< –40
Output reflectance		dB	< –40	< –40
Pump leakage at input end		dBm	< –30	< –30
Maximum reflectance tolerable at input end		dB	–27	–27
Maximum reflectance tolerable at output end		dB	–27	–27
Maximum total output power		dBm	20	23
Gain response time to add/drop the channel		ms	< 10	< 10
Channel gain		dB	23	23
Channel gain range		dB	21 – 25	21 – 25
Gain flatness		dB	≤ 2	≤ 2
Multi-channel gain tilt		dB/dB	≤ 2	≤ 2
Polarization dependent loss (PDL)		dB	≤ 0.5	≤ 0.5

6.7.3 OPU

Table 6-24 Parameters of OPU

Item		Unit	Performance parameter
Working wavelength range		nm	1529.16–1560.61
Total input power		dBm	–32 to –8
Single channel input power range	32 channels	dBm	–32 to –23
	40 channels	dBm	–32 to –24
	80 channels	dBm	–32 to –27
Noise figure (NF)		dB	<5.5
Input reflectance		dB	<–40
Output reflectance		dB	<–40
Pump leakage at input end		dBm	<–30
Maximum reflectance tolerable at input end		dB	–27
Maximum reflectance tolerable at output end		dB	–27
Maximum total output power		dBm	15
Gain response time to add/drop the channel		ms	<10
Channel gain		dB	23
Channel gain range		dB	21–25
Gain flatness		dB	≤2
Multi-channel gain tilt		dB/dB	≤2
Polarization dependent loss (PDL)		dB	≤0.5

6.7.4 HBA

Table 6-25 Parameters of HBA

Item	Unit	Performance parameter	
		40-channel	**10-channel**
Working wavelength range	nm	192.1–196.0 THz	192.1–194.0 THz
Total input power range	dBm	–19 to –3	–19 to –9
Noise figure (NF)	dB	<8	<8
Output reflectance	dB	<–45	<–45
Output power range	dBm	10–26	16–26
Gain response time to add/drop the channel	ms	<10	<10
Channel gain	dB	29	35
Gain flatness	dB	≤2.5	≤2.5
Polarization dependent loss (PDL)	dB	<0.5	<0.5
Polarization mode dispersion (PMD)	ps	<0.5	<0.5

6.7.5 Raman Amplifier

Table 6-26 Parameters of Raman amplifier

Item	Unit	Performance parameter	
Pump wavelength range	nm	1400–1500	
Board type	-	C band: RPC	C+L band: RPA
Maximum pump power	dBm	29	30
Channel gain on G.652 fibre (Note 1)	dB	>10	>10
Channel gain on LEAF fibre (Note 1 & Note 2)	dB	>12	>10
Channel gain on TW RS fibre (Note 1 & Note 3)	dB	>13	>10
Effective noise figure on G.652 fibre	dB	≤1	≤1
Effective noise figure on LEAF fibre	dB	≤0	≤0.5
Effective noise figure on TW RS fibre	dB	≤–1.5	≤0
Polarization dependent loss (PDL)	dB	≤0.5	≤0.5
Temperature characteristic	nm/°C	≤1	≤1
Output connector type	-	LSH/APC (Note 4)	LSH/APC

Note 1: This gain refers to the on-off gain, that is, the power difference between amplifier ON and amplifier OFF.
Note 2: LEAF fibre is a kind of fibre called large effective aperture fibre.
Note 3: TW RS fibre is a kind of fibre called True Wave Reduced Slope fibre, belongs to NZDSF.
Note 4: The LSH/APC connector is also called E2000/APC connector.

6.8 Optical Transponder Unit (OTU)

The OTU, optical transponder unit, converts client signals into a standard G.692-compliant DWDM wavelength. Its interface parameter specifications meet the requirements given in the following tables. All the specifications provided by Huawei assume the worst case, that is, these specifications can meet the requirements under the permitted worst working conditions at EOL (end of life).

6.8.1 Specifications of Client Side Optical Module at 2.5 Gbit/s and Lower

Table 6-27 Specifications of client side SDH optical module at 2.5 Gbit/s and lower

Parameters	Unit	Specifications			
Optical Interface type	-	I-16	S-16.1	L-16.1	L-16.2
Line code format	-	NRZ	NRZ	NRZ	NRZ
Optical source type	-	MLM	SLM	SLM	SLM
Target distance	km	2	15	40	80
Transmitter parameter specifications at point S					
Working wavelength range	nm	1260–1360	1260–1360	1260–1360	1500–1580
Maximum mean launched power	dBm	–3	0	+3	+3
Minimum mean launched power	dBm	–10	–5	–2	–2
Minimum extinction ratio	dB	+8.2	+8.2	+8.2	+8.2
Maximum –20 dB spectrum width	nm	1	1	1	1
Minimum SMSR	dB	NA	30	30	30
Dispersion tolerance	ps/nm	NA	NA	NA	1600
Eye pattern mask	-	Compliant with G.957			
Receiver parameter specifications at point R					
Receiver type	-	PIN	PIN	APD	APD
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–18	–18	–27	–28
Receiver overload	dBm	–3	0	–9	–9
Maximum reflectance	dB	–27	–27	–27	–27

Table 6-28 Specifications of client side GE optical module

Parameters	Unit	Specifications	
Optical Interface type		1000BASE-LX	1000BASE-SX
Transmitter parameter specifications at point S			
Laser operating wavelength	nm	1270–1355	770–860
Maximum mean launched power	dBm	–3.0	0
Minimum mean launched power	dBm	–11.5	–9.5
Minimum extinction ratio	dB	+9	+9
Receiver parameter specifications at point R			
operating wavelength range	nm	1270–1355	770–860
Receiver sensitivity	dBm	–19	–17
Receiver overload	dBm	–3	0
Maximum reflectance	dB	–12	–12

6.8.2 Specifications of 10 Gbit/s Optical Module at Client Side

Table 6-29 Specifications of 10 Gbit/s SDH optical module at client side

Parameters	Unit	Specifications				
Optical interface type	-	I-64.1	I-64.2	S-64.2b	Se-64.2a	Le-64.2
Line code format	-	NRZ	NRZ	NRZ	NRZ	NRZ
Optical source type	-	SLM	SLM	SLM	SLM	SLM
Target distance	km	2	25	40	40	60
Transmitter parameter specifications at point S						
Working wavelength range	nm	1290–1330	1530–1565	1530–1565	1530–1565	1530–1565
Maximum mean launched power	dBm	–1	–1	+2	+2	+4
Minimum mean launched power	dBm	–6	–5	–1	–1	+1
Minimum extinction ratio	dB	6	+8.2	+8.2	+8.2	+8.2
Maximum -20 dB spectrum width	nm	NA	NA	0.3	0.3	0.3
Minimum side-mode suppression ratio (SMSR)	dB	NA	NA	30	30	30
Eye pattern mask	NA	Compliant with G.691				

Parameters	Unit	Specifications				
Receiver parameter specifications at point R						
Receiver type	-	PIN	PIN	PIN	APD	APD
Operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–11	–14	–14	–21	–21
Receiver overload	dBm	–1	–1	–1	–8	–8
Maximum reflectance	dB	–27	–27	–27	–27	–27

Table 6-30 Specifications of 10 Gbit/s GE optical module at client side

Parameters	Unit	Specifications	
Optical Interface type	-	10G Base -LR	10G Base -ER
Optical interface bit rate	Gbit/s	10.3125	10.3125
Line code format	-	NRZ	NRZ
Optical source type	-	SLM	SLM
Target distance	km	2	25
Transmitter parameter specifications at point S			
Working wavelength range	nm	1290~1330	1530~1565
Maximum mean launched power	dBm	–1	+2
Minimum mean launched power	dBm	–6	–4.7
Minimum extinction ratio	dB	+6	+8.2
Receiver parameter specifications at point R			
Receiver type	-	PIN	PIN
Receiver sensitivity	dBm	–11	–14
Receiver overload	dBm	–1	–1
Maximum reflectance	dB	–27	–27

6.8.3 Specifications of 2.5 Gbit/s Fixed Wavelength Optical Module at DWDM Side

Table 6-31 Specifications of 2.5 Gbit/s fixed wavelength optical module at DWDM side

Parameters	**Unit**	**Specifications**	
		12800 ps/nm-APD	**12800 ps/nm-PIN**
Channel spacing	GHz	100	
Line code format	-	NRZ	
Transmitter parameter specifications at point Sn			
Maximum mean launched power	dBm	0	
Minimum mean launched power	dBm	–10	
Minimum extinction ratio	dB	+10	
Central frequency	THz	192.10–196.00	
Central frequency deviation	GHz	±10	
Maximum –20dB spectral width	nm	0.2	
Minimum SMSR	dB	35	
Maximum dispersion	ps/nm	12800	
Eye pattern mask	-	Compliant with G.957	
Receiver parameter specifications at point Rn			
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

Note 1: For the LWX, the line code format at DWDM side is adopted according to that at client side. The line code format is NRZ if the signal at DWDM side is SDH signal or OTN signal.
Note 2: For the LWX, the eye pattern at DWDM side is adopted according to the type of the services at client side. The eye pattern mask is compliant with G.957 if the signal at DWDM side is SDH signal or OTN signal.

6.8.4 Specifications of 2.5 Gbit/s Tunable Wavelength Optical Module at DWDM Side

Table 6-32 Specifications of 2.5 Gbit/s tunable wavelength optical module at DWDM side

Parameters	**Unit**	**Specifications**	
		12800 ps/nm-APD-tunable	**12800 ps/nm-PIN-tunable**
Channel spacing	GHz	100	
Line code format	-	NRZ	
Transmitter parameter specifications at point Sn			
Maximum mean launched power	dBm	0	
Minimum mean launched power	dBm	–10	
Minimum extinction ratio	dB	+10	
Central frequency	THz	192.10–196.00	
Central frequency deviation	GHz	±10	
Maximum –20dB spectral width	nm	0.2	
Minimum SMSR	dB	35	
Maximum dispersion	ps/nm	12800	
Eye pattern mask	-	Compliant with G.957	
Receiver parameter specifications at point Rn			
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

Note 1: For the LWX, the line code format at DWDM side is adopted according to that at client side. The line code format is NRZ if the signal at DWDM side is SDH signal or OTN signal.
Note 2: For the LWX, the eye pattern at DWDM side is adopted according to the type of the services at client side. The eye pattern mask is compliant with G.957 if the signal at DWDM side is SDH signal or OTN signal.

6.8.5 Specifications of 10 Gbit/s Fixed Wavelength Optical Module at DWDM Side

Table 6-33 Specifications of 10 Gbit/s optical module at DWDM side

Parameters	Unit	Specifications			
Channel spacing	GHz	50		100	
Line code format	-	NRZ	CRZ	NRZ	CRZ
Transmitter parameter specifications at point Sn					
Maximum mean launched power	dBm	0	0	0	0
Minimum mean launched power	dBm	–5	–5	–5	–5
Minimum extinction ratio	dB	+10	+13	+10	+13
Nominal Central frequency	THz	192.10–196.05, 186.95–190.90	192.10–196.05	192.10–196.00, 186.95–190.95	192.10–196.00
Central frequency deviation	GHz	±5	±5	±10	±10
Maximum -20dB spectral width	nm	0.3	0.56	0.3	0.64
Minimum SMSR	dB	35	30	35	30
Maximum dispersion	ps/nm	800	–300 to +500	800	–300 to +500
Eye pattern mask	-	Compliant with G.691	NA	Compliant with G.691	NA
Receiver parameter specifications at point Rn					
Receiver type	-	PIN	PIN	PIN	PIN
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–14	–16	–14	–16
Receiver overload	dBm	–1	0	0	0
Maximum reflectance	dB	–27	–27	–27	–27

6.8.6 Specifications of 10 Gbit/s Tunable Wavelength Optical Module at the DWDM side

Table 6-34 Specifications of 10 Gbit/s tunable wavelength optical module at the DWDM side

Parameters	Unit	Specifications	
Channel spacing	GHz	50	100
Line code format	-	NRZ	NRZ
Transmitter parameter specifications at point S			
Maximum mean launched power	dBm	0	0
Minimum mean launched power	dBm	–5	–5
Minimum extinction ratio	dB	+10	+10
Nominal Central frequency	THz	192.10–196.05	192.10–196.00
Central frequency deviation	GHz	±5	±10
Maximum -20dB spectral width	nm	0.3	0.3
Minimum SMSR	dB	35	35
Maximum dispersion	ps/nm	800	800
Eye pattern mask	-	Compliant with G.691	Compliant with G.691
Receiver parameter specifications at point R			
Receiver type	-	PIN	PIN
operating wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–14	–14
Receiver overload	dBm	–1	0
Maximum reflectance	dB	–27	–27

6.8.7 LWF and LWFS

Table 6-35 Optical interface parameter specifications at the client side of the LWF board

Parameters	Unit	Specifications				
Optical interface type	-	I-64.1	I-64.2	S-64.2b	Se-64.2a	Le-64.2
Line code format	-	NRZ	NRZ	NRZ	NRZ	NRZ
Optical source type	-	SLM	SLM	SLM	SLM	SLM

Parameters	Unit	Specifications				
Target distance	km	2	25	40	40	60
Transmitter parameter specifications at point S						
Working wavelength range	nm	1290–1330	1530–1565	1530–1565	1530–1565	1530–1565
Maximum mean launched power	dBm	–1	–1	+2	+2	+4
Minimum mean launched power	dBm	–6	–5	–1	–1	+1
Minimum extinction ratio	dB	6	+8.2	+8.2	+8.2	+8.2
Maximum -20 dB spectrum width	nm	NA	NA	0.3	0.3	0.3
Minimum side-mode suppression ratio (SMSR)	dB	NA	NA	30	30	30
Eye pattern mask	NA	Compliant with G.691				
Receiver parameter specifications at point R						
Receiver type	-	PIN	PIN	PIN	APD	APD
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–11	–14	–14	–21	–21
Receiver overload	dBm	–1	–1	–1	–8	–8
Maximum reflectance	dB	–27	–27	–27	–27	–27
Jitter characteristics	NA	Compliant with G.783				

Table 6-36 Optical interface parameter specifications at the DWDM side of the LWF/LWFS board

Parameters	Unit	Specifications			
Channel spacing	GHz	50		100	
Line code format	-	NRZ	CRZ	NRZ	CRZ
Transmitter parameter specifications at point Sn					
Maximum mean launched power	dBm	0	0	0	0
Minimum mean launched power	dBm	–5	–5	–5	–5
Minimum extinction ratio	dB	+10	+13	+10	+13
Nominal Central frequency	THz	192.10–196.05, 186.95–190.90	192.10–196.05	192.10–196.00, 186.95–190.90	192.10–196.00

Parameters	Unit	Specifications			
Central frequency deviation	GHz	±5	±5	±10	±10
Maximum -20dB spectral width	nm	0.3	0.56	0.3	0.64
Minimum SMSR	dB	35	30	35	30
Maximum dispersion	ps/nm	800	–300 to +500	800	–300 to +500
Eye pattern mask	-	Compliant with G.691	NA	Compliant with G.691	NA
Receiver parameter specifications at point Rn					
Receiver type	-	PIN	PIN	PIN	PIN
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–14	–16	–14	–16
Receiver overload	dBm	–1	0	0	0
Maximum reflectance	dB	–27	–27	–27	–27

6.8.8 TMX and TMXS

Table 6-37 Optical interface parameter specifications at the client side of the TMX board

Parameters	Unit	Specifications			
Optical Interface type	-	I-16	S-16.1	L-16.1	L-16.2
Line code format	-	NRZ	NRZ	NRZ	NRZ
Optical source type	-	MLM	SLM	SLM	SLM
Target distance	km	2	15	40	80
Transmitter parameter specifications at point S					
Working wavelength range	nm	1260–1360	1260–1360	1260–1360	1500–1580
Maximum mean launched power	dBm	–3	0	+3	+3
Minimum mean launched power	dBm	–10	–5	–2	–2
Minimum extinction ratio	dB	+8.2	+8.2	+8.2	+8.2
Maximum –20 dB spectrum width	nm	1	1	1	1

Parameters	Unit	Specifications			
Minimum SMSR	dB	NA	30	30	30
Dispersion tolerance	ps	NA	NA	NA	1600
Eye pattern mask	-	Compliant with G.957			
Receiver parameter specifications at point R					
Receiver type	-	PIN	PIN	APD	APD
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–18	–18	–27	–28
Receiver overload	dBm	–3	0	–9	–9
Maximum reflectance	dB	–27	–27	–27	–27
Jitter characteristics	NA	Compliant with G.783			

Table 6-38 Optical interface parameter specifications at the DWDM side of the TMX/TMXS board

Parameters	Unit	Specifications			
Channel spacing	GHz	50		100	
Line code format	-	NRZ	CRZ	NRZ	CRZ
Transmitter parameter specifications at point Sn					
Maximum mean launched power	dBm	0	0	0	0
Minimum mean launched power	dBm	–5	–5	–5	–5
Minimum extinction ratio	dB	+10	+13	+10	+13
Nominal Central frequency	THz	192.10–196.05, 186.95–190.90	192.10–196.05	192.10–196.00, 186.95–190.90	192.10–196.00
Central frequency deviation	GHz	±5	±5	±10	±10
Maximum –20dB spectral width	nm	0.3	0.56	0.3	0.64
Minimum SMSR	dB	35	30	35	30
Maximum dispersion	ps/nm	800	–300 to +500	800	–300 to +500
Eye pattern mask	-	Compliant with G.691	NA	Compliant with G.691	NA
Receiver parameter specifications at point Rn					

Parameters	Unit	Specifications			
Receiver type	-	PIN	PIN	PIN	PIN
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–14	–16	–14	–16
Receiver overload	dBm	–1	0	0	0
Maximum reflectance	dB	–27	–27	–27	–27

6.8.9 LBE and LBES

Table 6-39 Optical interface parameter specifications at the client side of the LBE/LBES board

Parameters	Unit	Specifications	
Optical Interface type	-	10G Base -LR	10G Base -ER
Optical interface bit rate	Gbit/s	10.3125	10.3125
Line code format	-	NRZ	NRZ
Optical source type	-	SLM	SLM
Target distance	km	10	40
Transmitter parameter specifications at point S			
Working wavelength range	nm	1290~1330	1530~1565
Maximum mean launched power	dBm	–1	+2
Minimum mean launched power	dBm	–6	–4.7
Minimum extinction ratio	dB	+6	+8.2
Receiver parameter specifications at point R			
Receiver type	-	PIN	PIN
Receiver sensitivity	dBm	–11	–14
Receiver overload	dBm	–1	–1
Maximum reflectance	dB	–27	–27

Table 6-40 Optical interface parameter specifications at the DWDM side of the LBE board

Parameters	Unit	Specifications			
Channel spacing	GHz	50		100	
Line code format	-	NRZ	CRZ	NRZ	CRZ
Transmitter parameter specifications at point Sn					
Maximum mean launched power	dBm	0	0	0	0
Minimum mean launched power	dBm	–5	–5	–5	–5
Minimum extinction ratio	dB	+10	+13	+10	+13
Nominal Central frequency	THz	192.10–196.05, 186.95–190.90	192.10–196.05	192.10–196.00, 186.95–190.85	192.10–196.00
Central frequency deviation	GHz	±5	±5	±10	±10
Maximum –20dB spectral width	nm	0.3	0.56	0.3	0.64
Minimum SMSR	dB	35	30	35	30
Maximum dispersion	ps/nm	800	–300 to +500	800	–300 to +500
Eye pattern mask	-	Compliant with G.691	NA	Compliant with G.691	NA
Receiver parameter specifications at point Rn					
Receiver type	-	PIN	PIN	PIN	PIN
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–14	–16	–14	–16
Receiver overload	dBm	–1	0	0	0
Maximum reflectance	dB	–27	–27	–27	–27

The parameter specifications of the LRF and the TMR are the same as the that of the LWF and the LBE on DWDM side. The parameter specifications of the LRFS and the TMRS are the same as that of the LWFS and the LBES on DWDM side.

6.8.10 LOG and LOGS

Table 6-41 Optical interface parameters at the client side of the LOG and LOGS boards

Item	Unit	Parameter		
Optical interface rate	Gbit/s	GE(1.25 Gbit/s)/FC100 (1.062 Gbit/s)		FC200 (2.125 Gbit/s)
Transmitter parameters at point S				
Laser operating wavelength	nm	1260–1360	770–860	770–860
Maximum mean launched power	dBm	–3.0	0	–2.5
Minimum mean launched power	dBm	–11.5	–9.5	–9.5
Minimum extinction ratio	dB	+9	+9	+9
Receiver parameters at point R				
operating wavelength range	nm	1270–1650	770–860	770–860
Receiver sensitivity	dBm	–19	–17	–17
Receiver overload	dBm	–3	0	0
Maximum reflectance	dB	–12	–12	–12

The optical interface parameters of the LOG and LOGS boards on DWDM side are the same as that of the LBE and LBES boards on DWDM side. Refer to Table 6-40.

6.8.11 LWC1

Table 6-42 Optical interface parameter specifications at client side of the LWC1 board

Parameters	Unit	Specifications			
Optical Interface type	-	I-16	S-16.1	L-16.1	L-16.2
Line code format	-	NRZ	NRZ	NRZ	NRZ
Optical source type	-	MLM	SLM	SLM	SLM
Target distance	km	2	15	40	80
Transmitter parameter specifications at point S					
Working wavelength range	nm	1260–1360	1260–1360	1260–1360	1500–1580
Maximum mean launched power	dBm	–3	0	+3	+3
Minimum mean launched power	dBm	–10	–5	–2	–2

Parameters	Unit	Specifications			
Minimum extinction ratio	dB	+8.2	+8.2	+8.2	+8.2
Maximum –20 dB spectrum width	nm	1	1	1	1
Minimum SMSR	dB	NA	30	30	30
Dispersion tolerance	ps/nm	NA	NA	NA	1600
Eye pattern mask	-	Compliant with G.957			
Receiver parameter specifications at point R					
Receiver type	-	PIN	PIN	APD	APD
operating wavelength range	nm	1200–1650	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–18	–18	–27	–28
Receiver overload	dBm	–3	0	–9	–9
Maximum reflectance	dB	–27	–27	–27	–27
Jitter characteristics	NA	Compliant with G.783			

Table 6-43 Optical interface (OTU1) parameter specifications at the DWDM side of the LWC1 board

Parameters	Unit	Specifications
Channel spacing	GHz	100
Line code format	-	NRZ
Transmitter parameter specifications at point Sn		
Maximum mean launched power	dBm	0
Minimum mean launched power	dBm	–10
Minimum extinction ratio	dB	+10
Central frequency	THz	192.10–196.00
Central frequency deviation	GHz	±10
Maximum –20dB spectral width	nm	0.2
Minimum SMSR	dB	35
Maximum dispersion	ps/nm	12800
Eye pattern mask	-	Compliant with G.957
Receiver parameter specifications at point Rn		

Parameters	Unit	Specifications	
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

The optical interface parameter specifications of the TRC1 are listed in Table 6-43.

6.8.12 LWM and LWMR

Table 6-44 Optical interface parameter specifications at the client side of the LWM board

Parameters	Unit	Specifications		
Optical interface rate	-	STM-1/4/16, OC-3/12/48	STM-1/4/16, OC-3/12/48	STM-1/4/16, OC-3/12/48
Line code format	-	NRZ	NRZ	NRZ
Optical source type	-	MLM	SLM	SLM
Target distance	km	2	15	80
Transmitter parameter specifications at point S				
Working wavelength range	nm	1260–1360	1260–1360	1500–1580
Maximum mean launched power	dBm	–3	0	+3
Minimum mean launched power	dBm	–10	–5	–2
Minimum extinction ratio	dB	+8.2	+8.2	+8.2
Maximum –20 dB spectrum width	nm	1	1	1
Minimum side-mode suppression ratio	dB	NA	30	30
Dispersion tolerance	ps/nm	NA	NA	1600
Eye pattern mask	-	Compliant with G.957	Compliant with G.957	Compliant with G.957
Receiver parameter specifications at point R				
Receiver type	-	PIN	PIN	APD

Parameters	Unit	Specifications		
operating wavelength range	nm	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–18	–18	–28
Receiver overload	dBm	–3	0	–9
Maximum reflectance	dB	–27	–27	–27
Jitter characteristics	NA	Compliant with G.783		

Table 6-45 Optical interface parameter specifications at DWDM side of the LWM board

Parameters	Unit	Specifications	
Channel spacing	GHz	100	
Line code format	-	NRZ	
Transmitter parameter specifications at point Sn			
Maximum mean launched power	dBm	0	
Minimum mean launched power	dBm	–10	
Minimum extinction ratio	dB	+10	
Central frequency	THz	192.10–196.00	
Central frequency deviation	GHz	±10	
Maximum –20dB spectral width	nm	0.2	
Minimum SMSR	dB	35	
Maximum dispersion	ps/nm	12800	
Eye pattern mask	-	Compliant with G.957	
Receiver parameter specifications at point Rn			
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

The parameter specifications of the LWMR board are the same as that of the LWM board on the DWDM side.

6.8.13 LWX and LWXR

Table 6-46 Optical interface parameter specifications at the client side of the LWX board

Parameters	Unit	Specifications		
Optical interface rate	-	34M–2.7G	34M–2.7G	34M–2.7G
Line code format	-	NRZ	NRZ	NRZ
Optical source type	-	MLM	SLM	SLM
Target distance	km	2	15	80
Transmitter parameter specifications at point S				
Working wavelength range	nm	1260–1360	1260–1360	1500–1580
Maximum mean launched power	dBm	–3	0	+3
Minimum mean launched power	dBm	–10	–5	–2
Minimum extinction ratio	dB	+8.2	+8.2	+8.2
Maximum –20 dB spectrum width	nm	1	1	1
Minimum side-mode suppression ratio	dB	NA	30	30
Dispersion tolerance	ps/nm	NA	NA	1600
Eye pattern mask	-	Compliant with G.957	Compliant with G.957	Compliant with G.957
Receiver parameter specifications at point R				
Receiver type	-	PIN	PIN	APD
operating wavelength range	nm	1200–1650	1200–1650	1200–1650
Receiver sensitivity	dBm	–18	–18	–28
Receiver overload	dBm	–3	0	–9
Maximum reflectance	dB	–27	–27	–27

Table 6-47 Optical interface parameter specifications at the DWDM side of the LWX board

Parameters	Unit	Specifications	
Channel spacing	GHz	100	
Line code format	-	NRZ	
Transmitter parameter specifications at point Sn			
Maximum mean launched power	dBm	0	
Minimum mean launched power	dBm	–10	
Minimum extinction ratio	dB	+10	
Central frequency	THz	192.10–196.00	
Central frequency deviation	GHz	±10	
Maximum –20dB spectral width	nm	0.2	
Minimum SMSR	dB	35	
Maximum dispersion	ps/nm	12800	
Eye pattern mask	-	Compliant with G.957	
Receiver parameter specifications at point Rn			
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

The parameter specifications of the LWXR board are the same as that of the LWX board on the DWDM side.

6.8.14 LDG

Table 6-48 Optical interface parameter specifications at the client side of the LDG board

Parameters	Unit	Specifications	
Optical interface rate	Gbit/s	1.25	
Transmitter parameter specifications at point S			
Laser operating wavelength	nm	1270–1355	770–860
Maximum mean launched power	dBm	–3.0	0
Minimum mean launched power	dBm	–11.5	–9.5
Minimum extinction ratio	dB	+9	+9
Receiver parameter specifications at point R			
operating wavelength range	nm	1270–1355	770–860
Receiver sensitivity	dBm	–19	–17
Receiver overload	dBm	–3	0
Maximum reflectance	dB	–12	–12

Table 6-49 Optical interface parameter specifications at the DWDM side of the LDG board

Parameters	Unit	Specifications
Channel spacing	GHz	100
Line code format	-	NRZ
Transmitter parameter specifications at point Sn		
Maximum mean launched power	dBm	0
Minimum mean launched power	dBm	–10
Minimum extinction ratio	dB	+10
Central frequency	THz	192.10–196.00
Central frequency deviation	GHz	±10
Maximum –20dB spectral width	nm	0.2
Minimum SMSR	dB	35
Maximum dispersion	ps/nm	12800
Eye pattern mask	-	Compliant with G.957
Receiver parameter specifications at point Rn		

Parameters	Unit	Specifications	
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

6.8.15 FDG

Table 6-50 Optical interface parameter specifications at the client side of the FDG board

Parameters	Unit	Specifications	
Optical interface rate	Gbit/s	1.25	
Transmitter parameter specifications at point S			
Laser operating wavelength	nm	1270–1355	770–860
Maximum mean launched power	dBm	–3.0	0
Minimum mean launched power	dBm	–11.5	–9.5
Minimum extinction ratio	dB	+9	+9
Receiver parameter specifications at point R			
operating wavelength range	nm	1270–1355	770–860
Receiver sensitivity	dBm	–19	–17
Receiver overload	dBm	–3	0
Maximum reflectance	dB	–12	–12

Table 6-51 Optical interface parameter specifications at the DWDM side of the FDG board

Parameters	Unit	Specifications
Channel spacing	GHz	100
Line code format	-	NRZ
Transmitter parameter specifications at point Sn		
Maximum mean launched power	dBm	0
Minimum mean launched power	dBm	–10

Parameters	Unit	Specifications	
Minimum extinction ratio	dB	+10	
Central frequency	THz	192.10–196.00	
Central frequency deviation	GHz	±10	
Maximum –20dB spectral width	nm	0.2	
Minimum SMSR	dB	35	
Maximum dispersion	ps/nm	12800	
Eye pattern mask	-	Compliant with G.957	
Receiver parameter specifications at point Rn			
Receiver type	-	APD	PIN
Working wavelength range	nm	1200–1650	1200–1650
Receiver sensitivity	dBm	–25	–18
Receiver overload	dBm	–9	0
Maximum reflectance	dB	–27	–27

6.8.16 Jitter Transfer Characteristics

The OTU has the same jitter transfer characteristics as the SDH regenerator. Its jitter transfer function should be below the curve shown in Figure 6-2. For its parameter specifications, refer to Table 6-52.

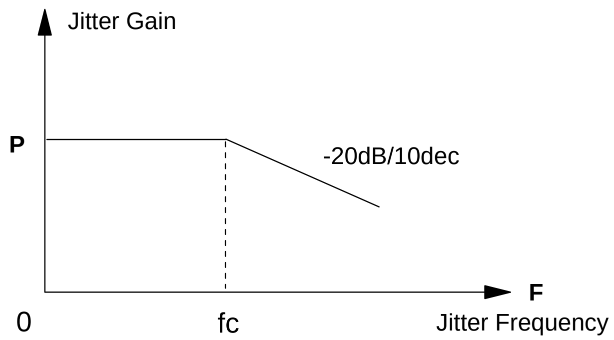


Figure 6-2 OTU jitter transfer characteristics

Table 6-52 OTU jitter transfer characteristics parameter specifications

STM Level	Fc (kHz)	P (dB)
STM-1/OC-3 (A)	130	0.1
STM-4/OC-12 (A)	500	0.1

STM Level	Fc (kHz)	P (dB)
STM-16/OC-48 (A)	2000	0.1
STM-64/OC-192 (A)	1000	0.1

When the OTU with out-band FEC function is employed, the jitter transfer function should be tested by a pair of OTUs, that is, an OTU with coding function and an OTU with decoding function are combined (P = 0.2 dB) to peform the test. See Figure 6-3.

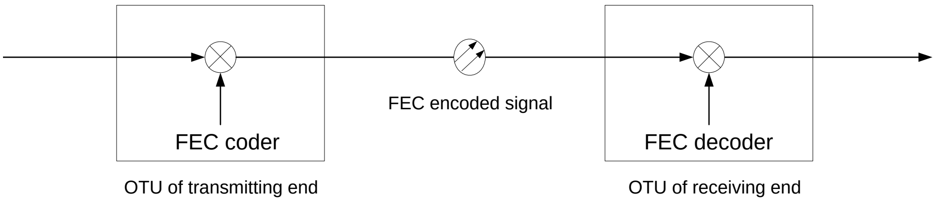


Figure 6-3 OTU with out-band FEC function

6.8.17 Input Jitter Tolerance

The OTU is able to tolerate the input jitter pattern shown in Figure 6-4. The parameter specifications are given in Table 6-53.

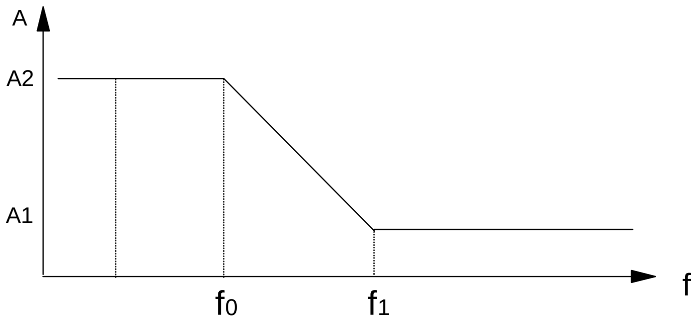


Figure 6-4 OTU input jitter tolerance

Table 6-53 OTU input jitter tolerance parameter specifications

STM Level	f_1 (kHz)	f_0 (kHz)	A_1 (kHz)	A_2 (kHz)
STM-1/OC-3 (A)	6.5	65	0.15	1.5
STM-4/OC-12 (A)	25	250	0.15	1.5
STM-16/OC-48 (A)	1,000	100	0.15	1.5
STM-64/OC-192 (A)	4,000	400	0.15	1.5

6.8.18 Jitter Generation

Jitter generation for the OTU should be in compliance with the requirements listed in Table 6-54.

Table 6-54 Jitter generation parameter specifications for OTU

STM Level	Interface Measurement band		Peak-peak amplitude (UI)
	High-pass (KHz)	Low-pass (MHz)	
STM-1/OC-3 (A)	0.5	1.3	0.3
	65	1.3	0.1
STM-4/OC-12 (A)	1	5	0.3
	250	5	0.1
STM-16/OC-48 (A)	5	20	0.30
	1000	20	0.10
STM-64/OC-192 (A)	20	80	0.30
	4000	80	0.10

6.9 Optical Multiplexer/Demultiplexer/Add and Drop multiplexer

The parameter specifications of the optical multiplexer M40/V40 and demultiplexer D40 provided by Huawei comply with ITU-T G.671, ITU-T G.692 and related recommendations.

6.9.1 M40 and V40

The parameter specifications of the M40 and V40 are listed in Table 6-55.

Table 6-55 Parameter specifications of the M40 and V40

Parameters	Unit	Specifications (40-channel)
Channel spacing	GHz	100
Insertion loss	dB	<8 /10 (Note 1)
Reflectance	dB	<–40
Working wavelength range	nm	1529–1561/1570–1604 (Note 2)
Isolation (adjacent channels)	dB	>22
Isolation (non-adjacent channels)	dB	>25

Parameters	Unit	Specifications (40-channel)
Polarization dependent loss (PDL)	dB	<0.5
Temperature characteristics	pm/°C	<2
Maximum channel insertion loss difference	dB	<3

Note: (1) The value 8 is for the M40 while the value 10 is for the V40. Before delivery, the VOA value of each channel in the V40 is set as 3 dB. Thus, the value of insertion loss may be 13 dB in testing. The VOA value can be adjusted according to the actual requirement.
(2) The wavelength of the C-band multiplexer ranges from 1529 nm to 1561 nm, and that of the L-band multiplexer ranges from 1570 nm to 1604 nm.

6.9.2 D40

The parameter specifications of the D40 board are listed in Table 6-56.

Table 6-56 Parameter specifications of the D40

Parameters	Unit	Specifications (40-channel)
Channel spacing	GHz	100
Insertion loss	dB	<8
Reflectance	dB	<–40
Isolation (adjacent channels)	dB	>25
Isolation (non-adjacent channels)	dB	>25
Polarization dependent loss (PDL)	dB	<0.5
Temperature characteristics	pm/°C	<2
Maximum channel insertion loss difference	dB	<3
–1dB spectral width	nm	>0.2
–20dB spectral width	nm	<1.4

6.9.3 MR2

The MR2 provided by Huawei is of the multi-layer dielectric film interference filter type. Its parameter specifications are listed in Table 6-57.

Table 6-57 Parameter specifications of the MR2

Parameters	Unit	Specifications
Channel spacing	GHz	100GHz

Parameters	Unit	Specifications
Working wavelength range	nm	C band: 1529–1570
1dB spectral width	nm	>0.2
Insertion loss of Add/Drop wavelength channel	dB	<2.5
Insertion loss of pass-through channel	dB	<3.0
Isolation of adjacent channels	dB	>25
Return loss	dB	≥40
Polarization dependent loss (PDL)	dB	<0.2
Polarization mode dispersion (PMD)	ps	≤0.15
Maximum input power	dBm	24
Working temperature	°C	–5 to +55
Temperature characteristics	pm/°C	<2
Insertion variation with temperature	dB/°C	<0.006

6.9.4 DWC

The parameters of the DWC board are listed in Table 6-58.

Table 6-58 Parameters of the DWC board

Parameters		Indices	Unit
Channel spacing		100	GHz
Working wavelength range		1529–1561	nm
Working wavelength number		40	-
Channel attenuation range		0–15	dB
Insertion loss	IN-DROP	≤8.0	dB
	IN-MO (Note1)	≤12.0	dB
	MI-OUT	≤2.0	dB
	ADD-OUT	≤8.0	dB
Insertion loss uniformity		1.0	dB
–0.5 dB bandwidth(Pass bandwidth)		> 50	GHz
Block extinction ratio		> 35	dB

Parameters	Indices	Unit
PMD	< 0.5	ps
PDL	< 0.7	dB
Return loss	> 40	dB
Maximum input optical power	25	dBm
Module response time	< 50	ms

Note1: This is the insertion loss when the build-in VOA is set to 0.

6.10 Other Units

6.10.1 FIU

The parameter specifications of the FIU provided by Huawei comply with related ITU-T recommendations. They are listed in Table 6-59, Table 6-60, Table 6-61 and Table 6-62.

Table 6-59 Parameter specifications of FIU-01(C+L+1510)

Parameters	Unit	Specifications
Working wavelength range	nm	C-band: 1529–1561
		L-band: 1570–1604
		Supervisory channel in C-band: 1500–1520
Insertion loss	dB	IN→TC: ≤ 1.5
		IN→TL: ≤ 1.5
		RC→OUT: ≤ 1.5
		RL→OUT: ≤ 1.5
		IN→TM (@λM): < 2.0
		RM→OUT(@λM): < 2.0
Isolation	dB	IN to TM (@ λC): > 40
		IN to TC (@ λL:) > 35
		IN to TC (@ λM): > 20
		IN to TL (@ λC): > 40
Return loss	dB	> 40
Directivity	dB	> 55

Parameters	Unit	Specifications
Polarization dependent loss (PDL)	dB	< 0.2

Note1: @λM, indicates the measured value of the 1510-nm optical supervisory signals.
@λC, indicates the measured value of the C－band optical signals.
@λL, indicates the measured value of the L－band optical signals.

Table 6-60 Parameter specifications of FIU-02(C+L+1510+1625)

Parameters	Unit	Specifications
Working wavelength range	nm	C-band: 1529–1561
		L-band: 1570–1604
		Supervisory channel in C-band: 1500–1520
		Supervisory channel in L-band: 1615–1635
Insertion loss	dB	IN→TC: ≤ 1.5
		IN→TL: ≤ 1.5
		RC→OUT: ≤ 1.5
		RL→OUT: ≤ 1.5
		IN→TM (@λM): < 2.0
		IN→TMB(@λMB): < 2.0
		RM→OUT(@λM): < 2.0
		RMB→OUT(@λMB): < 2.0
Isolation	dB	IN to TM (@ λC): > 40
		IN to TMB (@ λL): > 40
		IN to TC (@ λL): > 35
		IN to TC (@ λM): > 20
		IN to TL (@ λC): > 40
		IN to TL (@ λMB): > 12
Return loss	dB	> 40
Directivity	dB	> 55
Polarization dependent loss (PDL)	dB	< 0.2

Note1: @ λMB, indicates the measured value of the 1625-nm optical supervisory signals.

Table 6-61 Parameter specifications of FIU-03/06 (C+1510)

Parameters	Unit	Specifications
Working wavelength range	nm	C-band: 1529–1561
		Supervisory channel in C-band: 1500–1520
Insertion loss	dB	IN→TC: ≤ 1.0
		RC→OUT: ≤ 1.0
		IN→TM (@λM): < 1.5
		RM→OUT(@λM): < 1.5
Isolation	dB	IN to TM (@ λC): > 40
		IN to TC (@ λM): > 12
Return loss	dB	> 40
Directivity	dB	> 55
Polarization dependent loss (PDL)	dB	< 0.2

Table 6-62 Parameter specifications of FIU-04 (L+1625)

Parameters	Unit	Specifications
Working wavelength range	nm	L-band: 1570–1604
		Supervisory channel in L-band: 1615–1635
Insertion loss	dB	IN→TL: ≤ 1.0
		RL→OUT: ≤ 1.0
		IN→TMB (@λMB): < 1.5
		RMB→OUT(@λMB): < 1.5
Isolation	dB	IN to TMB (@ λL): > 40
		IN to TL (@ λMB): > 12
Return loss	dB	> 40
Directivity	dB	> 55
Polarization dependent loss (PDL)	dB	< 0.2

6.10.2 ITL

The parameter specifications of the ITL provided by Huawei comply with related ITU-T recommendations. Its parameter specifications are listed in Table 6-63.

Table 6-63 Parameter specifications of ITL

Parameters	Unit	Specifications
Working wavelength range	nm	C-band: 1529.16–1560.61
		L-band: 1570.42–1603.57
Input channel spacing (Note1)	GHz	100
Output channel spacing (Note1)	GHz	50
Insertion loss	dB	< 3
Maximum channel insertion loss difference	dB	< 1
Isolation	dB	> 25
Return loss	dB	> 40
Directivity	dB	> 55
Polarization mode dispersion (PMD)	ps	< 0.5
Polarization dependent loss (PDL)	dB	< 0.5
Input optical power range	dBm	≤ 24

Note1: Input and output are defined according to the multiplexing process of the ITL.

Instead of using an interleaver, a coupler can be used for multiplexing to achieve a 50-GHz channel spacing system.

6.10.3 OCP

Table 6-64 OCP board specifications

Item	Unit	Value
Range of wavelength	nm	1290~1330 1530~1565
Insertion loss (working channel)	dB	<4
Insertion loss (protection channel)	dB	<5.5

6.10.4 OLP

Table 6-65 OLP board specifications

Parameters		Unit	Specifications
Insertion loss at the receive end	TI-TO1 TI-TO2	dB	< 4
Insertion loss at the receive end	RI1-RO RI2-RO	dB	< 1.5
Range of the input optical power		dBm	–35 to 7
Alarm threshold of optical power difference		dB	3
Switching threshold of optical power difference		dB	5

6.10.5 SCS

Table 6-66 SCS board specifications

Parameters	Unit	Specifications
Single-mode insertion loss	dB	< 4
Multimode insertion loss	dB	< 4.5

6.10.6 GFU

The parameter specifications of the GFU board are listed in Table 6-67, Table 6-68 and Table 6-69.

Table 6-67 Parameter specifications of GFU01 and GFU02

Parameters	Unit	Specifications
Working wavelength range	nm	1529–1561
Channel insertion loss	dB	1.5–12
Polarization dependent loss (PDL)	dB	≤ 0.5

Table 6-68 Parameter specifications of GFU03

Parameters	Unit	Specifications
Working wavelength range	nm	1529–1561
Channel insertion loss	dB	1.0–5.0
Polarization dependent loss (PDL)	dB	≤ 0.5

Table 6-69 Parameter specifications of GFU04

Parameters	Unit	Specifications
Working wavelength range	nm	1529–1561
Channel insertion loss	dB	0.5–6.0
Polarization dependent loss (PDL)	dB	≤ 0.5

6.10.7 DGE

The parameter specifications of the DGE board are listed in Table 6-70.

Table 6-70 Parameter specifications of DGE

Parameters	Unit	Specifications
Working wavelength range	nm	1529–1561
Dynamic attenuation range	dB	6–21
Fixed insertion loss	dB	<6

6.10.8 DSE

The parameter specifications of the DSE board are listed in Table 6-71.

Table 6-71 Parameter specifications of DSE

Parameters	Unit	Specifications
Working wavelength range	nm	1529–1570
Fixed insertion loss	dB	<3.0

6.10.9 VOA

Table 6-72 VOA board specifications

Parameters	Unit	Specifications
Attenuation range	dB	2–20
Adjustment accuracy	dB	0.5

6.10.10 VA4

Table 6-73 VA4 board specifications

Parameters	Unit	Specifications
Attenuation range	dB	2–20
Adjustment accuracy	dB	0.5

6.10.11 MCA

The parameter specifications of the MCA board are listed in Table 6-74.

Table 6-74 Parameter specifications of MCA

Parameters	Unit	Specifications
Working wavelength range	nm	C-band: 1529–1561
		L-band: 1570–1604
Detect range for single channel optical power	dBm	–10 to –30
Detect accuracy for optical power	dBm	±1.5
OSNR accuracy	dB	±1.5 (OSNR detect range: 13 to 19) ±2 (OSNR detect range: 19 to 23)
Detect accuracy for central wavelength	nm	±0.1

Note: The OSNR detection function of the MCA is supported by the NRZ/CRZ system with a channel spacing of 100 GHz and the NRZ system with a channel spacing of 50 GHz. It is not supported by the CRZ system with a channel spacing of 50 GHz. The MCA in the CRZ system with a channel spacing of 50 GHz only supports the function to detect the power and the center wavelength..

6.10.12 OSC

Table 6-75 Optical interface parameter specifications of OSC

Parameters		Specifications	
Type		Normal power	High power
Working wavelength range (nm)		C band: 1500–1520 or L band: 1615–1635	C band: 1500–1520
Signal rate (Mbit/s)	SC1/SC2	2.048	2.048
	TC1/TC2	8.192	8.192
Line code format		CMI	CMI
Launched power (dBm)		–7 to 0	5 to 10
Optical source type		MLM LD	MLM LD
Minimum receiver sensitivity (dBm) (BER=1×10^{-12})	SC1/SC2	–48	–48
	TC1/TC2	–48	–48

6.10.13 FMU

Table 6-76 Parameter specifications of FMU

Item	Unit	Index	
		Online monitor	**Standby fibre monitor**
Test wavelength	nm	1310 ±25	1550 ±25
OTDR dynamic range	dB	39.5 (Note1)	38.5 (Note 1)
Event dead zone	m	10 (Note 2)	
Attenuation dead zone	m	30 (Note 3)	
Pulse width		10ns, 30ns, 100ns, 300ns, 1µs, 3µs, 10µs, 20µs	10ns, 30ns, 100ns, 300ns, 1µs, 3µs, 10µs, 20µs
Pulse output power	dBm	≤ 20	
Distance accuracy	m	±1m±5 x 10^{-5} x test distance ± spacing between the sample points (not including the group index error)	
Readout resolution	dB	0.001	
Reflection measurement resolution	dB	±2.0	

Item	Unit	Index	
		Online monitor	Standby fibre monitor
Linearity	dB/dB	±0.05	
Group index		1.400–1.700	
Working temperature	°C	–5 to +55	

Note1: The loss brought by online optical switch and the coupler is considered for the FMU. The dynamic value is 1–2 dB smaller than the value of the OTDR component. Besides, the OTDR effective dynamic range in online monitor mode is different from that in standby fibre monitor mode.
Note2: Test conditions: The pulse width of the test signal is 10 ns; the return loss is not more than –35 dB.
Note3: Test conditions: The pulse width of the test signal is 10 ns; the return loss is not more than –35 dB.

6.10.14 MWF

Table 6-77 Parameter specifications of MWF

Item	Unit	Index
Passband wavelength range	nm	1500–1635
Stopband wavelength range	nm	1280–1340
Passband insertion loss (including that of the connector)	dB	1.2
Flatness (whole working wavelength range)	dB	0.4
Isolation (passband versus stopband)	dB	≥ 40
Return loss	dB	≥ 40
Polarization dependent loss	dB	≤ 0.1
Polarization mode dispersion	ps	≤ 0.1
Maximum input power	dBm	27
Working temperature	°C	–5 to +55

6.10.15 MWA

Table 6-78 Index requirement of the MWA

Item	Unit	Index
Wavelength range of the transmission channel	nm	1500–1635
Wavelength range of the reflection channel	nm	1280–1340

Item	Unit	Index
Insertion loss of the transmission channel (including that of the connector)	dB	1.2
Insertion loss of the reflection channel (including that of the connector)	dB	1.0
Flatness (whole working wavelength range)	dB	0.4
Isolation (transmission channel vs reflection channel)	dB	≥ 40
Isolation (reflection channel vs transmission channel)	dB	≥ 40
Return loss	dB	≥ 45
Directivity	dB	≥ 55
Polarization dependent loss	dB	≤ 0.1
Polarization mode dispersion	ps	≤ 0.1
Maximum input power	dBm	27
Working temperature	°C	–5 to +55

6.11 DCM

Currently, different DCM types are available for both C and L bands. Their parameter specifications are listed in Table 6-79, Table 6-80 and Table 6-81.

Table 6-79 Performance requirement of dispersion compensation optical fibre of C-band (G.652 fibre)

Item / Type	Distance (km)	Max. insertion loss(dB)	DSCR	PMD (ps)	PDL (dB)	Max. allow power (dBm)	Operation wavelength (nm)
DCM(A)	20	4	90%–110%	0.4	0.1	20	1525–1565
DCM(B)	40	5		0.5	0.1	20	
DCM(C)	60	7		0.6	0.1	20	
DCM(D)	80	8		0.7	0.1	20	
DCM(E)	100	9		0.8	0.1	20	
DCM(F)	120	10		0.8	0.1	20	
DCM(S)	5	2.5		0.3	0.1	20	

The DCM(S) is only used in a system with Super CRZ line encoding.

Table 6-80 Performance requirement of dispersion compensation optical fibre of L-band (G.652 fibre)

Item / Type	Distance (km)	Max. insertion loss(dB)	DSCR	PMD (ps)	PDL (dB)	Max. allow power (dBm)	Operation wavelength (nm)
DCM(A)	20	4	90%–110 %	0.6	0.1	20	1570–1605
DCM(B)	40	5.3		0.9	0.1	20	
DCM(C)	60	7		1.0	0.1	20	
DCM(D)	80	8.4		1.0	0.1	20	

Table 6-81 Performance requirement of dispersion compensation optical fibre of C-band (G.655 LEAF fibre)

Item / Type	Distance (km)	Max. insertion loss(dB)	DSCR	PMD (ps)	PDL (dB)	Max. allow power (dBm)	Operation wavelength (nm)
DCM(A)	20	4	90%–110%	0.4	0.3	24	1525–1565
DCM(B)	40	5		0.5	0.3	24	
DCM(C)	60	6		0.6	0.3	24	
DCM(D)	80	7		0.7	0.3	24	
DCM(E)	100	8		0.8	0.3	24	

6.12 Channel Allocation

Table 6-82 C-band channel allocation (80 channels with 50GHz spacing)

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
196.05	1529.16	194.05	1544.92
196.00	1529.55	194.00	1545.32
195.95	1529.94	193.95	1545.72
195.90	1530.33	193.90	1546.12
195.85	1530.72	193.85	1546.52
195.80	1531.12	193.80	1546.92
195.75	1531.51	193.75	1547.32
195.70	1531.90	193.70	1547.72

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
195.65	1532.29	193.65	1548.11
195.60	1532.68	193.60	1548.51
195.55	1533.07	193.55	1548.91
195.50	1533.47	193.50	1549.32
195.45	1533.86	193.45	1549.72
195.40	1534.25	193.40	1550.12
195.35	1534.64	193.35	1550.52
195.30	1535.04	193.30	1550.92
195.25	1535.43	193.25	1551.32
195.20	1535.82	193.20	1551.72
195.15	1536.22	193.15	1552.12
195.10	1536.61	193.10	1552.52
195.05	1537.00	193.05	1552.93
195.00	1537.40	193.00	1553.33
194.95	1537.79	192.95	1553.73
194.90	1538.19	192.90	1554.13
194.85	1538.58	192.85	1554.54
194.80	1538.98	192.80	1554.94
194.75	1539.37	192.75	1555.34
194.70	1539.77	192.70	1555.75
194.65	1540.16	192.65	1556.15
194.60	1540.56	192.60	1556.55
194.55	1540.95	192.55	1556.96
194.50	1541.35	192.50	1557.36
194.45	1541.75	192.45	1557.77
194.40	1542.14	192.40	1558.17
194.35	1542.54	192.35	1558.58
194.30	1542.94	192.30	1558.98
194.25	1543.33	192.25	1559.39

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
194.20	1543.73	192.20	1559.79
194.15	1544.13	192.15	1560.20
194.10	1544.53	192.10	1560.61

The odd number wavelengths belong to the C-ODD band and the even number wavelengths belong to the C-EVEN band.

Table 6-83 L-band channel allocation (80 channels with 50GHz spacing)

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
190.90	1570.42	188.90	1587.04
190.85	1570.83	188.85	1587.46
190.80	1571.24	188.80	1587.88
190.75	1571.65	188.75	1588.30
190.70	1572.06	188.70	1588.73
190.65	1572.48	188.65	1589.15
190.60	1572.89	188.60	1589.57
190.55	1573.30	188.55	1589.99
190.50	1573.71	188.50	1590.41
190.45	1574.13	188.45	1590.83
190.40	1574.54	188.40	1591.26
190.35	1574.95	188.35	1591.68
190.30	1575.37	188.30	1592.10
190.25	1575.78	188.25	1592.52
190.20	1576.20	188.20	1592.95
190.15	1576.61	188.15	1593.37
190.10	1577.03	188.10	1593.79
190.05	1577.44	188.05	1594.22
190.00	1577.86	188.00	1594.64
189.95	1578.27	187.95	1595.06
189.90	1578.69	187.90	1595.49

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
189.85	1579.10	187.85	1595.91
189.80	1579.52	187.80	1596.34
189.75	1579.93	187.75	1596.76
189.70	1580.35	187.70	1597.19
189.65	1580.77	187.65	1597.62
189.60	1581.18	187.60	1598.04
189.55	1581.60	187.55	1598.47
189.50	1582.02	187.50	1598.89
189.45	1582.44	187.45	1599.32
189.40	1582.85	187.40	1599.75
189.35	1583.27	187.35	1600.17
189.30	1583.69	187.30	1600.60
189.25	1584.11	187.25	1601.03
189.20	1584.53	187.20	1601.46
189.15	1584.95	187.15	1601.88
189.10	1585.36	187.10	1602.31
189.05	1585.78	187.05	1602.74
189.00	1586.20	187.00	1603.17
188.95	1586.62	186.95	1603.57

The odd number wavelengths belong to L-ODD band and the even number wavelengths belong to L-EVEN band.

Table 6-84 C-band channel allocation of 8-channel system (G.653 fibre)

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
192.10	1560.61	195.10	1536.61
192.30	1558.98	195.50	1533.47
192.60	1556.55	195.80	1531.12
193.00	1553.33	196.00	1529.55

Table 6-85 C-band channel allocation of 12-channel system (G.653 fibre)

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
192.10	1560.61	194.00	1545.32
192.20	1559.79	194.10	1544.53
192.40	1558.17	195.30	1535.04
192.80	1554.94	195.70	1531.90
193.00	1553.33	195.90	1530.33
193.10	1552.52	196.00	1529.55

Table 6-86 C-band channel allocation of 16-channel system (G.653 fibre)

Central frequency (THz)	Central wavelength (nm)	Central frequency (THz)	Central wavelength (nm)
192.10	1560.61	195.00	1537.40
192.20	1559.79	195.10	1536.61
192.30	1558.98	195.40	1534.25
192.40	1558.17	195.50	1533.47
192.60	1556.55	195.70	1531.90
192.70	1555.75	195.80	1531.12
193.00	1553.33	195.90	1530.33
193.10	1552.52	196.00	1529.55

6.13 Electromagnetic Compatibility (EMC)

Strictly followed international standards and EMC measures, the OptiX BWS 1600G is suitable for any kinds of telecommunication networks and markets.

Electromagnetic Safety Standards

CSA C22.2 No. 950

UL 1950

EN 60950, Safety of Information Technology Equipment

EN 60825–1 Safety of Laser Products - Part 1: Equipment Classification, Requirements and User's Guide

EN 60825–2 Safety of Laser Products - Part 2: Safety of Optical Fibre Communication Systems

EMC Standards

ETSI EN300 386–1.2.1 (2000)	-
CISPR55022 (1999)	-
FCC PART 15 including:	-
Radiation emission (RE):	CISPR22, ETSI EN 300 127 (V1.2.1)
Conduction emission (CE):	CISPR22, ETSI EN 300 386-–1.2.1
Electric static discharge (ESD):	IEC61000–4–2
Fast transient pulse string (EFT/B):	IEC61000–4–4
Conductive susceptibility (CS):	IEC61000–4–6
Radiation sensitivity (RS):	IEC61000–4–3
Surge:	IEC61000–4–5
Voltage drop (DIP):	IEC61000–4–29 (DC)
Power induction (PI):	ITU K.20
Power magnetic field sensitivity (PMS):	IEC61000–4–8
These standards are applied for communication equipment production:	
IEC 61000–4–6 (1996)	-
IEC 61000–4–3 (1995)	-
IEC 61000–4–2 (1995)	-
IEC 61000–4–5 (1995)	-
IEC 61000–4–8 (1993)	-
IEC 61000–4–29 (2000)	-
IEC 61000–4–4 (1995)	-
IEC 61000–3–2 (1995)	-
IEC 61000–3–3 (1995)	-
ETSI EN 300 127 (V1.2.1)	-
ITU k.20	-

6.14 Environment Requirement

This environment requirement is set by referring to the following international standards:

(1) GF 014–95: Environment conditions of the telecommunication equipment room

(2) ETS 300 019–1–3: Class 3.2 Partly temperature-controlled locations

(3) NEBS GR–63-CORE: Network Equipment-Building System (NEBS) Requirements: Physical Protection

6.14.1 Storage Environment

Climate Environment

Table 6-87 Requirements for climate environment

Item	Range
Altitude	≤5000 m
Air pressure	70 kPa–106 kPa
Temperature	–40°C–+70°C
Temperature change rate	≤1°C /min
Relative Humidity	10%–100%
Solar radiation	≤1120 W/s^2
Heat radiation	≤600 W/s^2
Wind speed	≤30 m/s

Waterproof Requirement

(1) Equipment storage requirements at the customer site: Generally the equipment is stored indoors.

(2) Where there is no water on the floor and no water leakage on the packing boxes of the equipment. The equipment should not be stored in places where leakage is probable, such as near the auto firefighting and heating facilities.

(3) If the equipment is required to be stored outdoors, the following four conditions should be met at the same time:

- The packing boxes are intact.
- Necessary rainproof measures should have been taken to prevent rainwater from entering the packing boxes.

- There is no water on the ground where the packing boxes are stored, let alone water entering into the packing boxes.
- The packing boxes are not directly exposed to the sun.

Biologic Environment

(1) Avoiding the reproduction of animalcule, such as epiphyte and mildew.

(2) Getting rid of rodent (such as mouse).

Clarity of Air

(1) No explosive, conductive, magnetic conductive nor corrosive dust.

(2) The density of mechanical active substance complies with the requirements of Table 6-88.

Table 6-88 Requirements for the density of mechanical active substance

Mechanical active substance	Content
Suspending dust	≤5.00 mg/m³
Precipitable dust	≤20.0 mg/m²·h
Sand	≤300 mg/m³

(3) The density of chemical active substance complies with the requirements of Table 6-89.

Table 6-89 Requirements for the density of chemical active substance

Chemical active substance	Content
SO2	≤0.30 mg/m³
H2S	≤0.10 mg/m³
NO2	≤0.50 mg/m³
NH3	≤1.00 mg/m³
CI2	≤0.10 mg/m³
HCI	≤0.10 mg/m³
HF	≤0.01 mg/m³
O3	≤0.05 mg/m³

Mechanical Stress

Table 6-90 Requirements for mechanical stress

Item	Subitem	Range	
Sinusoidal vibration	Displacement	≤7.0 mm	-
	Acceleration	-	≤20.0 m/s²
	Frequency range	2 Hz–9 Hz	9 Hz–200 Hz
Non-steady impact	Impact response spectrum II	≤250 m/s²	
	Static load	≤5 kPa	

Note:

Impact response spectrum: the curve of the maximum acceleration response generated by the equipment under the stipulated impact motivation. Impact response spectrum II indicates the duration of semi sinusoidal impact spectrum is 6ms.

Static load: The pressure from upside, that the equipment with package can endure when the equipment is piled as per stipulation.

6.14.2 Transport Environment

Climate Environment

Table 6-91 Requirements for climate environment

Item	Range
Altitude	≤5000 m
Air pressure	70 kPa–106 kPa
Temperature	–40°C–+70°C
Temperature change rate	≤3°C /min
Relative Humidity	10%–100%
Solar radiation	≤1120 W/s²
Heat radiation	≤600 W/s²
Wind speed	≤30 m/s

Waterproof Requirement

The following conditions should be met during the transportation:

- The packing boxes are intact.
- Necessary rainproof measures should be taken for the means of transport to prevent rainwater from entering the packing boxes.
- There is no water in the means of transportation.

Biologic Environment

(1) Avoiding the reproduction of animalcule, such as epiphyte and mildew.

(2) Getting rid of rodent (such as mouse).

Clarity of Air

(1) No explosive, conductive, magnetic conductive nor corrosive dust.

(2) The density of mechanical active substance complies with the requirements of Table 6-92.

Table 6-92 Requirements on the density of mechanical active substance

Mechanical active substance	Content
Suspending dust	No requirement
Precipitable dust	≤3.0 $mg/m^2 \cdot h$
Sand	≤100 mg/m^3

(3) The density of chemical active substance complies with the requirements of Table 6-93.

Table 6-93 Requirements for the density of mechanical active substance

Chemical active substance	Content
SO_2	≤0.30 mg/m^3
H_2S	≤0.10 mg/m^3
NO_2	≤0.50 mg/m^3
NH_3	≤1.00 mg/m^3
CI_2	≤0.10 mg/m^3
HCI	≤0.10 mg/m^3
HF	≤0.01 mg/m^3

Chemical active substance	Content
O_3	≤0.05 mg/m³

Mechanical Stress

Table 6-94 Requirements for mechanical stress

Item	Subitem	Range		
Sinusoidal vibration	Displacement	≤7.5 mm	-	-
	Acceleration	-	≤20.0 m/s²	≤40.0 m/s²
	Frequency range	2 Hz–9 Hz	9 Hz–200 Hz	200 Hz–500 Hz
Random vibration	Acceleration spectrum density	10 m²/s³	3 m²/s³	1 m²/s³
	Frequency range	2 Hz–9 Hz	9 Hz–200 Hz	200 Hz–500 Hz
Non-steady impact	Impact response spectrum II	≤300 m/s²		
	Static load	≤10 kPa		
Note: *Impact response spectrum: the curve of the maximum acceleration response generated by the equipment under the stipulated impact motivation. Impact response spectrum II indicates the duration of semi sinusoidal impact spectrum is 6ms.* *Static load: The pressure from upside, that the equipment with package can endure when the equipment is piled as per stipulation.*				

6.14.3 Operation Environment

Climate Environment

Table 6-95 Requirements for temperature, humidity

Equipment name	Temperature		Relative humidity	
	Long-term operation	Short-term operation	Long-term operation	Short-term operation
	0°C–40°C	–5°C–45°C	10%–90%	5%–95%

Equipment name	Temperature		Relative humidity	
	Long-term operation	Short-term operation	Long-term operation	Short-term operation

Note:

Testing point of product temperature and humidity: when the cabinet of the product has no protection board in the front and at the back, the value is tested 1.5 meter above the floor and 0.4 meter in front of the cabinet.

Short-term working condition means that the successive working time does not exceed 96 hours and the accumulated time every year does not exceed 15 days.

Table 6-96 Other requirements for climate environment

Item	Range
Altitude	≤4000 m
Air pressure	70–106 kPa
Temperature change rate	≤5°C /h
Solar radiation	≤700 W/s²
Heat radiation	≤600 W/s²
Wind speed	≤1 m/s

Biologic Environment

(1) Avoiding the reproduction of animalcule, such as epiphyte and mildew.

(2) Getting rid of rodent (such as mouse).

Clarity of Air

(1) No explosive, conductive, magnetic conductive nor corrosive dust.

(2) The density of mechanical active substance complies with the requirements of Table 6-97.

Table 6-97 Requirements for the density of mechanical active substance

Mechanical active substance	Content
Dust particle	≤3 × 105 /m³
Suspending dust	≤0.4 mg/m³

Mechanical active substance	Content
Precipitable dust	≤15 mg/m²·h
Sand	≤100 mg/m³

(3) The density of chemical active substance complies with the requirements of Table 6-98.

Table 6-98 Requirements for the density of mechanical active substance

Chemical active substance	Content
SO_2	≤0.20 mg/m³
H_2S	≤0.006 mg/m³
NH_3	≤0.05 mg/m³
CI_2	≤0.01 mg/m³
HCI	≤0.10 mg/m³
HF	≤0.01 mg/m³
O_3	≤0.005 mg/m³
CO	≤5.0 mg/m³

Mechanical Stress

Table 6-99 Requirements for mechanical stress

Item	Subitem	Range	
Sinusoidal vibration	Displacement	≤3.5 mm	-
	Acceleration	-	≤10.0 m/s²
	Frequency range	2–9 Hz	9–200 Hz
Non-steady impact	Impact response spectrum II	≤100 m/s²	
	Static load	0	

Item	Subitem	Range
Note: *Impact response spectrum: the curve of the maximum acceleration response generated by the equipment under the stipulated impact motivation. Impact response spectrum II indicates the duration of semi sinusoidal impact spectrum is 6ms.* *Static load: The pressure from upside, that the equipment with package can endure when the equipment is piled as per stipulation.*		

A Measures in DWDM Network Designing

A.1 Dispersion Limited Distance

Chromatic Dispersion

Chromatic dispersion is a dominant factor restricting the transmission distance. It is caused by the characteristics of the transmitting optical source and transmission media (optical fibre).

Transmission Restriction

With the increasing transmission rate in the optical fibre system and the cascading of multiple EDFAs in the optical transmission system, the overall dispersion and related dispersion costs in the transmission link will become higher. This is a serious issue. At present, dispersion limitation has become a vital factor in deciding many system regeneration section distances. In the single module optical fibre, the dispersion mainly includes material dispersion and wave-guide dispersion, which might cause different time delays in different frequencies. In terms of time domain, this might lead to the extension of optical pulses, which can cause the interference between optical pulses. The result is the deterioration of transmitted signals.

Effect-Reducing Method

In some optical amplification sub-systems, the passive dispersion compensation device can be combined with the optical amplifier. This sub-system will add limited chromatic dispersion to the system, making the dispersion coefficient reverse to the original one and reducing the system chromatic dispersion. This device can be mounted together with EDFA to compensate for the loss related with the passive dispersion compensation. In addition, the use of G.655 and G.653 optical fibres, are beneficial to minimise the chromatic dispersion.

Network Design Consideration

During the DWDM network design, the whole network is divided into several regeneration sections. Each section should be less than the dispersion-restricted distance of the optical source. Thus the dispersion of the whole network can be tolerated.

📖 **Tips**

In dispersion calculation, for G.652 fibres, the typical dispersion coefficient in 1550 nm window is 17 ps/nm.km. In engineering design, the budget should be 20 ps/nm.km.

A.2 Signal Power

Long-distance transmission of the optical signals requires that the signal power be enough to offset optical fibre loss. It is natural, that with distance increasing, the optical power becomes less and less. This phenomenon is known as attenuation. The attenuation coefficient of the G.652 optical fibre in the 1550 nm window is generally about 0.25 dB/km. Considering the optical connector, optical fibre redundancy and other factors, the composite optical fibre attenuation coefficient is usually less than 0.275 dB/km.

In specific calculation, power budget is normally calculated between two adjacent equipments in the transmission network. The distance (loss) between two adjacent equipments in a transmission network, is called trunk distance (loss).

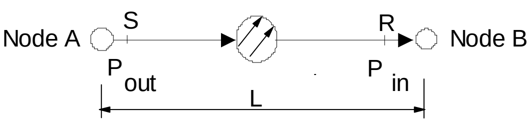


Figure A-1 Trunk loss calculation principle

If P_{out} is the output power (dBm) of a single channel at point S, and P_{in} is the minimum allowed input power (dBm) of a single channel at point R, then

Regenerator distance = $(P_{out} - P_{in}) / a$

Where “a” is the accumulative attenuation of optical cables (dB/km) per km (according to relevant ITU-T recommendation, a=0.275 dB/km).

Power budget calculations are used to determine distance between regeneration sections.

A.3 Optical Signal-to-Noise Ratio

Noise Generation Principle

The optical amplifier also generates the light signals with broad bandwidth, called amplified spontaneous emission (ASE). In a transmission system with several cascaded EDFAs, like original signals, ASE noise of the optical amplifier can be attenuated and amplified. As the entered ASE noise is amplified in each optical amplifier and is overlapped on the ASE generated by the optical amplifier, the total ASE noise power is increased in proportion to the number of optical amplifiers. The noise power might be more than the signal power.

ASE noise spectrum distribution varies with the system length. When ASE noise from the first optical amplifier is sent to the second optical amplifier, the gain distribution of the second optical amplifier will cause ASE noise due to gain saturation, which will cause gain distribution change. Similarly, the valid gain distribution of the third optical amplifier will also be changed. This effect will be transmitted to the next optical amplifier towards downstream. Even the implementation of narrow-band filter cannot avoid this noise, because the noise exists in the same band in which the original signal exists.

The optical signal-to-noise ratio (OSNR) is defined as:

OSNR =signal optical power per channel/noise optical power per channel

Transmission Restriction

ASE noise accumulation affects the system's OSNR, because the receiving signal OSNR deterioration is mainly related to ASE beat noises. Beat noises are increased linearly with the increase of optical amplifier number. Therefore, the error rate is deteriorated together with the increase of optical amplifier number. In addition, noises are accumulated as exponentially with the gain range of amplifiers.

As a result of optical amplifier gain, ASE noise spectrum with the accumulation of ASE noises from multiple optical amplifiers will have a wavelength peak caused by the spontaneous emission effect. It should be noted that in a closed full optical loop network system equivalent to innumerable optical amplifiers are cascaded, ASE noises will be infinitely accumulated. In the system with narrow band filters, the ASE accumulation will be reduced due to the filter, but the in-band ASE will be increased with the increase of optical amplifiers. Therefore, OSNR will be smaller for more optical amplifiers.

Consideration of OSNR in DWDM Network Design

(Note: This section contains additional information. You may skip this section).

For different network applications, the OSNR requirements are more or less similar, as given in Table A-1.

Table A-1 Recommended OSNR values for different spans

Amplifier cascade type	OSNR (dB)
5 × 20 dB system (5 × 72 km)	20
2 × 24 dB system (2 × 87 km)	20
1 × 28 dB system (1 × 101 km)	20

OSNR is an important factor of DWDM system error performance. For a DWDM system with multiple cascaded line optical amplifiers, the optical power of noises are mainly controlled by the ASE noises of the amplifiers.

In the actual DWDM system, the different EDFA gain might cause different output power per channel and different EDFA noise coefficient. Therefore, in designing, OSNR of the worst channel should be considered to stretch the working limits.

A.4 Other Effects

The above three factors should be considered in DWDM networking. In addition, many other factors might affect system performance, such as SBS (Stimulated Brillouin Scattering), SRS (Stimulated Raman Scattering), SPM (Self Phase Modulation), XPM (ex-Phase Modulation), FWM (Four-Wave Mixing), PMD (Polarized Mode Dispersion) and PDL (Polarisation Dependent Loss). The effect of these parameters on the system is not significant and is not considered in network designing. But in case of some unusual system response, these parameters should be checked carefully.

B Technology Introduction

B.1 FEC

The optical wavelength conversion units have forward error correction (FEC) function or Enhanced FEC (EFEC) function.

In fact, the FEC technology is the error correction technology. The OTU adopts Reed-Solomon Coding. It can correct eight byte errors at most in any location per 255 bytes, and has a fairly powerful capability of error correction. Due to redundancy codes added, the digital rate is increased. The FEC employed in the OptiX BWS 1600G is in compliance with the ITU-T G.709 or G.975 and supports the processing of overhead as stated in the ITU-T G.709.

The EFEC technology, compared with FEC, adopts much more predominant encoding/decoding technology. Two-degree encoding/decoding can evenly distribute the burst error code, and enable much more powerful error correction capability.

The FEC function can improve the OSNR budget of the DWDM transmission system and increase the transmission distance. In addition, the FEC function can reduce bit error rate in line transmission, and alleviate the effects on the signal transmission quality caused by the aging components or deterioration of fibre performance, thereby improving the communication quality of the DWDM transmission network.

B.2 SuperWDM

Introduction

SuperWDM is a transmission solution provided by Huawei DWDM products for long-haul application. Super CRZ encoding is the core technology for SuperWDM solution. It inherits all the features of RZ encoding and is enhanced with a unique phase modulation capability. Therefore, the Super CRZ encoding is capable of effectively suppressing the non-linear effects in transmission and improving the noise tolerance capability.

With the SuperWDM technology, the OptiX BWS 1600G achieves ultra long haul transmission in the absence of Raman amplification. Compared with NRZ encoding, Super CRZ encoding widens its spectrum thus effectively suppressing the non-linear effects in ultra long haul transmission. As a result, the linear transmission distance of the DWDM system without REG is greatly extended to 2000 km.

Features

- Improve the optical noise tolerance capability, increasing the receiver’s OSNR tolerance by 3 dB (compared with NRZ encoding).
- Effectively reduce the non-linear effects due to its adequate spectrum width and special phase modulation technology.
- Improve the transmission performance due to excellent clock jitter performance and higher extinction ratio.
- The application of SuperWDM technology in the system requires excellent dispersion management.

B.3 Raman Amplification

The Raman amplifier is an important application of stimulated Raman scattering (SRS). Quartz fibre has a very broad SRS gain spectrum. It has a broad peak near the frequency of 13 THz. If a weak signal and a strong pump light are transmitted in the fibre simultaneously, and their frequency difference is within the range of Raman gain spectrum, the weak signal beam can be amplified. The gain spectrum of the fibre Raman amplifier is shown in the Figure B-1.

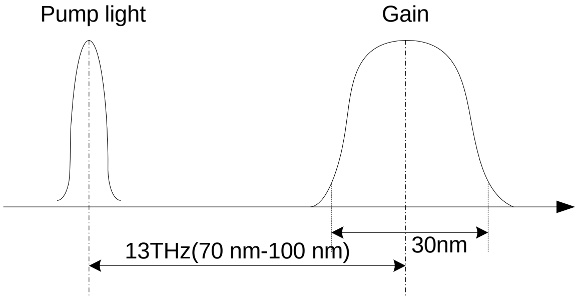


Figure B-1 Raman amplifier gain spectrum

The fibre Raman amplifier is always used with the EDFA amplifier at the receive end. It adopts distributed amplification mechanism for extra long haul and extra long span applications, as shown in Figure B-2.

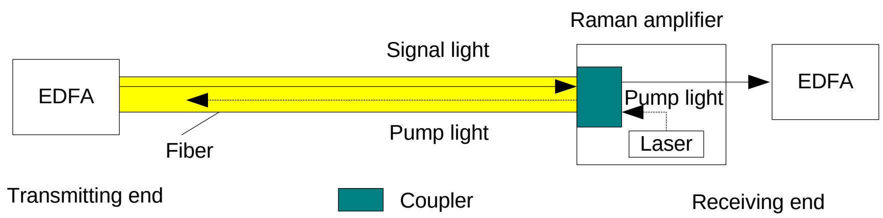


Figure B-2 Raman amplification application in OptiX BWS 1600G system

Usually the optical fibre Raman amplifier is used at the receive end of DWDM system to amplify optical signals. Mainly composed of pumping lasers, the Raman amplifier works in a way of counter pumping.

Note

Counter pumping means the pump light is injected at the fibre end and the direction is opposite to the main signals. This kind of pumping achieves a big phase difference between the main signals and the pump light. And the Raman pump power vibration is leveled in the direction opposite to signal transmission, thus effectively suppressing the noise created by the pump.

C Glossary

This document defines the following terms:

Numerics

3R	Regenerating, Reshaping and Retiming.

A

ADM	Add/Drop Multiplexing. Network elements that provide access to all, or some subset of the constituent signals contained within an STM-N signal. The constituent signals are added to (inserted), and/or dropped from (extracted) the STM-N signal as it passed through the ADM.
Administrator	A user who has access rights to all the Management Domains of the EMLCore product. He has access to the whole network and to all the management functionalities.
Agent	Agent is used to describe the entity that represents certain attributes and behaviour of a resource. The agent allows interaction between various resources and management and control functions. More than one agent may represent a resource.
Alarm boolean value	The value to alarm, which set to define, simplify and manipulate logical function based on statements which are true or false.
Attenuator	A passive component that produces a controlled signal attenuation in an optical fiber transmission line.

B

Bandwidth	The highest frequency that can be transmitted by an analog system. Also, the information-carrying capacity of a system (especially for digital systems).

C

Chain network	Type of network that all network nodes are connected one after one to be in series.
CRZ	Chirped Return to Zero.

D

DCC	Data Communication Channel. Within an STM-N signal there are two DCC channels, comprising bytes D1-D3, giving a 192 kbit/s channel, and bytes D4-D12, giving a 576 kbit/s channel. D1-D3 (DCCR) are accessible by all SDH NEs whereas D4-D12 (DCCM), not being part of the regenerator section overhead, are not accessible at regenerators.
DCF	Data Communication Function.
DCN	Data Communication Network. A communication network within a TMN or between TMNs which supports the data communication function (DCF).
Distributed service	The transmitting services are distributed between each neighboring nodes connected over a ring network.
DVB-ASI	Digital Video Broadcasting-Asynchronous Serial Interface.
DWDM	Dense Wavelength Division Multiplexing. DWDM technology utilizes the characteristics of broad bandwidth and low attenuation of single mode optical fiber, employs multiple wavelengths with spacing of 100GHz or 50GHz as carriers, and allows multiple channels to transmit simultaneously in the same fiber.

E

ECC	Embedded Control Channel. An ECC provides a logical operations channel between SDH NEs, utilizing a data communications channel (DCC) as its physical layer.
EDFA	Erbium-Doped Fiber Amplifier. Optical fiber doped with the rare earth element erbium, which can amplify at 1530 to 1610 nm when pumped by an external light source.
ESC	Electric Supervisory Channel. It owns the same function with OSC to realize the communication among all the nodes and transmit the monitoring data in the optical transmission network. The difference is monitoring data of ESC is introduced into DCC service overhead and is transmitted with service signals.
ESCON	Enterprise System Connection.
Ethernet	A data link level protocol comprising the OSI model's bottom two layers. It is a broadcast networking technology that can use several different physical media, including twisted pair cable and coaxial cable. Ethernet usually uses CSMA/CD. TCP/IP is commonly used with Ethernet networks.
Extinction ratio	The extinction ratio (EX) is defined as: $EX = 10 \log_{10} (A/B)$ where A is the average optical power level at the centre of the logical "1"; and B is the average optical power level at the centre of the logical "0".
Eye pattern	A graphic presentation formed by the superimposition of the waveforms of all possible pulse sequences.

F

FC	Fiber Channel. A standard for transmitting signals at 100 Mbit/s to 4.25Gbit/s over fiber or (at slow speeds) copper.
FDDI	Fiber Distributed Data Interface. A standard for a 100-Mbit/s fiber-optic local-area network.
FE	Fast Ethernet.
FEC	Forward Error Correction. A method to detect and correct certain error conditions with redundant coding.
FICON	Fiber Connection.

G

Gain spectrum-shape pre-tilt	The technology to keep the gain into being a basically fixed value.
GE	Gigabit Ethernet.

I

Insertion loss

It is the reduction in optical power between an input and output port of a passive component in decibels. It is defined as:

$$IL = -10\log\left(\frac{P_{out}}{P_{in}}\right)$$

where:

P_{in} is the optical power launched into the input port and P_{out} the optical power received from the output port.

IPA	Intelligent Power Adjustment. The system controls and adjusts automatically the optical power in the transmission link in order to be against the situations like as fiber is broken, the performance of equipments trend to be inferior or the connector is not plugged well. Also the maintenance engineers are not hurt by the laser being sent out from the slice of broken fiber.
Isolation	A non-reciprocal optical device intended to suppress backward reflections along an optical fibre transmission line while having minimum insertion loss in the forward direction.

J

Jitter	Variations in a short waveform caused by voltage fluctuations.
Jitter transfer	This is the relationship between jitter applied at the input port and the jitter appearing at the output port.

L

Laser	One of the wide range of devices that generates light by that principle. Laser light is directional, covers a narrow range of wavelengths, and is more coherent than ordinary light. Semiconductor diode lasers are the used light source in fiber-optic system.
LCN	Local Communication Network.

M

MAN	Metropolitan Area Network. An IEEE-approved network that supports high speeds over a metropolitan area.
Mean launched power	The average power of a pseudo-random data sequence coupled into the fiber by the transmitter.
MF	Mediation Function. In telecommunications network management, a function that routes or acts on information passing between network elements and network operations.

N

NE	Network Element. A stand-alone physical entity that supports at least network element functions and may also support operations system function or mediation functions. It contains managed objects, a message communication function and a management applications function.
NEF	Network Element Function. A function block which represents the telecommunication functions and communicates with the TMN OSF function block for the purpose of being monitored and/or controlled.
NM	Network Management. Any aspect of monitoring or controlling a network, including all administration details.
Noise figure	The specification to scale the random signal in the system presenting in addition to any wanted signal.

O

OCP	Optical Channel Protection. With the way to back up the working optical channel, it supports primary channel with multiple wavelengths and standby one in order to be against the situation that there is any fault in the primary channel.
OLP	Optical Line Protection. With the way to back up the working link, it supports primary optical transmitting link with multiple wavelengths and standby one in order to be against the situation that there is any fault in the primary link.
Optical amplifier	A device or subsystem in which optical signals can be amplified by means of the stimulated emission taking place in an suitable active medium. In this active medium a population inversion, needed to advantage stimulated emission with respect to absorption, is achieved and maintained by means of a suitable pumping system.
Optical channel	

Optical demultiplexer	A device which performs the inverse operation of a wavelength multiplexer, where the input is an optical signal comprising two or more wavelength ranges and the output of each port is a different preselected wavelength range.
Optical multiplexer	A branching device with two or more input ports and one output port where the light in each input port is restricted to a preselected wavelength range and the output is the combination of the light from the input ports.
Optical return loss	It is the fraction of input power that is returned from the input port of a passive component. It is defined as: RL = –10 log (Pr / Pi) where : Pi is optical power launched into the input port and Pr the optical power received back from the same input port.
OS	Operations System. A physical block which performs operations systems functions (OSFs).
OSC	Optical Supervisory Channel. It realizes the communication among the nodes in the optical transmission network and transmits the monitoring data in the certain channel (the wavelength of the working channel for it is 1510nm and that of the corresponding protection one is 1625nm).
OSNCP	Optical Sub-Network Connection Protection.
OSNR	Optical Signal-to-Noise Ratio. Ratio of the amplitude of the transmitted optical signal to the noise on the received signal.

P

PDH	Plesiochronous Digital Hierarchy. It is the first multiplexing hierarchy used in digital transmission systems. The base frequency was 64Kbit/s, multiplexed up to 2048, 8448, 34,368 and 139,264 kbit/s. There was more than one standard system and it varied between Europe, the US and Japan.
PIN	A semiconductor detector with an intrinsic (i) region separating the p- and n-doped regions. It has fast linear response and is used in fiber-optic receivers.
Polarization dependence loss	The maximum variation of loss due to a variation of the state of polarization of the input signal at nominal operating conditions.

Q

QA	Q Adapter. A physical block that is characterized by a contained Q adapter function block and which connects NE-like or OS-like physical entities with non-TMN compatible interfaces (at m reference points) to Q interfaces.
QoS	Quality of Service. The collective effect of service performances, which determine the degree of satisfaction of a user of the service.

R

Reflection coefficient	The difference between the amount of light incident and the amount that is reflected back from a surface.
Regenerator	A receiver-transmitter pair that detector and amplifiers a weak signal for retransmission through another length of fiber.
ROADM	Reconfigurable Optical Add/Drop Multiplexer. A device that can block or pass through any wavelength channel carrying the multiplexing signals so as to implement the reconfiguration of the corresponding wavelength in the main optical path. Therefore, it can configure flexibly and dynamically the wavelength resource among each node in the network under the situation not to impact the running of the working channel.

S

SDH	Synchronous Digital Hierarchy. A hierarchical set of digital transport structures, standardized for the transport of suitably adapted payloads over physical transmission networks.
Self-healing	Establishment of a replacement connection by network without the NMC function. When a connection failure occurs the replacement connection is found by the network elements and rerouted depending on network resources available at that time.
Service protection	The measures to make sure the service transmitting not to be damaged or corrupted.
Side mode suppression ratio	The ratio of the largest peak of the total source spectrum to the second largest peak.
Splitter	A device that divides incident light into two separate beams.
Star network	Network of several nodes where each terminal is linked individually to a central node.
STM	Synchronous Transport Module. It is the information structure used to support section layer connections in the SDH. It consists of information payload and SOH information fields organized in a block frame structure. The information is suitably conditioned for serial transmission on the selected media at a rate which is synchronized to the network.
Sub-wavelength	One of the several wavelengths carrying service signal on the client side of OTU board.
SuperWDM	A technical solution can extend effectively the transmitting distance of DWDM system with the application of Super CRZ encoding and the advanced phase modulation capability.

T

Telecom management network	The entity which provides the means used to transport and process information related to management functions for the telecommunications network.

U

Unit management layer	Designates the management functions performed on units assembled in a network.

V

VOA	Variable Optical Attenuator. An attenuator in which the attenuation can be varied.

W

Wavelength	The distance an electromagnetic wave travels in the time it takes to oscillate through a complete cycle. Wavelengths of light are measured in nanometers (10^{-9} m) or micrometers (10^{-6} m).
WDM	Wavelength-Division Multiplexing. WDM technology utilizes the characteristics of broad bandwidth and low attenuation of single mode optical fiber, employs multiple wavelengths as carriers, and allows multiple channels to transmit simultaneously in a single fiber.
WS	Workstation. The full set of both working and (upper) unprotected channels in a multiplex section.

D Acronyms and Abbreviations

A

ADM	Add and drop multiplexer
AGC	Automatic gain control
ALC	Automatic level control
ALS	Automatic laser shutdown
APE	Automatic power equilibrium
APS	Automatic protection switching
ASE	Amplified spontaneous emission
AWG	Arrayed waveguide grating

B

BA	Booster amplifier
BER	Bit error ratio

C

CLNS	Connectionless network service
CMI	Coded mark inversion
CPU	Central processing unit
CRC	Cyclical redundancy check
CRZ	Chirped return to zero
CSES	Continuous severely errored second

D

DCC	Data communication channel
DCF	Dispersion compensation fibre
DCM	Dispersion compensation module

DCN	Data communication network
DDN	Digital data network
DFB	Distributed feedback
DSP	Digital signal processing
DSCR	Dispersion slope compensation rate
DWDM	Dense wavelength division multiplexing
E	
ECC	Embedded control channel
EDFA	Erbium-doped fibre amplifier
EFEC	Enhanced forward error correction
ELH	Extra long haul
EMC	Electromagnetic compatibility
ETSI	European Telecommunication Standards Institute
F	
FEC	Forward error correction
FWM	Four-wave mixing
G	
GE	Gigabit Ethernet
GFF	Gain flattening filter
GUI	Graphic user interface
I	
IEEE	Institute of Electrical and Electronic Engineers
IPA	Intelligent power adjustment
ITU-T	International Telecommunication Union-Telecommunication Standardisation Sector
L	
LAN	Local area network
LCN	Local communication network
LCT	Local craft terminal
LD	Laser diode

M

MCF	Message communication function
MD	Mediation device
MPI-R	Main path interface at the receiver
MPI-S	Main path interface at the transmitter
MQW	Multi-quantum well

N

NE	Network element
NF	Noise figure
NRZ	Non return to zero

O

OA	Optical amplifier
OADM	Optical add and drop multiplexer
OAM	Operation, administration and maintenance
OAMS	Optical fibre line automatic monitoring system
OD	Optical demultiplexing
ODF	Optical distribution frame
OEQ	Optical equaliser
OHP	Overhead processing
OLA	Optical line amplifier
OM	Optical multiplexing
OMS	Optical multiplex section
ORL	Optical return loss
OS	Operations system
OSI	Open systems interconnection
OSNR	Optical signal to noise ratio
OTDR	Optical time domain reflectometer
OTM	Optical terminal multiplexer
OTS	Optical transmission section
OTT	Optical tunable transponder
OTU	Optical transponder unit

P

PDH	Plesiochronous digital hierarchy
PDL	Polarisation dependent loss
PIN	Positive intrinsic negative
PMD	Polarisation mode dispersion
POS	Packet Over SDH/SONET

R

RS	Reed-Solomon
RTU	Remote test unit

Q

QA	Q adaptation

S

SBS	Stimulated Brillouin Scattering
SCC	System control & communication
SDH	Synchronous digital hierarchy
SLIP	Serial line internet protocol
SLM	Single longitudinal mode
SONET	Synchronous optical network
SPM	Self phase modulation
SRS	Stimulated Raman Scattering
STM	Synchronous transport module
Super CRZ	Super chirped return to zero

T

TCP/IP	Transport control protocol / Internet protocol
TDM	Time division multiplexing
TEC	Thermoelectric cool
TMN	Telecommunication management network
TTL	Transistor-transistor logic

X

XPM	Cross phase modulation

W

WDM	Wavelength division multiplexing
WS	Work station

Index

S

T

V

W