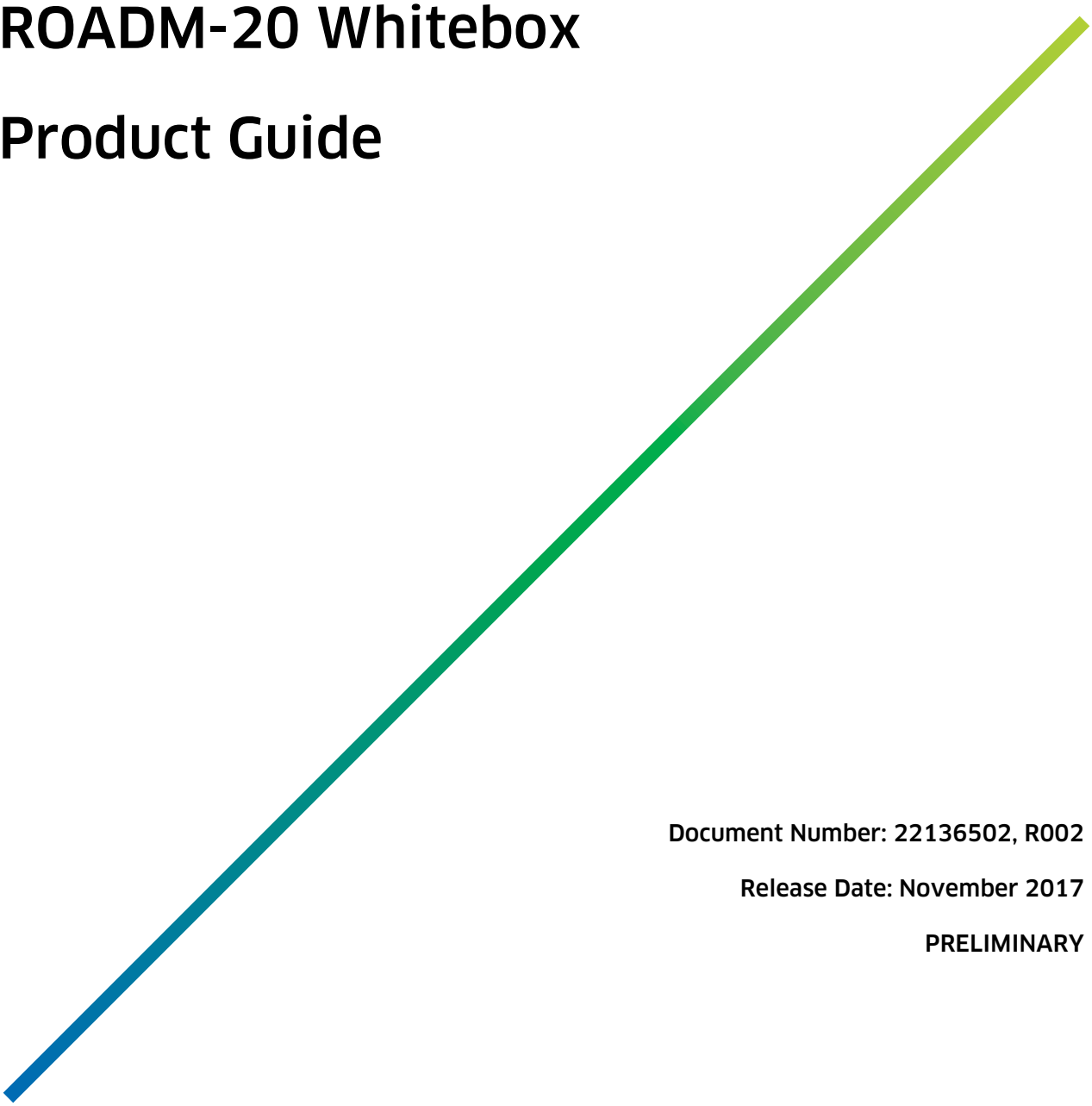
LUMENTUM

ROADM-20 Whitebox

Product Guide



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PRELIMINARY

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Document history

Date	Document Number	Reason for Revision
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September, 2017	22136502, R001	Updated hardware descriptions, regulatory compliance statements
November 2017	22136502, R002	Updated Order codes, compliance statements, frontplate labelling.

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Chapter 1: ROADM-20 Product Description

This chapter describes the ROADM-20 .

This chapter contains the following topics:

- *The ROADM-20*
  - *Functional overview*
  - *Key Features and Functions*
- *The ROADM-20 physical interface and access*

The ROADM-20

Figure 1: ROADM-20

The ROADM-20 combines all necessary functions of a traditional node into a single 1RU element that is easy to deploy and easy to manage.

All ROADM-20 variants can be deployed with other equipment, and in all supported network configurations (single span, multi-span, single span with line protection).

The ROADM-20 has three variants:

_ 1. AC-powered ROADM-20

_ 2. DC-powered ROADM-20

_ 3. Flex-powered ROADM-20 accepts both AC and DC power supply

See *Lumentum order codes* for part numbers and ordering information.

Functional overview

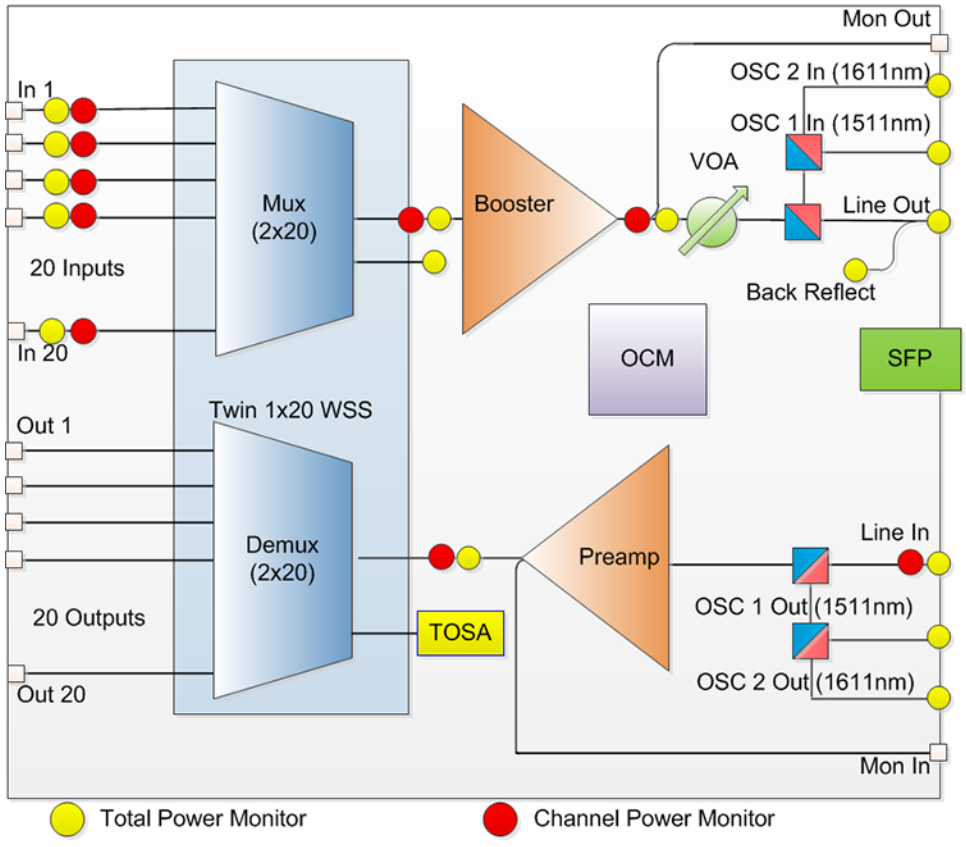
The operation and datapaths of the ROADM-20 are described in the following illustration.

The ROADM-20 includes three basic sections to support various combinations of features and deployment configurations: a mux/demux, booster amplifier, and pre-amplifier.

- Each amplifier section includes a switchable and a variable gain EDFA, an output back reflection monitor port and an optical monitor port.
  - The booster section provides an output VOA and associated PD and optical add ports for two OSC wavelengths.
  - The pre-amplifier section contains optical drop ports for the OSC wavelengths.
- An OCM monitors the output of both EDFAs.

The booster and pre-amplifier EDFA designs have different performance characteristics, described in *ROADM-20 pre-amplifier EDFA specifications* and *ROADM-20 booster EDFA specifications*. The booster amplifier operates at lower gain range (as low as 5 dB) while the pre-amplifier can achieve up to 30 dB gain.

Figure 2: ROADM-20 block diagram



Key Features and Functions

ROADM-20 have the following key features:

- TWIN WSS (3xN)

  - 20 input Mux WSS with output channel power control and input channel discovery
  - 20 output Demux WSS
- Flex spectrum channel management with 6.25GHz granularity
- Switchable gain EDFA:
  - Preamplifier EDFA with 23dBm output
  - Booster EDFA with 23dBm output
- Line Output VOA
- Power monitoring:
  - Total power monitoring at all Mux input ports, Line Out and all OSC add/drop ports
  - Per channel power monitoring at all Mux inputs and all EDFA input and outputs
  - Passive monitor ports for EDFA outputs
- Out of band light source and monitor for connectivity checks
- OSC ports
  - Passive sdd/drop ports for 1511 and 1611nm OSC wavelengths
  - Termination point for single OSC wavelength

The ROADM-20 supports the following high level management functions:

- Chassis hardware management
  - Power module control
  - Fan module control
  - Temperature monitoring
  - Status LED control
- User management
  - Console access serial port
  - NETCONF control interface
  - 3x Ethernet management ports
  - Configuration CLI
- Inventory data retrieval
- Fault monitoring:
  - Alarm reporting
  - Performance Monitoring
  - Diagnostic logging
  - Equipment and port level status LEDs
- Amplifier operating modes:
  - Constant power mode
  - Constant gain mode
- Pre-amplifier and Booster gain tilt control

- Closed loop attenuation control of Booster output VOA
- Optical total power monitoring at EDFA inputs/outputs, all OSC ports and MUX inputs
- OSC GE/100MbE traffic termination
- Optical channel power monitoring at EDFA outputs and MUX input ports

Example network configurations

ROADM-20 Whitebox equipment is intended to support a wide variety of network deployments, some examples are shown here. Other configurations are possible.

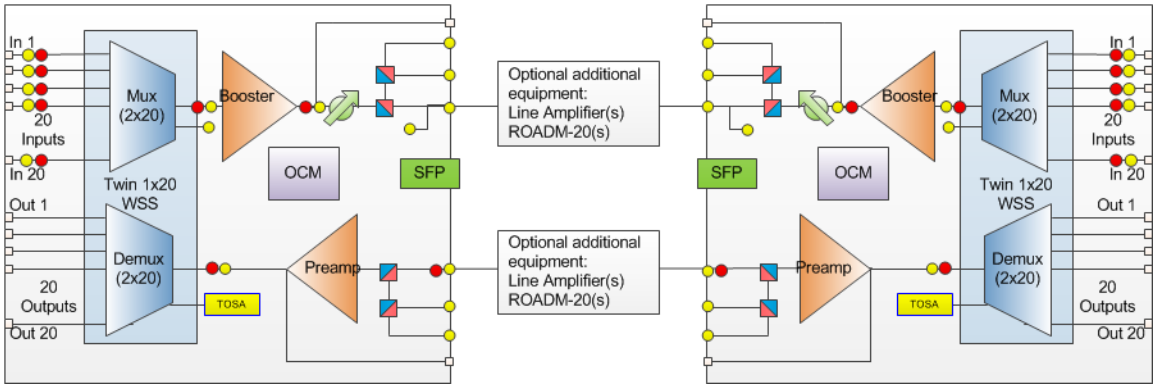
Single span, point to point, ROADM as Mux/Demux

Figure 3 shows a single span point to point system using the ROADM in a Mux/Demux application.

Booster and pre-amplifiers bookend the span, with Mux/Demux connected to provide channel ingress/egress to the system. A 2xN WSS is used as a MUX/DEMUX.

On both ends, the MUX side is connected to a Booster amplifier and the total output power launched into the fiber is controlled through output VOA. Design fiber span loss range from 10 to 30dB are supported in this configuration, but longer spans may be supportable depending on receiver OSNR and power requirements CHANGE IMAGE TO REFLECT BETA ROADM..

Figure 3: Single span ROADM system



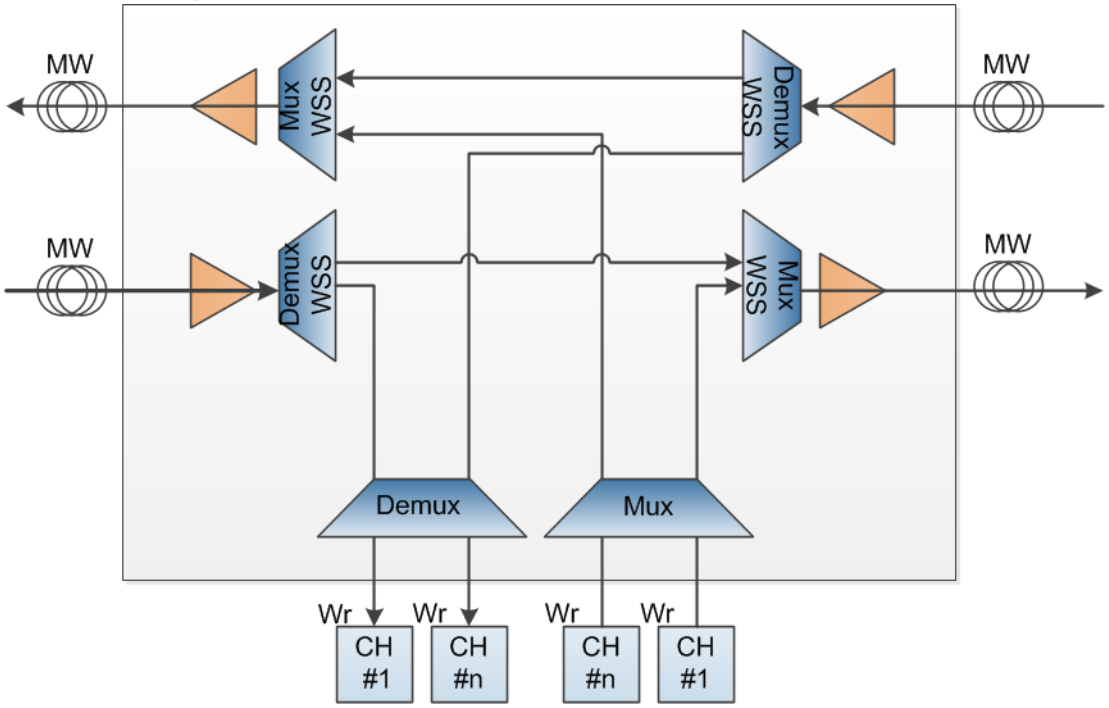
Two degree ROADM node

The ROADM-20 Whitebox ROADM-20 is intended to form the building block of a ROADM degree node for agile DWDM networks.

An N degree ROADM node can be built using N ROADMs connected together. DWDM signals can be added and dropped in different directions using multiple combination of ROADM-20 Whitebox ROADM-20s.

Figure 4 shows a two Degree ROADM node configuration. Up to twenty (20) degree nodes are possible.

Figure 4: Two degree ROADM node



Amplifier operating modes

Whitebox amplifiers have two operating modes:

- Constant Power Mode (default mode),
- Constant Gain Mode, and

Constant Signal Gain Mode

When the amplifier is configured to the **Constant Signal Gain** operating mode, the module maintains a constant signal gain by automatically adjusting the pump laser bias current in response to changes in optical input power to the device.

The factory default target gain for each variant is 6.5 dB.

Constant Total Output Power Mode

When the amplifier is configured to **Constant Total Output Power** operating mode, the module maintains a constant total output power by automatically adjusting the pump laser bias current.

The factory default target power for each variant is 5 dBm.

There are some important limitations to the EDFA's behavior when operating in **Constant Power Mode**.

_ 1. Constant Power mode does not operate consistently at all points in the gain mask. Switching between constant gain and constant power mode at low input power will generate output power glitches.

_ 2. Transient control is not supported

_ 3. Tilt cannot be maintained as signal gain can be set out of the supported range for tilt implementation

_ 4. Signal power cannot be set at low input power levels. This is because, in Constant Power mode, the module controls to a total output power target including noise and signal power.

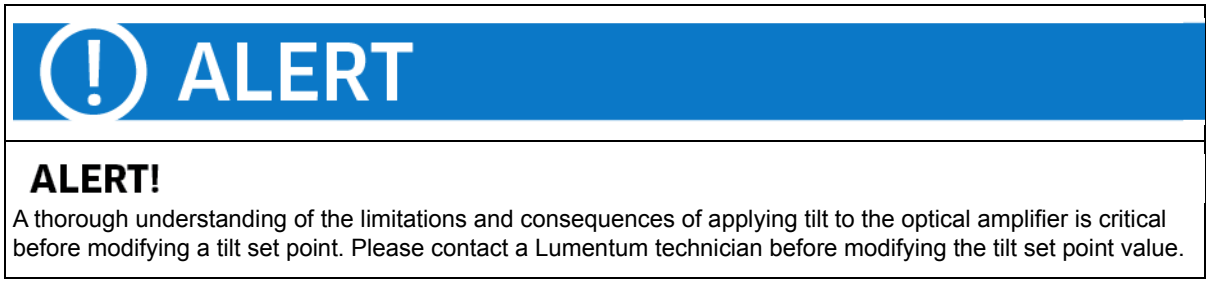
However, at low input power the signal-to-noise ratio is lower, so there is more noise in relation to the signal. As a result, while the module sets the correct total output power target (the minimum being -4 dBm) since the input signal power is much lower, the amplified signal will be below the gain mask for output power.

EDFA tilt control

It is important to note that only tilt control capable amplifiers will allow tilt to be applied.

The system will induce tilt based on static (wavelength dependent loss) and dynamic (number of channels and channel input power) conditions to compensate for the system induced tilt.

When propagating DWDM optical signals over a long fiber span, the optical spectrum experiences a non-uniform power distribution. After multiple spans this wavelength dependence of power accumulates and significantly degrades OSNR if not corrected. In some cases, the wavelength dependence is random (Mux / Demuxes) over the spectra, but a net induced tilt is often exhibited at the far end.



The primary contributors are:

- Transmission fibers: more IL at lower wavelengths
- Stimulated Raman Scattering: higher carrier frequencies pump lower ones (or, lower wavelengths pump higher ones)
- In-line attenuation pads
- Gratings

Provisioning EDFA Tilt can compensate for the system induced tilt by inducing tilt based on static (wavelength dependent loss) and dynamic (number of channels and channel input power) conditions, without recourse to more expensive power balancers.

Tilt is applied in Constant Signal Gain Mode. EDFA Tilt should NOT be relied on to obtain a deterministic wavelength-dependent amount of gain (such as 25dB at 1530 and 21dB at 1560).

For more information about the features, functionality, deployment and configuration of the Tilt Control, see the Application Note: *Utilizing EDFAs with Tilt Control*. To obtain this Application Note, please contact Technical Support.

Limitations

To determine the amount of tilt required, determine the required change in tilt settings while adding additional channels to the network and then configure these determined tilt settings, consult the Application Note: *Utilizing EDFAs with Tilt Control*.

To obtain this Guide, please contact Technical Support.

The following are preliminary guidelines for the calculation and implementation of EDFA Tilt:

- It is better to apply the tilt compensation at the pre-amplifier rather than the booster. This is because the tilt induced into the system is known at this point since it has affected the spectrum.
- In order to minimize transient effects, the optimal solution is to deploy all channels upon installation and initial turn-up, with no opportunity for growth.
  - For static systems, the tilt can therefore more-or-less be a “set and forget”.
  - For dynamic systems, in which the number of channels can vary (typically increase) over time, the provisioned tilt setting will need to be adjusted.

    Optimally, channels should be added in pairs (or in factors of 2), symmetrically balanced about the center of the spectrum.
- Ideally adding channels where the SRS effect can be deterministically predicted and compensate for additional SRS induced tilt using active feedback from amplifier output.
- Over a long link, the end spectral tilt can be estimated, and the tilt divided and distributed across each of the amplifiers. This needs to be done iteratively until the spectrum is flattened from an OSNR perspective.

Mux/Demux control modes

Mux and demux WSS functions are primarily managed through the*lumentum-ote-connection* yang module, which focuses on logical channels passing through the ROADM-20 rather than on the physical hardware.

In addition to the connection entities, physical port entities corresponding to the WSS inputs and outputs are used to provide cross -connection end points and per port monitoring and alarming.The connection model conceptually allows two forms of operation.

- Direct attenuation control, available on connections through the demux WSS only, where the WSS is entirely operated by the end user, and
- Channel power control, where WSS loss is automatically controlled by the ROADM-20 in order to maintain output power targets specified by the user. Channel power control is only available on connections through the mux WSS.

All creation and deletion of connection entities is done using the RPCs defined in the Lumentum-ote-connection module. Direct addition/deletion from the connections list is not permitted.

Direct Attenuation Control

Direct attentuation control mode is available on demux connections only. In direct attenuation control mode, the attenuation for each connection is set by the user. The WSS will acquire and maintain the configured attenuation until changed. Since direct attenuation control mode is open-loop, the attenuation through the WSS will remain stable regardless of input power fluctuations.

Direct attenuation control mode is configured:

- Manually via a user-management interface, or
- Automatically when the connection is operating in power control mode, and
  - The input power is insufficient to achieve the target output or
  - The maximum number of control iterations is exceeded.

Direct attenuation control is enabled on a per-connection basis by setting the **power-control-enabled** parameter for the connection to **disable** then configuring the required attentuation, or globally forced ON (over-riding all per connection settings) by setting the **control-state** parameter of the connection to **disabled** in the *lumentum-ote-connection* module.

Optional slot attenuation adjusts individual slot attentuations relative to the overall connection attenuation. Slot attenutation can be positive or negative. As a result, if a relative profile for the overall connection has been set, the individual slot attenuations may be different than the overall connection attenuation.

Channel Power Control

Channel power control mode is available on mux connections only. In channel power control mode, the output output target power is set by the user and the ROADM-20 then automatically maintains this power, adjusting the connection attenuation as required, using the measured output power as feedback.

Channel power control is based on the total power reported by the OCM within the spectral range associated with the connection.

Spectrum shaping using slot attenuation settings is supported in power control mode. The relative slot attenuation profile will be kept constant and all slots will be attenuated by the same amount in order to maintain the correct total power. If the relative profile is changed, it is expected that all slots may adjust attenuation as a result in order to maintain the same total power.

Power control has two phases:

- The **Search** phase occurs when channel power control mode is initially engaged on a connection.

  Attenuation moves to the target set point and then slowly ramps down until the channel is detected on the output OCM.
- At this point the **Control** phase begins. Attenuation is adjusted using the OCM feedback to achieve and maintain the target output power.

  The optional timeout-cycles parameter will automatically switch to direct attenuation control mode after a set number of control iterations. If set to zero then connections will remain in the Control state indefinitely.

Port Total Power Monitoring

Port total power monitoring is available at each mux input port using the relevant physical-port entities. Demux ports do not have power monitoring capability.Port total power monitoring has the following characteristics:

- Power monitoring results are refreshed every 1000 ms at a minimum.
- Minimum and maximum power levels are also tracked and are reset on read.
- The internal sampling rate used to support minimum and maximum tracking is faster than the externally visible power updates, allowing the minimum and maximum function to have approximately 25Hz bandwidth.

Two alarms are provided, LOS and Degrade low. These behave as all other power based alarms.

Optical supervisory channel (OSC)

SFP transponders, and two faceplate optical ports in Whitebox equipment supporting two different nominal OSC wavelengths, provide the system's OSC link.

This OSC link is Ethernet-based, supporting 1000BASE-LX and 100BASE-FX compatible optical signaling.

ALERT!

It is important to note Whiteboxes DO NOT currently provide any Ethernet loop prevention. If Ethernet loops are created, broadcast storms may occur which will interfere with the operation of the network.
Avoid setting loopbacks or creating network loops between OSC and/or electrical Ethernet ports on the same Whitebox!

Intended application of the provided OSC wavelengths is as follows:

- **1511nm**: Intended as the primary OSC wavelength, full OSC optical power monitoring is provided on the 1511 nm (OSC 1) ports.
- **1611nm**: Mainly intended for connections to subtending equipment, power monitoring is not provided on the 1611 nm (OSC 2) ports. However, the system itself will operate normally if 1611nm is used as the OSC wavelength.

An OSC link between a ROADM-20 Whitebox and remote equipment effectively operates as a LAN extension from the faceplate Ethernet ports to the remote device. This allows a number of possible uses of the OSC link.

_ 1. Management access to the remote end equipment via the faceplate connectors

_ 2. Management access to the host CPU from the remote end equipment

_ 3. Connection from local faceplate connectors to remote ROADM-20 Whitebox faceplate connectors

It is important to note the following requirements of OSC communications:

- Communication with remote devices requiring fixed link parameters is not supported.
- The OSC transponder wavelengths must be matched at both ends of a link.
- Both OSC wavelengths can be used simultaneously if required, however since only one SFP port is provided, the secondary wavelength traffic must be terminated externally.
- OSC traffic is not VLAN wrapped or encrypted.
- RSTP or equivalent loop prevention is not currently provided by DCI Whiteboxes; avoid broadcast storms by ensuring that Ethernet loops are not created through faceplate cabling or the OSC link.
- Lumentum Whitebox laser safety mechanisms require that far-end equipment must be in compliance with OpenROADM laser safety specifications, especially:
  - The presence of an Ethernet OSC link, and
  - The ability to turn off C-band power on detection of a fiber cut.

ROADM-20 OSC links

The ROADM-20 is a Hazard Level 1M product.

HAZARD LEVEL 1M products are compliant with laser safety standard: IEC60825-2 2004 + A1:2006 + A2:2010.

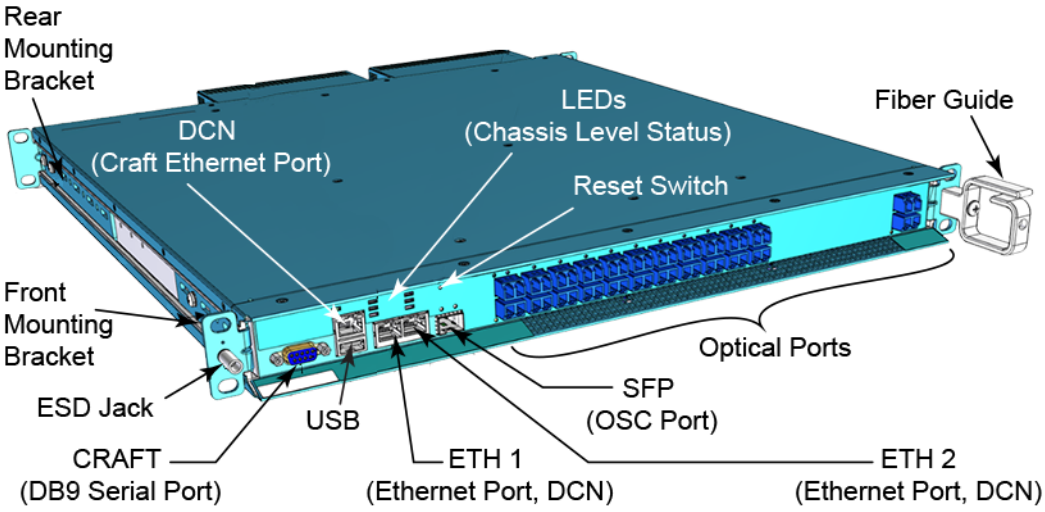
This equipment meets IEC80625-2 Hazard Level 1M requirements when operated in a system.
It is important to note that for proper operation of Lumentum Whitebox laser safety mechanisms, far-end equipment must be in compliance with OpenROADM laser safety specifications, especially:

- The presence of an Ethernet OSC link, and
- The ability to turn off C-band power on detection of a fiber cut.

The ROADM-20 physical interface and access

ROADM-20 Whiteboxes provide the following interfaces on the front of the unit.

Figure 5: ROADM-20 front view



- **Craft DB9 serial port:** Supports local configuration of the node's IP address.(see *CLI procedures*) .
- **DCN (Craft Ethernet port):** Has a fixed, non-configurable IP address: 169.254.0.1 with a netmask of 255.255.0.0. Supports local configuration of the node's IP address, and local OA&M management of the ROADM-20 node using a variety of management software applications.
- **ETH 1 and ETH 2 (DCN Ethernet ports) and SFP (OSC port):** Share the node's DHCP or user-assigned IP address. A DHCP IP address will persist as long as the node is connected to the LAN. DHCP can be disabled and a static IP address assigned via a command line interface (via the craft ports) or OA&M management software.The Ethernet ports also support OA&M management of the node. The Ethernet ports are currently isolated and cannot be used to daisy-chain to additional co-located ROADM-20s, or to subtending nodes via the OSC port.
- **USB port**: Inactive, not required by ROADM-20 functionality.

- Faceplate optical ports
  - SFP - One (1) optical Ethernet port, host port for pluggable OSC transponder
  - LC connectors - 24 optical ports

In addition to these interfaces, the front face of the ROADM-20 also provides:

_ 1. Status indicator LEDs

_ 2. Reset button

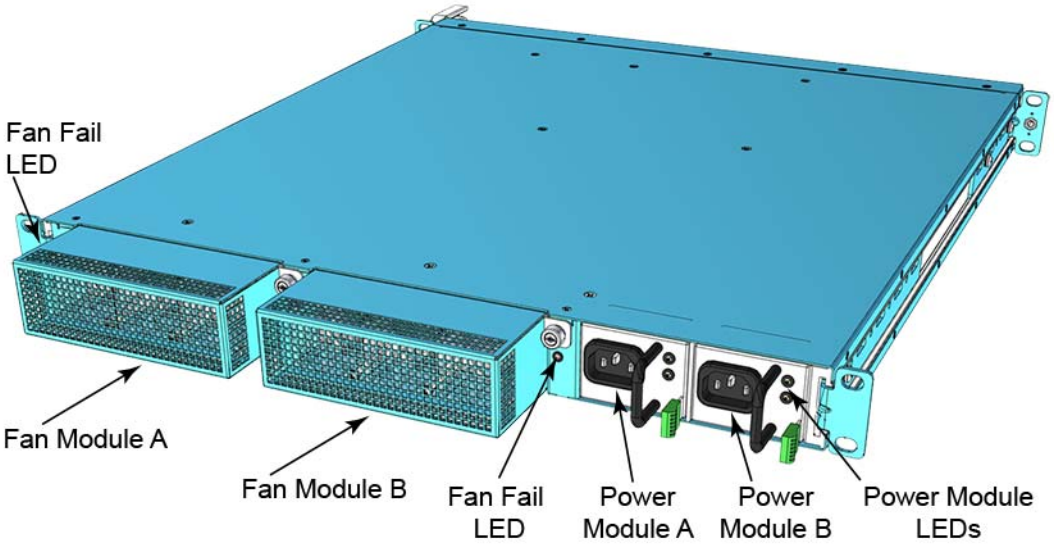
_ 3. ESD grounding strap jack

_ 4. Fiber guide clip

The physical location and arrangement of these interfaces depends on the equipment variant and its intended application

The following interfaces are provided on the rear of the unit:

Figure 6: ROADM-20 rear view



_ 1. Status indicator LEDs

_ 2. Two field replaceable AC or DC power modules, depending on equipment.

_ 3. Two field replaceable fan modules, with three fans in each.

DB9 craft port

Direct craft connections bypass the need for a known IP address.

Craft connections are used to establish a direct connection to the ROADM-20 Whitebox equipment in order to perform initial configuration of the equipment, including - if required - the configuration of an IP address, enabling subsequent Ethernet connections.

Direct serial connections can also be used for routine management sessions.

The craft serial port uses standard RS323 signals; the pin out allows straight through cables to be used to connect to standard PC serial ports.

RJ45 Ethernet ports

All Ethernet ports are RJ45 with standard pin outs supporting up to GigE connections, per IEEE 802.3z, with both full and half duplex mode, and auto-negotiation. Auto MDI-X allows the use of straight-through or cross-over cabling.

ALERT!

It is important to note Whiteboxes DO NOT currently provide any Ethernet loop prevention. If Ethernet loops are created, broadcast storms may occur which will interfere with the operation of the network.
Avoid setting loopbacks or creating network loops between OSC and/or electrical Ethernet ports on the same Whitebox!

Two LEDs are provided for each port, indicating link state and traffic, described below.

Table 1: Whitebox Ethernet port LEDs

LED	Location	Color	Description
1	Left of receptacle	GREEN	Lights when link is up
2	Right of receptacle	AMBER	Lights to indicate traffic

Faceplate optical ports

All optical connections used on the ROADM-20 are LC/UPC type connectors, arranged in duplex pairs. Connectors are organized in two rows across the faceplate, with the bottom row arranged upside down to allow easier finger access to the fiber removal latches; connectors and their labels are reversed to OUT/IN. In addition, their LEDs are shifted to the right..

The IN/OUT connector pairs are arranged to be connected to standard transponders using duplex cables if desired.All fiber is ITU G.652.D compliant and connectors meet Telcordia GR-326 and Verizon FOC standards.

Figure 7 and *Table 2: ROADM-20 faceplate optical ports* defines the location and function of the optical ports on the faceplate.

Figure 7: ROADM-20 faceplate optical ports

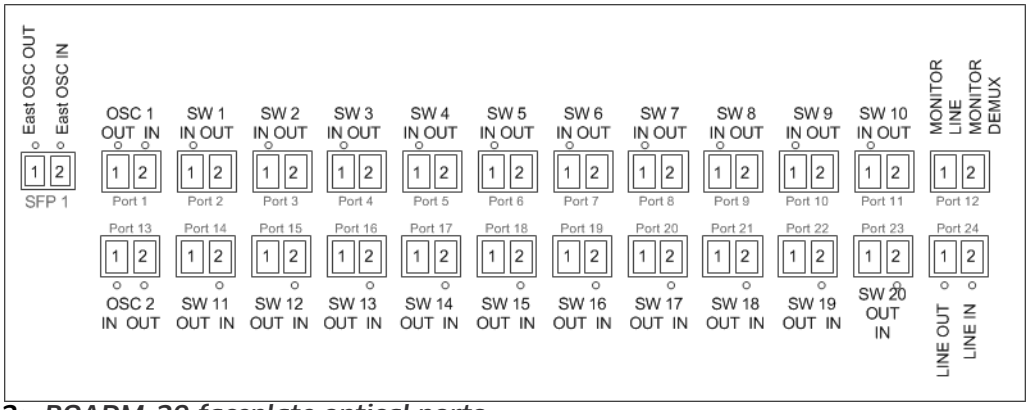


Table 2: ROADM-20 faceplate optical ports

Faceplate Position	Faceplate Label	Port Type	Signal Type	Description
SFP1	OSC OUT	SFP Cage	Ethernet	OSC Out
	OSC IIN			OSC In
Port 1	OSC 1 OUT	LC connector	OSC (1511nm)	Drop port for OSC RX
	OSC 1 IN			Add port for OSC TX
Port 2	SW 1 IN	LC connector	C Band, single or multichannel	Mux input port
	SW 1 OUT			Demux output port
To…				
Port 11	SW 10 IN	LC connector	C Band, single or multichannel	Mux input port
	SW 10 OUT			Demux output port
Port 12	MONITOR LINE	LC connector	C Band, multichannel	Preamp EDFA output monitor
	MONITOR DEMUX			Booster EDFA output monitor
Port 13	OSC 2 IN	LC connector	OSC (1611nm)	Add port for OSC TX
	OSC 2 OUT			Drop port for OSC RX
Port 14	SW 11 OUT	LC connector	C Band, single or multichannel	Demux output port
	SW 11 IN			Mux input port
To…				
Port 23	SW 20 OUT	LC connector	C Band, single or multichannel	Demux output port
	SW 20 IN			Mux input port
Port 24	LINE OUT	LC connector	C Band, multichannel	LINE (Booster) output port
	LINE IN			LINE (Pre-amplifier) input port

SFP port

The SFP port uses the standard pin out as per the SFP MSA and accepts MSA compliant transponders. See *Supported SFPs* for more information.

Two LEDs on the SFP port indicate RX LOS and TX state.

Front panel LEDs

LEDs indicate the operating state of equipment (chassis, and ports) without requiring a management session. There are two basic categories of front panel LEDs on the ROADM-20:

Equipment level described in *Table 3: ROADM-20 equipment level LEDs*, and

Port level LREDs described in *Table 4: ROADM-20 port level LEDs*.

Table 3: ROADM-20 equipment level LEDs

LED Label	LED Color(s)	Description
STATUS	RED	Power on
	BLINKING GREEN	Booting
	SOLID GREEN	Completed bootup, operational.
CRIT	RED	One or more critical alarms are present.
MAJ	RED	One or more major alarms are present.
MIN	YELLOW	One or more minor alarms are present.
PWR FAIL	RED	An AC power modules has failed. (Will not be lit for missing module.)
FAN FAIL	RED	One of the fan modules has failed. (Will not be lit for missing module.)
ID	BLUE	Turned on/off via management command, used to positively identify device during maintenance. (Future feature)

Table 4: ROADM-20 port level LEDs

Port Label	LED Color(s)	Description
SFP 1 OUT	OFF	Laser OFF
	GREEN	Laser ON, normal conditions
	RED	Laser ON, internal fault
SFP 1 IN	YELLOW	ON when LOS active
SW 1 IN . . . SW 20 IN	YELLOW	ON when LOS active
LINE IN	YELLOW	ON when LOS active

Port Label	LED Color(s)	Description
LINE OUT	OFF	Booster OFF
	GREEN	Booster ON, normal conditions
	YELLOW	Booster ON, APR active
	RED	Booster on, internal fault
OSC 1 IN, OSC 2 IN	YELLOW	On when LOS active
OSC 1 OUT, OSC 2 OUT	YELLOW	On when LOO active

Rear panel LEDs

Rear LEDs indicate status of the field replaceable modules located at the rear of the chassis.

LED Location	LED Color(s)	Description
Top LED on power modules	Input power status.	
	Solid GREEN	Input power OK
	Blinking GREEN	Input over/under voltage warning
	OFF	IInput outside operational range or not present
Bottom LED on power modules	Output power status.	
	Solid GREEN	Power OK
	Blinking GREEN	Module in standby
	Blinking YELLOW	Internal warning
	Solid YELLOW	Internal failure
Left of Fan module 1	RED	Fan module 1 has failed.
Right of fan module 2	RED	Fan module 2 has failed.

Reset button

A recessed reset button provides the opportunity to initiate a warm or cold reset of a device without a management session. This reset button has the following characteristics:

The recessed style button requires a tool to activate.

- Depressing the button for between 200ms and 5 seconds initiates a warm restart of the main CPU.
- Depressing the button for more than 5 seconds initiates a cold restart of the entire module. This cold restart has the same effect on the equipment as a “power-on” restart.

Power modules

Two field replaceable power supply modules provide redundant power from the back of the ROADM-20 Whitebox. A single power module is capable of powering the ROADM-20 Whitebox indefinitely, should a failure occur or only one power module be installed.

According to variant, ROADM-20 Whiteboxes are AC-powered or DC-powered.

- AC power modules are high-efficiency front end modules with universal AC input.

  The power connector is a standard IEC C14 shrouded male connector and includes a cable retention feature to prevent accidental power cable removal.

- DC power modules are high-efficiency front end modules with telecom style 48V nominal input.

  Power is connected via a terminal block.

The power modules are secured in the chassis by a latching mechanism; a latch release and separate pull handle allow removal.

Fan Modules

Lumentum Whiteboxes are fan-cooled, with airflow from front to rear.

Two field replaceable fan modules at the rear of the chassis, each containing three fans, provide cooling to Whiteboxes. They are powered through their connection to the equipment and pull air through the chassis from front faceplate mesh openings. (Each power supply module also incorporates an internal fan.) the fan modules are held in place by thumbscrews.

When the module's temperature sensor reports a value above set high temperature threshold, fan speed will increase, remaining at the higher speed setting until the temperature returns to a set low temperature threshold.Temperature thresholds and supported fan speeds are not user configurable and may vary between different ROADM-20 Whitebox variants, depending on the thermal requirements.

The ROADM-20 Whitebox can operate safely for a short period (two minutes) with one fan unit removed for replacement.

Chapter 2: ROADM-20 Specifications

This chapter describes the technical specifications and safety and compliance information for the ROADM-20.

All optical specifications in this document are over life, operational wavelength, and over the operational temperature range at average polarization unless otherwise noted.

This section contains the following topics:

- *System performance*
  - *General optical requirements*
  - *Supported operating ranges*
- *ROADM-20 amplifier optical performance specifications*
  - *ROADM-20 amplifier control specifications*
  - *ROADM-20 pre-amplifier EDFA specifications*
  - *ROADM-20 booster EDFA specifications*
  - *ROADM-20 WSS specifications*
  - *ROADM-20 optical channel monitor specifications*
  - *ROADM-20 optical supervisory channel (OSC) specifications*
  - *ROADM-20 laser safety*
- *ROADM-20 module specifications*
  - *ROADM-20 electrical specifications*
  - *ROADM-20 environmental specifications*
  - *ROADM-20 mechanical specifications*
- *ROADM-20 safety and compliance information*
  - *Environmental standards compliance*
  - *RoHS compliance*
  - *REACH compliance*
  - *FCC standards compliance*
  - *UL standards compliance*

- *Laser safety standards compliance*

System performance

General optical requirements

The optical parameters below shall be met over the full operating temperature range, over life, over wavelength and over polarization range.

Table 5: ROADM-20 Wavelength range definitions defines the various wavelength range requirement of the ROADM-20.

Table 5: ROADM-20 Wavelength range definitions

Parameters		Minimum	Typical	Maximum
C-Band		1528.578 nm		1566.928 nm
		191.325 THz		196.125 THz
OSC Band	Band 1, at 1511 nm	1504 nm	1511 nm	1518 nm
	Band 2, at 1611 nm	1604 nm	1611 nm	1616 nm
TOSA Signal Band		1566.928 nm	1567.18 nm	1567.33 nm

The ROADM-20 supports the following isolation requirements for signal bands at various optical paths.

Table 6: ROADM-20 optical signal bands isolation requirements

Signal Band	Path Isolation		Minimum
	From	To	
OSC-Band 1	Line In	Line In PD	55 dB
OSC-Band 1	Line In	Through Pre-amp	40 dB
OSC-Band 2	Line In	Line In PD	60 dB
OSC-Band 2	Line In	Through Pre-amp	50 dB
C-Band	Line In	1511 OSC Out	55 dB
C-Band	Line In	1611 OSC Out	60 dB

The ROADM-20 supports the following fixed grid channel plan as default. The system will operate with any number, spacing or combination of channels within this range.

Table 7: Channel plan

Parameter	Minimum	Maximum
Channel Count	1	96

Parameter	Minimum	Maximum
Channel Frequency Range	191.325 THz	196.125 THz
Channel Spacing	50	50 GHz

Supported operating ranges

The ROADM-20 supports the following ranges for various operating parameters for all network configurations.

Table 8: ROADM-20 operating ranges

Parameter	Minimum	Maximum
Channel power range MUX IN[a]	-22 dBm/ch	+3 dBm/ch
Channel power range DEMUX OUT[b]	- dBm/ch	+ dBm/ch
Span loss range[c]	10 dB	30 dB

a. 50 GHz spacing
b. 50 GH spacing
c. The span loss ranges listed are recommended limits; proper system design is required to cover alternate span losses.

ROADM-20 amplifier optical performance specifications

The ROADM-20 includes a booster section and a pre-amplifier section.

Each section provides:

- A switchable and a variable gain EDFA,
- An output back reflection monitor port
- An optical monitor port, and
- An OCM to monitor the output of both EDFAs.

In addition,

- The booster section also provides an output VOA and associated PD and optical add ports for two OSC wavelengths.
- The preamp section contains optical drop ports for the OSC wavelengths.

it should be noted that the booster and preamp EDFA designs have different performance characteristics. The booster is target to operate at lower gain range (as low as 5 dB) while the preamp can achieve up to 30 dB gain

ROADM-20 es support the following ranges for various operating parameters for all network configurations, except where noted otherwise.

ROADM-20 amplifier control specifications

The following section details the specifications for amplifier control, including gain, tilt, and VOA of the amplifiers. These specification applies independently to both pre-amplifier and boosters.

Table 9: ROADM-20 amplifier control specifications

Parameter		Minimum	Maximum
Output power stability (P-to-P), over 1 s			0.25 dB
Absolute Gain Accuracy		-0.8 dB	+0.8 dB
Relative Gain Accuracy[a]		-0.1 dB	0.1 dB
Gain Control Resolution			0.1 dB
Gain change response time, up to 3 dB step		100 dB	1000 dB
Gain overshoot/undershoot, up to 3 dB step			0.25 dB
Relative Gain Tilt Control Accuracy[b]		-0.1 dB	0.1 dB
Tilt Control Resolution			0.1 dB
Tilt change response time, up to 1 dB step		100 dB	1000 dB
Tilt overshot/undershoot, up to 1 dB step			0.25 dB
Line Out VOA	VOA Attenuation Accuracy	-0.75 dB	0.75 dB
	VOA Slew Rate	5 dB/s	20 dB/s
	VOA overshot/undershoot, any step size		0.25 dB

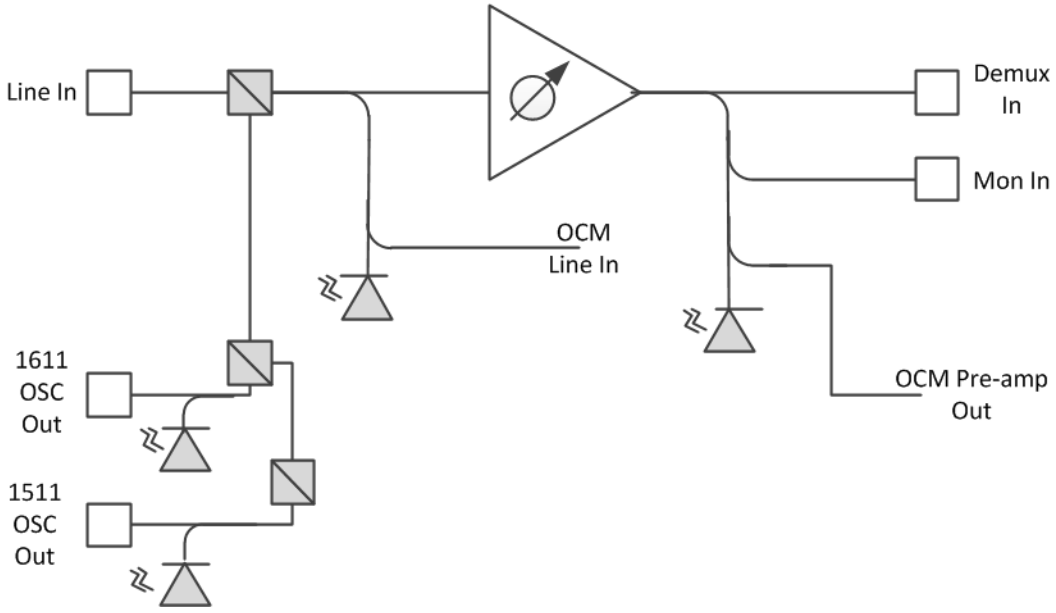
a. Change in gain control accuracy following a change in gain set point over the gain operating range, at any fixed temperature
b. Change in gain tilt control accuracy following a change in tilt control set point over the tilt control operating range, at any fixed temperature

ROADM-20 pre-amplifier EDFA specifications

The ROADM-20 pre-amplifier has the following EDFA specifications.

Unless otherwise stated, all the input power values are referenced to **Line In** and the output power values are referenced to **Demux In**, as shown below.

Figure 8: ROADM-20 Whitebox pre-amplifier optical layout



The pre-amplifier operates and meets all performance specifications over the ranges given below.

Table 10:ROADM-20 pre-amplifier operating specifications

Parameters		Minimum	Typical	Maximum
Operating Wavelength	C-Band, see *Table 5: ROADM-20 Wavelength range definitions*			
Gain Range 1 (LOW GAIN)				
LOW Gain (Typical range)	Total input power range	-25.3 dBm		13.2 dBm
	Total output power range	-0.5 dBm		23 dBm
	Gain range, flat operation	9.8 dB		19.8 dB
LOW Gain (Extended range)	Total input power range	-25.3 dBm		13.2 dBm
	Total output power range	-0.5 dBm		23 dBm
	Gain range, non-flat operation	19.8 dB		24.8 dB
Gain Tilt Control Range		-3 dB		+1 dB
Gain Ripple (Over operating conditions)				0.9 dB
MPI (Flat gain condition.)			-48 dB	-40 dB
Gain Range 2 (HIGH GAIN)				
HIGH Gain (Typical range)	Total input power range	-35.3 dBm		8.2 dBm
	Total output power range	-0.5 dBm		23 dBm
	Gain range, flat operation	14.8 dB		29.8 dB

Parameters		Minimum	Typical	Maximum
HIGH Gain (Extended range)	Total input power range	-35.3 dBm		8.2 dBm
	Total output power range	-0.5 dBm		23 dBm
	Gain range, non-flat operation	29.8 dB		34.8 dB
Gain Tilt Control Range		-3 dB		+1 dB
Gain Ripple (Over operating conditions)				1.0 dB
MPI (Flat gain condition.)			-45 dB	-40 dB
OTHER SPECIFICATIONS				
PMD				0.3 ps
PDL/PDG				0.35 dB
Optical Return Loss - All ports @ C-band				40 dB
Ratio of output at port **Demux In** and port **Mon In**		17 dB		21 dB
Loss from port “Line In” to “1511 OSC Out”[a]		0.5 dB		1.9 dB
Loss from port “Line In” to “1611 OSC Out”[b]		0.5 dB		1.9 dB

a.At OSC Band 1, at 1511 nm
b.At OSC Band 2, at 1611 nm

Pre-amplifier noise figure performance

The noise figure specification of the pre-amplifier is given below. Values are over the full operating gain range, including noise figure values in the overlapping gain range for both gain ranges, 1 and 2.

These specified noise figure values are the worst case noise figure for all operating conditions, including channel loading. All conditions for NF below are for full channel load and zero (0) tilt.

Table 11:Pre-amplifier noise figure specifications

Signal Gain (dB)	P in	Maximum Noise Figure	
		Gain Range 1	Gain Range 2
19.8 dB	Pin = 3.2	6.2 dB	
	Pin = -10	6.3 dB	
	Pin = -15	6.5 dB	
14.8 dB	Pin = 8.2	7.6 dB	
	Pin = -15.3	7.3 dB	
9.8 dB	Pin = 13.2	11.9 dB	
	Pin = -10.3	10.3 dB	

Signal Gain (dB)	P in	Maximum Noise Figure	
		Gain Range 1	Gain Range 2
29.8 dB	Pin = -6.8		5.8 dB
	Pin = -20		6.2 dB
	Pin = -30.3		6.5 dB
19.8 dB	Pin = 3.2		8.4 dB
	Pin = -20.3		7.6 dB
14.8 dB	Pin = 8.2		13.1 dB
	Pin = -15.3		10.8 dB

The gain masks for the ROADM-20 pre-amplifier EDFA are shown below.

Figure 9: ROADM-20 pre-amplifier EDFA low gain mask

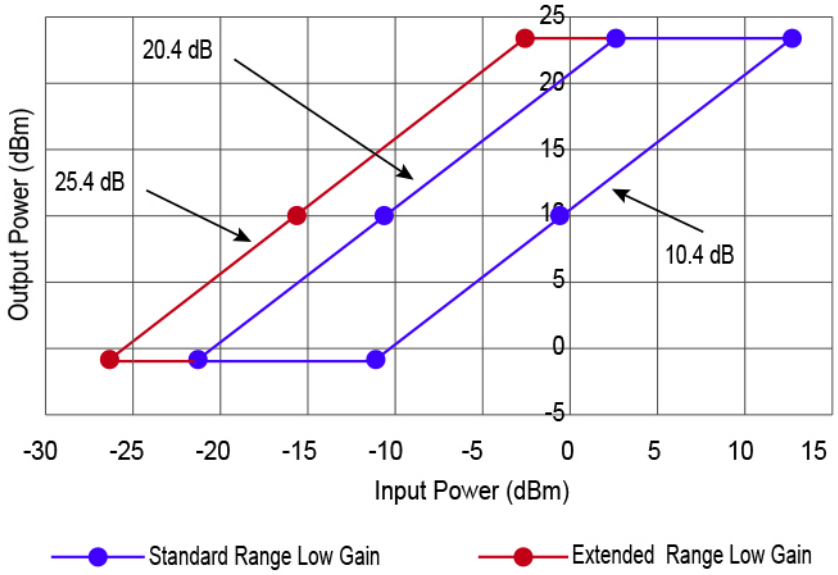
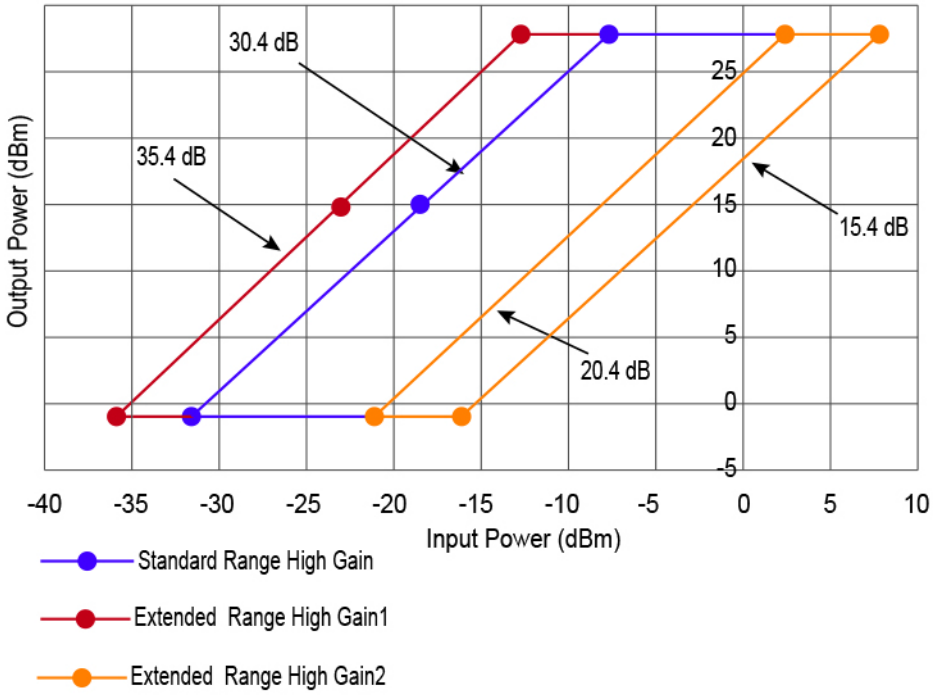


Figure 10:ROADM-20 preamplifier EDFA high gain mask



Pre-amplifier optical power monitoring specifications

All of the monitor points referenced below monitor total power.

Two power ranges are defined for each monitor:

- **Operation** - the optical power range over which the amplifier is expected to meet all operating performance requirements (i.e. gain control etc.).
- **Alarm** - the optical power range over which the amplifier is not expected to maintain required optical performance, but monitoring is still required in order to have proper system alarming and fault detection.

Table 12:Pre-amplifier optical monitoring power monitoring ranges

Monitor Name	Reference Point	Alarm Range (dBm)		Operation Range (dBm)	
		Minimum	Maximum	Minimum	Maximum
Line In	Line In	-45 dBm	14.7 dBm	-35.3 dBm	13.2 dBm
Pre-amp Out	Demux In	-14 dBm	25.5 dBm	-0.5 dBm	23 dBm
OSC1 Line In	Line In	Not applicable		Not applicable	
OSC2 Line In	Line In	Not applicable		Not applicable	
OSC1 Out	OSC1 Out	-48 dBm	14 dBm	-42 dBm	+3 dBm
OSC2 Out	OSC2 Out	-48 dBm	14 dBm	-42 dBm	+3 dBm

***Table 13:** Pre-amplifier monitor accuracy specifications*

Parameter		Minimum	Maximum
Operation Range	Absolute PD Accuracy	-0.6 dB	0.6 dB
	Absolute OSC PD Accuracy	-1 dB	1 dB
Alarm Range	Absolute PD Accuracy – (exclude the operation range)	-2 dB	+2 dB
Relative PD Accuracy (relative change in error over operating range at fixed temperature)		-0.2 dB	0.2 dB

ROADM-20 booster EDFA specifications

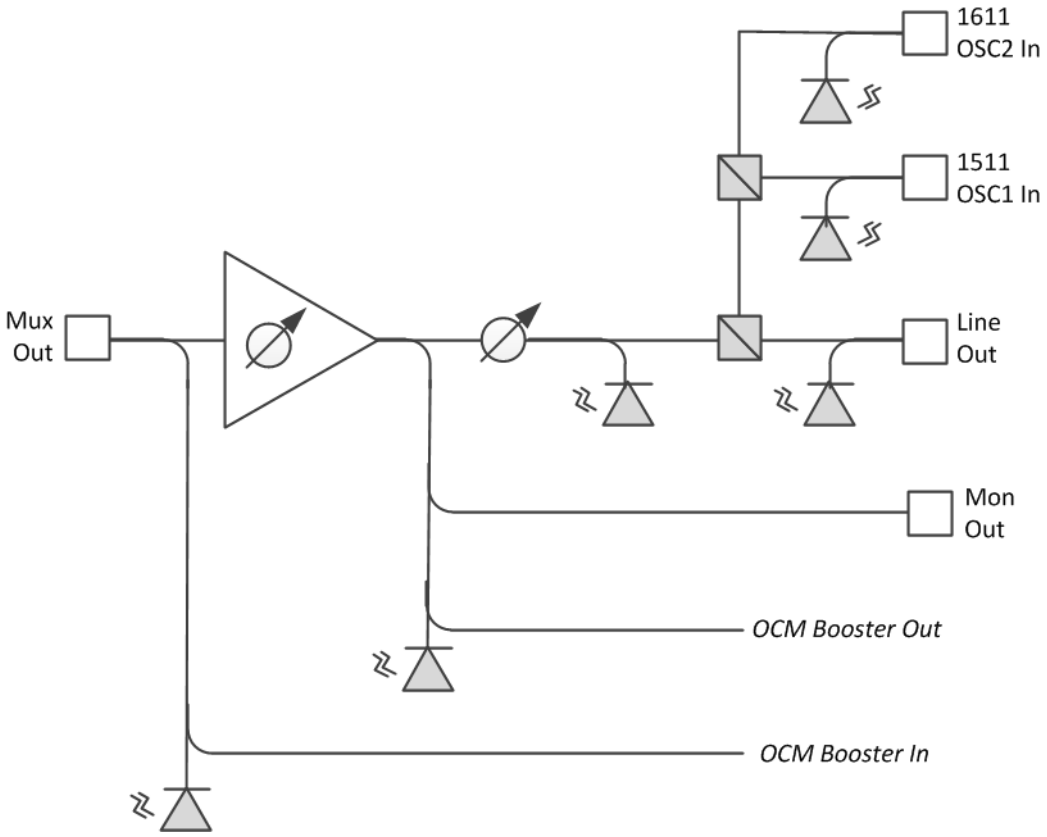
The ROADM-20 booster has the following EDFA specifications.

Unless otherwise stated, all the input power values are referenced to **Mux Out** and the output power values are referenced to **Line Out**.

The power ranges shown assume the output VOA target is set at 0dB attenuation. The VOA itself may be at higher than minimum Insertion Loss (IL) depending on how the 0dB attenuation point is calibrated. Specifications apply from the Mux In connector to either the Line Out connector (unprotected versions) or virtual point B (protected versions).

Optical gain can be set higher or lower than the values shown here. An alarm will be raised indicating that the amplifier is operating outside the gain mask.Input channel power may operate lower than these values.

Figure 11:ROADM-20 booster optical layout



The booster operates and meets all performance specifications over the ranges given below.

Table 14:ROADM-B Whitebox booster operating EDFA specifications

Parameter		Minimum	Typical	Maximum
Operating Wavelength	C-Band, see *Table 5: ROADM-20 Wavelength range definitions*			
Gain Range 1 (LOW GAIN)				
LOW Gain (Typical range)	Total input power range	-20.4 dBm		19.5 dBm
	Total output power range	-3.0 dBm		22.9 dBm
	Gain range, flat operation	3.4 dB		13.4 dB
LOW Gain (Extended range)	Total input power range	-20.4 dBm		19.5 dBm
	Total output power range,	-3.0 dBm		22.9 dBm
	Gain range, non-flat operation	13.4 dB		17.4 dB
Gain Tilt Control Range		-3 dB		+1 dB
Gain Ripple (Over operating conditions)				0.8 dB
MPI (Flat gain condition).			-48 dB	-40 dB

Parameter		Minimum	Typical	Maximum
Gain Range 2 (HIGH GAIN)				
HIGH Gain (Typical range)	Total input power range	-30.4 dBm		12.9 dBm
	Total output power range	-3.0 dBm		22.9 dBm
	Gain range, non-flat operation	13.4 dB		23.4 dB
HIGH Gain (Extended range)	Total input power range	-30.4 dBm		12.9 dBm
	Total output power range	-3 dBm		22.9 dBm
	Gain range, non-flat operation	23.4 dB		27.4 dB
Gain Tilt Control Range		-3 dB		+1 dB
Gain Ripple (Over operating conditions)				1.0 dB
MPI			-45 dB	-40 dB
OTHER SPECIFICATIONS				
VOA Attenuation Range		0 dB		15 dB
PMD				0.3 dB
PDL/PDG				0.35 dB
Optical Return Loss	All ports @ C-band			40 dB
Ratio of output at port **Line Out** and port **Mon Out**		18 dB		23 dB
Loss from port “1511 OSC1 In” to “Line Out”[a]		0.5 dB		1.9 dB
Loss from port “1511 OSC2 In” to “Line Out”[b]		0.5 dB		2.4 dB

a. At OSC Band 1, at 1511 nm
b. At OSC Band 2, at 1611 nm

ROADM-20 booster noise figure specifications

Booster noise factor versus gain performance requirements are given in the table below. Specifications apply over the full input power range for any given gain as defined in the gain mask. Specifications apply for zero tilt operation only.

Table 15:ROADM-20 booster noise figure specifications

Signal Gain (dB)	P in	Maximum Noise Figure	
		Gain Range 1	Gain Range 2
13.4 dB	Pin = 9.5	6.7 dB	
	Pin = -10	7.4 dB	
	Pin = -16.4	8.7 dB	

Signal Gain (dB)	P in	Maximum Noise Figure	
		Gain Range 1	Gain Range 2
9.4 dB	Pin = 13.5	9.3 dB	
	Pin = -12.4	11.2 dB	
3.4 dB	Pin = 18	17.6 dB	
	Pin = -6.4	18.9 dB	
23.4 dB	Pin = -0.5		5.6 dB
	Pin = -20		5.9 dB
	Pin = -26		6.0 dB
15.4 dB	Pin = 7.5		9.0 dB
	Pin = -18.4		8.3 dB
9.4 dB	Pin = 12.9		15.7 dB
	Pin = - 12.4		14.2 dB

The gain masks for the ROADM-20 booster EDFA are shown below.

Figure 12:ROADM-20 booster EDFA low gain mask

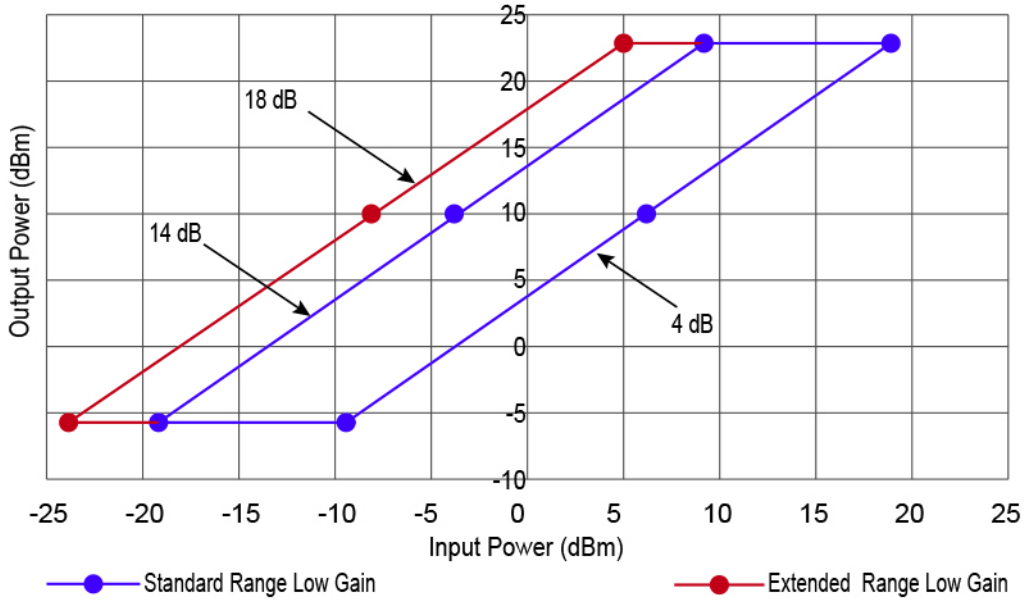
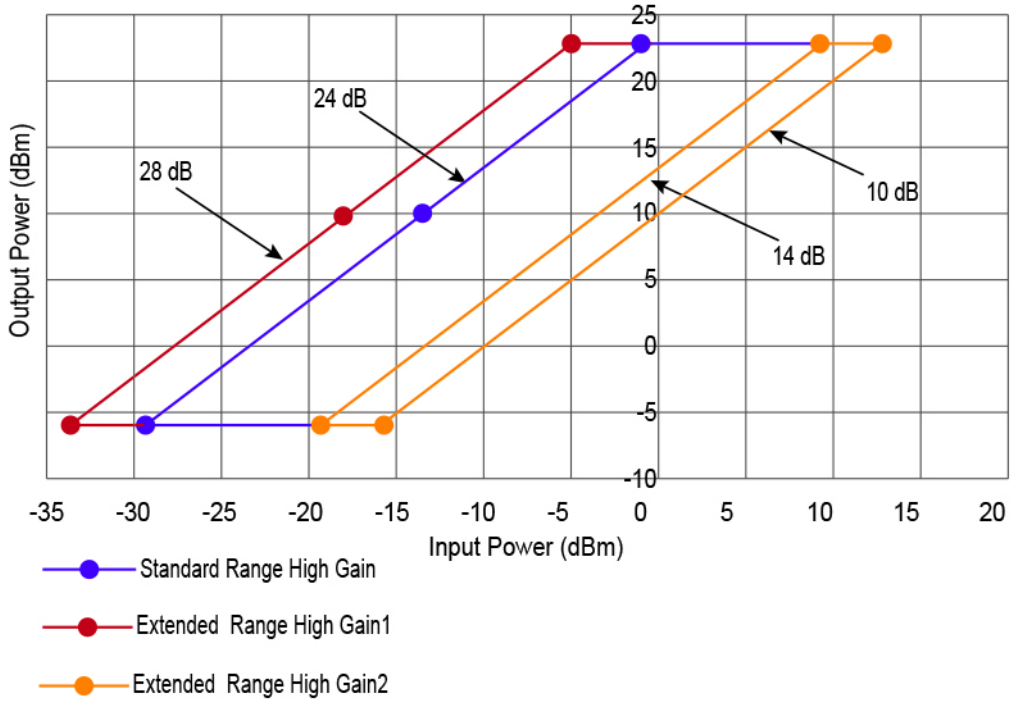


Figure 13:ROADM-20 booster EDFA high gain mask



ROADM-20 booster optical power monitoring specifications

The ROADM-20 monitors total power at each of the monitor points referenced below.

Two power ranges are defined for each monitor:

- **Operation** - the optical power range over which the amplifier is expected to meet all operating performance requirements (i.e. gain control etc.).
- **Alarm** - the optical power range over which the amplifier is not expected to maintain required optical performance, but monitoring is still required in order to have proper system alarming and fault detection.

Table 16:ROADM-20 booster optical power monitoring ranges

Reference Point	Monitor Name	Alarm Range		Operation Range	
		Minimum	Maximum	Minimum	Maximum
Mux Out	Booster In	-45 dBm	22 dBm	-30.4 dBm	19.5 dBm
Line Out (VOA set to 0 dB)	Booster Out C-Band power only	-10 dBm	27.5 dBm	-3 dBm	22.9 dBm

Reference Point	Monitor Name	Alarm Range		Operation Range	
		Minimum	Maximum	Minimum	Maximum
Line Out	Line Out C-Band power only	-25 dBm	27 dBm	-18 dBm	22.9 dBm
	OSC1 Line Out OSC1 power only	Not applicable		Not applicable	
	OSC2 Line Out OSC2 power only	Not applicable		Not applicable	
	Back Reflect Total C-Band + OSC	-43 dBm	14 dBm	--27 dBm	+10 dBm
OSC In	OSC1 In OSC1 power only	-47 dBm	+15 dBm	-10 dBm	+10 dBm
	OSC2 In OSC2 power only	-47 dBm	+15 dBm	-10 dBm	+10 dBm

Table 17:ROADM-20 booster monitor accuracy specifications

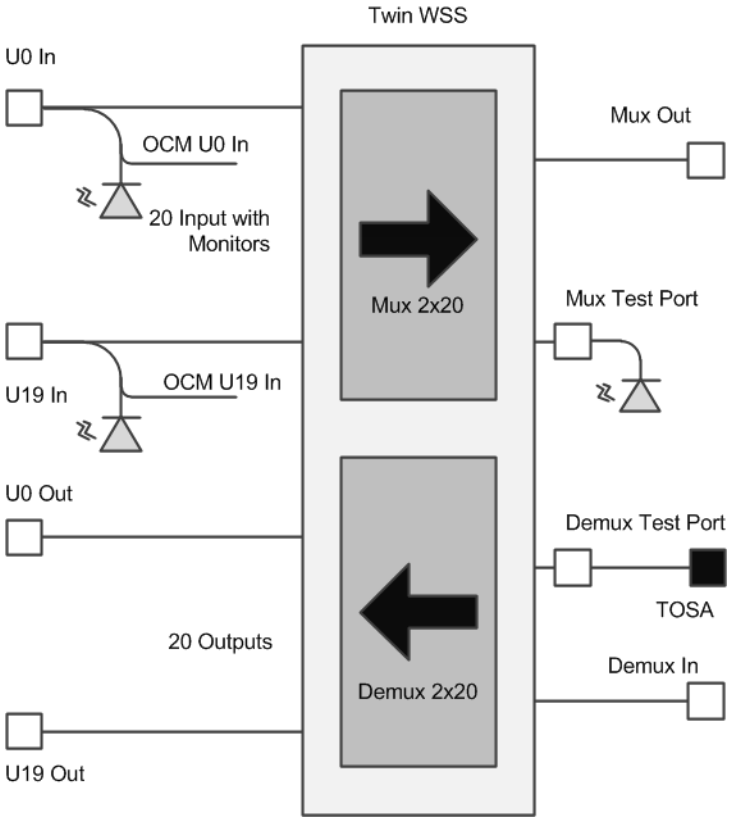
Parameter		Minimum	Maximum
Operation Range	Absolute PD Accuracy	-0.6 dB	+0.6 dB
Alarm Range	Absolute PD Accuracy (exclude the operation range)	-2 dB	+2 dB
Relative PD Accuracy (relative change in error over operating range at fixed temperature)		-0.2 dB	0.2 dB

ROADM-20 WSS specifications

The following illustration describes the reference points for the measurement of power levels of the add/drop block.All the input powers of the **Mux** path are referenced to the faceplate port labeled **Mux In**. Output power is referenced to an internal reference port; Mux Out (which is the same reference point for the booster input power, as shown in *Figure 11*.)

All the input powers of the **Demux** path are referenced to an internal reference point; **Demux In** (which is the same reference point for the Pre-amp output power, as shown in *Figure 8*). The output power is referenced to the faceplate port labeled **Mux Out**.

Figure 14:ROADM-20 Whitebox add/drop optical layout



The table below lists the optical channel functionality requirements of the Mux and Demux paths.

Table 18:ROADM-20 add / drop optical path losses

Parameter		From	To	Minimum	Maximum
WSS attenuation range				0	15 dB
Insertion Loss, Mux Path (WSS attenuation at 0dB)		Mux In	Mux Out	2.5 dB	8.0 dB
Insertion Loss, Demux Path (WSS attenuation at 0dB)		Demux In	Mux Out	2.5 dB	7.6 dB
Insertion Loss Ripple	0 dB	Mux In (Demux In)	Mux Out (Mux Out)		0.5 dB
	10.0 dB				0.7 dB
	15.0 dB				0.9 dB
Insertion Loss Uniformity	Channel Uniformity	Mux In (Demux In)	Mux Out (Mux Out)		2.0 dB
	Port Uniformity				3.0 dB
Polarization Dependent Loss (PDL)		Mux In (Demux In)	Mux Out (Mux Out)		1.1 dB
Return Loss	Static	At all Ports		30 dB	

Unless stated otherwise, all the specifications listed in *Table 19: ROADM-20 optical channel functionality specifications* and *Table 20: ROADM-20 mux and demux optical performance specifications*, apply to traffic carrying common port, **com1** to/from switching ports.

Table 19: ROADM-20 optical channel functionality specifications

Parameters		Minimum	Typical	Maximum
Frequency Range	C-Band + TOSA, See *Table 5: ROADM-20 Wavelength range definitions*			
Port Configuration			2 × 20	
Number of Ports	• One common port • One test port, and • Twenty switching ports/WSS		44	
Slice Width Granularity		6.25 GHz		
Number of 6.25GHz Slice				768
Settable Channel Bandwidth		37.5 GHz		4800 GHz
Number of Channel	@ 37.5GHz			128
ITU Band (or Passband) around ITU Centre	@ 50GHz Channel	-14 GHz		+14 GHz
	@ 37.5GHz Channel	-7.75 GHz		+7.75 GHz
	75GHz~500GHz	+/- 26.5 GHz		+/- 239 GHz

Table 20: ROADM-20 mux and demux optical performance specifications

Parameters		Minimum	Typical	Maximum
Adjacent Channel (Port) Isolation		35 dB		
Channel Extinction Ratio (ER)		35 dB		
Port Isolation, C-band		25 dB		
Port Isolation, TOSA Band		25 dB		
Polarization Mode Dispersion (PMD)	Attenuation 0~15dB			0.6 ps
Chromatic Dispersion (CD)	Attenuation 0~15dB	-10 ps/nm		+10 ps/nm
Attenuation Setting Resolution				0.1
Attenuation Setting Accuracy	Attenuation 0~10dB			1.0 dB
	Attenuation 10.1~15dB			1.5 dB
Attenuation Setting Time (Hitless, all channels)	Attenuation from 0dB to 15dB			850 ms
	Attenuation ≤ 2dB			350 ms

Table 21:ROADM-20 TOSA optical specifications

Parameters		Minimum	Typical	Maximum
Transmitted Wavelength		1566.93 nm		1567.33 nm
Transmitted Power, Average	DEMUX OUT	-7 dBm	-4 dBm	
Transmitted Power, Maximum	DEMUX OUT			0 dBm

WSS power monitoring specifications

All of the monitor points referenced in this section are total power monitors, using photodiodes (PD).

Table 22:ROADM-20 channel selection optical power monitor ranges

Monitor Name	Reference Point	Alarm Range		Operation Range	
		Minimum	Maximum	Minimum	Maximum
Mux In	Mux In	-29 dBm	27 dBm	-22.4 dBm	+23 dBm
Mux Test Port	Mux Test Port				

The table below specifies the monitor accuracy requirements relative to the power referenced to the associated faceplate connector port.

Table 23:ROADM-20 channel selection PD monitor accuracy

Parameter	Minimum	Typical	Maximum
Absolute PD Accuracy – Operation Range	-1 dB		1 dB
Absolute PD Accuracy – Alarm Range[a]	-2 dB		2 dB
Relative PD Accuracy[b]	-0.2 dB		0.2 dB

a. Power levels within the alarm range that is not included within the operation range
b. Relative change monitor error over the operating range, at any fixed temperature

WSS channel power control specifications

Channel power control is accomplished by monitoring the channel power at the input of the Post-amp and adjusting the channel attenuation through the WSS until the specified channel power target is achieved.

The table below lists the channel power control requirements.

Parameter	Minimum	Typical	Maximum
Channel power control target (for any possible flex channel)	dBm	dBm	TBD
Channel (37.5GHz~200GHz) Power Control Accuracy	dBm	dBm	TBD
Convergence Time to 1dB Step Change at Input (fixed target)	dBm	dBm	TBD

Parameter	Minimum	Typical	Maximum
Short Term Channel Power Stability (static) [a]	dBm	dBm	TBD
Long Term Channel Power Stability (static)	dBm	dBm	TBD

a. At fixed polarization (not including PDL)

ROADM-20 optical channel monitor specifications

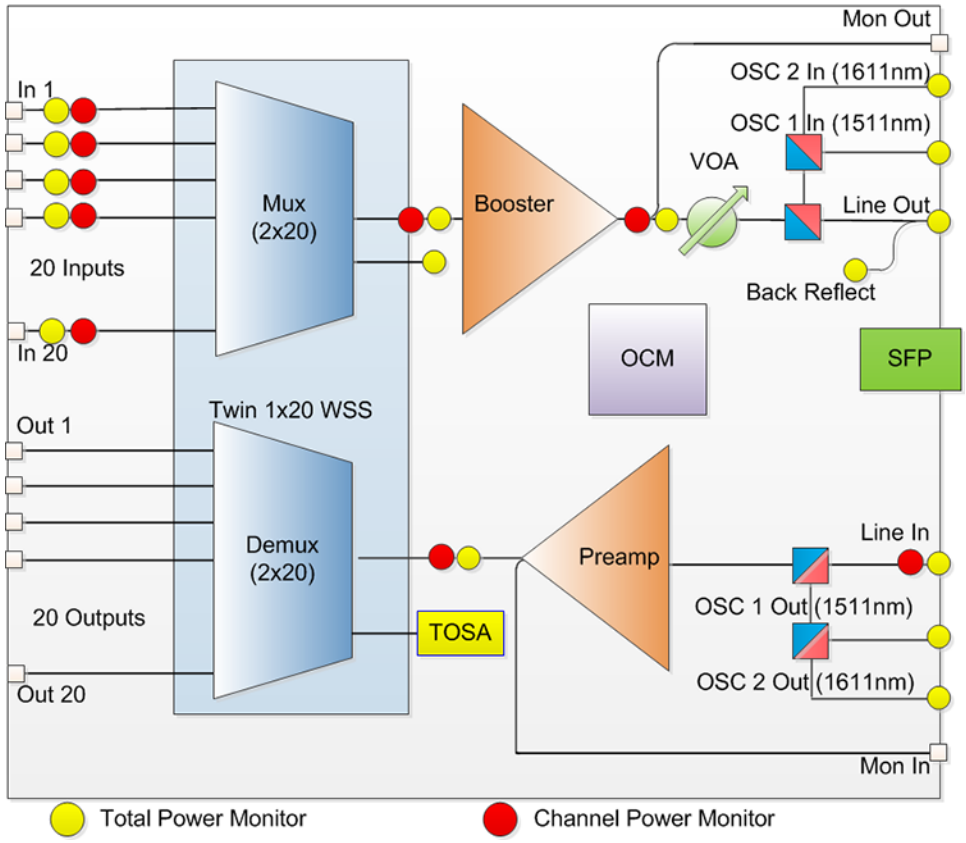
The optical channel monitor (OCM) supports power measurement for each of the 96 channels in the system, and for all the functional blocks; Pre-amp, Booster, and Add/Drop, as shown in the optical layouts of each block. This data can be used for system control or reported to the end user through the management interface.

The fundamental functionality is:

- Individual channel power reporting
- Individual power reporting per 12.5 GHz slice width
- Support for signal data rate from 10Gbps to 600Gbps
- OSNR reporting is not required

There are a total of 24 power monitoring points within the ROADM-20. The OCM monitoring points are defined in *Figure 15* and *Table 24: ROADM-20 Whitebox power monitoring points* below.

Figure 15:ROADM-20 Whitebox power monitoring points



All optical power levels specified are referenced to either an external faceplate port of the device or an internal reference point as defined in *Table 24: ROADM-20 Whitebox power monitoring points*.

Table 24:ROADM-20 Whitebox power monitoring points

Monitor Name	Reference Point	Description
Mux In	Mux In	All the Mux inputs, ports 0 through 19 referenced to the **Mux In** faceplate port
Booster In	Mux Out	**Mux Out** is the same reference point as the input of booster block, as shown in *Figure 11*
Booster Out	Line Out(VOA=0 dB)	Referenced to **Line Out** faceplate port, with VOA at 0 dB
Line In	Line In	**Line In** faceplate port
Pre-amp Out	Demux In	**Demux In** is the same reference point as the output of the Pre-amp block, as shown in *Figure 8*

Per-channel power is defined as the total power contained within the defined channel width, which is equal to the sum of the power present in all of the slices that make up the channel. *Table 25: ROADM-20 Whitebox power monitoring ranges* specifies the required per-channel and per-slice power levels at the reference points for each power monitor point.

Table 25: ROADM-20 Whitebox power monitoring ranges

Monitor Name	Monitor Name	Alarm Range		Operation Range	
		Minimum	Maximum	Minimum	Maximum
Optical Power Per 12.5GHz Slice	Booster In	-38.5 dBm		-36.42 dBm	-6.2 dBm
	Booster Out	-14 dBm		-9.0 dBm	-2.94 dBm
	Line In	-38.5 dBm		-41.3 dBm	-12.6 dBm
	Pre-amp Out	-11.5 dBm		-6.5 dBm	-2.8 dBm
	Mux In	-30.5 dBm		-28.4 dBm	-4.5 dBm
Optical Power Per 37.5GHz channel[a]	Booster In	-38.5 dBm		-31.65 dBm	-1.75 dBm
	Booster Out	-9 dBm		-4.2 dBm	1.83 dBm
	Line In	-38.5 dBm		-36.55 dBm	-8.0 dBm
	Pre-amp Out	-7 dBm		-1.75 dBm	2.0 dBm
	Mux In	-28.5 dBm		-23.5 dBm	0.25 dBm
Optical Power Per any Channel (channel BW from 37.5GHz to 200GHz)	Booster In	-38.5 dBm		-24.38 dBm	5.7 dBm
	Booster Out	-2 dBm		3.0 dBm	9.1 dBm
	Line In	-37 dBm		-29.28 dBm	-0.6 dBm
	Pre-amp Out	0.5 dBm		5.52 dBm	9.2 dBm
	Mux In	-28.5 dBm		-16.4 dBm	7.5 dBm

a. Channels with a spectral width greater than 37.5GHz will still maintain a spectral power density that is within these limits

The following performance requirements apply to the ROADM-20 OCM. Note that larger channel power ranges and channel power disparity may be supported but with potentially reduced accuracy performance.

Table 26: ROADM-20 OCM Specifications

Parameter		Minimum	Typical	Maximum
Operating wavelength range	C-band + TOSA, Refer *Table 5: ROADM-20 Wavelength range definitions*			
Channel spacing	Flexible grid			
Port update rate[a],[b]	Booster In		2 sec	
	Booster Out		6 sec	
	Line In		6 sec	
	Pre-amp Out		2 sec	
	Mux In		30 sec	

Parameter			Minimum	Typical	Maximum
Power reporting resolution				0.01 dB	
Absolute power accuracy @ 12.5 GHz slice width	Operation power range				
	Alarm power range				
Absolute channel power Accuracy (37.5GHz~200GHz)[c]	Operation power range	Pin=0 dBm to -30 dBm			2.1 dB
		Pin = -30 dBm to -45 dBm			2.5 dB
		Pin = -45 dBm to -50 dBm			3.0 dB
	Alarm power range				
Relative 12.5 GHz slice power accuracy					1.2 dB
Relative channel power accuracy (37.5GHz~200GHz)					

a. Includes device sweep time, processing and data transfer as well as allowance for optical selector switch to settle.
b. Over all possible loading conditions, changes in channel power, and presence
c. Booster In OCM channel power error measured relative to Post-amp In PD reading.

ROADM-20 optical supervisory channel (OSC) specifications

The ROADM-20 has the following optical supervisory channel specifications.

Table 27:ROADM-20 OSC add/drop filter specifications

Parameter		Minimum	Maximum
OSC wavelength range	OSC Band 1 - Primary wavelength range (1511 nm)	1504 nm	1518 nm
	OSC Band 2 - Secondary wavelength range (1611 nm)	1604 nm	1618 nm
OSC ADD path IL, both wavelength bands		0.5 dB	1.8 dB
OSC DROP Path IL, both wavelength bands		0.5 dB	1.8 dB
OSC Band Isolation, rejection from passing through EDFA		25 dB	
OSC Band Isolation, Line In to Preamp Input PD		50 dB	
Signal Band Isolation, from Line In to OSC 1/2 Out		30 dB	

Supported SFPs

The following SFPs are recommended for use with DCI Whiteboxes but all SFP MSA compliant devices are supported.

For detailed optical specifications for these supported SFPs, see the *Lumentum Pluggables Reference Guide*.

DANGER

DANGER - LASER!

If an optical connection is removed, laser power may be accessible. Use caution and avoid direct exposure to this laser energy.

Table 28:Recommended SFPs

SFP[a]	Parameter	Specification
WRT-SFPI3C10SC-051 / -061 / -0xx	Wavelength	1510 nm/ 1610 nm
	Speed	1.25 Gbps
	Minimum Output Power	-5 dBm
	RX Power Range	-23 dBm to -3 dBm
	Supported Span Loss	0 to 11 dB
WRT-SFPL3C10SC-051 / -061 /-0xx	Wavelength	xxxx / 1510 / 1610 nm
	Speed	1.25 Gbps
	Minimum Output Power	0 dBm
	RX Power Range	-32 dBm to -5 dBm
	Supported Span Loss	6 to 25 dB
WRT-SFPL3C10XC-051 / -061 /-0xx	Wavelength	xxxx / 1510 / 1610 nm
	Speed	1.25 Gbps
	Minimum Output Power	0 dBm
	RX Power Range	-32 dBm to -5 dBm
	Supported Span Loss	6 to 25 dB

a. Span loss ranges shown refer to fiber plant loss external to the NE. Add/drop internal losses are included in the values given here.

ROADM-20 laser safety

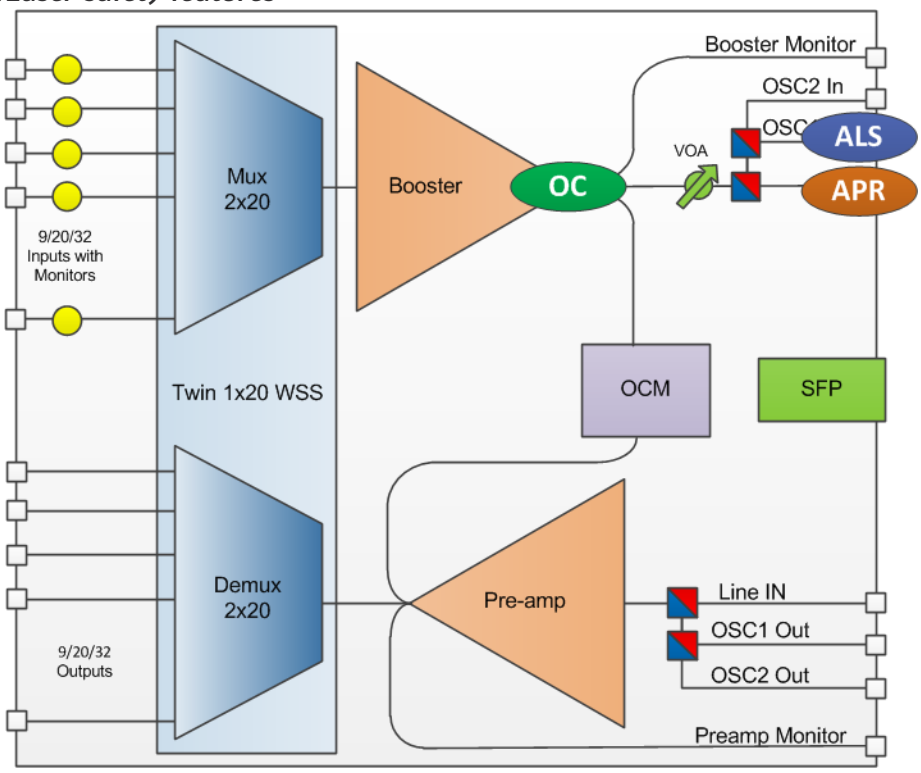
The ROADM-20 Whitebox is a Class 1M Product with a Hazard Level 1M System Hazard Level.

To meet this classification, the maximum output must be less than +10dBm. This is accomplished through three mechanisms:

- Automatic Power Reduction (APR), and
- Automatic Line Shutdown (ALS).

- Output Power Clamp (OC)

Figure 16:Laser safety features



Automatic power reduction (APR)

Description

APR reduces output power when it is determined that the output connector is open. The connector is determined to be open by calculating the optical return loss (ORL), using readings from the back reflection PS and the output PD.

Trigger calculations and implementation

If the ORL is under the threshold for 250ms or more, APR is triggered. When the ORL is over the threshold + hysteresis, APR is canceled and normal operation is restored.

The ORL Threshold, hysteresis, and safe power level are not configurable. The following values are used:

- ORL Threshold = 17dB
- Hysteresis = 3dB
- Safe Power Level = +3dBm

APR action

APR reduces output power to a safe level of +3dBm if the power is above that level when APR is triggered.

- If power was already below +3dBm, output power should not be affected.

- An output power clamp must become engaged at +3dBm so that the output cannot increase above that level due to input increases.

Automatic line shutdown (ALS)

The ALS operates as follows:

DANGER

DANGER - LASER!

It is important to note that the eye safety system will be disabled when ALS is disabled.
To prevent serious injury, line ports **must** be disconnected before ALS is disabled.

Description

ALS is designed to completely de-energize both directions of a span in the event of a detected fiber fault (cut, jumper pulled). The EDFA output power will drop below +10dBm within 1s of a fiber cut or pull. and will be shut off when a combination of input LOS and OSC link down occur on the opposite EDFA.

Nodes at both ends of the span function independently but the control loops interact to effectively coordinate shutdown.

Trigger and clear conditions

The booster EDFA ALS is activated when:

a) EDFA 2 input LOS is raised, and

b) Related OSC Ethernet link state is down

ALS is deactivated when either condition a) or b) is no longer true.

ALS Action

ALS actions for both the booster EDFA ALS controller is as follows. ALS actions for pre-amp are reversed:

a) Booster EDFA is forced to shutdown state

b) Booster EDFA raises Automatic Shutoff Alarm

c) Pre-Amp EDFA raises Optical Line Failure Alarm

ALS Alarming

There are three ALS related alarms:

a) Automatic Shutoff:

Raised when an EDFA has ALS activated

b) Optical Line Failure:

Raised when an EDFA has detected input LOS and associated OSC Ethernet link is down

c) Laser Safety Disable:

Raised if ALS has been disabled for maintenance.

The ROADM-20 provides a mechanism to disable ALS for maintenance purposes.

ALS will automatically re-engage after 10 minutes.

Output Power Clamp (OC)

The OC operates as follows:

Description

OC clamps the EDFA output power to a maximum value based on the output PD reading.

Trigger calculations and implementation

There are no trigger conditions, the clamp is active at all times under normal operation.

OC Action

OC prevents the EDFA output power from exceeding a maximum value (+23.3 dBm) based on the EDFA output PD.

OC Implementation

Output power clamp is active in both target gain and target power control modes. It can not be enabled or disabled, and the maximum output power value is not user configurable.

ROADM-20 module specifications

The ROADM-20 module has the following physical specifications.

ROADM-20 electrical specifications

Two field replaceable power supply modules are used to power ROADM-20 Whiteboxes. The power modules are installed in the back of the equipment and secured by latches.

The power supply modules have the following specifications.

NOTE: *The field replaceable fan modules power requirements are included in these values.*

Table 29: *Whitebox electrical specifications*

Parameter		Minimum	Typical	Maximum
AC power	Input Voltage	100 V		240 V
	Input Frequency		50/60Hz	
	Input Current		9 A	
	Grounding and return	Tied to Earth ground through the power module connectors. AC power supply units must be connected to an earth grounded mains socket outlet.		
	Disconnect Device	Unplug the power supply cord from the power module		

Parameter		Minimum	Typical	Maximum
DC power	Input Voltage	-48 V		-60 V
	Current		16.5 A	
	Grounding and return	Tied to Earth ground through the power module connectors. DC power supply units must be connected to an earth grounded power supply.		
	Disconnect Device	Remove power module. First disconnect the power cables, then disengage the latch by pushing it toward the center of the module, and pull the module out of its slot by its handle.		
Power consumption			< 150 W	250W
Fusing	Each power module is internally fused. Fuses are not customer accessible.			

Grounding

The chassis, mounting brackets and FRU (power modules and fan units) housings are tied to a common chassis ground level. Chassis grounding to external ground is provided through the power modules

ROADM-20 environmental specifications

The ROADM-20 supports the primary environmental requirements contained in GR-63-CORE (NEBS Level 3).

NOTE: *These specifications are indicated ambient to the chassis. Temperatures of components inside the chassis itself will be higher.*

Table 30: *ROADM-20 environmental specifications*

Parameter	Minimum	Maximum
Operating Temperature	5 °C	55 °C
	41 °F	131 °F
Storage Temperature	-40 °C	85°C
	-40 °F	185 °F
Operating Relative Humidity (non-condensing)	5% RH	85% RH

ROADM-20 mechanical specifications

Whitebox components support flexible mounting point options.

Both four- and two-post (front and rear) mounting is supported for the ROADM-20 with mounting point depth to both the front and back chassis surfaces can be adjusted.

The rear mounting brackets can be extended beyond the chassis rear surface by up to 5.35 inches (136 mm) for installation in four post racks with up to 23.62 inch (600mm) post spacing

The ROADM-20 has the following mechanical dimensions.

Parameter	Dimension
H x W x D excluding mounting brackets, cable guides, and fan units	1.70 in x 17.6 in x 18.98 in
	43.1 mm x 447 mm x 482 mm
H x W x D including mounting brackets, cable guides, and fan units	1.70 in x 19.02 in x 22.91 in
	43.1 mm x 483 mm x 582 mm
Field Replaceable Units (FRU)	
H x W	1.57 (1RU) x 2.15 inches
	4.0 x 5.46 cm
Depth, front face of module to rear face of module	9.25 inches
	23.49 cm
Depth, including connectors, latches and cable guides	10.875 inches
	27.62 cm
Other Parameters	
Rack mounting options	19-inch (482.60 mm) EIA
Optical connector type (all ports)	LC/PC bulkhead
Fiber type	9/125 µm single-mode
Cooling	Forced air inside chassis from field replaceable fan modules. (Two fan units of three fans each.)

ROADM-20 safety and compliance information

Lumentum Whiteboxes conform to the following standards.

Environmental standards compliance

RoHS compliance

The RoHS Directive stands for “the restriction of the use of certain hazardous substances in electrical and electronic equipment”.

This Directive bans the placing on the EU market of new electrical and electronic equipment containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants.

At the time of publication of this document, this product has been tested to and found to be RoHS compliant with Directive 2011/65/EU, 3 January 2013 (RoHS 6/6) and China RoHS standards.

REACH compliance

REACH is the “Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals”.

This product has been tested to and is found to be Reg. 1907/2006/EC REACH compliant.

Safety standards compliance

The DCI Whitebox complies with the following safety standards.

FCC standards compliance

The Federal Communications Commission (FCC) of the United States of America requires that equipment operating in that country does not cause interference to communications.

The unit has been tested and found to comply with the limits for a Class A digital device, pursuant to Subpart B (Unintentional Radiators) Part 15 of Title 47 of the Code of Federal Regulations for Radio Frequency Devices. Operation is subject to the following two conditions, which the FCC requires to be labeled on the unit:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

FCC rules require that the following note and subsequent information be included in this manual:

NOTE: *This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

Any user modification made to the unit voids the user's authority to operate the unit under the FCC rules.If this unit is used in a residential setting, resulting interference must be corrected by the user.For more information, see Title 47 of the Code of Federal Regulations at http://www.fcc.gov.

UL standards compliance

When tested and approved, this product will comply with the following U.S. and Canadian requirements under the Component Recognition Program of Underwriters Laboratories Inc

- UL 60950 3rd Edition, December 2000
- CAN/CSA-C22.2 No. 950-95

Laser safety standards compliance

The ROADM-20 is a Hazard Level 1M product.

HAZARD LEVEL 1M products are compliant with laser safety standard: IEC60825-2 2004 + A1:2006 + A2:2010.

<table>
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This equipment meets IEC80625-2 Hazard Level 1M requirements when operated in a system.
It is important to note that for proper operation of Lumentum Whitebox laser safety mechanisms, far-end equipment must be in compliance with OpenROADM laser safety specifications, especially:
• The presence of an Ethernet OSC link, and
• The ability to turn off C-band power on detection of a fiber cut.</td>
</tr>
</table>

Chapter 3: Claims, Returns and Technical Support

How to make a Claim or Return

These Lumentum policies and procedures apply to units found to be defective or incomplete when received, or fail after installation.

Please direct all inquiries about these procedures to customer.service@lumentum.com

Contact Technical Support before implementing these procedures. See *How to contact Technical Support* for contact information.

Claims

Immediately inform Lumentum and, if necessary, the carrier, if:

- the contents of the shipment are incomplete
- the unit or any of its components are damaged or defective
- the unit does not pass the initial inspection

Returns

Lumentum only accepts returns for which an approved Return Material Authorization (RMA) has been issued by Lumentum sales personnel.

Contact Customer Service and Sales at customer.service@lumentum.com to obtain an RMA.

The RMA must be obtained before returning any equipment to Lumentum.

NOTE: *The owner's name and address, the model number and full serial number of the unit, the RMA number and an itemized statement of claimed defects must be included with the returned material.*

Shipping

Materials should be returned in the original packing material and shipping container.

If these are not available, follow these packaging guidelines:

- Wrap the unit in anti-static packaging. Use anti-static connector covers, as applicable.

- Pack the unit in a reliable shipping container.
- Use enough shock-absorbing material (10-15 cm or 4-6 in.) on all sides to cushion the unit and prevent it from moving inside the container. Pink poly anti-static foam is the best material.
- Seal the shipping container securely.
- Clearly mark FRAGILE/RMA on its surface.
- Always provide the model and serial number of the unit and the RMA number on any accompanying documentation.
- Do not ship the module with SFP or XFP pluggable client interface modules installed.
- Pluggables should be packaged separately from the module.

How to contact Customer Service and Sales Support

Customer support is available 8:00 AM - 8:00 PM ET(GMT-5), Monday through Friday, excluding Canadian holidays.

For any problems using the following toll-free numbers, please contact customer.service@lumentum.com or call +1 613-843-5378

Toll Free Phone Numbers

Most international customers have toll free access to Customer Support. Dial one of these toll free telephone numbers and follow the voice prompts to page a specialist.

Region	Toll Free Numbers	
North America	Phone	844-810-LITE (5483)
	Fax	844 910 5483
Outside North America	Phone	800-000-LITE (5483)
	Fax	800 010 5483
APAC	Phone	800-0825-LITE (5483)
	Fax	800 010 5483
China	Phone	400-120-LITE (5483)
	Fax	400 121 5483

Toll Free Access Codes by Country Use the following access codes when dialing toll free from one of these countries.			
Country	Code	Country	Code
Australia	0011	Malaysia	00
Europe	00	New Zealand	00

Toll Free Access Codes by Country Use the following access codes when dialing toll free from one of these countries.					
Country		Code	Country		Code
Hong Kong	Phone	001	Singapore		001
	Fax	002	South Korea	Korea Telecom	001
Israel		014		Dacom	002
Japan	KDD	001	Sweden	Telia	009
	ITJ	0041		Tele2	007
	IDC	0061	Taiwan		00

Web and E-mail Addresses

Learn more about Lumentum at: http://www.lumentum.com/

Contact Lumentum customer service at: customer.service@lumentum.com.

How to contact Technical Support

Technical support is available 7 days a week, 24 hours a day.

Phone Numbers

For any problems using the following toll-free numbers, please contact support@lumentum.com or call +1-408-404-0612.

Region	Toll Free Numbers
North America	1-800-406-9559
Germany	08001822595
Japan	(0066) 006633868039
Korea	0808993108
Switzerland	0800561728
Taiwan	0809091869
China	400-1208861

Web and E-Mail Addresses

Learn more about Lumentum at: http://www.lumentum.com/

E-mail: support@lumentum.com

Chapter 4: Ordering codes and documents

Refer to the following tables for more information about Lumentum products and documentation.

Lumentum order codes

Use the following part numbers and descriptions when ordering Whitebox equipment.

Table 31: Lumentum Whitebox equipment

Part Number	Description
Terminal Amplifier	
WB-TAP-3000-AC	Terminal with OCM and Protection with US AC Supply
WB-TAP-3000-DC	Terminal with OCM and Protection with DC Supply
Line Amplifier	
WB-LA-2000-AC	Line Amplifier with US AC supply
WB-LA-2000-DC	Line Amplifier with DC supply
Mux/Demux	
WB-MD-9600	96-ch Mux Demux
ROADM-20	
WB-RDM-3200-AC	ROADM with Twin 1x20 WSS with TOSA and Dual US AC supply
WB-RDM-3200-DC	ROADM with Twin 1x20 WSS with TOSA and Dual DC supply
WB-RDM-3200-UK	ROADM with Twin 1x20 WSS with TOSA and Dual UK AC supply
Fan Modules	
WB-FAN-2000	1U Fan Module Azure Blue
Power Modules	

Part Number	Description
WB-DC-2000	1U DC Power Supply Packaged
WB-AC-2000	1U AC Power Supply with AC Power Cord North America
WB-AC-2001	1U AC Power Supply with AC Power Cord UK

Lumentum documents

Refer to this table when requesting additional Lumentum documentation.

Document Number	Product
SYSTEM OVERVIEW	
22135143	Lumentum System Overview Guide
PRODUCT GUIDES	
22127184	Lumentum Terminal Amplifier Product Guide
22132895	Lumentum Line Amplifier Product Guide
22127186	Lumentum Mux/Demux Product Guide
22133973	Lumentum ROADM-Alpha Product Guide
22136502	Lumentum ROADM-20 Product Guide
USER GUIDES	
22149788	Lumentum Terminal Amplifier User Guide
22149789	Lumentum Line Amplifier User Guide
22149790	Lumentum ROADM-Alpha User Guide
22149791	Lumentum ROADM-20 User Guide
SOFTWARE GUIDES	
22128462	Lumentum NETCONF Reference Guide
22135232	Lumentum NETCONF Software Upgrade Guide
QUICK START GUIDES	
22128460	Lumentum Protected Variant Terminal Amplifier Quick Start Guide
22135452	Lumentum Unprotected Variant Terminal Amplifier Quick Start Guide
22132897	Lumentum Line Amplifier Quick Start Guide
22128461	Lumentum Mux/Demux Quick Start Guide
22133974	Lumentum ROADM Quick Start Guide
RELATED GUIDES	

Document Number	Product
22028376	Lumentum Pluggables Reference Guide
21124196	Lumentum Fiber Cleaning Guide