Document Number	EDCS-23982035
Revision	DRAFT
Originator	CISCO Team
Date	Feb 7th, 2024

CISCO Open Line System Handbook

Revision number	Date	Note
DRAFT	6-Apr-23	First Draft
Draft v2	14-Apr-23	Added Optical Specifications
Draft V3	28 April	Added Section 3 Control Loop Algorithm, Section Platform SW section1, 3, and 4. Added Section 9 OTDR SW config and Performance Monitoring for each LC type with its own CLI
Draft V4	12 May	Added Section with CLI config, Target control and related alarms, Channel groups and management, Connection validation And Spectrum analyser support (from OCM) and ZTP and DHCP table.
Draft v5	17th May	Added more details on each CLI under section Target control and related alarms
Draft v6	19th May	Updated Platform SW section with ZTP, Logs, Licensing. Also rearrange the section numbers to match the index page
Draft v7	23th May	Updated the COSM config in Day-0 section under Platform software
Draft v8	26th May	Updated the CLIs for the new features under Section 23 under Photonic SW & features. Also updated the index page with right section numbers
Draft v9	29th May	Updated the COSM bring up section under Platform software section#2
Draft v10	15th June	ed the Index page and updated the Cisco Process Manager section under Platform Software
Draft v11	15th August	Added AAA (TACACs) and Syslog information under SW section
Draft v12	2nd Dec	Updated: Optical Line Terminal – Optical Channel Monitor & Photo Diode Scheduler
Draft v13	2nd Feb 2024	Updated the OSC behaviour on reloads under section 9.7, Section 10.16 for ORL And alarms, and Security, Smart Licensing

Draft v14	13th Feb 2024	Updated the Syslog section
Draft v15	15th Feb 2024	Updated some of the CLIs and fixed comments in Section#2
Draft v16	15th Apr 2024	Updated ALC calibration section with a schema
Draft v17	23rd Apr 2024	Added sequence diagrams and flow chart for ALC procedure
Draft V18	25th Apr 2024	Added Power Regulation During ALC Procedure Section
Draft V19	29th May 2024	Added OTDR auto scan details
Draft V20	13th Jun 2024	Modified ALC calibration to reflect baselining flow changes. Added new sections for ALC status reporting and fault handling
Draft V21	20th Jun 2024	Adding ASE Hysteresis details
Draft V22	24th Jun 2024	Added the Disaster Recovery (CPU replacement) section
Draft V23	27th Jun 2024	Added “Spanloss Computation logic” section
Draft V24	09th Aug 2024	Added Photo diodes supporting fast sampling in sections 12.2 and 12.4
Draft V25	21th Dec 2024	Added NCS1020 block diagram, added notes related to NCS1020 RP and SSD. Updated for SW Features added as a part of IOSXR Release 24.4.15

Table of Figures

Abbreviations Used in This Document

Abbreviation	Full form
OLT	Optical Line Terminal
ILA	Inline Amplifier
PD	Photo Diode
OCM	Optical Channel Monitor
OSC	Optical Supervisory Channel
CPU	Central Processing Unit
EITU	External Interface and Timing Unit
LC	Line card
PSU	Power Supply Unit
BIOS	Basic Input Output System
NCS	Network Convergence System
OBFL	On Board Failure Logging
TL OOB	Tunable Laser Out of Band

1 Platform HW

1.1 Documentation References

- NCS1010 Installation Guide:
  https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/hardware/guide/b-ncs1010-hardware-guide/m-install-ncs-1010.html

- NCS1010 Datasheet:
  https://www.cisco.com/c/en/us/products/collateral/optical-networking/network-convergence-system-1000-series/network-conver-system-1010-ds.html

- NCS1014 Installation Guide:
  https://www.cisco.com/c/en/us/td/docs/optical/ncs1014/hardware/guide/b-ncs1014-hig/m-cisco-ncs-1014-overview.html

- NCS1014 Datasheet:
  https://www.cisco.com/c/en/us/products/collateral/optical-networking/network-convergence-system-1000-series/network-convergence-system-1014-ds.html

- NCS1014 Line card Installation Guide:
  https://www.cisco.com/c/en/us/td/docs/optical/ncs1014/hardware/video/ncs1k14-2-4t-k9-line-card-installation.html

- NCS1020 Installation Guide:
  https://www.cisco.com/c/en/us/td/docs/optical/ncs1020/hardware/guide/b-ncs1020-hardware-guide.html

- NCS1020 System Spec:
  https://www.cisco.com/c/en/us/td/docs/optical/ncs1020/hardware/guide/b-ncs1020-hardware-guide/m-cisco-ncs-1020-system-specs.pdf

1.1.1 NCS1010 Shelf Overview

NCS1010 is a 3RU box including a Backplane, a Timing Unit (EITU), a CPU board, 2 redundant FAN trays and 1 Optical tray that can be configured based on customer needs. The EITU and backplane are fixed in the chassis (not removable parts), while the PSU, CPU, the FAN trays, and the Optical tray are removable parts.

Below is reported the functional block diagram of the NCS1010 control plane detailing the EITU, CPU and Backplane functionalities.

Key parts of the platform:

- Intel Atom C3758 (SKU7) - 8 Cores - 2.2Ghz (on CPU)
- 1x RDIMM slot, provided with 32GB DDR4, 1200MHz (2400MT/s) (on CPU)
- Dual BIOS support with Aikido Secure Boot (on CPU)
- 1x SSD M.2 connector (both SATA and NVMe supported) provided with 480GB SATA3 SSD (on CPU)
- 1x 480GB SSD M.2 SATA backup storage (mounted on EITU board, not removable part)
- NFC support (on CPU)

- Bluetooth v5.0 low energy support (on CPU)
- OBFL (On-Board Fault Logging) FLASH 256Mbit
- Control FPGA (Vance on CPU, Dewey on EITU board) to provide Interrupt management, I2C and SPI buses management, Sirius control signals management, various configuration registers
- ADM1266 Super Sequencer® to control/supervise power rail and CPU/EITU power-up sequence.
- Intelligent 5/12V power management on the EITU 3x USB 2.0 ports for standard USB key or proprietary Alpha Centauri passive modules
- GPS Timing support
- 1x serial UART interface for debug (on EITU).
- 1x USB 3.0 on CPU front side for SW installation and log downloading (on CPU)
- 3x USB 2.0 with Alpha Centauri support (5V/12V power management) (on EITU)
- Enhanced PTP 15888 and Sync-E Timing support on 10/100/1000 Copper, 1GE Optical and RS-485 ports (on EITU)

1.1.2 NCS1010 EITU

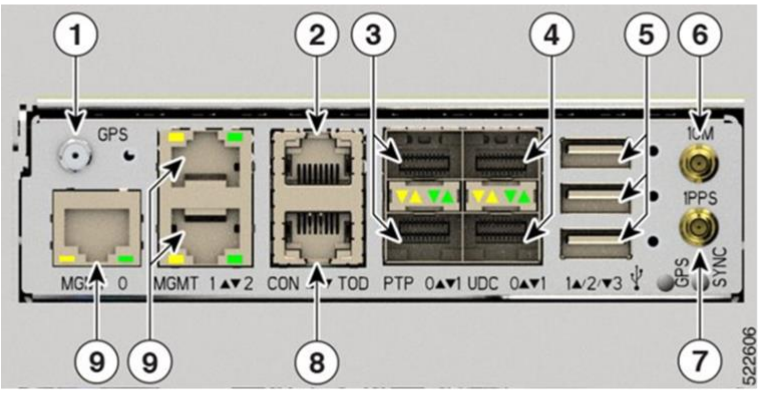


Figure 1: EITU Face Plate

Detailed description of the EITU port Failed channel switch is reported below:

1	**Coaxial connector for GPS antenna RF input (with +5V antenna power, if necessary) (1x)**
2	Console/Universal Asynchronous Receiver/Transmitter (UART) Interface (1x)
3	SFP for 1GE optical PTP port (1588 and SyncE) (2x)

4	SFP for 1GE optical User Data Channels (UDC) (2x)
5	USB 3.0 type A, 1.8A max @5V/12V (with Cisco NCS 1000 Breakout Patch Panel support) (3x)
6	Coaxial connector for 10MHz sync signal (bidirectional) (1x)
7	Coaxial connector for 1PPS sync signal (bidirectional) (1x)
8	RJ45 for 1588 TOD(1x)
9	10/100/1000 RJ-45 Ethernet management ports and Interconnection Link (ILINK) (3x)

1.1.3 NCS1010 CPU

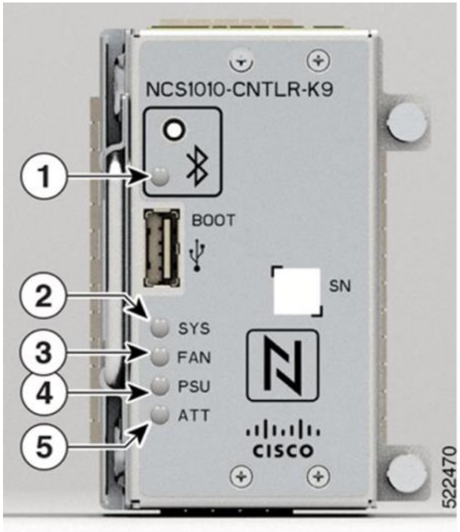


Figure 2: CPU Faceplate

USB: is a standard USB3 port. It can be used for SW installation or LOG downloading.

LED #	LED Description	Default Status (at the time of Power On and when the System is not Up)	Color	Status
1	Bluetooth Low Energy (BLE) Status LED	OFF	OFF	Not supported

2	System Status LED (during controller boot)	RED	RED	Indicates that the controller unit is powering ON.
			RED (flashing slowly)	Indicates BIOS loading.
			YELLOW (flashing slowly)	Indicates operating system loading.
			RED (flashing fast)	Indicates secure boot failure. Replace the controller.
			YELLOW (flashing fast)	Indicates that the controller unit is not seated properly. Remove and replace the controller properly.
	System Status LED (controller is operational)		RED	Major or critical infrastructure or environment alarm
			YELLOW	Minor infrastructure or environment alarm
			GREEN	Operational without any infrastructure or environment alarm
3	Fan Status LED	RED	GREEN	Indicates all fans present in the chassis are in working condition.
			RED	Indicates either a fan is missing from its slot or is faulty.
4	Power Supply Status LED	RED	GREEN	Indicates all PSUs' present in the chassis are in working condition.
			RED	Indicates either a PSU is missing from its slot or is faulty, or there is no input

				power.

5	Attention LED	OFF	BLUE	Used to identify a specific chassis in a rack or room.
				This is used for troubleshooting purposes
				such as replacing the fiber and field-replaceable units.
				It can be controlled through the software CLI.
				Use the following command to activate this LED, manually:
				
				To activate :
				hw-module attention-led location 0/RP0/CPU0 → commit
				
				To deactivate:
				no hw-module attention-led location 0/RP0/CPU0 → commit
				
				the status can be checked using show led
				<u>Default condition</u>
				`RP/0/RP0/CPU0:OLT-1#show led | i Attention`
				`Tue Feb 13 22:05:16.907 IST`
				`Attention OPERATIONAL OFF`
				<u>When the LED is activated</u>
				`RP/0/RP0/CPU0:OLT-1#show led | i Attention`
				`Tue Feb 13 22:07:16.204 IST`
				`Attention OPERATIONAL BLUE`

1.1.4 NCS1010 HW Configuration

The different System NE are composed, for the HW standpoint, by and NCS1010 chassis equipped with the following list of common PIDs:

- NCS1010-SA= shelf assembly, already including the backplane and the Timing Unit (EITU);
- NCS1010-CNTLR-K9= CPU unit;
- NCS1010-FAN= fan tray;
- NCS1010-FTF= fan tray filter;
- 2x Power Supply Unit either:
    - NCS1010-DC-PSU= for DC power supply;
    - NCS1010-AC-PSU= for AC power supply;
- 2x NCS1010-DC-CBL-ET= power supply cable;
- NCS1010-ACC-KIT= mechanical accessory kit for 19-inch rack (mandatory).

Content of the kit is detailed below:

Item description	Qty
LUG,RING, UNIN, 6 to 6 AWG, 0.21",Bright Sn	1
SCR, M, PAN, PH, M5.0x1OmmL, CSwZN	2
SCR, C, PAN, PH, 12-24x0.50"1. CSwZN	8
WSHR,LKEX,M6,11mmOD,1.4mmT,ZN	2
STDF,HEX,6mmW,M4x0.7x4.7mmL,36mmH,CSwZNwPCH,CLEAR,M/F,M3x0.5x6.4mmL	2
FABMTL,STMPD,FIXED SLIDER BRACKET,LEFT,NCS1010	1
FABMTL,STMPD,FIXED SLIDER BRACKET,RIGHT,NCS1010	1
FABPLSTC,COVER,DIECUT,PROTECTION,NCS1010,SIRIUS	1

Depending on the optical feature required at the specific NE (channels amplification or channels Add/Drop, with or without Raman) a specific Optical Module shall be also included into the NCS1010 chassis.

Depending also on the type of rack present the following additional mechanical mounting kits shall be used:

- NCS1010-23-KIT= ANSI 23” rack mount:
- NCS1010-ETSI-KIT= ETSI rack mount:

The power consumption of the different PIDs together with the weight is reported in the table below:

PID	Weight [kg]	Typ. power consumpt. [W]	Max power consumpt. [W]	Note
NCS1010-SA=	6.60	48	70	no USB load
NCS1010-CNTLR-K9=	1.0	30	50	
NCS1010-FAN=	0.80	104	125	
NCS1010-DC-PSU=	0.85	-	-	
NCS1010-AC-PSU=	0.85	-	-	
NCS1010-FTF=	0.15	-	-	
NCS1010-ACC-KIT=	0.80	-	-	
NCS1010-23-KIT=	0.40	-	-	
NCS1010-ETSI-KIT=	0.50	-	-	
NCS1010-DC-CBL-ET=	1.0	-	-	

- SA - Shelf Assembly
- CNTLR - Controller
- PSU - Power supply unit
- FTF - Fan Tray Filter

1.2 NCS 1020 Shelf Overview

Cisco NCS1020 is a 10RU chassis with built-in External Interface Timing Unit (EITU) and the following field-replaceable modules:

- 2 Chassis Controllers (active and backup)
- A single back-up disk (SSD)
- 2 Power Supply Units (PSU)
- Up to four front fan trays, plus additional four rear fan trays.
- up to two NCS1010-OLT optical line cards
- Up to eight NCS1K14-CCMD optical line cards.

1.2.1 NCS1020 Front and Rear view

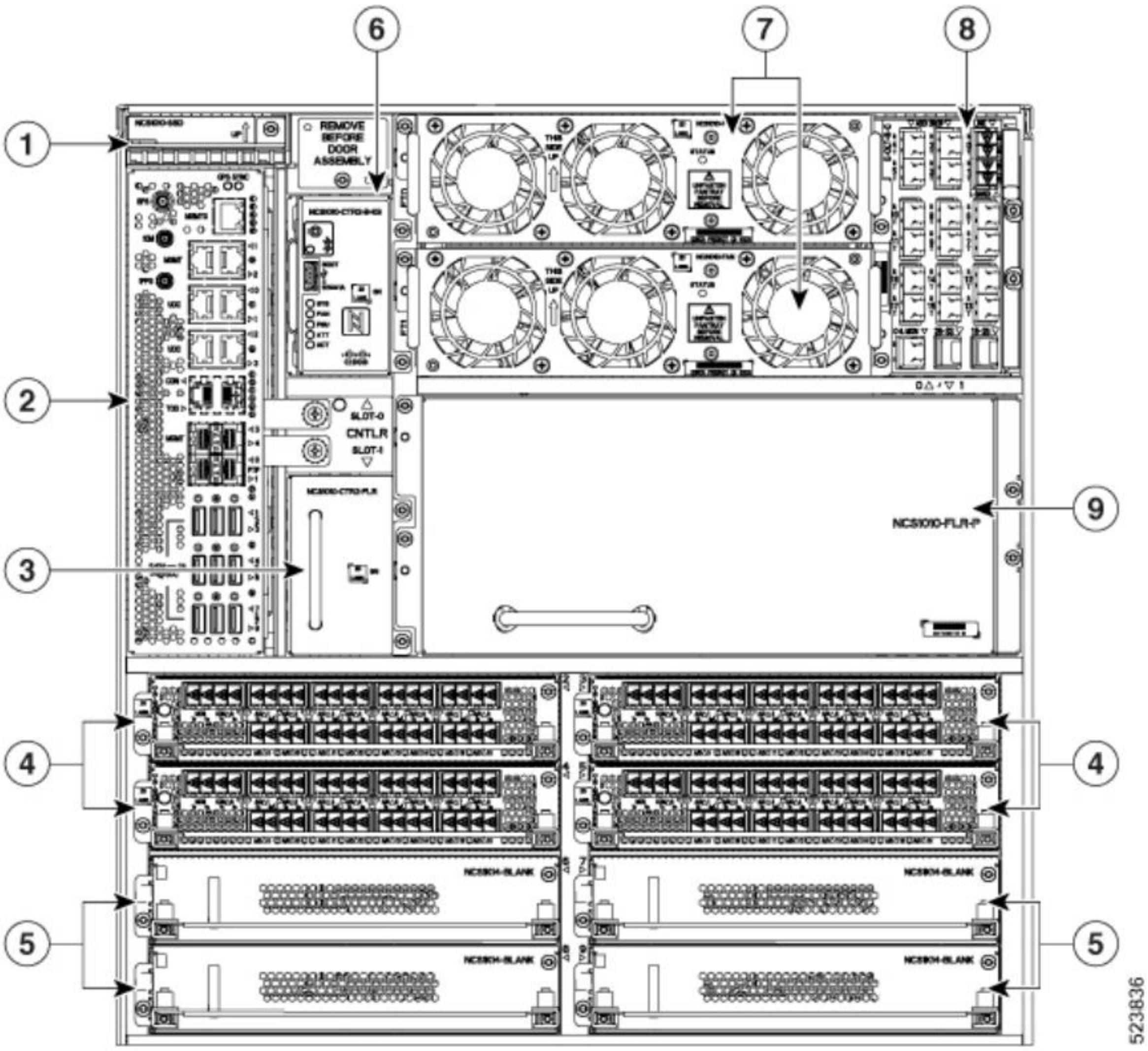


Figure 3: NCS1020 – Front View

Item#	PID	Description	Comment
1	NCS1010-SSD	Chassis removable back-up disk	
2	EITU	Chassis EITU – not field replaceable	
3	NCS1010-CTR2-FLR	Chassis Controller Filler	
4	NCS1K4-CCMD-C/L	16 channel CCMD, C or L band	
5	NCS1K14-BLANK	Line card filler	
6	NCS1010-CTR2-B-K9	Chassis controller card	
7	NCS1010-FTA	Front Fan Tray	
8	NCS1010-E-OLT-C	Terminal Optical Line card	
9	NCS1010-FLR-P	Line card filler	
10	NCS1K4-AC-PSU-2	AC Power Supply – 2.5KW	
11	NCS1020-FAN	Rear Fan Tray	
12	NCS1020-FAN-BLANK	Rear Fan Tray filler	

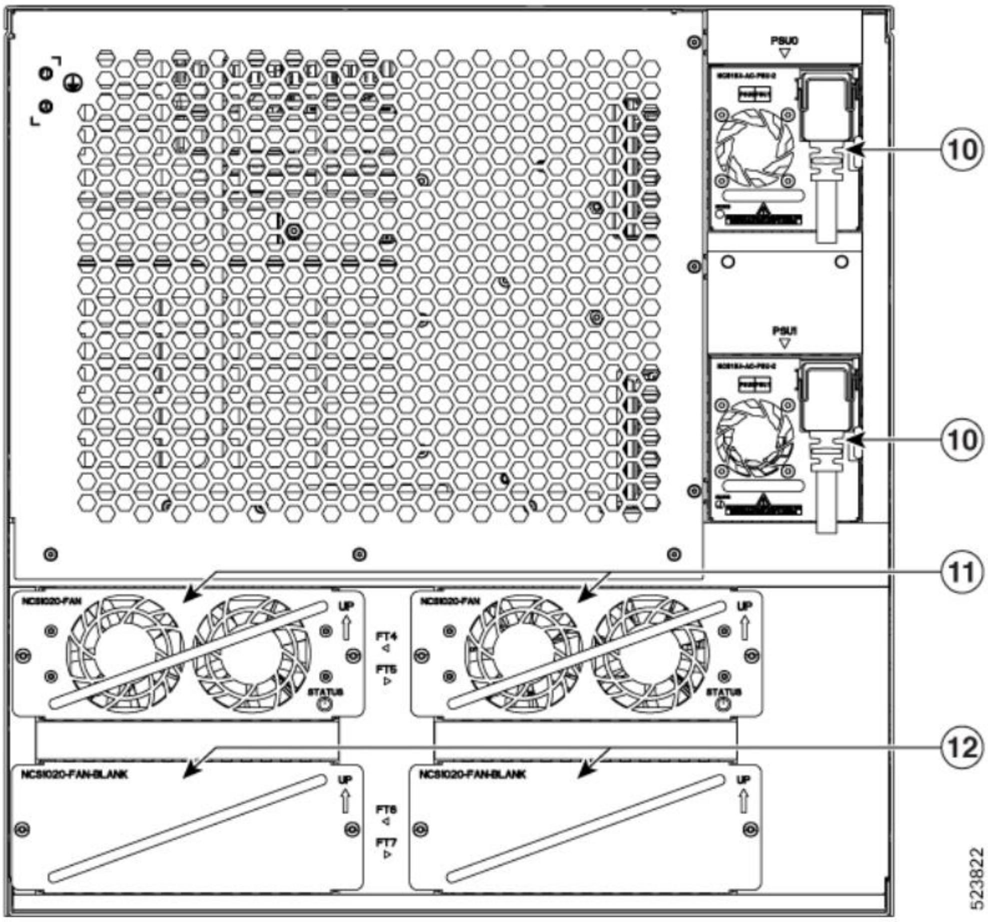


Figure 4: NCS1020 – Rear View

1.2.2 NCS 1020 Chassis EITU

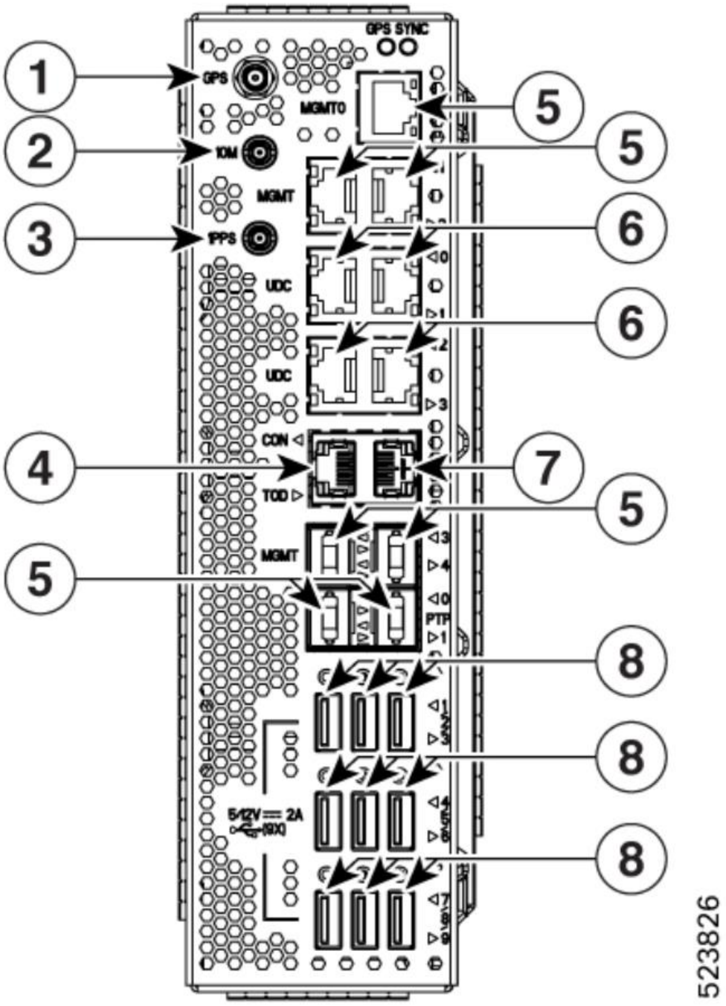


Figure 5: NCS1020 EITU

Item#	Description	Comment
1	GPS RF Connector	Coaxial connector for GPS antenna RF input (with +5V antenna power, if necessary)
2	10MHz IN/Out Clock	Coaxial connector for 10MHz sync signal (bidirectional)
3	1 PPS In/ Out Signal	Coaxial connector for 1PPS sync Signal (bidirectional)
4	Console Port – RS 232	Console / Universal Asynchronous Receiver/Transmitter (UART) Interface
5	4x SFP Optical PTP Ports	Upper 2 can also be used as Aux Management Ports
6	4x Eth. UDC Ports	User Dats Channel

7	Time of Day Port	RJ45 for 1588 TOD
8	USB 2.0 type A Ports	Not used for MSFT configuration

LED	Color	Status
GPS LED	Green	GPS phase is locked.
	Yellow	GPS is enabled.
	Off	GPS is not enabled.
	Red	GPS is used.
Sync LED	Green	Time core is synchronized to an external source including IEEE1588.
	Flashing green	System is in Synchronous Ethernet mode.
	Amber	Acquiring state or Holdover: Time core is in acquiring state or holdover mode.
	Off	Time core clock synchronization is disabled or in a free-running state.
Ethernet Copper Ports (MGMT 0/1/2/3/4) LEDs	Green	The link is ON.
	Yellow	Link is up but without traffic.
	Flashing yellow	Link is up but with traffic.
Ethernet Optical SFP Ports (PTP0/1, UDC 0/1/2/3) LEDs	Green	Indicates the presence of duplex or traffic collision.
	Yellow	LINK is up but without traffic.
	Flashing yellow	LINK is up but with traffic.

1.2.3 NCS 1020 Controller Card

The NCS1010-CTR2-B-K9 controller card supports a default of 9600 bps baud rate on the RS232 console port. The controller card has a USB 2.0 and six status LEDs.

When a single Controller Card is used, it MUST be installed in RP Slot 0 (Top slot).

Note: *NCS1010-CTR2-B is specific to NCS1020 and cannot be plugged into NCS1010.*

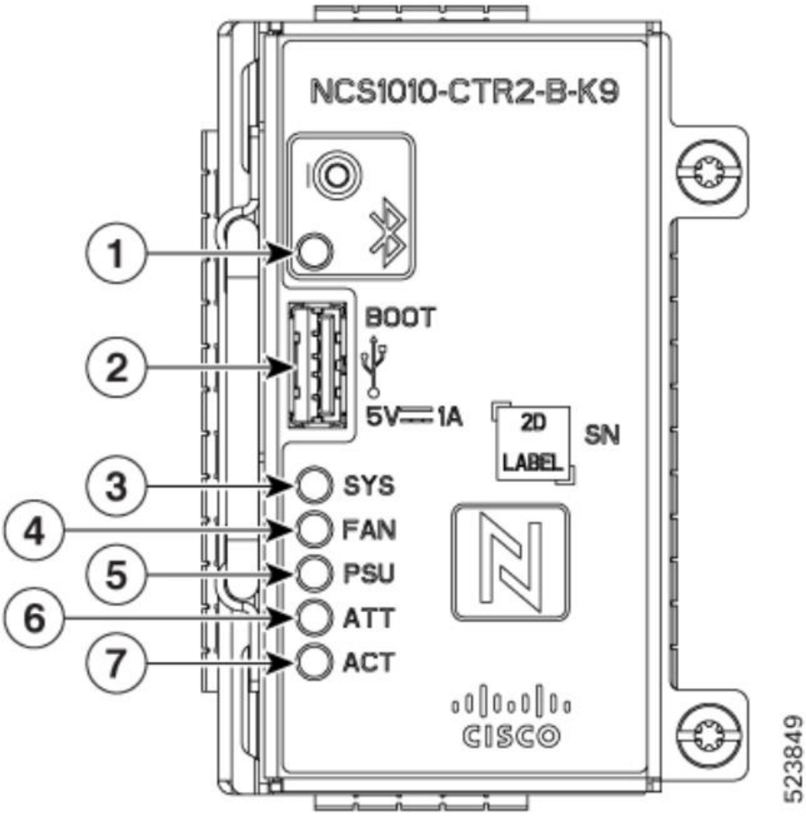


Figure 6: Chassis Controller Faceplate

Item#	Description	Comment
1	Bluetooth Low Energy (BLE) Status LED	Currently it is disabled
2	USB Interface	For data transfer purpose
3	System Status LED	
4	Fan Status LED	
5	Power Supply Status LED	
6	Attention LED	
7	ACT LED	

LED	Default Status of LED (At the time of Power On and when the System is not Up)	Color	Status
BLE LED	Off	Off	Not supported.
System LED (during controller boot up)	Red	Red	Indicates that the controller unit is powering ON.
		Red (flashing slowly)	Indicates BIOS loading.
		Yellow (flashing slowly)	Indicates operating system loading.
		Red (flashing fast)	Indicates secure boot failure. Replace the controller.
		Yellow (flashing fast)	Indicates that the controller unit is not seated properly. Remove and replace the controller properly.
System LED (controller is operational)	Red	Red	Indicates a major or critical alarm.
		Yellow	Indicates a minor alarm.
		Green	The module is operational and has no active alarms.
Fan LED	Red	Green	Indicates all fans present in the chassis are in working condition.
		Red	Indicates either a fan is missing from its slot or is faulty.
PSU LED	Red	Green	Indicates all PSUs present in the chassis are in working condition.
		Red	Indicates either a PSU is missing from its slot or is faulty, or there is no input power.

LED	Default Status of LED (At the time of Power On and when the System is not Up)	Color	Status
Attention LED	Off	Blue	Used to identify a specific chassis in a rack or room. Use this LED for troubleshooting purposes such as replacing the fiber and field-replaceable units. You can control it through the software CLI. Use the following command to activate this LED, manually: **hw-module attention-led location 0/RP0/CPU0**
ACT LED	Red	Red	Indicates either a controller is missing from its slot or is faulty, or there is no input power.
		Green	Indicates all controllers present in the chassis are in working condition.

1.2.4 NCS 1020 Removable SSD

The field-replaceable SSD is accessible from the front of the Cisco NCS 1020 chassis. This chassis SSD acts as the backup software storage in case the SSD inside the CPU fails. It has 480 GB storage space to store the running software and configuration. This backup storage enables Cisco NCS 1020 to quickly recover to functional state if either route processor (RP) corruption or replacement occurs.

Before removing this SSD from the system, follow the procedure to have it properly unmounted ahead of extraction.

1.2.5 NCS 1020 Bluetooth and NFC

RP includes a Bluetooth and NFC interface which are disabled by default. Those features are not supported in current SW release.

1.2.6 NCS 1020 Chassis Components and Weight

PID	Description	Weight [kg]
NCS1020-SA	10RU Chassis	40.0
NCS1010-CTR2-B-K9	Chassis Controller Card	1.0
NCS1010-SSD	Removable Back-up Disk	0.4
NCS1010-FLR-P	NCS1010 Line-card Filler	1.8
NCS1010-CTR2-FLR	Controller Card Filler	0.5
NCS1010-FAN=	Front Fan Tray	0.8
NCS1K4-AC-PSU-2	2.5KW AC Power Supply	1.5
NCS1020-FAN=	Rear Fain Tray	0.8
NCS1020-FAN-BLANK=	Rear Fan Tray Filler	0.5
NCS1020-DR=	Chassis Door Assembly	7.8
NCS1020-ACC-KIT	Accessory Kit	2.8
NCS1020-23-KIT	23 inch rack mounting brackets	1.3
NCS1020-ETS-KIT	ETSI rack mounting brackets	0.9

2 System Cooling

Airflow is front to back for all shelf variants:

- NCS1010
- NCS1020

3 Power Budget and Power Cords

The detailed power consumption figures are available at this link.
Below a summary table for each PID, and the total shelf consumption in different typical cases.
All figures include the efficiency of the PSU, i.e. represent the power actually drained from the power rails.

PID	Description	Max consumption, EOL, >40C, including start-up [W]	Typ consumption, BOL, 25C, steady state [W]
NCS1010-CTLR-B-K9	Shelf controller - NCS1010	78	43
NCS1010-CTR2-B-K9	Shelf controller - NCS1020	111	65
NCS1010-FAN	Fan Tray - NCS1010 and NCS1020	122	38
NCS1020-FAN	Fan Tray - NCS1020	81	25
NCS1K-E-OLT-C=	OLT, C-Band, no Raman	158	99
NCS1K-E-OLT-R-C=	OLT, C-Band, w/ Raman	282	151
NCS1K-E-OLT-L=	OLT, L-Band	166	101
NCS1K-ILA-C=	ILA, C-Band, no Raman	98	65
NCS1K-E-ILA-R-C=	ILA, C-Band, w/ Raman at port Line-0	222	117
NCS1K-E-ILA-R-C-2	ILA, C-Band, w/ Raman at port Line-2	222	117
NCS1K-E-ILA-2R-C=	ILA, C-Band, w/ Raman on both Line ports	347	170
NCS1K-ILA-L=	ILA, L-Band	110	60
NCS1K4-CCMD16C=	CCMD, 16-Channels, C-Band	122	87
NCS1K4-CCMD16L=	CCMD, 16-Channels, L-Band	122	87
NCS1K14-CTLR-B-K9=	Shelf controller - NCS1014 Shelf	133	87

NCS1K4-FAN=	Fan Tray for NCS1014	178	65
NCS1K14-2.4T-K9	Line-Card + 2x CIM-8 800G + 4x Grey 400G	456	394

Chassis type (Infra only)	Configuration	Max consumption, EOL, >40C, including start-up [W]	Typ consumption, BOL, 25C, steady state [W]
NCS1010	1x CNTRL + 2x NCS1010 FAN	322	120
NCS1014	1x CNTRL + 3x NCS1014 FAN	667	283
NCS1020 - C-only	1x CNTRL + 2x NCS1010 FAN + 2x NCS1020 FAN	519	192
NCS1020 - C+L	1x CNTRL + 4x NCS1010 FAN + 4x NCS1020 FAN	926	319

NCS1014 TXP Chassis	Configuration	Max consumption, EOL, >40C, including start-up [W]	Typ consumption, BOL, 25C, steady state [W]
4 channel Grid	1x NCS1014 Chassis + 4x PULSAR LC	2489	1860
32 Channel Grid	4x NCS1014 Chassis + 16x PULSAR LC	9956	7442
34 Channel Grid	5x NCS1014 Chassis + 17x PULSAR LC	11078	8119

NCS1020 Terminal Chassis	Configuration	Max consumption, EOL, >40C, including start-up [W]	Typ consumption, BOL, 25C, steady state [W]
C-band, no Raman	NCS1020 Chassis + E-OLT-C + 3x CCMD-C	1043	552
C-band, w/ Raman	NCS1020 Chassis + E-OLT-R-C + 3x CCMD-C	1167	604

NCS1010 - Complete ILA Chassis	Configuration	Max consumption, EOL, >40C, including start-up [W]	Typ consumption, BOL, 25C, steady state [W]
C-Band, no Raman	NCS1010 Chassis + ILA-C	420	185
C-Band, single Raman	NCS1010 Chassis + E-ILA-R-C / E-ILA-R-C-2	544	237
C-Band, dual Raman	NCS1010 Chassis + E-ILA-2R-C	669	289

Here below the details of the power cords:

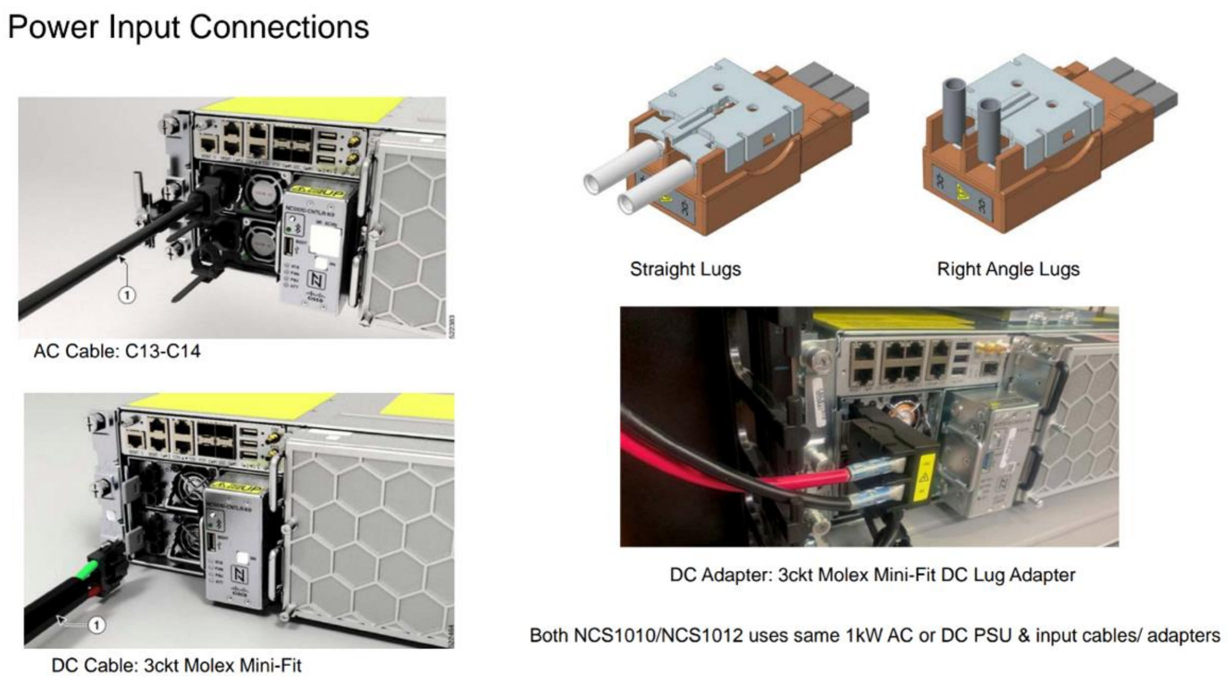


Figure 1 : Power Input Connections

4 Fiber Management

5 Photonics

5.1 OLS2.0 Channel Plan

	Freq. [THz]	Wavelength [nm]
OSC-C service channel C-band	198.5	1510.29
OTDR	197.45	1518.32
-band traffic operative optical bandwidth	196.175 ~ 191.337	1528.19 ~ 1566.83
OLT TL C-band OOB signal	191.175	1568.16
Raman Probe	191.1	1568.77
OLT TL L-band OOB signal	191.1	1568.97
band traffic operative optical bandwidth	190.887 ~ 186.05	1570.52 ~ 1611.35
OSC-L service channel L-band	184.45	1625.33

OSC-C is embedded in the OLT-C and ILA-C Line Card variants.

OTDR is embedded in the OLT-C and ILA-C Line Card variants.

OLT TL C-band OOB signal is embedded in the OLT-C Line Card variants.

OLT TL L-band OOB signal is embedded in the OLT-L Line Card variants.

DFB Raman is embedded into OLT-R-C and ILA-R-C, ILA-2R-C and ILA-R-C-2 in the direction where Raman is present.

OSC-L is embedded in the OLT-L and ILA-L Line Cards.

TL OOB -> Tunable Laser Out Of Band - is the signal used for connection verification

Additional 2 filters used to measure the OSC SNR and trigger the safety in case of Raman noise:

- C-band noise filter has central freq. 199.15THz and 3dB BW 200GHz.
- L-band noise filter has central freq. 185.1THz and 3dB BW 200GHz.

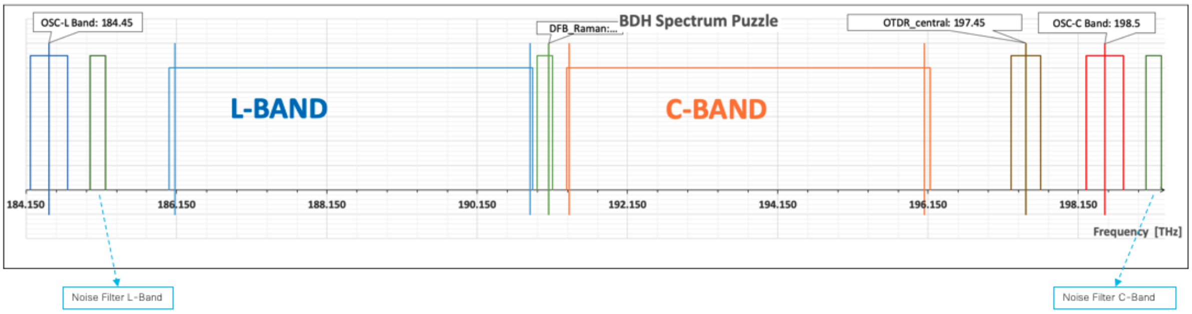


Figure 2 : Spectrum with different application frequencies

C-band 32 channels grid – 150 GHz spacing

Channel#	CCMD LC#	CCMD port#	Ch Central Freq [GHz]	Ch Central wavelength [nm]	WSS freq_start [GHz]	WSS freq_stop [GHz]
1	1	1	191425.0	1566.11	191350.00	191500.00
2	1	2	191575.0	1564.88	191500.00	191650.00
3	1	3	191725.0	1563.66	191650.00	191800.00
4	1	4	191875.0	1562.44	191800.00	191950.00
5	1	5	192025.0	1561.22	191950.00	192100.00
6	1	6	192175.0	1560.0	192100.00	192250.00
7	1	7	192325.0	1558.78	192250.00	192400.00
8	1	8	192475.0	1557.57	192400.00	192550.00
9	1	9	192625.0	1556.35	192550.00	192700.00
10	1	10	192775.0	1555.14	192700.00	192850.00
11	1	11	192925.0	1553.93	192850.00	193000.00
12	1	12	193075.0	1552.73	193000.00	193150.00
13	1	13	193225.0	1551.52	193150.00	193300.00
14	1	14	193375.0	1550.32	193300.00	193450.00
15	1	15	193525.0	1549.11	193450.00	193600.00
16	1	16	193675.0	1547.92	193600.00	193750.00
17	2	1	193825.0	1546.72	193750.00	193900.00
18	2	2	193975.0	1545.52	193900.00	194050.00
19	2	3	194125.0	1544.33	194050.00	194200.00
20	2	4	194275.0	1543.13	194200.00	194350.00
21	2	5	194425.0	1541.94	194350.00	194500.00
22	2	6	194575.0	1540.76	194500.00	194650.00
23	2	7	194725.0	1539.57	194650.00	194800.00
24	2	8	194875.0	1538.38	194800.00	194950.00
25	2	9	195025.0	1537.2	194950.00	195100.00
26	2	10	195175.0	1536.02	195100.00	195250.00
27	2	11	195325.0	1534.84	195250.00	195400.00

28	2	12	195475.0	1533.66	195400.00	195550.00
29	2	13	195625.0	1532.49	195550.00	195700.00
30	2	14	195775.0	1531.31	195700.00	195850.00
31	2	15	195925.0	1530.14	195850.00	196000.00
32	2	16	196075.0	1528.97	196000.00	196150.00

C-band 34 channels grid – 137.5 GHz spacing

Channel #	CCMD LC#	CCMD port#	Ch Central Freq [GHz]	Ch Central Wavl [nm]	WSS freq_start [GHz]	WSS freq_stop [GHz]
1	1	1	191425.00	1566.11	191356.25	191493.75
2	1	2	191562.50	1564.99	191493.75	191631.25
3	1	3	191700.00	1563.86	191631.25	191768.75
4	1	4	191837.50	1562.74	191768.75	191906.25
5	1	5	191975.00	1561.62	191906.25	192043.75
6	1	6	192112.50	1560.50	192043.75	192181.25
7	1	7	192250.00	1559.39	192181.25	192318.75
8	1	8	192387.50	1558.27	192318.75	192456.25
9	1	9	192525.00	1557.16	192456.25	192593.75
10	1	10	192662.50	1556.05	192593.75	192731.25
11	1	11	192800.00	1554.94	192731.25	192868.75
12	1	12	192937.50	1553.83	192868.75	193006.25
13	2	1	193075.00	1552.73	193006.25	193143.75
14	2	2	193212.50	1551.62	193143.75	193281.25
15	2	3	193350.00	1550.52	193281.25	193418.75
16	2	4	193487.50	1549.42	193418.75	193556.25
17	2	5	193625.00	1548.31	193556.25	193693.75

18	2	6	193762.50	1547.22	193693.75	193831.25
19	2	7	193900.00	1546.12	193831.25	193968.75
20	2	8	194037.50	1545.02	193968.75	194106.25
21	2	9	194175.00	1543.93	194106.25	194243.75
22	2	10	194312.50	1542.84	194243.75	194381.25
23	2	11	194450.00	1541.75	194381.25	194518.75
24	2	12	194587.50	1540.66	194518.75	194656.25
25	3	1	194725.00	1539.57	194656.25	194793.75
26	3	2	194862.50	1538.48	194793.75	194931.25
27	3	3	195000.00	1537.40	194931.25	195068.75
28	3	4	195137.50	1536.31	195068.75	195206.25
29	3	5	195275.00	1535.23	195206.25	195343.75
30	3	6	195412.50	1534.15	195343.75	195481.25
31	3	7	195550.00	1533.07	195481.25	195618.75
32	3	8	195687.50	1532.00	195618.75	195756.25
33	3	9	195825.00	1530.92	195756.25	195893.75
34	3	10	195962.50	1529.85	195893.75	196031.25

5.2 Photonics Hardware Description

5.3 List of SKUs

PID	Description	pMTBF [hrs]
NCS1K-E-OLT-C	Terminal Amplifier – C-Band	296'280
NCS1K-E-OLT-R-C	Terminal Amplifier with embedded Raman module – C-Band	232'650
NCS1K-E-OLT-L	Terminal Amplifier – L-Band	304,670 **
NCS1K-ILA-C	In-Line Amplifier – C-Band	465'720 **
NCS1K-E-ILA-R-C	In-Line Amplifier - Raman module in Direction 1 (LINE-0) – C-Band ***	324'190
NCS1K-E-ILA-R-C -2	In-Line Amplifier - Raman module in Direction 2 (LINE-2) – C-Band ***	324'190
NCS1K-E-ILA-2R-C	In-Line Amplifier - Raman module in both directions – C-Band	244'870
NCS1K-ILA-L	In-Line Amplifier – L-Band	435,020
NCS1014-CCMD16-C	Color-less 16-Channels A/D – C-Band	622,700
NCS1014-CCMD16-L	Color-less 16-Channels A/D – L-Band	581,580
NCS1K14-2.4T-K9	Pulsar Line-card	727,480
CIM-8	DWDM Pluggable	487,570

** The optical diagram and the internal component are different between OLT and ILA. The OLT integrates a higher number of components compared to ILA, leading to the different value of total pMTBF.

*** The definition of "Direction" is used only in this table, to identify "Direction 1" with LINE-0 port, and "Direction 2" with LINE-2 port.

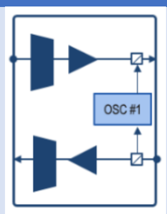
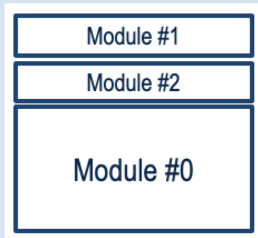
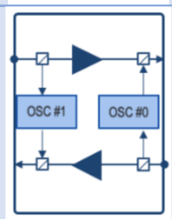
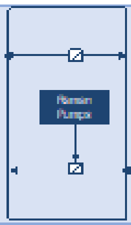
Breakdown of FIT rate for major component / components groups for the CIM-8 pluggable:

	nominal 40C	nominal 55C	nominal 75C
Optical daughter board	**33**	**84**	**307**
Optics	**105**	**257**	**873**
PCBA	**384**	**872**	**2927**
Capacitors	73	89	115
Inductors	69	89	120
IC	129	421	1750
Resistors	41	53	72
Power	31	102	437
OEMCM (Jannu, Apex, PIC, driver, TIA, and off the shelf electronics)	**413**	**1200**	**4480**

5.4 SKU Building Elements and Assembly Diagram

All the NCS1010 / NCS1012 line-cards share the same mechanical and electrical architecture. According to the Line-card variants, different building blocks (aks Optical Modules) are arranged within the Line-card mechanics, with optical and electrical interconnections, and different Front Panel connections.

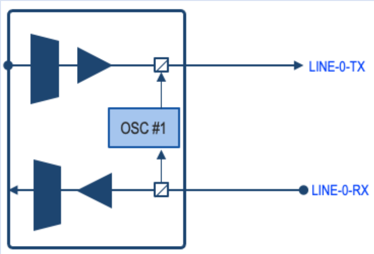
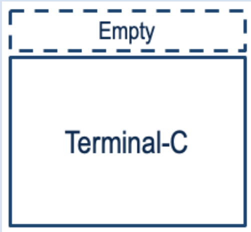
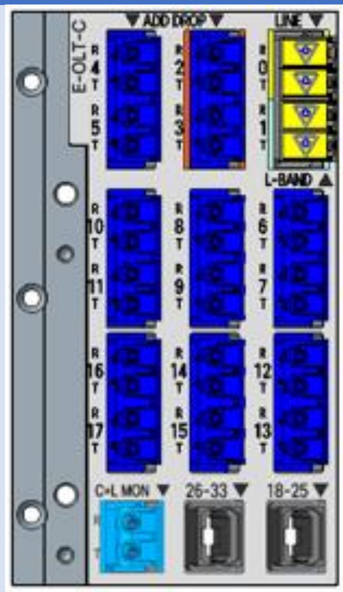
A total of 5 Optical Modules are considered:

Optical Module	Schematic Diagram	Generic Line-Card Assembly Diagram
Terminal -C		 
Terminal -L		
Line Amplifier -C		
Line Amplifier -L		
Raman Module		

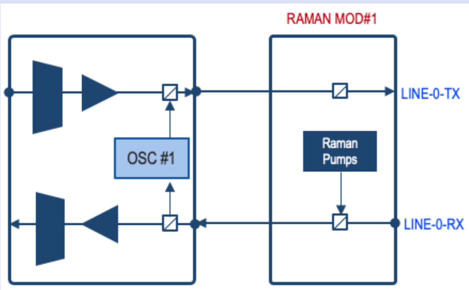
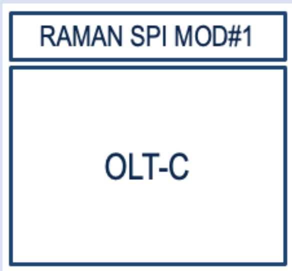
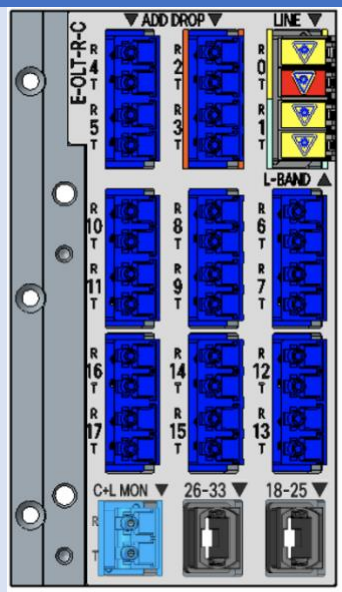
This is a generic figure for NCS1010 SKU. The ports description for each specific configuration are detailed in section 9.1 thru 9.4.

Module#0 can be Terminal-C or Terminal-L or Line Amplifiers-C or Line Amplifier-L according to the specific SKU selected. Module#1 and Module#2 are the Raman module if present.

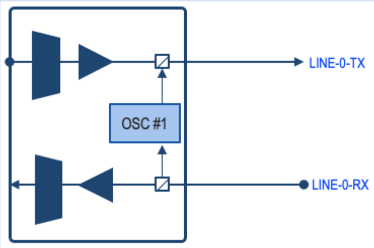
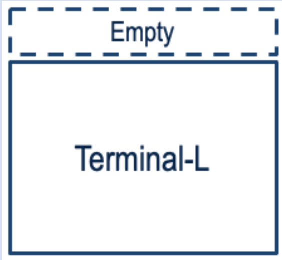
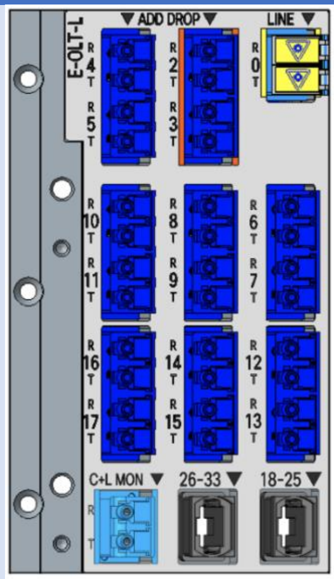
5.4.1 NCS1K-E-OLT-C

Block Diagram	Modules Configuration	Line-Card faceplate
		

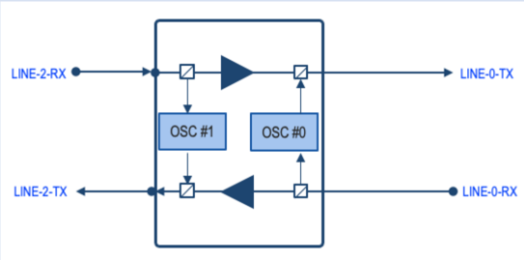
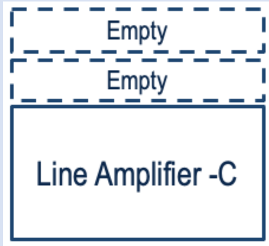
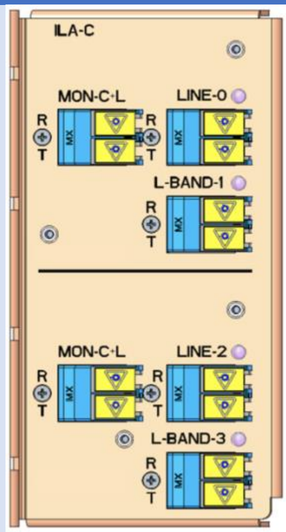
5.4.2 NCS1K-E-OLT-R-C

Block Diagram	Modules Configuration	Line-Card faceplate
		

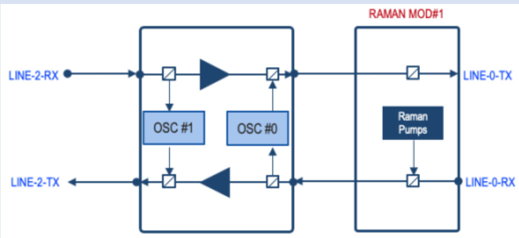
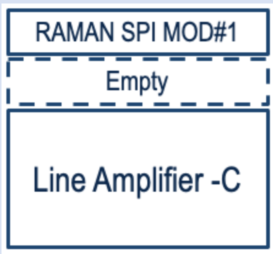
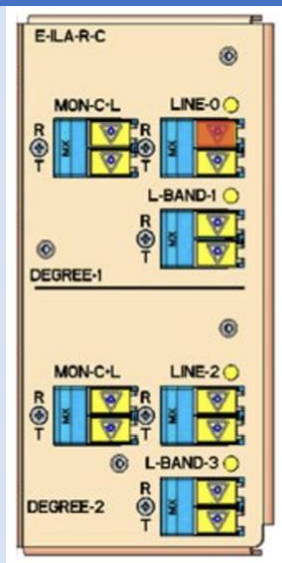
5.4.3 NCS1K-E-OLT-L

Block Diagram	Modules Configuration	Line-Card faceplate
		

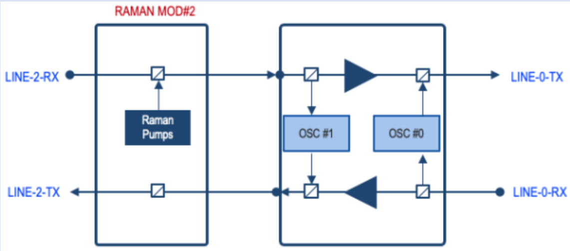
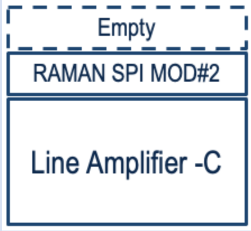
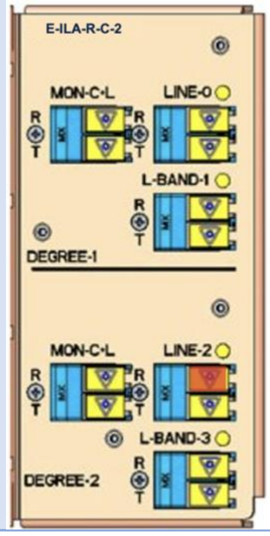
5.4.4 NCS1K-ILA-C

<table>
<tr><th>Block Diagram</th><th>Modules Configuration</th><th>Line-Card faceplate</th></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
</table>

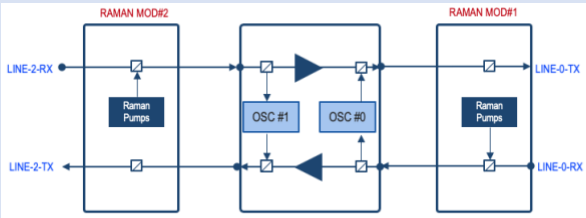
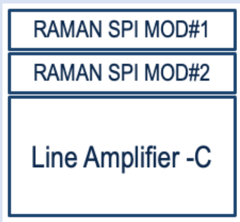
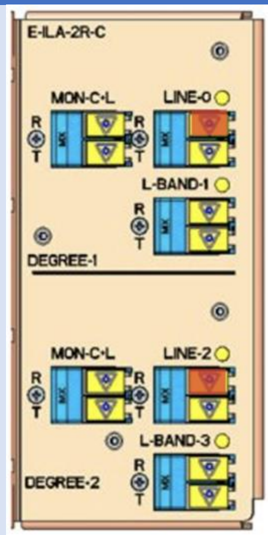
5.4.5 NCS1K-E-ILA-R-C

<table>
<tr><th>Block Diagram</th><th>Modules Configuration</th><th>Line-Card faceplate</th></tr>
<tr><td>
</td><td>
</td><td>
</td></tr>
</table>

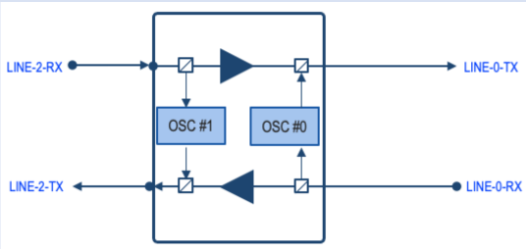
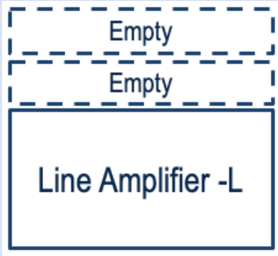
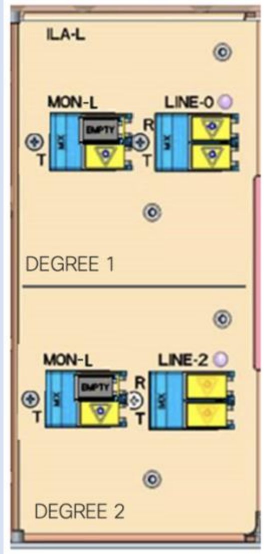
5.4.6 NCS1K-E-ILA-R-C-2

Block Diagram	Modules Configuration	Line-Card faceplate
		

5.4.7 NCS1K-E-ILA-2R-C

Block Diagram	Modules Configuration	Line-Card faceplate
		

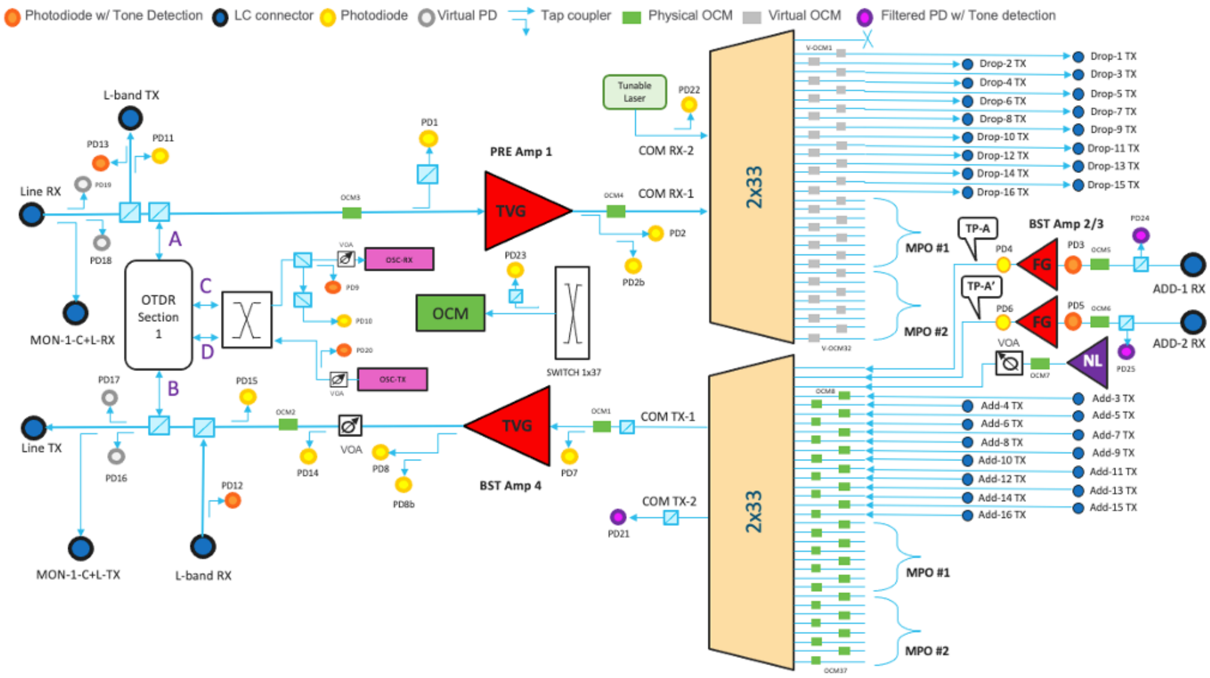
5.4.8 NCS1K-ILA-L

<table>
<tr><th>Block Diagram</th><th>Modules Configuration</th><th>Line-Card faceplate</th></tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
</table>

5.5 HW and System Configurations and Optical Modules HW Specifications

5.5.1 Terminal -C

Optical Block Diagram



Key Features:

- 25 dBm Line Pre-amp True Variable Gain EDFA w/ (PRE Amp1) two switchable gain ranges
- 23 dBm Line Boost-amp TVG EDFA (BST AMP4) - single range (total in fiber power 21.5dBm in presence of the Raman module)
- Dedicated ASE source for Noise Loading (NL)
- Embedded OTDR for LINE-RX / TX monitoring
- 37 ports OCM for channels monitoring
- Integrated Tunable Laser enabling CV and patch-cord discovery (for Connection Verification between the OLT and the A/D units, the TXP and between different sides of a ROADM node).
- Wavelength Selective Switch – Route and Select - 30 EXP ports
- 2x specialized A/D ports for low-power QDD-ZR, with embedded Fixed Gain amplification (BST Amp2/3) (for external AWGs)
- Embedded OSC (Optical Service Channel) – FE / GE rate (FE default)
- OSC transmit direction can be reversed by means of internal 2x2 optical switch
- Integrated C+L combiner / separator optical filters
- Back-Reflection measurement at LINE-TX by means of dedicated photodiodes (PD15)

Optical Interfaces

Signal	Connector Type	Connector label	Logical port Nr.	Operating freq. range [THz, (nm)]	Monitored Power Range [dBm]	Accuracy [dB]	Note
LINE-TX/RX	LC	LINE	0	199.25 – 184.2 (1504.6 – 1627.6)	TX:-5 ~ +28 RX: -40 ~ +18	+/-0.5	C+L bands signals + OSC-C + OSC-L + OTDR + Raman DFB
MON-TX/RX	LC	MON-C-L	NA	199.25 – 184.2 (1504.6 – 1627.6)	NA	NA	Replica of the LINE signals ~20dB below the actual power levels. Both are output ports.
Lband-TX/RX	LC	L-BAND	1	190.8875 – 184.2 (1570.5 – 1627.6)	TX: -40 ~ +5 RX: 0 ~ 30	+/-0.5	L band signals + OSC-L
ADD/DROP-1	LC	A/D 2	2	196.175 – 191.3375 (1528.2 – 1566.8) Traffic operative range	Add: -25 ~ +18 Drop: -35 ~ +5	Add: +/-0.5	Input ADD p h inte amplifica to be u with po interf (C
ADD/DROP-2	LC	A/D 3	3	191.3375 - 191.15 (1566.8 – 1568.4) Reserved for CV internal signals		Drop: +/- 1	

WSS RX/TX-3	LC	A/D 4	4	196.175 – 191.3375 (1528.2 – 1566.8) Traffic operative range 191.3375 - 191.15 (1566.8 – 1568.4) Reserved for CV internal signals	Add: -35 ~ +5 Drop: -35 ~ +5	+/-1	LC express or p
WSS RX/TX-4	LC	A/D 5	5				
WSS RX/TX-5	LC	A/D 6	6				
WSS RX/TX-6	LC	A/D 7	7				
WSS RX/TX-7	LC	A/D 8	8				
WSS RX/TX-8	LC	A/D 9	9				
WSS RX/TX-9	LC	A/D 10	10				
WSS RX/TX-10	LC	A/D 11	11				
WSS RX/TX-11	LC	A/D 12	12				
WSS RX/TX-12	LC	A/D 13	13				
WSS RX/TX-13	LC	A/D 14	14				
WSS RX/TX-14	LC	A/D 15	15				
WSS RX/TX-15	LC	A/D 16	16				
WSS RX/TX-16	LC	A/D 17	17				
WSS RX/TXi, i=17¸24	MPO (#1)	A/D 18-25	18 ¸ 25				MPO additi expres A/D p
WSS RX/TXi, i=25¸32	MPO (#2)	A/D 26-33	26 ¸ 33				

Detailed Optical Specs:

Unit	Parameter	Unit	Min.	Typ.	Max	Note
PRE **(Amp1)**	Gain range1 (from Line-RX to COM RX-1)	dB	12		22 (*)	(*) max gain can be extended up to 25dB with uncontrolled tilt
	Gain range2 (from Line-RX to COM RX-1)	dB	20		35 (*)	(*) max gain can be extended up to 38dB with uncontrolled tilt
	Total input power range	dBm	-26 (1) -39 (2)		13 (1) 5 (2)	(1) Gain Range1 (2) Gain range2
	Typical per-channel Input Power range	dBm	-15 (1) -28 (2)		-5 (1) -13 (2)	
	Total output power range	dBm	-1		25	
	Typical per-channel Output Power range	dBm		7		with 64 channels
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-0.8		
BST **(Amp4)**	Gain range (from COM-TX-1 to LINE-TX with VOA-LINE=0dB)	dB	16		24 (*)	(*) max gain can be extended up to 31dB with uncontrolled tilt
	Total input power range	dBm	-26		7	

	Typical per-channel Input Power range	dBm	-19		-11	
	Total output power range	dBm	5		23	With LINE-VOA=0dB
	Typical per-channel Output Power range	dBm		5		with 64 channels
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-0.8		
ADD BST **(Amp2/3)**	Gain range (from ADD-RX-1/2 to TP-A/A')	dB		16 (*)		(*) Amp designed for fixed flat gain. +/-3dB gain tolerance with uncontrolled tilt
	Total input power range	dBm	-4	-1.5		
	Typical per-channel Input Power range	dBm	-19	-16.5		
	Total output power range	dBm			15	
	Typical per-channel Output Power range	dBm		-0.5		with 32 channels
VOA	Dynamic range	dB	0		15	

LINE-TX						
2x33 WSS	Operating frequency	THz	191.3375 191.15 (*)		196.175	(*) 4.8375 THz for optical traffic + 0.1875 THz for the CV channel management
	Channel Bandwidth	GHz	25		4837.5	With a resolution of 6.25GHz
	Insertion Loss (COM-RX-1 to any EXP-TX-i ADD-RX-i or EXP-RX-i to COM-TX-1	dB	3	6	9	With VOA=0dB
	VOA dynamic range	dB	0		15	Channel shut-off attenuation (AVS) is 25dB
L-band upgrade Path Loss	Path Loss for L-band insertion (from L-BAND-RX port to LINE-TX port)	dB	0.3	1.3	1.8	Additional loss to be accounted in the VOA-LINE regulation of OLT-L
	Path Loss for L-band extraction (from LINE-RX port to L-BAND-TX port)	dB	0.3	1	1.3	Additional loss to be accounted in the gain calculation of OLT-L

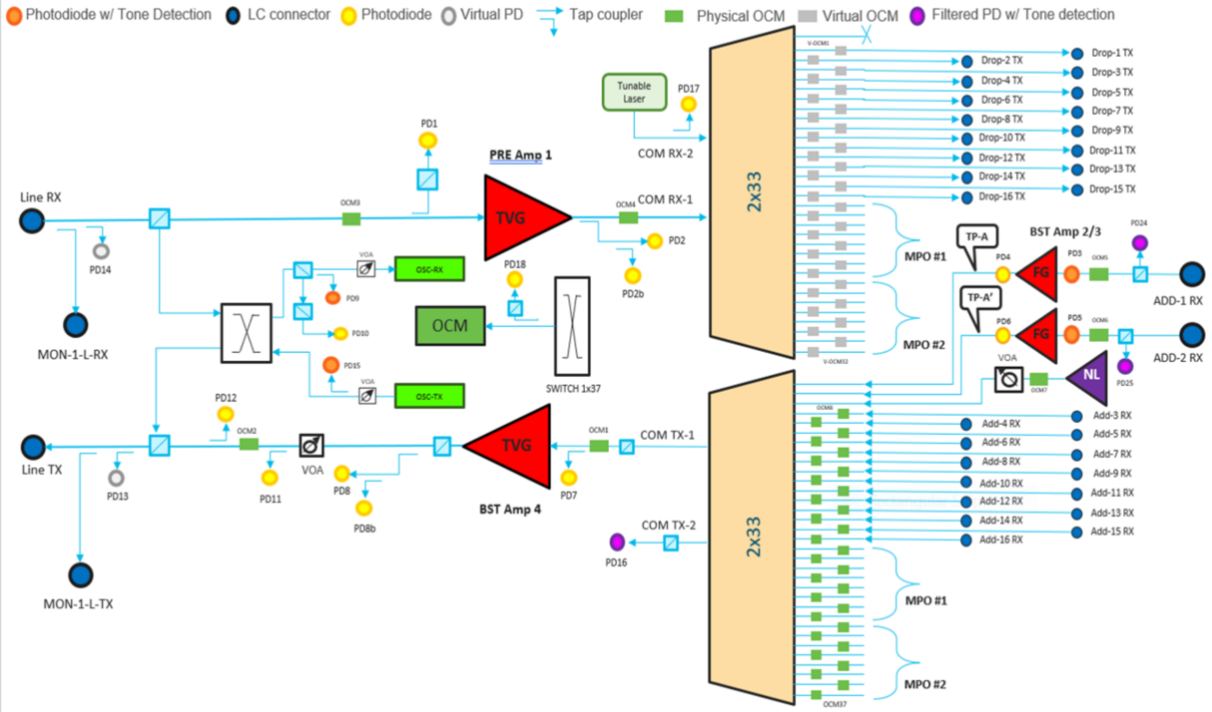
Monitors

Monitor	Port reference	Description	Min. [dBm]	Max [dBm]	Accuracy [dB]	Precision [dB]

PD1	LINE-RX	C-band total input power	-44	18	+/-0.5 [-40 ~ 18] +/-1 [-44 ~ -40]	+/- 0.1
PD14	LINE-TX	C-band total output power	-5	28	+/- 0.5	
PD23	ADD-i [i = 4~33]	Aggregated input power @ WSS-RX-i Add Shared monitor between all Add ports .	-15	10	+/- 1	
PD11	L-band-TX	L-band total output power form the LINE-RX delivered to L-band OLT	-45	17	+/- 0.5 [-40 ~ 18] +/- 1 [-44 ~ -40]	
PD12	L-band-RX	L-band total output power form L-band OLT delivered to LINE-TX	0	25.5	+/- 0.5	

5.5.2 Terminal -L

Optical Block Diagram:



Key Features:

- 25 dBm Line Pre-amp True Variable Gain EDFA w/ two switchable gain ranges
- 24.5 dBm Line Boost-amp TVG EDFA - single range
- Dedicated ASE source for noise loading
- 37 ports OCM for channels monitoring
- Integrated Tunable Laser enabling CV and patch-cord discovery
- Wavelength Selective Switch - Route and Select - 30 EXP ports
- 2x specialized A/D ports for low-power QDD-ZR, with embedded Fixed Gain amplification (for external AWGs)
- Embedded Optical Service Channel - FE / GE rate (FE default)
- OSC transmit direction can be reversed by means of internal 2x2 optical switch
- Back-Reflection measurement at LINE-TX by means of dedicated photodiodes

Optical Interfaces

Logical Port	Connector Type	Connector label	Logical port Nr.	Operating freq. range [THz, (nm)]	Note

LINE-TX/RX-L	LC	**LINE**	0	190.8875 – 184.2 (1570.5 – 1627.6)	L band signals + OSC-L
MON-TX/RX-L	LC	**MON-L**	NA	190.8875 – 184.2 (1570.5 – 1627.6)	Replica of the LINE signals ~20dB below the actual power levels. <u>Both are output ports.</u>
ADD/DROP-1-L	LC	**A/D 2**	2	190.8875 – 186.05 (1570.52 – 1611.35) Traffic operative range 191.125 – 190.8875 (1568.6 – 1570.5) CV internal signals	Input ADD ports have internal amplification to be used with low power interfaces (QDD)
ADD/DROP-2-L	LC	**A/D 3**	3		
WSS RX/TX-3	LC	**A/D 4**	4	190.8875 – 186.05 (1570.52 – 1611.35) Traffic operative range 191.125 – 190.8875 (1568.6 – 1570.5) Reserved for CV internal signals	LC express or A/D ports
WSS RX/TX-4	LC	**A/D 5**	5		
WSS RX/TX-5	LC	**A/D 6**	6		
WSS RX/TX-6	LC	**A/D 7**	7		
WSS RX/TX-7	LC	**A/D 8**	8		
WSS RX/TX-8	LC	**A/D 9**	9		
WSS RX/TX-9	LC	**A/D 10**	10		
WSS RX/TX-10	LC	**A/D 11**	11		
WSS RX/TX-11	LC	**A/D 12**	12		

WSS RX/TX-12	LC	**A/D 13**	13		
WSS RX/TX-13	LC	**A/D 14**	14		
WSS RX/TX-14	LC	**A/D 15**	15		
WSS RX/TX-15	LC	**A/D 16**	16		
WSS RX/TX-16	LC	**A/D 17**	17		
WSS RX/TXi, i=17¸24	MPO (#1)	**A/D 18-25**	18 ¸ 25		MPO additional express or A/D ports
WSS RX/TXi, i=25¸32	MPO (#2)	**A/D 26-33**	26 ¸ 33		

Detailed Optical Specs

Unit	Parameter	Unit	Min.	Typ.	Max	Note
PRE (Amp1)	Gain range1 (from Line-RX to COM RX-1)	dB	13.3		23.3 (*)	(*) max gain can be extended up to 26.3dB with uncontrolled tilt
	Gain range2 (from Line-RX to COM RX-1)	dB	21.3		36.3 (*)	(*) max gain can be extended up to 39.3dB with uncontrolled tilt
	Total input power range	dBm	-27.3 (1) -40.3 (2)		11.7 (1) 3.7 (2)	(1) Gain Range1 (2) Gain range2
	Typical per-channel Input Power range	dBm	-16.3 (1) -29.3 (2)		-6.3 (1) -19.3 (2)	

	Total output power range	dBm	-1		25	
	Typical per-channel Output Power range	dBm		7		with 64 channels
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-1		
BST **(Amp4)**	Gain range (from COM-TX-1 to LINE-TX with VOA-LINE=0dB)	dB	17.5		25.5 (*)	(*) max gain can be extended up to 32.5dB with uncontrolled tilt
	Total input power range	dBm	-26		7	
	Typical per-channel Input Power range	dBm	-19		-11	
	Total output power range	dBm	6.5		24.5	With LINE-VOA=0dB
	Typical per-channel Output Power range	dBm		6.5		with 64 channels
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-1		
ADD BST **(Amp2/3)**	Gain range (from ADD-RX-1/2	dB		16 (*)		(*) Amp designed for fixed flat gain. +/-3dB gain

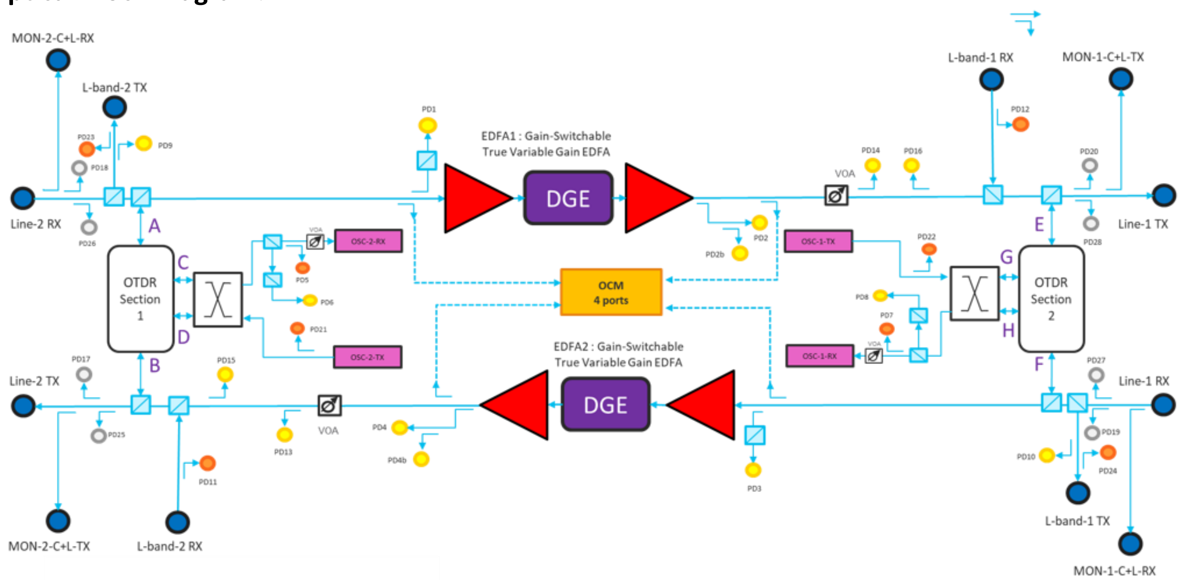
	to TP-A/A')					tolerance with uncontrolled tilt
	Total input power range	dBm	-4	-1.5		
	Typical per-channel Input Power range	dBm	-19	-16.5		
	Total output power range	dBm			15	
	Typical per-channel Output Power range	dBm		-0.5		with 32 channels
VOA LINE-TX	Dynamic range	dB	0		15	
2x33 WSS	Operating frequency	THz	186.05		191.125(*) 190.925	4.8375 THz for optical traffic + 0.225 THz for the CV channel management (*)
	Insertion Loss (COM-RX-1 to any EXP-TX-i ADD-RX-i or EXP-RX-i to COM-TX-1	dB	3	5	9	With VOA=0dB
	VOA dynamic range	dB	0		15	Channel shut-off attenuation (AVS) is 25dB

Monitors

Monitor	Port reference	Description	Min. [dBm]	Max [dBm]	Accuracy [dB]	Precision [dB]
PD1	LINE-RX	L-band total input power	-45	17	+/-0.5 [-41 ~ 17] +/-1 [-45 ~ -41]	+/- 0.1
PD11	LINE-TX	L-band total output power	-5	29	+/- 0.5	
PD18	ADD-i [i = 4~33]	Aggregated input power @ WSS-RX-i Add Shared monitor between all Add ports.	-15	10	+/- 1	

5.5.3 In-Line Amplifier – C

Optical Block Diagram:



Key Features:

- 2-directions In-Line Amplifier
- 23 dBm True Variable Gain EDFA amplifiers – two switchable gain ranges
- 4 OCM ports OCM for channels monitoring

- Embedded OTDR for LINE-RX / TX monitoring
- Integrated Dynamic Gain Equalizer
- Embedded Optical Service Channel – FE / GE rate (FE default)
- OSC transmit direction can be reversed by means of internal 2x2 optical switch
- Integrated C+L combiner / separator optical filters

Optical Interfaces:

Port	Connector Type	Connector label	Logical port Nr.	Operating freq. range [THz, (nm)]	Note
DEGREE-1 LINE-TX/RX	LC	**DEGREE-1 LINE-0**	0	199.25 – 184.2 (1504.6 – 1627.6)	C+L bands signals + OSC-C + OSC-L + OTDR + Raman DFB
DEGREE-1 MON-TX/RX	LC	**DEGREE-1 MON-C-L**	NA	199.25 – 184.2 (1504.6 – 1627.6)	Replica of the DEGREE-1 LINE signals ~20dB below the actual power levels. Both are output ports.
DEGREE-1 Lband-TX/RX	LC	**DEGREE-1 L-BAND**	1	190.8875 – 184.2 (1570.5 – 1627.6)	DEGREE-1 L band signals + OSC-L
DEGREE-2 LINE-TX/RX	LC	**DEGREE-2 LINE**	2	199.25 – 184.2 (1504.6 – 1627.6)	C+L bands signals + OSC-C + OSC-L + OTDR + Raman DFB
DEGREE-2 MON-TX/RX	LC	**DEGREE-2 MON-C-L**	NA	199.25 – 184.2 (1504.6 – 1627.6)	Replica of the DEGREE--2 LINE signals ~20dB below the actual power levels. Both are output ports.
DEGREE-2 Lband-TX/RX	LC	**DEGREE-2 L-BAND**	3	190.8875 – 184.2 (1570.5 – 1627.6)	DEGREE-2 L band signals + OSC-L

Detailed Optical Specs

Unit	Parameter	Unit	Min.	Typ.	Max	Note
EDFA	Gain range1	dB	8		17 (*)	(*) max gain can be extended up to 20dB reducing the DGE flat attenuation to 0dB and keeping the gain flat; and up to 23dB with uncontrolled tilt.
	Gain range2	dB	16		30 (*)	(*) max gain can be extended up to 33dB reducing the DGE flat attenuation to 0dB and keeping the gain flat; and up to 36dB with uncontrolled tilt.
	Total input power range	dBm	-26 (1) -39 (2)		15 (1) 7 (2)	(1) Gain Range1 (2) Gain range2
	Typical per-channel Input Power range	dBm	-15 (1) -28 (2)		-3 (1) -11 (2)	
	Total output power range	dBm	-3		23	
	Typical per-channel Output Power range	dBm		5		with 64 channels

VOA LINE-TX	Dynamic range	dB	0		15	
DGE & Tilt	DGE equalization dynamic range	dB	0		+3	
	Attenuation slope	dB/nm			5	Max slope variation is 0.8dB/nm.
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-0.8		
L-band upgrade Path Loss	Path Loss for L-band insertion (from L-BAND-RX port to LINE-TX port)	dB	0.3	1.3	1.8	Additional loss to be accounted in the VOA-LINE regulation of OLT-L
	Path Loss for L-band extraction (from LINE-RX port to L-BAND-TX port)	dB	0.3	1	1.3	Additional loss to be accounted in the gain calculation of OLT-L

Monitors

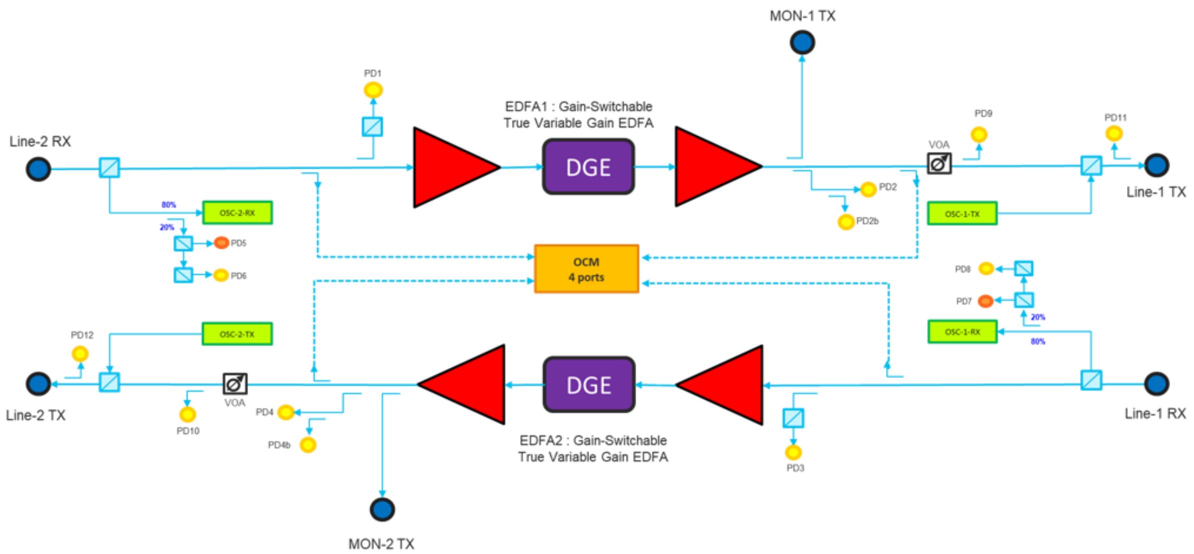
Monitor	Port reference	Description	Min. [dBm]	Max [dBm]	Accuracy [dB]	Precision [dB]
PD3	LINE-1-RX	C-band total input power LINE-0	-44	20	+/-0.5 [-40 ~ 20] +/-1 [-44 ~ -40]	+/- 0.1
PD14	LINE-1-TX	C-band total output power LINE-0	-28	28	+/-0.5 [-26 ~ 28]	

					+/-1 [-28 ~ -26]	
PD10	L-band-1-TX	L-band total output power form the LINE-0-RX delivered to L-band OLT	-45	19	+/- 0.5 [-43 ~ 19] +/- 1 [-45 ~ -43]	
PD12	L-band-1-RX	L-band total output power form L-band OLT delivered to LINE-0-TX	-26.5	29.5	+/- 0.5 [-25 ~ 29.5] +/- 1.5 [-26.5 ~ -25]	
PD1	LINE-2-RX	C-band total input power LINE-2	-44	20	+/-0.5 [-40 ~ 20] +/-1 [-44 ~ -40]	
PD14	LINE-2-TX	C-band total output power LINE-2	-28	28	+/-0.5 [-26 ~ 28] +/-1 [-28 ~ -26]	
PD10	L-band-2-TX	L-band total output power form the LINE-2-RX delivered to L-band OLT	-45	19	+/- 0.5 [-43 ~ 19] +/- 1 [-45 ~ -43]	
PD12	L-band-2-RX	L-band total output power	-26.5	29.5	+/- 0.5 [-25 ~ 29.5]	

		form L-band OLT delivered to LINE-2-TX			+/- 1.5 [-26.5 ~ -25]	

5.5.4 In-Line Amplifier – L

Optical Block Diagram:



Key Features:

- 25 dBm Line Pre-amp True Variable Gain EDFA w/ two switchable gain ranges
- 24.5 dBm Line Boost-amp TVG EDFA - single range
- Dedicated ASE source for noise loading
- 4 ports OCM for channels monitoring
- Integrated Tunable Laser enabling CV and patch-cord discovery features
- Wavelength Selective Switch - Route and Select - 30 EXP ports
- 2x specialized A/D ports for low-power QDD-ZR, with embedded Fixed Gain amplification (for external AWGs)
- Embedded Optical Service Channel - FE / GE rate (FE default)
- OSC transmit direction can be reversed by means of internal 2x2 optical switch
- Back-Reflection measurement at LINE-TX by means of dedicated photodiodes

Optical Interfaces

Port	Connector Type	Connector label	Logical port Nr.	Operating freq. range [THz, (nm)]	Note
DEGREE 1 LINE-TX/RX	LC	**LINE-0**	0	190.8875 – 184.2 (1570.5 – 1627.6)	L-band signals + OSC-L
DEGREE 1 MON-TX/RX	LC	**MON-L**	NA	190.8875 – 184.2 (1570.5 – 1627.6)	Replica of the LINE-0 signals ~20dB below the actual power levels. Both are output ports.
DEGREE 2 LINE-TX/RX	LC	**LINE-2**	2	190.8875 – 184.2 (1570.5 – 1627.6)	L-band signals + OSC-L
DEGREE 2 MON-TX/RX	LC	**MON-L**	NA	190.8875 – 184.2 (1570.5 – 1627.6)	Replica of the LINE-2 signals ~20dB below the actual power levels. Both are output ports.

Detailed Optical Specs

Unit	Parameter	Unit	Min.	Typ.	Max	Note
EDFA	Gain range1	dB	10.8		19.8 (*)	(*) max gain can be extended up to 22.8dB reducing the DGE flat attenuation to 0dB and keeping the gain flat; and up to 25.8dB with uncontrolled tilt.
	Gain range2	dB	18.8		32.8 (*)	(*) max gain can be extended up to 35.8dB reducing the DGE flat attenuation to 0dB and keeping the

						gain flat; and up to 38.8dB with uncontrolled tilt.
	Total input power range	dBm	-27.3 (1) -40.3 (2)		13.7 (1) 5.7 (2)	(1) Gain Range1 (2) Gain range2
	Typical per-channel Input Power range	dBm	-16.3 (1) -29.3 (2)		-4.3 (1) -12.3 (2)	
	Total output power range	dBm	-3		24.5	
	Typical per-channel Output Power range	dBm		6.5		with 64 channels
VOA **LINE-TX**	Dynamic range	dB	0		15	
DGE & Tilt	DGE equalization dynamic range	dB	0		+3	
	Attenuation slope	dB/nm			5	Max slope variation is 0.8dB/nm.
	Tilt setting range	dB	-5		5	
	Tilt/Gain variation	dB/dB		-1		

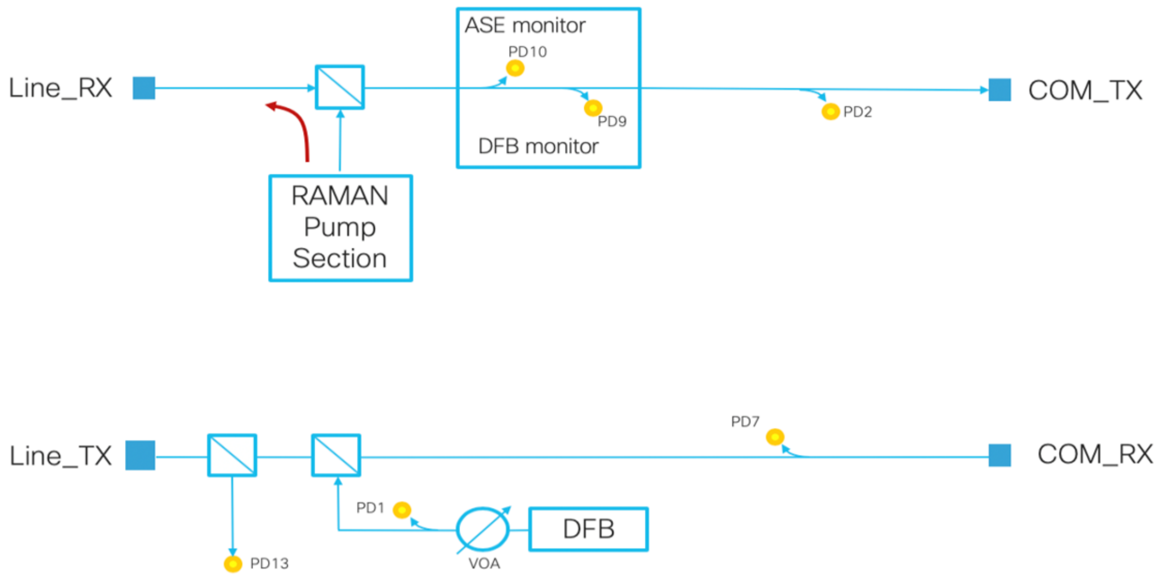
Monitors

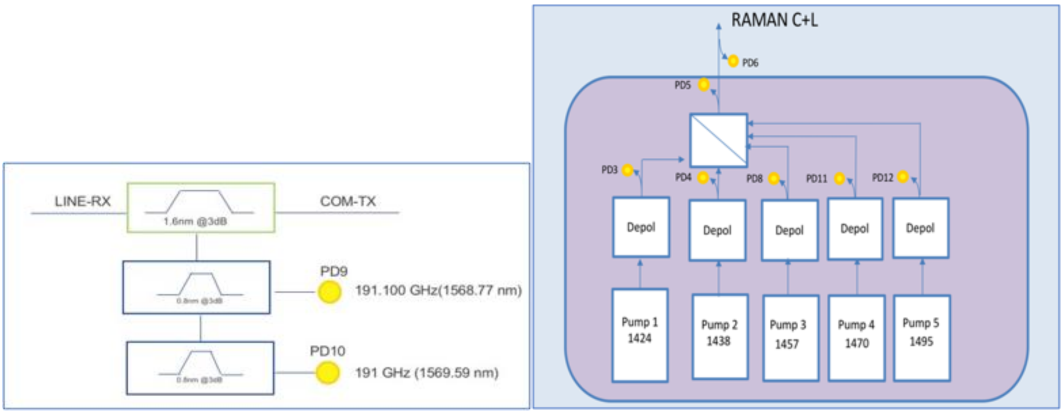
Monitor	Port reference	Description	Min. [dBm]	Max [dBm]	Accuracy [dB]	Precision [dB]
PD3	LINE-1-RX	L-band total input	-45	19	+/-0.5 [-41 ~ 19]	+/- 0.1

		power LINE-0			+/-1 [-45 ~ -41]	
PD10	LINE-1-TX	L-band total output power LINE-0	-27.5	30.5	+/-0.5 [-22 ~ 30.5] +/-1 [-27.5 ~ -22]	
PD1	LINE-2-RX	L-band total input power LINE-2	-45	19	+/-0.5 [-41 ~ 19] +/-1 [-45 ~ -41]	
PD9	LINE-2-TX	L-band total output power LINE-2	-27.5	30.5	+/-0.5 [-22 ~ 30.5] +/-1 [-27.5 ~ -22]	

5.5.5 Raman C+L

Optical Block Diagram





Key Features:

- 1.4W counter propagating Raman pump – total 5 pump wavelenght 1424nm to 1495nm
- Support Raman amplification in the C+L band range
- Optical Continuity check and Automatic Laser Shutdown by means of internal dedicated DFB probe source. ALS now considers presence of OSC signal also.

Detailed Optical Specs

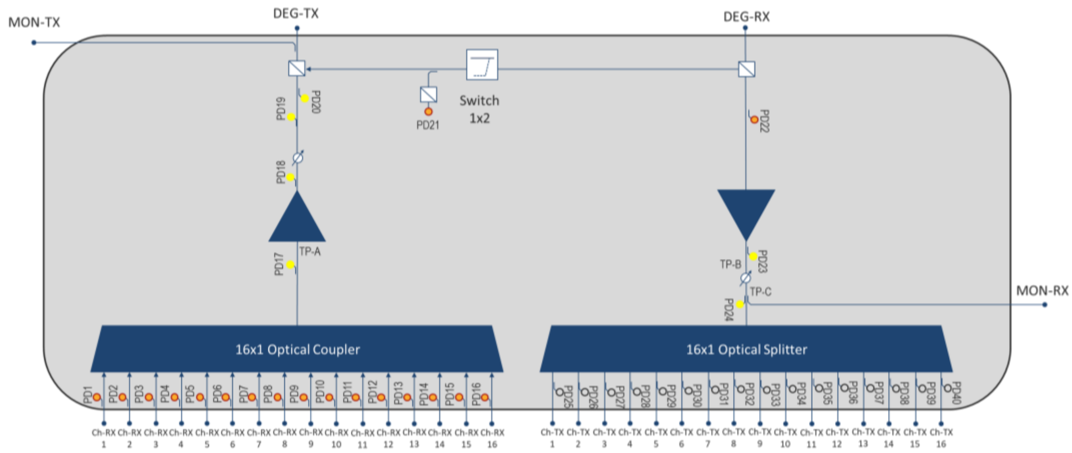
Unit	Parameter	Unit	Min.	Typ.	Max	Note
RAMAN C+L	Raman pumps power operating range	mW	148		1410	Combined power at LINE-RX port
	Raman Gain	dB	8	16	23 (*)	(*) depending on the fiber type
	Back reflected pump	dB			-20	Max power of back-reflected pumps at LINE-RX
	Path Insertion Loss (from Line-RX to COM-TX)	dB		1.2	1.7	Additional loss to be included on the path before LINE-TX and after LINE-RX ports when the Raman block is present
	Path Insertion Loss (from COM-RX to LINE-TX)	dB		1.4	2.1	
	DFB probe dynamic range	dBm	-14		5	Power referred at LINE-TX port

5.5.6 Colorless Add/Drop unit

Two similar units specialized for C-band and L-band channels Add/Drop:

- NCS1K14-CCMD-16-C for C-band operation
- NCS1K14-CCMD-16-L for L-band operation

Optical Block Diagram



Key Features:

- 1x16 coupler for the aggregation of 16 channels gridless in the Add direction
- 1x16 splitter for the splitting of the channel aggregate in the Drop direction
- 18dBm fixed gain EDFA with two switchable gain values for the amplification of the Add traffic.
- 23dBm fixed gain EDFA for the amplification of the Drop traffic.
- Dedicated VOA on Add and Drop paths (after the EDFA stages) to manage remotization loss that might be present between the A/D unit and the Terminal node.
- Dedicated optical power monitors at each CH-RX channel ports
- Virtual optical monitors at each CH-TX channel ports
- Dedicated loopback optical circuit for the management of the out-of-band Connection Verification channel.

Optical Interfaces

Signal	Connector Type	Connector label	Logical port Nr.	Operating freq. range [THz, (nm)]		Note
				C-band	L-band	
DEG-TX/RX	LC	COM	0	196.175 – 191.150 (1528.2 – 1568.4)	191.125 – 186.05 (1568.6 – 1611.4)	Including Out-of-band channels for CV
MON-TX/RX	LC	MON	NA	196.175 – 191.250	191.0 – 186.05	Replica of the COM signals ~20dB

				(1528.2 – 1567.6)	(1569.6 – 1611.4)	below the actual power levels without the OoB CV channels. Both are output ports.
CH-RX/TX-1	LC	A/D 1	1	196.175 – 191.3375 (1528.2 – 1566.8) Traffic operative range 191.3375 – 191.250 (1566.9 – 1567.6) Reserved for CV internal signals	190.8875 – 186.05 (1570.5 – 1611.4) Traffic operative range 191.0 – 190.8875 (1569.6 – 1570.5) Reserved for CV internal signals	Net traffic bandwidth. Any input optical signal outside this frequency range can be monitored at the CH-RX-i ports but cannot be expressed thru the unit.
CH-RX/TX-2	LC	A/D 2	2			
CH-RX/TX-3	LC	A/D 3	3			
CH-RX/TX-4	LC	A/D 4	4			
CH-RX/TX-5	LC	A/D 5	5			
CH-RX/TX-6	LC	A/D 6	6			
CH-RX/TX-7	LC	A/D 7	7			
CH-RX/TX-8	LC	A/D 8	8			
CH-RX/TX-9	LC	A/D 9	9			
CH-RX/TX-10	LC	A/D 10	10			
CH-RX/TX-11	LC	A/D 11	11			
CH-RX/TX-12	LC	A/D 12	12			
CH-RX/TX-13	LC	A/D 13	13			
CH-RX/TX-14	LC	A/D 14	14			
CH-RX/TX-15	LC	A/D 15	15			
CH-RX/TX-16	LC	A/D 16	16			

Detailed Optical Specs

Common to both C-band and L-band variants:

Section	Parameter	Unit	Min.	Typ.	Max	Note
ADD Section	Gain range1 (from any CH-RX-i to	dB	-3	2 (*)	7	(*) With 0dB tilt at Typ. gain value.

	DEG-TX port) With VOA-ADD=0dB					Min./max value are with uncontrolled tilt.
	Gain range2 (from CH-RX-i to DEG-TX) With VOA-ADD=0dB	dB	12	17 (*)	22	
	Per-channel Input Power range (at CH-TX-i ports)	dBm	-7 (1) -22 (2)	4 (1) -11 (2)	9 (1) -6 (2)	(1) Gain Range1 (2) Gain range2
	Total output power range	dBm	0		18	
	Typical per-channel Output Power range	dBm	0		6	with 16 channels
	Tilt/Gain variation	dB/THz		0.25 0.8dB/dB		
	16x1 Optical Coupler Insertion Loss (from CH-RX-i to TP-A internal point)	dB	12	13	14	
	VOA-ADD attenuation range	dB	0		15	
DROP **Section**	Gain range (from DEG-RX to any CH-TX-I port)	dB	0	5 (*)	10	(*) <u>With 0dB tilt at Typ. gain value.</u> Min./max value are with

	with VOA-DROP=0dB					uncontrolled tilt.
	Total input power range	dBm	-19		9	(at DEG-RX port)
	Typical per-channel Input Power range	dBm	-19	-8	-3	
	Total output power range	dBm			9	At CH-TX-I port with VOA-DROP=0dB
	Typical per-channel Output Power range	dBm	-9		-3	At CH-TX-i port with 16 channels with VOA-DROP=0dB
	Tilt/Gain variation	dB/THz		0.25 0.8dB/dB		
	1x16 Optical Splitter Insertion Loss (from TP-B internal point to any CH-TX-i port)	dB	12	13	14	With VOA-DROP=0dB
	VOA-DROP attenuation range	dB	0		15	
Out-of-Band loopback path	OoB signal C-band	THz		191.175		
	OoB signal L-band	THz		191.100		
	OoB path insertion loss	dB			2	

Monitors

Monitor	Port reference	Description	Min. [dBm]	Max [dBm]	Accuracy [dB]	Precision [dB]
PD1 – PD16	CH-RX-i	ADD input Channel power	-25	14	+/- 0.5	+/- 0.1
PD19	DEG-TX	Total ADD output channel power	-15	25		
PD22	DEG-RX	Total DROP input channel power	-20	20		
PD21	DEG-RX	Loopback monitor (filtered at loopback freq.)	-25	10		

CCMD-16 Setting:

The stages of CCMD-16 unit are regulated in gain control mode ad detailed below

ADD Path:

Egress EDFA gain range1

Egress EDFA gain = 2dB (defined from any CH-RX-i ports to DEG-TX port with TX-VOA=0dB, so including the IL of 1x16 coupler)

TX-VOA = 5dB

Total Gain (from CH-RX-i to DEG-TX) = -3dB

DROP Path:

Ingress EDFA gain = 5dB (defined from DEG-RX port to any CH-TX-I port with RX-VOA=0dB, so including the IL of 1x16 splitter)

RX-VOA = 0dB

Total Gain (from DEG-RX to CH-TX-i) = 5dB

5.6 OSC Spec and Supported Span Reach

OSC Optical Specs

	Reference Port	Note	Min.	Typ.	Max	Unit
Operating Wavelength C-Band		1510.29nm		198.5		THz
Operating Wavelength L-Band		1625.25nm		184.45		THz
Source Stability			-2		+2	nm
Launch Power OSC-C	@C-Line-TX	Optimize launch power based on span reach requirements	-10		3	dBm
Launch Power OSC-L	@C-Line-TX	Optimize launch power based on span reach requirements	-10		2.5	dBm

OSC Span Reach

Configuration	Condition	Note	Min.	Typ.	Max.	Unit
Span Reach @ FE rate C-Band only	Without Raman		0		35	dB
	With Raman	Considering Raman OFF	14		33	dB
Span Reach @FE rate C+L Band	Without Raman		0		32	dB
	With Raman	Considering Raman OFF	14		30	dB
Span Reach @ GE rate C-Band only	Without Raman		0		32	dB
	With Raman	Considering Raman OFF	14		30	dB
	Without Raman		0		30	dB

Span Reach @GE rate C+L Band	With Raman	Considering Raman OFF	14		28	dB

5.7 OCM

Unit	Parameter	Unit	Min.	Typ.	Max	Note
OLT-C	Dynamic ranges	dBm/12.5GHz	-10		10	Ports: LINE-TX, COM-RX-1 and internal Noise Loader port
			-30		0	Port LINE-RX
			-35		0	Ports: ADD-RX-1 and ADD-RX-2
			-35		5	Ports ADD/DROP-i (i=3..32) (on DROP ports OCM is virtual)
	Frequency range	THz	191.150		196.175	Out-of-band channel freq. 191.150 - 191.3375 THz are available only as row-data values.
ILA-C	Dynamic ranges	dBm/12.5GHz	-30		0	LINE-RX ports
			-10		10	LINE-TX ports
	Frequency range	THz	191.175		196.175	
OLT-L	Dynamic ranges	dBm/12.5GHz	-10		10	Ports: LINE-TX, COM-RX-1 and internal

						Noise Loader port
			-30		0	Port LINE-RX
			-35		0	Ports: ADD-RX-1 and ADD-RX-2
			-35		5	Ports ADD/DROP-i (i=3..32) (on DROP ports OCM is virtual)
	Frequency range	THz	186.05		191.125	Out-of-band channel freq. 190.8875 – 191.125 THz are available only as row-data values.
ILA-L	Dynamic ranges	dBm/12.5GHz	-30		0	LINE-RX ports
			-10		10	LINE-TX ports
	Frequency range	THz	186.05		190.8875	
Common to all units	Power accuracy	dB	+/-0.5		+/-2	Depending on the adjacent channel relative power
	Frequency accuracy (absolute)	GHz			+/- 5	
	Frequency accuracy (relative)	GHz			+/-3	
	Resolution Bandwidth	GHz		12.5		
	Frequency step	GHz	3.125			

	Scan Time	ms			250	Single port

5.8 Tilt vs Gain vs DGE

ILA-C Table:

Gain Range 1 C-Band		
Gain SetPoint [dB]	**Tilt SP Range [dB]**	**CISCO Reserved DGE Average loss SP [dB]**
8	-5 to +5	5.75
9	-5 to +5	4.75
10	-5 to +5	3.75
11	-5 to +4.8	3
12	-5 to +4	3
13	-5 to +3.2	3
14	-5 to +2.4	3
15	-5 to 1.6	3
16	-5 to 0.8	3
17	-5 to 0	3
18	-5 to 0	2
19	-5 to 0	1
20	-5 to 0	0
21	-5 to -0.8	0
22	-5 to -1.6	0
23	-5 to -2.4	0

Gain Range 2 C-Band		
Gain SetPoint [dB]	Tilt SP Range [dB]	CISCO Reserved DGE Average loss SP [dB]
16 to 21	-5 to +5	5.75
22	-5 to +5	4.75
23	-5 to +5	3.75
24	-5 to +4.8	3
25	-5 to +4	3
26	-5 to +3.2	3
27	-5 to +2.4	3
28	-5 to 1.6	3
29	-5 to 0.8	3
30	-5 to 0	3
31	-5 to 0	2
32	-5 to 0	1
33	-5 to 0	0
34	-5 to -0.8	0
35	-5 to -1.6	0
36	-5 to -2.4	0

OLT Table:

Gain Range 1 PRE C-Band [dB]	
Gain SetPoint [dB]	Tilt SP Range [dB]
12 to 15	-5 to +5
16	-5 to +4.8

17	-5 to +4
18	-5 to +3.2
19	-5 to +2.4
20	-5 to 1.6
21	-5 to 0.8
22	-5 to 0
23	-5 to -0.8
24	-5 to -1.6
25	-5 to -2.4

Gain Range 2 PRE C-Band	
Gain SetPoint [dB]	**Tilt SP Range [dB]**
20 to 28	-5 to +5
29	-5 to +4.8
30	-5 to +4
31	-5 to +3.2
32	-5 to +2.4
33	-5 to 1.6
34	-5 to 0.8
35	-5 to 0
36	-5 to -0.8
37	-5 to -1.6
38	-5 to -2.4

Booster C-Band	
Gain SetPoint [dB]	**Tilt SP Range [dB]**

16	-5 to +5
17	-5 to +5
18	-5 to +4.8
19	-5 to +4
20	-5 to +3.2
21	-5 to +2.4
22	-5 to 1.6
23	-5 to 0.8
24	-5 to 0
25	-5 to -0.8
26	-5 to -1.6
27	-5 to -2.4
28	-5 to -3.2en
29	-5 to -4
30	-5 to -4.8
31	-5.6

5.9 OTDR

Parameter	Notes	Min	Typ	Max	Unit
Operating Wavelength	197'450 GHz		1518		nm
Source Stability				+/-1.5	nm
Laser Spectral width	Maximum at -20dB width			1	nm
Mean Launched power	Default TX power	0	5	7	dBm
Max Peak Power	In all transmitting conditions			10	dBm
Detectable Span Reach	No launch Fiber required.	0		23.8	dB

	at LINE-TX/RX connectors Fiber end detectable range, equivalent to 119km at 0.2dB/km				
Dynamic Range	at LINE-TX/RX connectors, no Raman amplification base on 98% Noise Level measured in Auto-mode 20us pulse	28.8			dB
Event Distance		0			mt
Pulse width	Auto-Mode.	0.02		20	us
	Expert-Mode only	0.01		20	us
Distance Accuracy	Accuracy = Reported Distance – Actual distance % Relative to reported event's distance +/-2m for any Distance < 2Km. Single reflective event			+/- 0.1	%
Distance Precision	Aka stability of the measurement +/-1m for any Distance < 2Km. Single reflective event			+/- 0.05	%
Reflective Dead Zone	Referring to the shortest pulse (20 ns)			+/- 5	mt
Attenuation Dead Zone	Referring to the shortest pulse (20 ns)			+/- 20	mt
Reflection Event Measurement Range		-50		-20	dB
Event Reflection Measurement Accuracy				+/- 2	dB

Event Reflection Measurement Precision				+/- 2	dB
Loss Event Measurement Range		0.5		5	dB
Event Loss Measurement Accuracy				+/- 0.5	dB
Event Loss Measurement Precision				+/- 0.5	dB
Measurement Time				180	s

6 Photonic Software and Features

6.1 Measurement Values

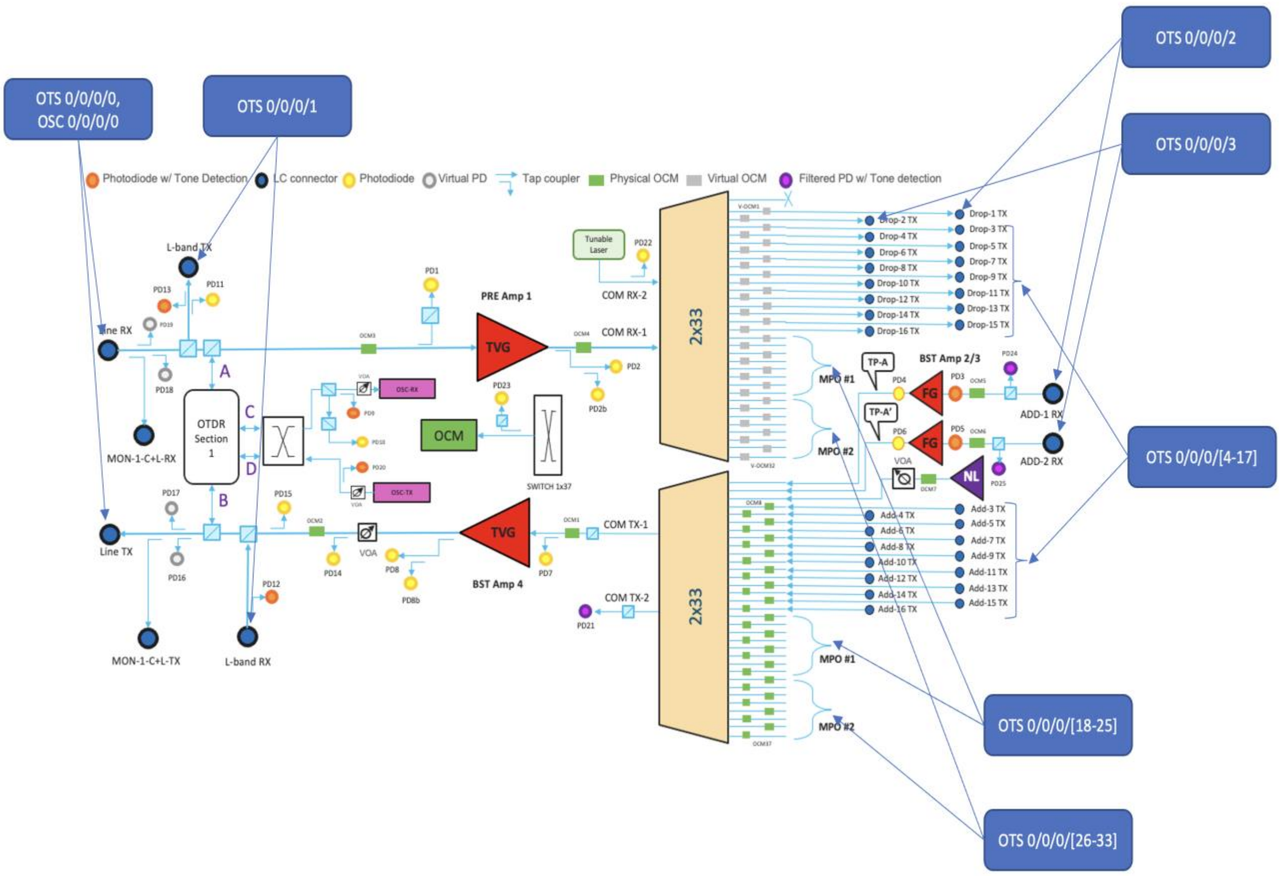
The Controller Mapping and Photo Diode to CLI Parameter Mapping captured in this section

Photo Diode Sampling Happens Once Every 50milliseconds. The polling can be delayed upto 200 milliseconds, when there is Device Access conflict in the system. Example EDFA Fiber , Laser Temperature monitoring , EDFA Gain Programming delays the Photo Diode Refresh since above mentioned operations is performed on the Same HW interface between CSCO SW and Vendor Module.

Micro Controller Unit Interface of the Photo Diode to CSCO SW interface changed to 0.01 dBm Resolution. By Design the ADC peek to peek is within 0.05 dBm. Long term stability test at room temperature indicates the power stability measurement of Photo Diode is within 0.02 dBm.

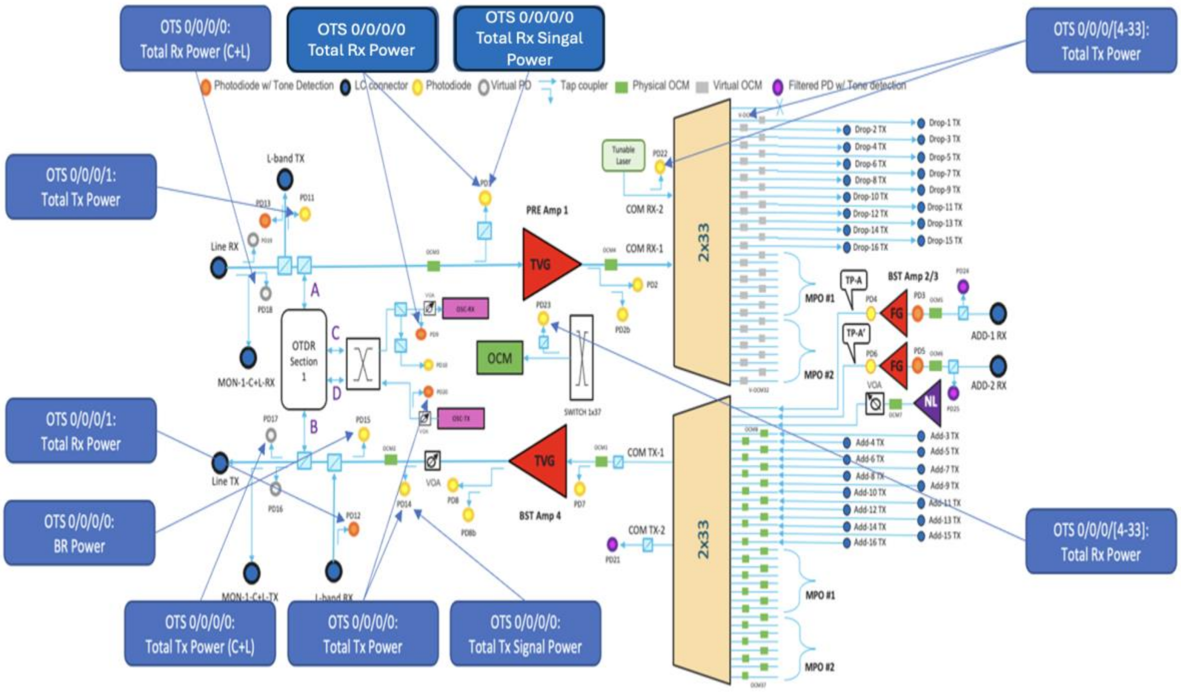
Optical Line Terminal C-Band Without RAMAN (OLT-C) Port Mapping

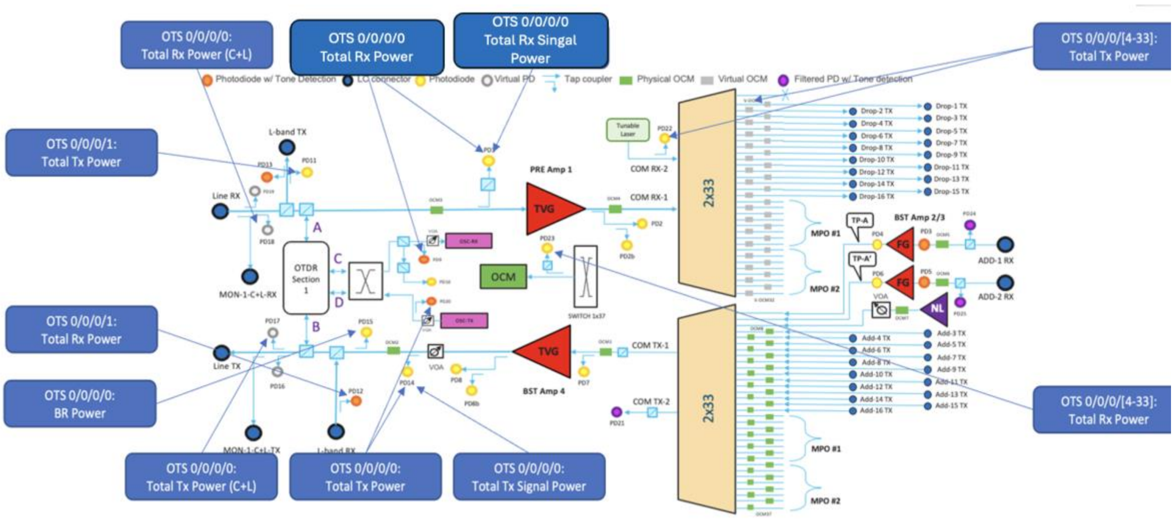
The interface/controller/Port Modelling of OLT-C module without RAMAN is captured in picture below. In IOSXR system the OTS /OSC/DFB Channels / Streams are Modelled by S/W entity “Controller”. The Line Port, L-Band Input Port and Add-Drop ports all are Modelled by OTS controller type. The OSC channel is Modelled by OSC controller type.



Optical Line Terminal C-Band without RAMAN (OLT-C) OTS Controller Photo Diode Parameter Mapping

The below picture captures the OTS Operational Parameters that are mapping Photo Diode measured power values:





Sample Command Line Interface Output of Optical Line Terminal C-Band without RAMAN (OLT-C) OTS Line Controller

```
RP/0/RP0/CPU0:NCS1020_P1B_06#show controllers Ots 0/0/0/0
Wed Jan 22 12:59:24.879 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Yellow

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 29
         RX-LOC = 1
         TX-POWER-FAIL-LOW = 4
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 1
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 29
         EGRESS-AMPLI-LASER-OFF = 0

         Parameter Statistics:
         ---------------------
         Total Rx Power(C+L) = 4.93 dBm
         Total Tx Power(C+L) = 17.31 dBm
         Total Rx Power = 4.93 dBm
         Total Tx Power = 17.32 dBm
         Rx Signal Power = 4.93 dBm
         Tx Signal Power = 17.30 dBm
         Tx Voa Attenuation = 5.7 dB
         Ingress Ampli Mode = Gain
         Ingress Ampli Gain = 20.1 dB
         Ingress Ampli Tilt = -0.5 dB
         Ingress Ampli Gain Range = Extended
         Ingress Ampli Safety Control mode = auto
         Ingress Ampli OSRI = OFF
         Ingress Ampli Force Apr = OFF
         Egress Ampli Mode = Gain
         Egress Ampli Gain = 19.5 dB
         Egress Ampli Tilt = -1.1 dB
         Egress Ampli Safety Control mode = auto
         Egress Ampli OSRI = OFF
         Egress Ampli Force APR = OFF
         Egress Ampli BR = ENABLE
         Egress Ampli BR Power = -15.16 dBm
         Egress Ampli BR Ratio = -32.50 dB
```

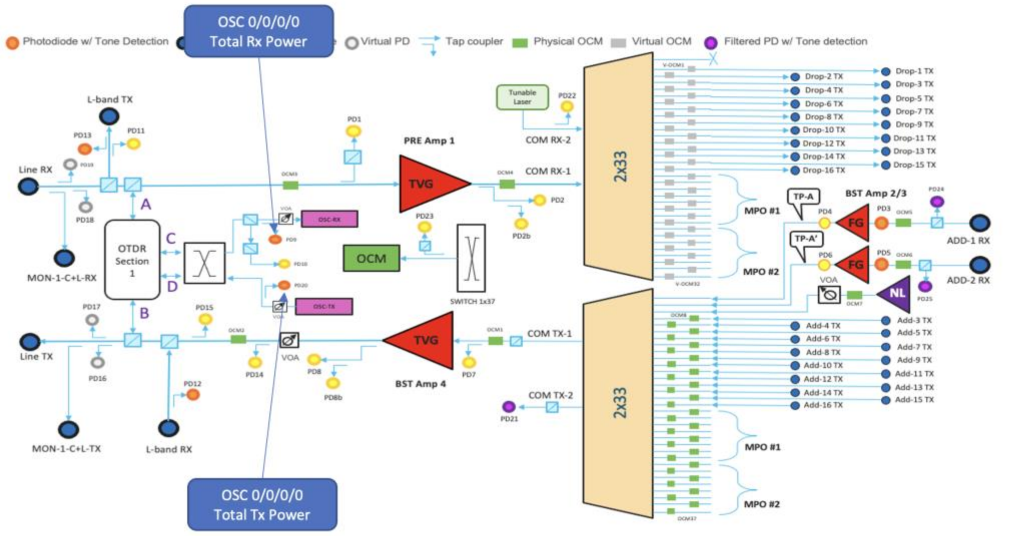
Sample Command Line Interface Output of Optical Line Terminal C-Band without RAMAN (OLT-C) OTS Add-Drop Controller

```
RP/0/RP0/CPU0:NCS1020_B0_02#show controllers Ots 0/0/0/4
Wed Jan 22 12:47:58.275 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Green

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 1
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 9
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 0
         EGRESS-AMPLI-LASER-OFF = 0

         Parameter Statistics:
         ---------------------
         Total Rx Power = 13.38 dBm
         Total Tx Power = 4.60 dBm



         Configured Parameters:
         -------------
```

```
RP/0/RP0/CPU0:NCS1020_P1D_04#show controllers Ots 0/0/0/3
Wed Jan 22 12:47:20.773 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Red

         Alarm Status:
         -------------
         Detected Alarms:
                 INGRESS-AMPLI-GAIN-LOW

         Alarm Statistics:
         -----------------
         RX-LOS-P = 0
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 1
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 1
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 0
         EGRESS-AMPLI-LASER-OFF = 0

         Parameter Statistics:
         ---------------------
         Total Rx Power = 1.37 dBm
         Total Tx Power = -15.69 dBm
         Ingress Ampli Mode = Gain
         Ingress Ampli Gain = 13.9 dB
         Ingress Ampli Tilt = 0.0 dB


         Configured Parameters:
         -------------
         Ingress Ampli Gain = 16.0 dB
         Ingress Ampli Tilt = 0.0 dB
```

Optical Line Terminal C-Band without RAMAN (OLT-C) OSC Controller Photo Diode Mapping.

The below picture captures the OSC Channel Operational Parameters that are mapping Photo Diode measured power values:

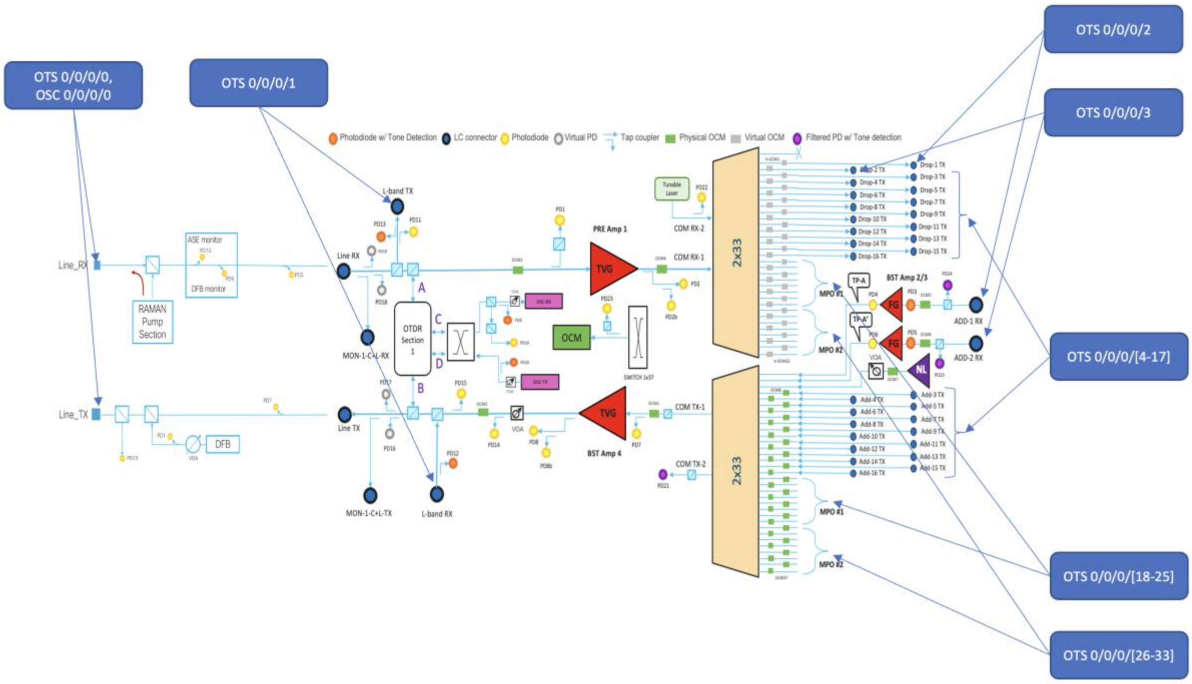


Sample Command Line Interface Output of Optical Line Terminal C-Band without RAMAN (OLT-C) OSC Controller.

```
RP/0/RP0/CPU0:NCS1010-PROD-07#show controllers Osc 0/0/0/0
Wed Jan 22 12:40:10.830 IST

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 0
         TX-POWER-FAIL-LOW = 0

         Parameter Statistics:
         ---------------------
         Total Tx Power = 0.96 dBm
         Total Rx Power = -23.34 dBm
         OSNR = 38.20 dB
```

Optical Line Terminal C-Band With RAMAN (OLT-R-C) Port Mapping

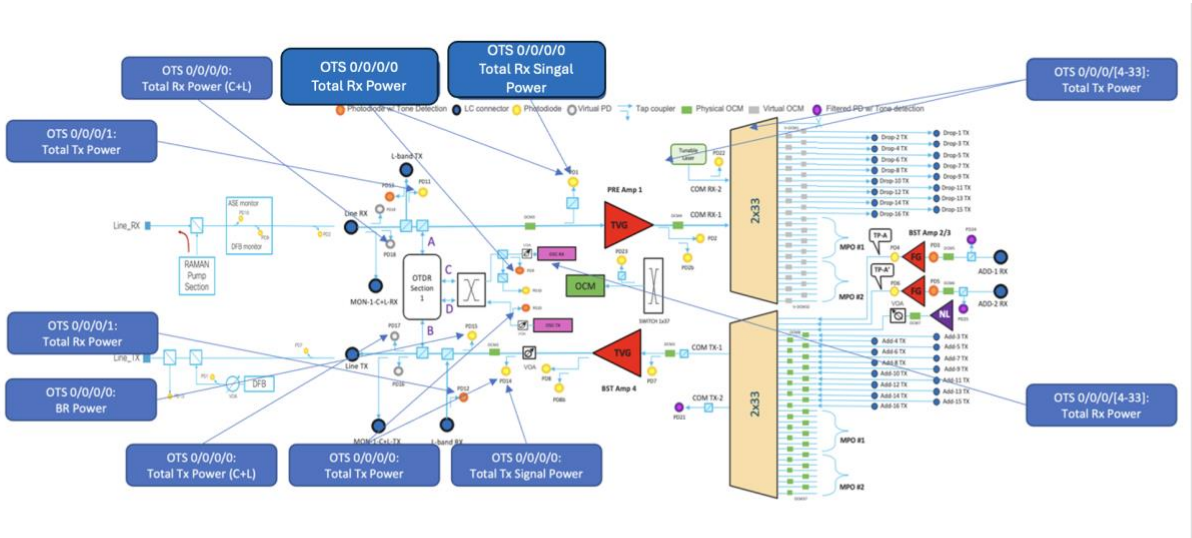
The interface/controller/Port Modelling of OLT-R-C module with RAMAN is captured in picture below. In IOS-XR system the OTS /OSC/DFB Channels / Streams are Modelled by S/W entity “Controller”. The Line Port, L-Band Input Port and Add-Drop ports all are Modelled by OTS controller type. The OSC channel is Modelled by OSC controller type. The RAMAN Monitoring parameters are Captured under the OTS Controller on the Line Side.



Optical Line Terminal C-Band with RAMAN (OLT-R-C) OTS Controller Photo Diode Parameter Mapping

The below picture captures the OTS Operational Parameters that are mapping Photo Diode measured power values.

The Photo Diode Measures are Calibrated to the Line Port of the RAMAN module as indicated in picture in Section 3.1.7



Sample Command Line Interface Output of Optical Line Terminal C-Band with RAMAN (OLT-R-C) OTS Line Controller

The Power Measures are Calibrated to Line Port of RAMAN Module.

```
RP/0/RP0/CPU0:P1D_DT_01#show controllers Ots 0/0/0/0
Wed Jan 22 12:53:11.380 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Green

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 1
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 1
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 1
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 1
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 0
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 1
         EGRESS-AMPLI-LASER-OFF = 1

         Parameter Statistics:
         ---------------------
         Total Rx Power(C+L) = 12.08 dBm
         Total Tx Power(C+L) = 16.19 dBm
         Total Rx Power = 12.08 dBm
         Total Tx Power = 16.20 dBm
         Rx Signal Power = 12.06 dBm
         Tx Signal Power = 16.00 dBm
         Tx Voa Attenuation = 6.1 dB
         Ingress Ampli Mode = Gain
         Ingress Ampli Gain = 12.9 dB
         Ingress Ampli Tilt = -1.7 dB
         Ingress Ampli Gain Range = Normal
         Ingress Ampli Safety Control mode = auto
         Ingress Ampli OSRI = OFF
         Ingress Ampli Force Apr = OFF
         Egress Ampli Mode = Gain
         Egress Ampli Gain = 20.8 dB
         Egress Ampli Tilt = -0.8 dB
         Egress Ampli Safety Control mode = auto
         Egress Ampli OSRI = OFF
         Egress Ampli Force APR = OFF
         Egress Ampli BR = ENABLE
         Egress Ampli BR Power = -15.36 dBm
         Egress Ampli BR Ratio = -32.70 dB
```

```
RP/0/RP0/CPU0:P1D_DT_01#show controllers Ots 0/0/0/0 raman-info
Wed Jan 22 12:53:15.847 IST

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RAMAN-AUTO-POW-RED = 0
         RAMAN-1-LOW-POW = 0
         RAMAN-2-LOW-POW = 0
         RAMAN-3-LOW-POW = 0
         RAMAN-4-LOW-POW = 0
         RAMAN-5-LOW-POW = 0
         RAMAN-1-HIGH-POW = 0
         RAMAN-2-HIGH-POW = 0
         RAMAN-3-HIGH-POW = 0
         RAMAN-4-HIGH-POW = 0
         RAMAN-5-HIGH-POW = 0

         Parameter Statistics:
         ---------------------
         Raman Safety Control mode = auto
         Raman OSRI = OFF
         Raman Force Apr = OFF
         Composite Raman Power = 824.00 mW
         Raman BR Power = -1.20 dBm
         Raman BR Ratio = -30.40 dB

         RAMAN Pump Info:
         ---------------------
         Instance        Wavelength(nm)  Power(mW)
          1               1424.00                 206.10
          2               1436.00                 212.50
          3               1451.00                 142.70
          4               1467.00                 86.80
          5               1495.00                 183.00
```

Sample Command Line Interface Output of Optical Line Terminal C-Band with RAMAN (OLT-C) OTS Add-Drop Controller

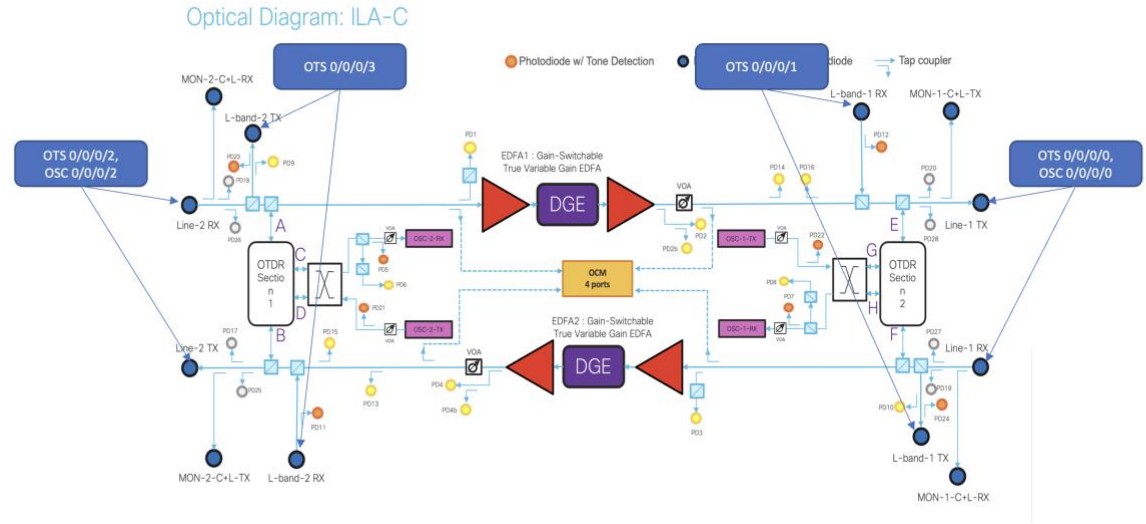
The Sample o/p will be similar to Picture captured in Section above

Sample Command Line Interface Output of Optical Line Terminal C-Band without RAMAN (OLT-C) OSC Controller

The Sample o/p will be Similar to Picture captured in Section above, the difference OSC Power Measures will be Calibrated to RAMAN Line Port.

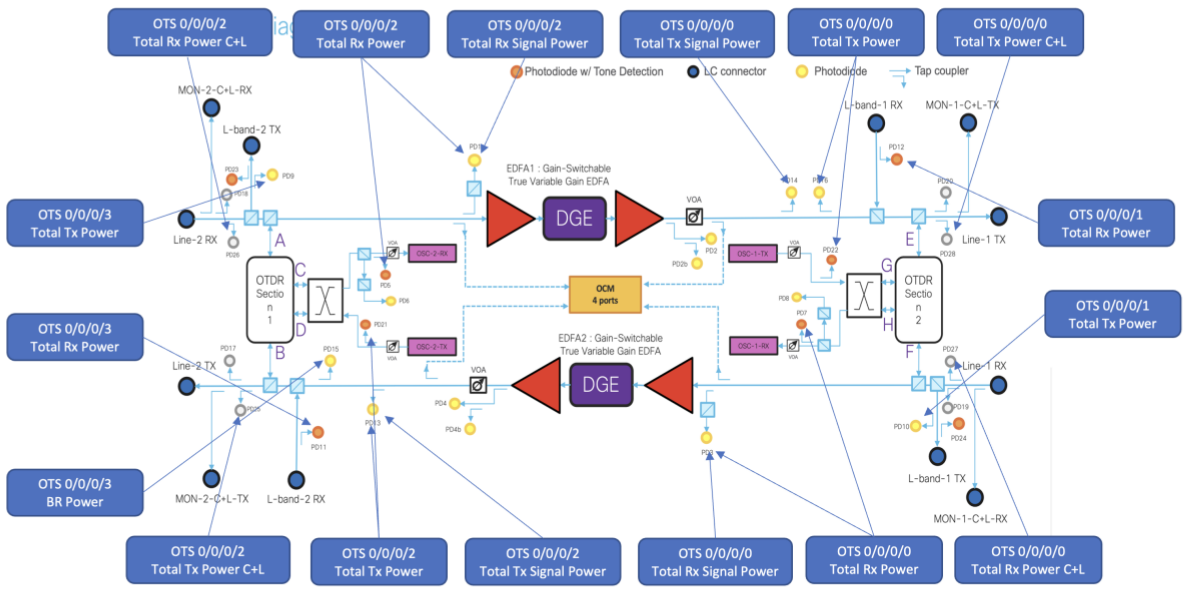
Inline Amplifier C-Band Without RAMAN (ILA-C) Port Mapping

The interface/controller/Port Modelling of ILA-C module without RAMAN is captured in picture below. In IOSXR system the OTS /OSC/DFB Channels / Streams are Modelled by S/W entity “Controller”. The Line Port, L-Band Input Port and Add-Drop ports all are Modelled by OTS controller type. The OSC channel is Modelled by OSC controller type.



Inline Amplifier C-Band without RAMAN (ILA-C) OTS Controller Photo Diode Parameter Mapping

The below picture captures the OTS Operational Parameters that are mapping Photo Diode measured power values:



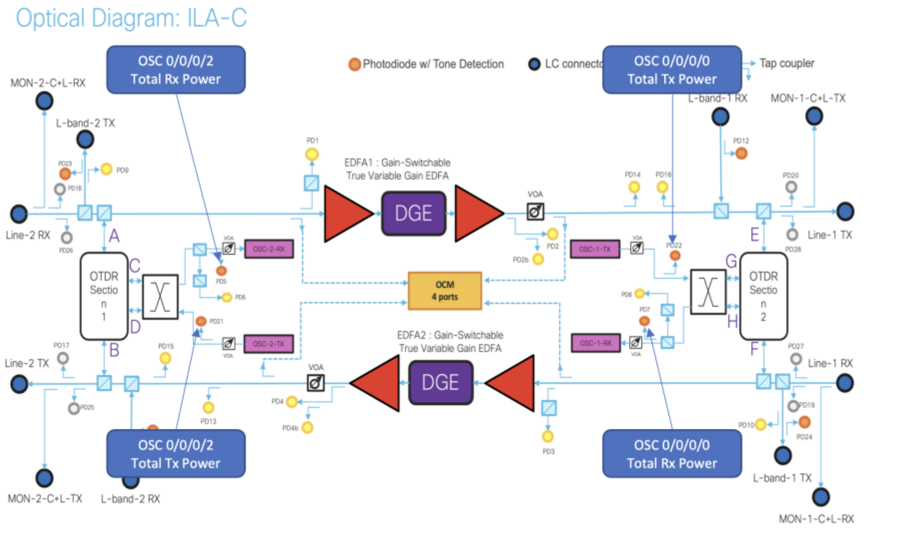
Sample Command Line Interface Output of Inline Amplifier C-Band without RAMAN (ILA-C) OTS Line Controller

The Sample output is captured for Controller OTS 0/0/0/0, the information shall be similar for Controller OTS 0/0/0/2.

```
RP/0/RP0/CPU0:NCS1010-PROD-07#show controllers Ots 0/0/0/0
Wed Jan 22 12:26:27.919 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Green

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 8
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 3
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 9
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 0
         EGRESS-AMPLI-LASER-OFF = 6

         Parameter Statistics:
         ---------------------
         Total Rx Power(C+L) = -1.10 dBm
         Total Tx Power(C+L) = 20.18 dBm
         Total Rx Power = -1.10 dBm
         Total Tx Power = 20.18 dBm
         Rx Signal Power = -1.12 dBm
         Tx Signal Power = 20.13 dBm
         Tx Voa Attenuation = 3.0 dB
         Egress Ampli Mode = Gain
         Egress Ampli Gain = 23.5 dB
         Egress Ampli Tilt = -2.6 dB
         Egress Ampli Gain Range = Extended
         Egress Ampli Safety Control mode = auto
         Egress Ampli OSRI = OFF
         Egress Ampli Force APR = OFF
         Egress Ampli BR = ENABLE
         Egress Ampli BR Power = -12.14 dBm
         Egress Ampli BR Ratio = -32.30 dB

RP/0/RP0/CPU0:NCS1010-PROD-07#show controllers Ots 0/0/0/0 raman-info
Wed Jan 22 12:26:31.877 IST

Raman info not supported on this port
```

Inline Amplifier C-Band without RAMAN (ILA-C) OSC Controller Photo Diode Mapping

The below picture captures the OSC Channel Operational Parameters that are mapping Photo Diode measured power values:



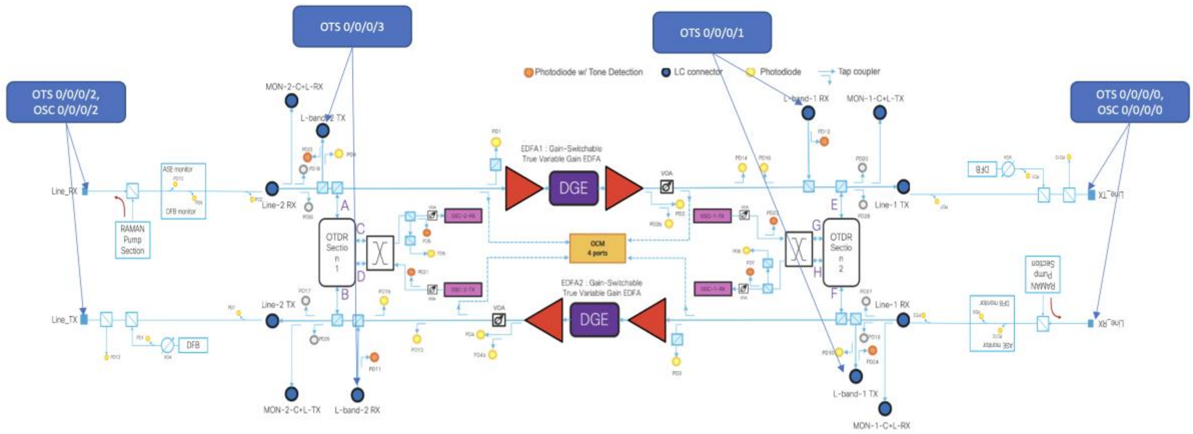
Sample Command Line Interface Output of Inline Amplifier C-Band without RAMAN (ILA-C) OSC Controller

The Sample output is captured for Controller OSC 0/0/0/0, the information shall be similar for Controller OSC 0/0/0/2.

```
RP/0/RP0/CPU0:NCS1010-PROD-07#show controllers Osc 0/0/0/0
Wed Jan 22 12:54:15.666 IST

 Controller State: Up

 Transport Admin State: In Service

 Laser State: On

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 0
         TX-POWER-FAIL-LOW = 0

         Parameter Statistics:
         ---------------------
         Total Tx Power = 0.96 dBm
         Total Rx Power = -23.23 dBm
         OSNR = 38.30 dB
```

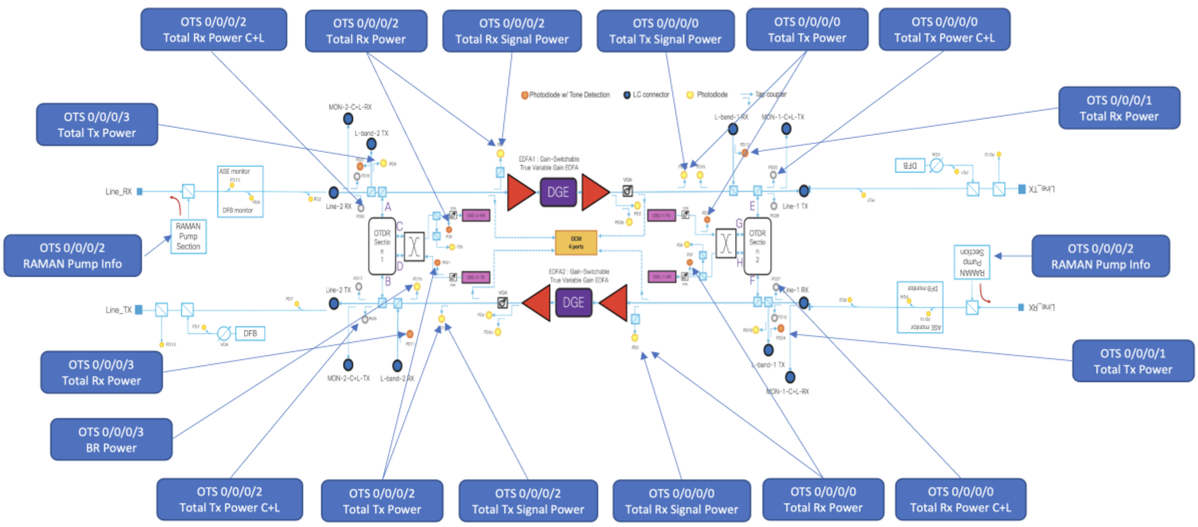
Inline Amplifier C-Band With Two Side RAMAN (ILA-2R-C) Port Mapping

The interface/controller/Port Modelling of ILA-C module with RAMAN is captured in picture below. In IOSXR system the OTS /OSC/DFB Channels / Streams are Modelled by S/W entity “Controller”. The Line Port, L-Band Input Port and Add-Drop ports all are Modelled by OTS controller type. The OSC channel is Modelled by OSC controller type. The RAMAN Monitoring parameters are Captured under the OTS Controller on the Line Side.



Inline Amplifier C-Band with Two Sides RAMAN (ILA-2R-C) OTS Controller Photo Diode Parameter Mapping

The below picture captures the OTS Operational Parameters that are mapping Photo Diode measured power values.



Sample Command Line Interface Output of Inline Amplifier C-Band with Two Side RAMAN (ILA-2R-C) OTS Line Controller

The Power Measures are Calibrated to Line Port of RAMAN Module. The Sample output is captured for Controller OTS 0/0/0/0, the information shall be similar for Controller OTS 0/0/0/2.

```
RP/0/RP0/CPU0:P2A_DT_10#show controllers Ots 0/0/0/0
Wed Jan 22 13:08:36.009 IST

 Controller State: Up

 Transport Admin State: In Service

 LED State: Green

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RX-LOS-P = 5
         RX-LOC = 0
         TX-POWER-FAIL-LOW = 14
         INGRESS-AUTO-LASER-SHUT = 0
         INGRESS-AUTO-POW-RED = 0
         INGRESS-AMPLI-GAIN-LOW = 0
         INGRESS-AMPLI-GAIN-HIGH = 0
         EGRESS-AUTO-LASER-SHUT = 0
         EGRESS-AUTO-POW-RED = 0
         EGRESS-AMPLI-GAIN-LOW = 1
         EGRESS-AMPLI-GAIN-HIGH = 0
         HIGH-TX-BR-PWR = 0
         HIGH-RX-BR-PWR = 0
         SPAN-TOO-SHORT-TX = 0
         SPAN-TOO-SHORT-RX = 0
         INGRESS-AMPLI-LASER-OFF = 0
         EGRESS-AMPLI-LASER-OFF = 19

         Parameter Statistics:
         ---------------------
         Total Rx Power(C+L) = 0.22 dBm
         Total Tx Power(C+L) = 21.13 dBm
         Total Rx Power = 0.23 dBm
         Total Tx Power = 21.13 dBm
         Rx Signal Power = 0.17 dBm
         Tx Signal Power = 21.05 dBm
         Tx Voa Attenuation = 1.2 dB
         Egress Ampli Mode = Gain
         Egress Ampli Gain = 23.2 dB
         Egress Ampli Tilt = -2.9 dB
         Egress Ampli Gain Range = Extended
         Egress Ampli Safety Control mode = auto
         Egress Ampli OSRI = OFF
         Egress Ampli Force APR = OFF
         Egress Ampli BR = ENABLE
         Egress Ampli BR Power = -2.09 dBm
         Egress Ampli BR Ratio = -24.40 dB
```

```
RP/0/RP0/CPU0:P2A_DT_10#show controllers Ots 0/0/0/0 raman-info
Wed Jan 22 13:08:46.990 IST

         Alarm Status:
         -------------
         Detected Alarms: None


         Alarm Statistics:
         -----------------
         RAMAN-AUTO-POW-RED = 0
         RAMAN-1-LOW-POW = 0
         RAMAN-2-LOW-POW = 0
         RAMAN-3-LOW-POW = 0
         RAMAN-4-LOW-POW = 0
         RAMAN-5-LOW-POW = 0
         RAMAN-1-HIGH-POW = 0
         RAMAN-2-HIGH-POW = 0
         RAMAN-3-HIGH-POW = 0
         RAMAN-4-HIGH-POW = 0
         RAMAN-5-HIGH-POW = 0

         Parameter Statistics:
         ---------------------
         Raman Safety Control mode = auto
         Raman OSRI = ON
         Raman Force Apr = OFF
         Composite Raman Power = 0.00 mW
         Raman BR Power = -30.80 dBm
         Raman BR Ratio = -16.70 dB

         RAMAN Pump Info:
         ---------------------
         Instance        Wavelength(nm)  Power(mW)
          1               1424.00                0.00
          2               1436.00                0.00
          3               1451.00                0.00
          4               1467.00                0.00
          5               1495.00                0.00
```

Sample Command Line Interface Output of Inline Amplifier C-Band with Two Side RAMAN (ILA-2R-C) OSC Controller

The Sample o/p will be Similar to Picture captured in Section 3.1.5, the difference OSC Power Measures will be Calibrated to RAMAN Line Port on Both OSC 0/0/0/0 and OSC 0/0/0/2. The Sample output is captured for Controller OSC 0/0/0/0, the information shall be similar for Controller OSC 0/0/0/2.

Inline Amplifier C-Band with RAMAN on Side -1 (ILA-R-C)

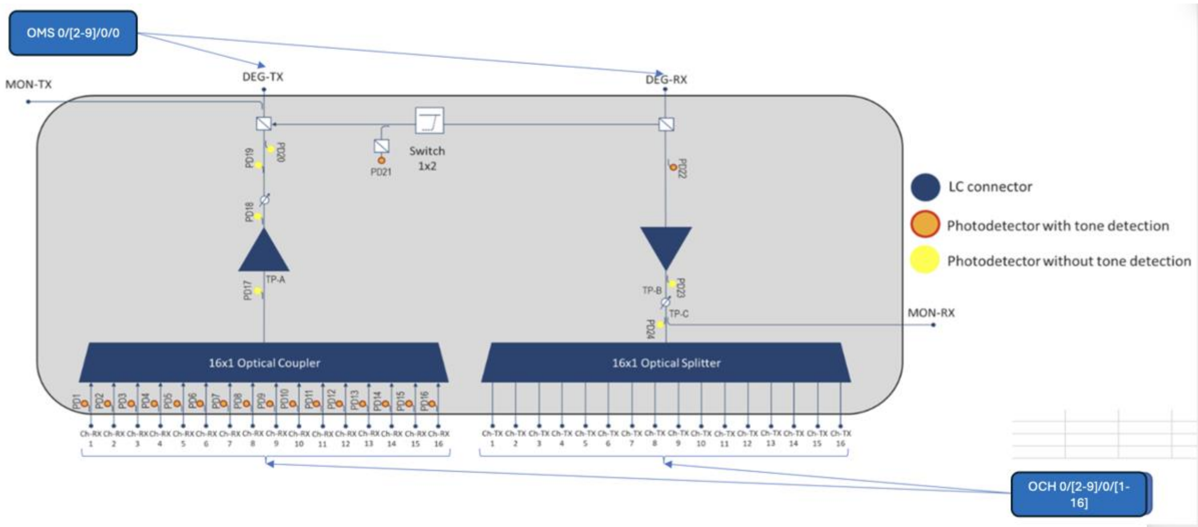
The Port Mapping Is like ILA-2R-C and ILA-C. With Port 0 (OTS 0/0/0/0) as RAMAN port and Port 2 (OTS 0/0/0/2) non-RAMAN port.
The Photo Diode Measures mapping follow the same scheme. The Sample o/p follow the same scheme too.

Inline Amplifier C-Band with RAMAN on Side -2 (ILA-R-C-2)

The Port Mapping Is like ILA-2R-C and ILA-C. With Port 0 (OTS 0/0/0/0) as non-RAMAN port and Port 2 (OTS 0/0/0/2) RAMAN port.
The Photo Diode Measures mapping follow the same scheme. The Sample o/p follow the same scheme too.

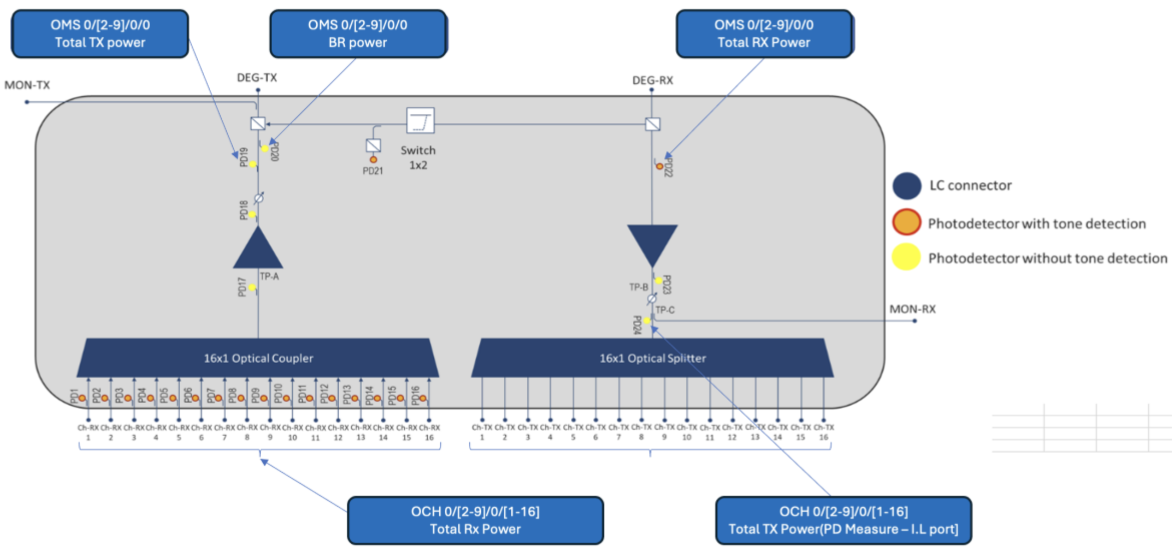
Colourless Mux Demux (CCMD-16) Port Mapping

The interface/controller/Port Modelling of CCMD16 module is captured in picture below. In IOSXR system the COM port and Channels Ports are Modelled by S/W entity “Controller”. The COM Port is modelled as OMS Controller. The Channel Port is modelled as OCH Controller.



Colourless Mux Demux (CCMD-16) Photo Diode Measures

The below picture captures the OMS/OCH Operational Parameters that are mapping Photo Diode measured power values.



6.2 Performance Monitoring

The system support 1 flex-bin history (10 seconds bin), 30 30-seconds history, 32 15-minute history, 7 24-hour history.

The Command to Read the History OTS Performance Monitor Data is as below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm history flex-bin optics 1 bucket 1?
<1-1>
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm history 30-sec optics 1 bucket ?
  <1-30>  Select bucket number to show performance monitoring history data in 30 second interval
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm history 15-min optics 1 bucket ?
  <1-32>  Select bucket number to show performance monitoring history data in 15 minute interval
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm history 24-hour optics 1 bucket ?
  <1-7>  Select bucket number to show performance monitoring history data in 24 hour interval
RP/0/RP0/CPU0:CVT-OLT-1#
```

The Command to Read Current Bin OTS Performance Monitor is as below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm current flex-bin optics 1?
1
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm current flex-bin optics 1 ?
  |      Output Modifiers
  <cr>
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm current 30-sec optics 1 ?
  |      Output Modifiers
  <cr>
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm current 15-min optics 1 ?
  |      Output Modifiers
  <cr>
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm current 24-hour optics 1 ?
  |      Output Modifiers
  <cr>
```

The format of output remains the same across the flex, 30-seconds, 15-minute, 24-hour bins.

Snapshot of Performance Monitor of OTS Controller Modelling Line Port of OLT/ILA Line Card without RAMAN Module Captured below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/0 pm history flex-bin optics 1 bucket 1
Thu Dec 12 11:40:35.867 IST

Optics in interval 1 [11:40:20 - 11:40:30 Thu Dec 12 2024]

Flexible bin interval size: 10 seconds

Optics history bucket type : Valid
              MIN       AVG       MAX
OPT[dBm]    : 21.57     21.57     21.57
OPR[dBm]    : -0.68     -0.68     -0.68
OPT(C+L)[dBm]    : 21.58     21.58     21.58
OPR(C+L)[dBm]    : -0.69     -0.69     -0.69
OPT(S)[dBm]    : 21.54     21.54     21.54
OPR(S)[dBm]    : -0.70     -0.70     -0.70
OPBR[dBm]    : -10.34    -10.34    -10.33
OPBRR[dB]    : -31.90    -31.90    -31.90
EAGN[dB]    : 19.90     19.90     19.90
EATL[dB]    : -2.40     -2.40     -2.40
IAGN[dB]    : 25.90     25.90     25.90
IATL[dB]    : 0.00      0.00      0.00
SLR(C+L)[dB]    : 21.99     21.99     21.99
SLT(C+L)[dB]    : 21.30     21.30     21.30
SLR(S)[dB]    : 21.98     21.98     21.98
SLT(S)[dB]    : 21.28     21.28     21.28
```

Snapshot of Performance Monitor of OSC Controller Modelling the Optical Service Channel on the Line Port of ILA/OLT Line Cards below:

```
RP/0/RP0/CPU0:CVT-OLT-1#sh controllers OSC 0/0/0/0 pm current flex-bin optics 1
Thu Dec 12 12:48:26.368 IST

Optics in the current interval [12:48:20 - 12:48:25 Thu Dec 12 2024]

Flexible bin interval size: 10 seconds

Optics current bucket type : Valid
              MIN       AVG       MAX      Operational      Configured      TCA   Operational      Configured     TCA
                                           Threshold(min)   Threshold(min)  (min) Threshold(max)   Threshold(max)  (max)
OPT[dBm]      : 0.96     0.96      0.96      0.00              NA              NO    0.00              NA              NO
OPR[dBm]      : -26.41   -26.39    -26.39    0.00              NA              NO    0.00              NA              NO
OSNR[dB]      : 35.90    35.90     35.90     0.00              NA              NO    0.00              NA              NO
SLR[dB]      : 24.35    24.35     24.35     0.00              NA              NO    0.00              NA              NO
SLT[dB]      : 23.71    23.71     23.71     0.00              NA              NO    0.00              NA              NO

Last clearing of "show controllers OPTICS" counters never
RP/0/RP0/CPU0:CVT-OLT-1#
```

Snapshot of Performance Monitor of OTS Controller Modelling Add-Drop Port of OLT Line Card Captured below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OTS 0/0/0/4 pm current flex-bin optics 1
Thu Dec 12 12:06:43.826 IST

Optics in the current interval [12:06:40 - 12:06:43 Thu Dec 12 2024]

Flexible bin interval size: 10 seconds

Optics current bucket type : Valid
             MIN       AVG       MAX       Operational      Configured      TCA   Operational      Configured     TCA
                                           Threshold(min)   Threshold(min)  (min) Threshold(max)   Threshold(max)  (max)
OPT[dBm]     : -50.00   -50.00    -50.00    0.00              NA              NO    0.00              NA              NO
OPR[dBm]     : 6.95     6.95      6.95      0.00              NA              NO    0.00              NA              NO

Last clearing of "show controllers OPTICS" counters never
RP/0/RP0/CPU0:CVT-OLT-1#
```

Snapshot of Performance Monitor of OMS Controller modelling CCMD-16 Line Card Mux-Demux Port Captured below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OMS 0/2/0/0 pm current flex-bin optics 1
Thu Dec 12 12:22:12.364 IST

Optics in the current interval [12:22:10 - 12:22:12 Thu Dec 12 2024]

Flexible bin interval size: 10 seconds

Optics current bucket type : Valid
             MIN       AVG       MAX       Operational      Configured      TCA   Operational      Configured     TCA
                                           Threshold(min)   Threshold(min)  (min) Threshold(max)   Threshold(max)  (max)
OPT[dBm]     : 6.90     6.90      6.90      0.00              NA              NO    0.00              NA              NO
OPR[dBm]     : -50.00   -50.00    -50.00    0.00              NA              NO    0.00              NA              NO
OPBR[dBm]     : -6.00    -6.00     -6.00     0.00              NA              NO    0.00              NA              NO
OPBRR[dB]     : -12.80   -12.80    -12.80    0.00              NA              NO    0.00              NA              NO
EAGN[dB]     : 2.00     2.00      2.00      0.00              NA              NO    0.00              NA              NO
EATL[dB]     : 0.00     0.00      0.00      0.00              NA              NO    0.00              NA              NO
IAGN[dB]     : 0.00     0.00      0.00      0.00              NA              NO    0.00              NA              NO
IATL[dB]     : 0.00     0.00      0.00      0.00              NA              NO    0.00              NA              NO

Last clearing of "show controllers OPTICS" counters never
```

Snapshot of Performance Monitor of OCH Controller modelling CCMD-16 Line Card Channel Port Captured below:

```
RP/0/RP0/CPU0:CVT-OLT-1#show controllers OCH 0/2/0/1 pm current flex-bin optics 1
Thu Dec 12 12:39:28.449 IST

Optics in the current interval [12:39:20 - 12:39:28 Thu Dec 12 2024]

Flexible bin interval size: 10 seconds

Optics current bucket type : Valid
             MIN       AVG       MAX       Operational      Configured      TCA   Operational      Configured     TCA
                                           Threshold(min)   Threshold(min)  (min) Threshold(max)   Threshold(max)  (max)
OPT[dBm]     : 6.40     6.40      6.40      0.00              NA              NO    0.00              NA              NO
OPR[dBm]     : 2.09     2.09      2.19      0.00              NA              NO    0.00              NA              NO

Last clearing of "show controllers OPTICS" counters never
RP/0/RP0/CPU0:CVT-OLT-1#
```

Definition of field captured in above Performance Monitor Snapshot captured above are:

- **OPT** – Total Optical Transmit Power
- **OPR** – Total Optical Receive Power
- **OPT(C+L)** – Total Optical Transmit Power C-Band and L-Band Combined
- **OPR(C+L)** – Total Optical Receive Power C-Band and L-Band Combined
- **OPT(S)** – Optical Transmit Signal Power
- **OPR(S)** – Optical Receive Signal Power
- **OPBR** – Optical Back Reflection Power
- **OPBRR** – Optical Back Reflection Power to Transmit Power Ratio
- **EAGN** – Egress Amplifier Gain
- **EATL** – Egress Amplifier Tilt
- **IAGN** – Ingress Amplifier Gain
- **IATL** – Ingress Amplifier Tilt
- **SLR(C+L)** – Span Loss Receive Direction Computed on C-Band and L-Band Power Combined
- **SLT(C+L)** – Span Loss Transmit Direction Computed on C-Band and L-Band Power Combined
- **SLR(S)** – Span Loss Receive Direction Computed on Signal Power
- **SLT(S)** – Span Loss Transmit Direction Computed on Signal Power

6.3 General Environment

C-band system, fixed grid, no ROADM.
Although MSFT is planning to install all channels from the beginning, system should work with partial user grid (configured channels not covering the whole spectrum),

6.4 Channel Grid

We operate in "fixed grid", configured in all nodes. This is important for ASE&APC.

The Configurations Needed for Optical Link Bring up is Generated by CONP tool as part of Link Planning activity. The CONP tool generates configuration node by node in Netconf Format. Below Command Line Interface method can be used on the Node to load the configurations generated by CONP tool.

```
RP/0/RP0/CPU0:CVT-OLT-1#netconf-yang-console file /harddisk:/olt-1.cfg ?
  <cr>
RP/0/RP0/CPU0:CVT-OLT-1#netconf-yang-console file /harddisk:/olt-1.cfg
Mon Dec 16 11:48:25.982 IST
# netconf_client_ztp_lib - version 1.3 #
```

6.5 Spanloss Computation Logic

Span loss is computed by receiving end of span based on:

- TX power measurement on upstream node of span
- RX power measurement on downstream node of span

TX measurement and RX measurement are not synchronous. TX measurement is taken every 10 seconds using 10 second timer running on upstream node and same is sent from upstream node to downstream node in a message as soon as TX measurement is taken. RX measurement is also taken every 10 seconds using 10 second timer running on downstream node. Expiry of 10 second timer may not be aligned and can have misalignment of up to 10 seconds. As a result, RX measurement taken can have offset of up to 10 seconds compared with when TX measurement was taken. This offset can sometimes lead to transient span loss value computation, particularly when power levels are changing e.g. during APC regulation. To avoid this, SW takes 3 consecutive measurements of TX power and RX power with gap of 10 seconds (as per 10 second timer) between 2 consecutive measurements and considers these measurements for span loss computation and reporting only if

- All 3 RX measurements are within 0.2 dB of variation (variation should be less than 0.2 dB)
- All 3 span loss values as per 3 TX measurements and 3 RX measurements are within 0.2 dB of variation (variation should be less than 0.2 dB)

Spanloss computed is the average of 3 spanloss computations as per 3 samples of TX and RX measurements

6.6 ASE Loading

In general, ASE is used:
To create channels in not allocated spectrum. When user OXC are created there, the correspondent ASE channels are switched off.
to substitute signal of failed user channels.

Considering that system works on a well-known fixed grid, regular ASE channels will be created with the same grid, respecting the configured SD: once the grid is configured, this is the same regardless of the channel kind.
This has several advantages:
1. Each node knows channel centre frequency, without exchanging information. This is leveraged by local control loops.
2. SD is more constant when switching from ASE to real channels.
3. Spectrum is consistent when shown on a OSA instrument...

6.7 ASE Channels Management SW

6.7.1 Show Commands and Alarms

Management interface will provide a method to retrieve the list of all channels, either user or ASE:

1. Centre Frequency and Channel Width.
2. Channel Number (N/A if it is a fill-in ASE channel).
3. The configured express port (N/A if it is a fill-in ASE channel).
4. Channel Status. This can be ACTIVE or ASE.

5. Channel Number(s) in case of Overlapping Channels

```
RP/0/RP0/CPU0:SOLN-OLT-1#sh hw-module location 0/0/NXR0 terminal-ampli
Mon Dec 16 12:08:00.757 IST

Legend:
NXC       - Channel not cross-connected
ACTIVE - Channel cross-connected to data port
ASE        - Channel filled with ASE
FAILED - Data channel failed, pending transition to ASE
PENDING_ACTIVATION - Data Channel pending transition to ACTIVE/FAIL

Location:              0/0/NXR0

Status:                Provisioned

Flex Grid Info

Channel Number       Centre Frequency(THz)        Channel Width(GHz)     Channel Status      Overlapping Channels
1                    191.425000                   150.000                ASE                   - ,   -
2                    191.575000                   150.000                ASE                   - ,   -
3                    191.725000                   150.000                ASE                   - ,   -
4                    191.875000                   150.000                ASE                   - ,   -
5                    192.025000                   150.000                ASE                   - ,   -
6                    192.175000                   150.000                ASE                   - ,   -
7                    192.325000                   150.000                ASE                   - ,   -
8                    192.475000                   150.000                ASE                   - ,   -
9                    192.625000                   150.000                ASE                   - ,   -
10                   192.775000                   150.000                ASE                   - ,   -
11                   192.925000                   150.000                ASE                   - ,   -
12                   193.075000                   150.000                ASE                   - ,   -
13                   193.225000                   150.000                ASE                   - ,   -
14                   193.375000                   150.000                ASE                   - ,   -
15                   193.525000                   150.000                ASE                   - ,   -
16                   193.675000                   150.000                ASE                   - ,   -
17                   193.825000                   150.000                ASE                   - ,   -
18                   193.975000                   150.000                ASE                   - ,   -
19                   194.125000                   150.000                ASE                   - ,   -
20                   194.275000                   150.000                ACTIVE                - ,   -
21                   194.425000                   150.000                ASE                   - ,   -
```

Note on alarms in case of channel failure.
When a user channel fails in add path:

1. CCMD card emits an LOS alarm on OCH port;
2. OLT emits a LOS or RX-BELOW-MIN-PSD alarm on express OTS-OCH port;
3. CHANNEL-NOISE-LOADED alarm is emitted when channel is filled with ASE. One alarm per channel, raised on OTS-OCH of line controller.
4. All ILA node will detect the missing power but hold-off timer is much longer of ASE intervention time. No channel monitoring alarms are raised.

There is no demoting between these alarms.

Actual switching criteria are described below.

6.7.2 ASE Channels Controls

It is possible to:
Disable single ase channels (more than one at a time). This command will be defined for all ASE channels, including ones substituting failed user channels. ASE-LOADING-DISABLED alarm will be raised on the LINE ots-och object when channel is disabled.

```
RP/0/RP0/CPU0:SOLN-OLT-1(config)#
RP/0/RP0/CPU0:SOLN-OLT-1(config)#hw-module location 0/0/NXR0 terminal-ampli
RP/0/RP0/CPU0:SOLN-OLT-1(config-hwmod-olt)#grid-mode flex channel-id 1 ase-loading disable
RP/0/RP0/CPU0:SOLN-OLT-1(config-hwmod-olt)#commit
```

1. Switch off the ASE EDFA. ASE-LOADING-DISABLED alarm alarm is raised on the Line Ots object.

```
RP/0/RP0/CPU0:SOLN-OLT-1(config)#
RP/0/RP0/CPU0:SOLN-OLT-1(config)#hw-module location 0/0/NXR0 terminal-ampli
RP/0/RP0/CPU0:SOLN-OLT-1(config-hwmod-olt)#ase-loading disable
RP/0/RP0/CPU0:SOLN-OLT-1(config-hwmod-olt)#commit
```

These are intended for troubleshooting; it is not expected the system behaves correctly:

2. Other channel regulation on OLT shouldn't be impacted (WSS control loop doesn't rely on the whole spectrum to be filled) BUT pausing APC (apc-pause command) on OLT is strongly recommended.

3. ILA APC is not impacted because regulation is triggered only by span loss changes.

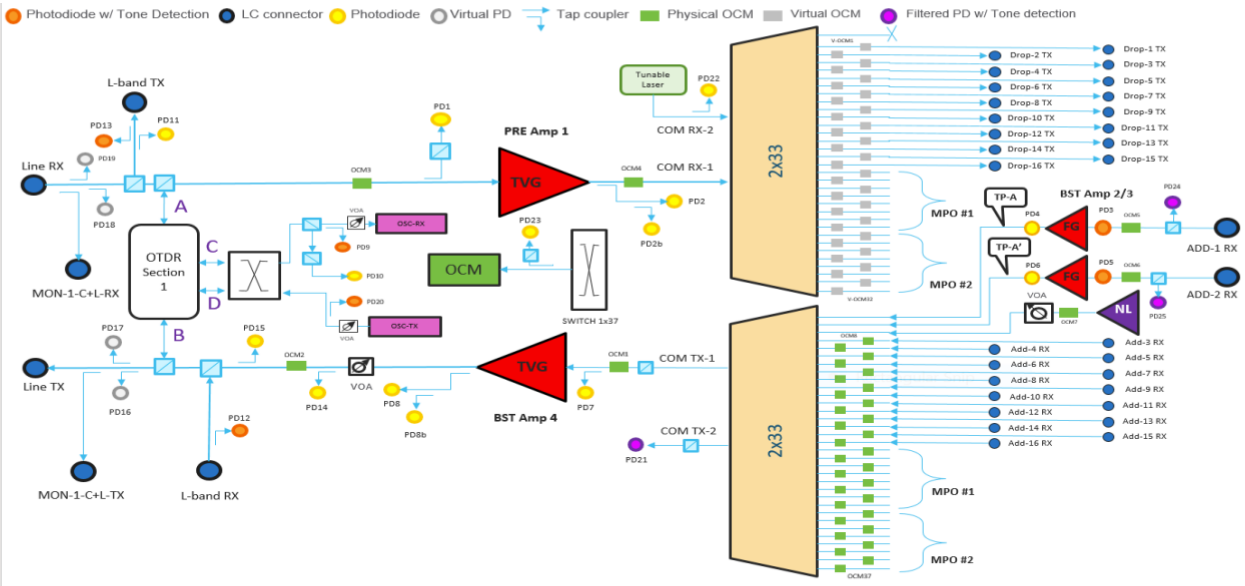
4. ILA channel monitoring may report alarms along the line; this is expected and accepted.

OLT Alarms are raised/cleared immediately, when the event/command is issued.

Channels are identified by their own central frequency.

6.8 WSS Programming

For reference, this is the optical diagram of C-Band OLT.



The 2x33 WSS on the Multiplexer Section is able to route a given spectrum selection from any input port ADD-RX-i either to COM-TX-1 or COM-TX-2 output ports or block the specific spectrum selection (i.e. the spectrum selection on the specific path is set to high attenuation state AVS). Similarly, the 2x32 WSS on the De-Multiplexer Section is able to route any given spectrum selection present on the input ports COM-RX-1 and COM-RX-2 to any DROP-TX-i output ports or block it.

The spectrum routing capability form input to output is “unique”, i.e. no broadcast capability is present (one input port to several output ports).

For each spectrum selection it is possible to set VOA value to attenuate the optical power passing thru the specific path. The attenuation range is max 15dBwith a resolution of 0.1dB.

The spectrum routing and attenuation is performed on a slice based (i.e. allocation of a given set of frequency slices on the specific input-to-output path). The WSS operates at optical level with Physical Slices with 3.125GHz width.

All channels must be aligned at the 3.125 grid: CentralF -width/2 and frequency+width/2 must be on the borders of some slices.

Each channel type has a specific rule to map its spectrum allocation <central frequency, width> to WSS slice programming. Each rule should maintain the target spectral density.

USER CHANNELS

All slices corresponding to [CentralF -width/2, frequency+width/2] are exclusively reserved to the channel. The user is expected to insert channels respecting the design spectral density.

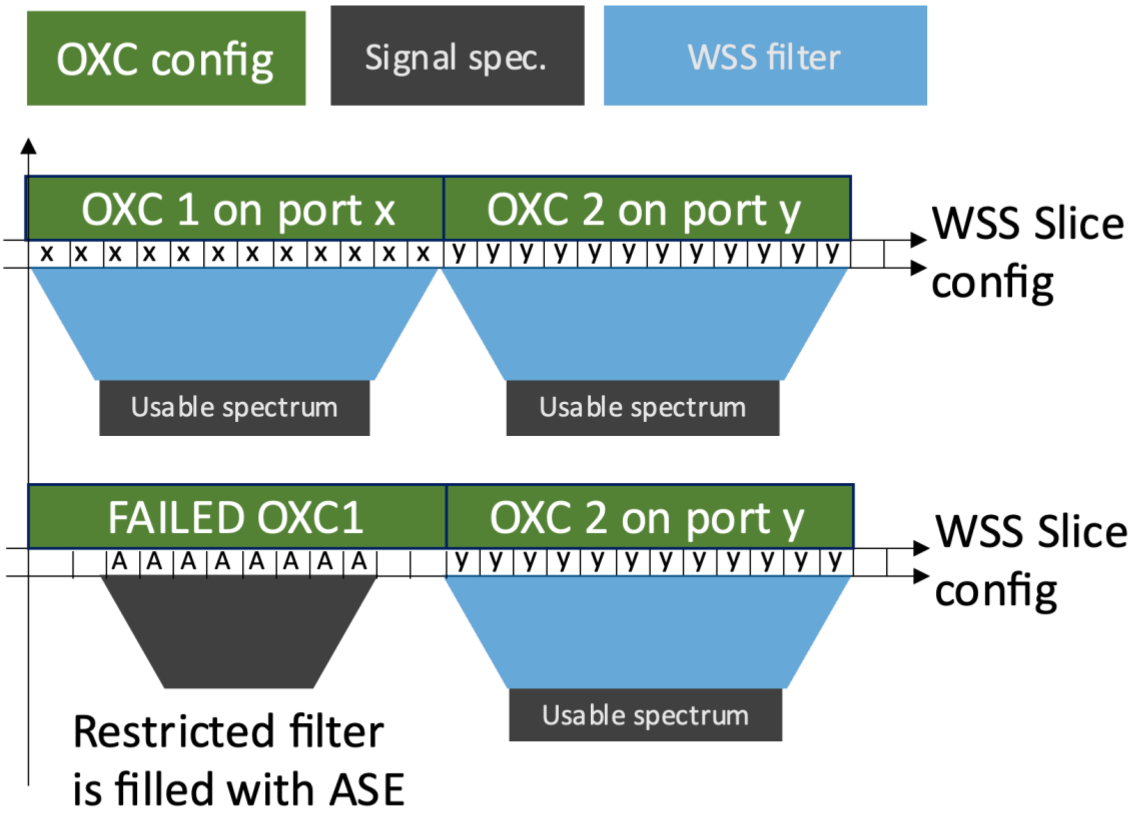
FILL-IN ASE CHANNELS

ASE channel signals have the shape of the WSS filter used to generate them. To create proper channels, gaps of blocking slices must be set between adjacent channels. Taking in account bandwidth properties of WSS, two slices per side (6.25 GHz) in each channel are excluded.

SUBSTITUTE ASE CHANNELS

Considering a user channel allocation N slice wide, routing all the slices on ASE port would create a channel wider than the user signal was passing through. This has two disadvantages: it may interfere with adjacent channels, and it doesn't respect the target spectral density. Because of this the same rule for fill-in ase channels is used: the user OXC N slices wide is substituted by a (N-4) slices wide ASE cross-connection.

The following picture shows the concept:
In the first row, two channels are created and active, and the correspondent slice configuration is shown. The second line shows the WSS configuration when OXC1 fails and it is substituted with ASE: not all the slices are routed from port X to port A (ASE), but two slides per side (6.25 Ghz each) are kept in blocking state (empty label in the picture).



6.9 Turnup Procedure (ALC)

Automatic Link Calibration is an application that sets up a linear link from the optical point of view, performing several checks and regulations.

A successful result of the turnup procedure is a milestone between link installation and payload bring up. It is a mandatory documentation presented by Cisco installers to MSFT.

6.9.1 Config, Prerequisites, and Checks

ALC is an application started through management interface on OLT. ALC operates on the OLT transmit direction. The other direction is setup by ALC started on the opposite OLT.

ALC is traffic affecting so for sure requires high level privileges.

Fiber loss is expected to increase during link lifetime; ALC must consider this at gain range selection; the increase of the span loss from BOL value is configurable, and its default is 3 dB. Name of the configuration at box CLI is <span-loss-margin>. Its usage is described below (gain range choice paragraph).

Prerequisites to Run ALC:

OLT-2-OLT topology is complete:

To ensure communication, OSPF topology on OLT is checked.

1. All nodes are queried to verify no LOC alarm nor OSC LOS alarms are present.
2. All the optical OXC are created. They must cover the whole spectrum. Typically, this channel grid comes as configuration data from design tool. T
3. All Raman-based spans are in the "Raman-go" condition (pumps can go to needed power). This is checked on all nodes.
4. All applications are configured in “manual” or “disable” mode, not enabled (Cisco behavior). This is checked on all nodes.

The prerequisites are checked before starting any traffic-affecting operation.

6.10 Saved Results

1. Each node will collect:
2. Timestamp of the ALC baseline.
3. Regulations performed along with a summary of their results:
   a. For raman tuning start and end timestamp, target gain, actual gain, pump powers
   b. For link tuner: all config parameters, the chosen gain range, the 33 PSD values.
   c. APC: Gain, tilt, VOA values, WSS attenuation and DGE attenuations, and current discrepancy vector (per channel gap between target and actual psd)
4. OSC span loss without signal power and without Raman
5. DFB Span loss with pumps off (applicable to line card with Raman)

6. Span loss based on total power (C+OSC)
7. Span loss based on total power (C+OSC) with pumps off (applicable to line card with Raman)
8. Measured OSC span loss with Raman pumps on and signal power (at target).
9. Powers measured at LINE PD.

OCM raw data for TX and RX ports, with Raman on if present.

This set of data is called the baseline is stored locally for future use. It must survive any cold/warm restart, power cycle etc.

Additional regulation info (such as Raman measurements) is retrievable through correspondent application show commands.

All saved data will be available through restconf interface.

Baseline is saved on span-by-span basis. If ALC fails at link level. Baseline data saved at ALC completed node will not be wiped out.

6.10.1 Calibrated Parameters

These are the parameters that are changed by ALC:

1. All EDFA: Gain, Tilt.
2. VOA on egress ports: Attenuation.
3. DGE: attenuation
4. Raman: Raman pump power
5. WSS: attenuation

6.10.2 SW Implementation

ALC will implement:

1. A token-based implementation, removing the OLT driven approach of phase 1.
2. Support for Raman.
3. New ALC alarm management.
4. Parallel baseline.

Looking at development effort, these are the relevant items:

5. Running alarm management. Instead of having “ALC in progress” alarm on OLT, all nodes will raise it during ALC.
6. Failed alarm. In case of failure, root cause node must raise the specific “ALC failed” alarm.
7. Node local status. Each node will have its own status published. OLT continues to report the state of the link calibration.
8. Local status must report reason of failures.)
9. A new baseline time is added to saved data. Same timestamp will be published in node level local CLI.

10. Already calibrated spans must be monitored for changes and alarms, to stop running ALC on the link
11. Raman support.
12. Remove of centralized approach. This implies:
    a. Currently link optimization runs in OLT, even though PSD are recalculated for node under calibration. The new implementation will run optimization code on the local node.
    b. APC regulation performed on the current span. Usage of centralized APC is removed.

ALC can be separated in two very high-level steps:

1. Optical calibration itself; this is the procedure that starts from OLT and brings channels at their optimal power levels. It concludes successfully when drop OLT is regulated. This is by definition a node-by-node procedure, because each node needs the upstream part of the link to be well-regulated and stable.

2. Baseline saving; this step collects all the baseline data in the nodes and save it on the nodes.

With distributed approach, it is important to report the status of the procedure. This is done using alarms and status data on management interfaces.

ALC Alarms

Two alarms are defined:

1. "ALC procedure in progress". This alarm is raised by ALL nodes on the link when ALC is running, it is raised when OLT starts the procedure, it is cleared after success completion of ALC at all nodes or immediately in case of failure.
2. "ALC procedure failed". This alarm is raised only in case of ALC failure, just after the end, by the node that caused the failure.

Details about the alarm:

Alarm Tag	Scope	Sev	Description
ALC-PROC-IN-PROG-TX	Ots R/S/I/P	Minor	Automatic-link-calibration procedure in-progress in TX direction. It is raised on launch OLT TX and ILA controllers
ALC-PROC-IN-PROG-RX	Ots R/S/I/P	Minor	Automatic-link-calibration procedure in-progress in RX direction. Raised on end OLT (where RX direction will be regulated).
ALC-PROC-FAILED-TX	Ots R/S/I/P	Critical	Automatic-link-calibration procedure failed in TX direction
ALC-PROC-FAILED-RX	Ots R/S/I/P	Critical	Automatic-link-calibration procedure failed in RX direction

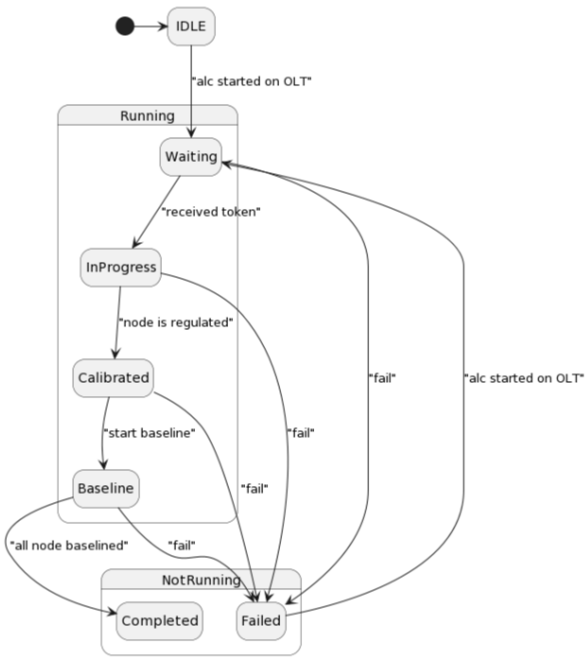
ALC status reporting. CLI + FSM

Each node will report its own ALC status.

Possible reported values:

- IDLE. ALC is not triggered yet.
- WAITING. ALC is running on the link, the node is waiting for regulation token.
- IN-PROGRESS. ALC is running, the node has received the token, and it is regulating.
- CALIBRATED. ALC is running, the node has been regulated. It is waiting to do baseline. This is internal state, not showen to the user.
- BASELINE. Node is doing baseline. This is internal state, not showen to the user.
- COMPLETED. ALC is not running, last run completed successfully.
- FAILED. ALC is not running, last run failed. In this case, failure reason is reported.

The finite state machine of this value is shown on the right.

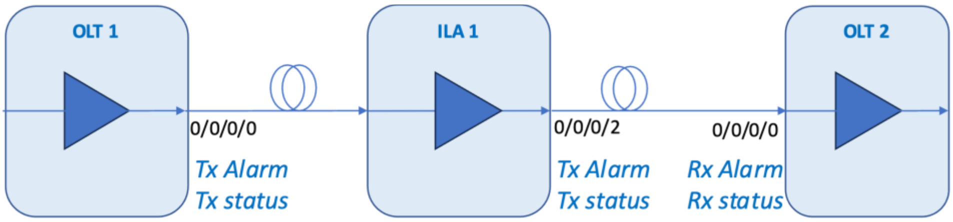


CLI command is:

```
show  olc alc-local status controller <otsR/S/I/P>  [rx/tx]
```

Regulation status will be reported also on restconf interface.

As per alarms, TX status applies to TX direction for launching OLT and ILA, and RX only to final OLT. An example is shown below.



Alarm and status locations for ALC started on OLT1 with
olc alc-start controller ots 0/0/0/0

Failure scenarios:

In case of failure, failure reporting is done through following CLI.

ALC status while running as seen from OLT:

```
RP/0/RP0/CPU0:NCS1020_P1D_04#show olc alc status
Thu Jan 23 13:04:50.852 IST

Controller                  : Ots0/0/0/0
ALC Status                  : IN-PROGRESS
ALC-Procedure started at    : 2025-01-23 12:59:45

Node RID                    : 24.1.1.1
ALC State                   : COMPLETE

Node RID                    : 24.1.1.2
ALC State                   : COMPLETE

Node RID                    : 24.1.1.3
ALC State                   : IN-PROGRESS

Node RID                    : 24.1.1.4
ALC State                   : WAITING

Node RID                    : 24.1.1.5
ALC State                   : WAITING
```

ALC status after failure as seen from OLT:

```
RP/0/RP0/CPU0:NCS1020_P1D_04#show olc alc status
Thu Jan 23 13:05:22.596 IST

Controller                  : Ots0/0/0/0
ALC Status                  : FAILED
Failed Reason               : [ CHANGE-IN-TOPOLOGY ]
ALC-Procedure started at    : 2025-01-23 12:59:45

Node RID                    : 24.1.1.1
ALC State                   : TERMINATED

Node RID                    : 24.1.1.2
ALC State                   : TERMINATED

Node RID                    : 24.1.1.3
ALC State                   : FAILED
Failed Reason               : [ Control loop Blocked ]

Node RID                    : 24.1.1.4
ALC State                   : UNREACHABLE

Node RID                    : 24.1.1.5
ALC State                   : UNREACHABLE
RP/0/RP0/CPU0:NCS1020_P1D_04#show olc alc-local status controller Ots 0/0/0/0
Thu Jan 23 13:05:57.191 IST

Controller                               : Ots0/0/0/0
Direction                                : Tx
ALC Status                               : TERMINATED
Failed Reason                            : [ Remote Failure ]
ALC Calibration triggered at             : 2025-01-23 12:59:45
ALC Calibration started at               : 2025-01-23 12:59:45
ALC Baselined at                         : 2025-01-23 13:02:14
```

ALC status after failure as seen from the failed node:

```
RP/0/RP0/CPU0:P2A_DT_06#show olc alc-local status controller Ots 0/0/0/2
Thu Jan 23 13:05:43.002 IST

Controller                               : Ots0/0/0/2
Direction                                : Tx
ALC Status                               : FAILED
Failed Reason                            : [ OSC Disconnected ]
ALC Calibration triggered at             : 2025-01-23 12:59:45
ALC Calibration started at               : 2025-01-23 13:04:22
ALC Baselined at                         : NA
```

In this case fiber cut was performed at Ots 0/0/02 of failed node.

For more details alarms shall be checked on the failed node via CLI: “show alarms brief system active”

When ALC is triggered, all nodes move to “IN-PROGRESS” state. But after failure, failed nodes move to “FAILED” state. And remaining node move to “TERMINATED” or “UNREACHABLE” state.

Several problems can occur during ALC. The following table summarizes them:

Failed reason at OLT	Failed reason at failed node	Failure description
Incompatible configuration	**"Incompatible config on Gain-estimator"**	Gain estimator application is not configured to manual or disable
Incompatible configuration	**"Incompatible config on Link-Tuner"**	Link tuner application is not configured to manual or disable
Incompatible configuration	**"Incompatible config on APC local"**	APC application is not configured to apc-span-mode
Incompatible configuration	**"Incompatible config on APC domain"**	APC application is not configured to manual
Incompatible configuration	**"Fiber-Type config missing or un-supported"**	Fiber type configuration is missing, or un-supported type is configured
Control loop Blocked	**"OSC Disconnected"**	OSC connection went down due to any reason e.g. fiber cut
Control loop Blocked	**"OTDR device is busy"**	OTDR scan is ongoing on span to be calibrated
Control loop Blocked	**"ASE Loading Disabled"**	ASE loading is disabled at OLT
Control loop Blocked	**"Amplifier Shutdown"**	Egress Amplifier is shutdown
Control loop Blocked	**"Amplifier APR"**	Egress Amplifier is in APR
Control loop Blocked	**"LOS blocking span-loss computation"**	C-band Signal is not present hence span loss computation cannot happen
APC local Failed	**"Out-of-range alarm in APC"**	APC went Out-of-range during ALC regulation
APC local Failed	**"APC unable to reach target power"**	APC unable to get Discrepancy of <=0.5 dB for one or more channels
APC local Failed	**"Discrepancy beyond alarm discrepancy threshold"**	At calibrated node Discrepancy went >1 dB for one or more channels during calibration in downstream node
APC local Failed	**"Application Restarted"**	OLC SW process crashed or restarted
APC local Failed	**"Amplifier APR"**	Egress amplifier is having 'HIGH-TX-BR-PWR' condition

Gain Estimator Failed	**"Span loss invalid"**	Measured 'Signal Span Loss' is not in range for LUT computation

Failure	Applicable state	Node reporting	Failure description
~~**Span loss is out of range (from design values)**~~	~~IN-PROGRESS~~	~~RX-NODE on regulation span~~	~~RX span loss exceeds design values~~
~~**Timeout on PSD calculation, or another timeout**~~	~~IN-PROGRESS~~	~~TX-NODE on regulation span~~	~~PSD calculation internal problem [TBD during tests]~~
~~**Raman is shut down because of Go-Nogo checks**~~	~~IN-PROGRESS~~	~~RX-NODE on regulation span~~	~~Raman go-nogo checks failed~~
~~**Raman gain cannot be achieved**~~	~~IN-PROGRESS~~	~~RX-NODE on regulation span~~	~~Raman gain cannot be reached~~
~~**Target PSD cannot be reached**~~	~~IN-PROGRESS~~	~~TX-NODE on regulation span~~	~~Regulation out-of-range~~
~~**Fiber cut on already regulated span, or on current span**~~	~~CALIBRATED/ IN-PROGRESS~~	~~RX-NODE on span~~	~~A fiber cut was detected on ingress span~~
~~**Fiber span loss change**~~	~~CALIBRATED~~	~~RX-NODE on span~~	~~Span loss changed~~
~~**Loss of C-band power**~~	~~CALIBRATED~~	~~Any node~~	~~No signal power on port~~
~~**OTDR excessive events**~~	~~IN-PROGRESS~~	~~Scanning node~~	~~TBD~~

~~In case of failure, all other nodes will move to "FAILED", with reason "ALC failed on another node". Please note that any fiber event on span not yet regulated is ignored.~~

Day-0 bring up regulation

Once XML file generated through the planning is imported to the device, OLT node computes and configures WSS attenuation for each of channel / channel slices so that channel has PSDmin power at EDFA input. It is done to ensure that meaningful power is launched into the system. This way un-wanted alarms are not raised in the system and fiber cut conditions are detected.

~~**Regulation starting working point.**~~

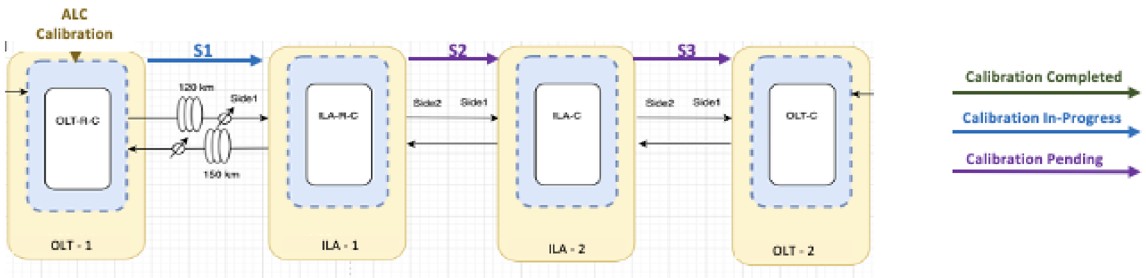
~~ALC is typically ran during link installation. The first time, optical modules will be at their default configurations: low gain in EDFA, and high VOA attenuation. Because of this, c-band optical power levels are not relevant before ALC is started. To facilitate first installation troubleshooting, most payload related alarms are kept demoted in this period.~~

~~**Parallel baselining.**~~

~~When the whole link is regulated, SW token is sent back hop-by-hop, triggering baseline saving in parallel. Because one item is the OTDR scans, baseline can take some minutes. Additionally, there is only one OTDR device per node, so its usage is serialized. This applies to scans of an ALC on rx and tx for an ILA, and in general when ALC is running on both directions at the same time.~~

6.10.3 ALC Procedure with Line-System Schema

Considering the below network, to illustrate the orchestration of ALC procedure and steps involved in calibration.



Details in this section are considering the final implementation of ALC. This section is also accounting for requirement to address ALC-baseline separate from OTDR baseline.

Assumptions here:

- OTDR scan results (both RX and TX) are already present before ALC procedure starts.
- Expectations of traffic/signal power status, before ALC procedure is outside the scope of this section.
- OTDR baseline flow is outside the scope of this section.

The ALC procedure can be broadly divided into 3 phases.

6.10.3.1 ALC Pre-Check

The goal of this phase is to make sure all the necessary conditions are met before proceeding with the calibration. An exclusive precheck is done to avoid touching data-path until system has all the necessary pre-conditions.

This phase involves.

- Checking compatible configuration
    - This is to make sure that the default behavior of control loops (Cisco default mode) is disabled for ALC based systems

- These configurations are generated by CONP tool. Copying these config files onto the box is done, outside the scope of ALC procedure.

- Complete Topology
    - End-to-end network should be discovered. This is an additional check to make sure we do not have any fiber/OSC/application bus connectivity issue.
    - These are necessary to orchestrate the entire sequence successfully.

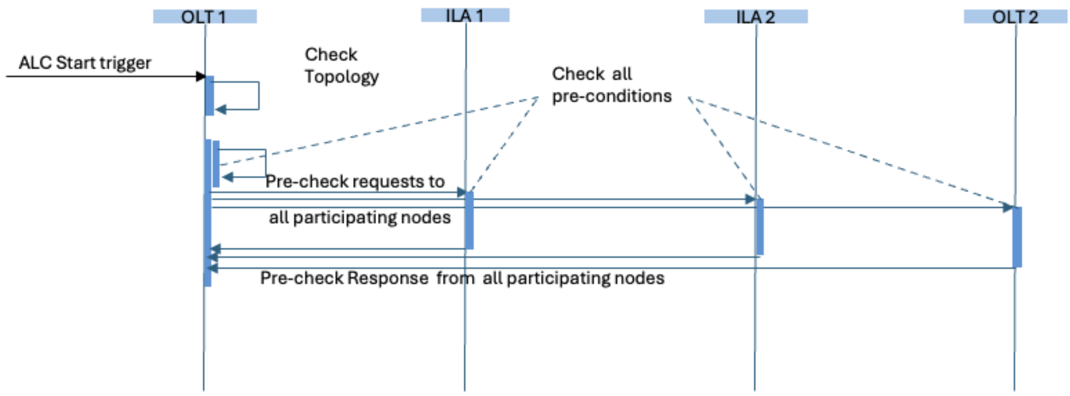
- ~~Sanity of connected fiber (using OTDR results)~~
    - ~~Making sure there are no alarming conditions found in OTDR scan results. Complete list of such conditions TBD~~
    - ~~Absence of OTDR results will fail this check.~~

Calibration is attempted only when all these necessary conditions are met.

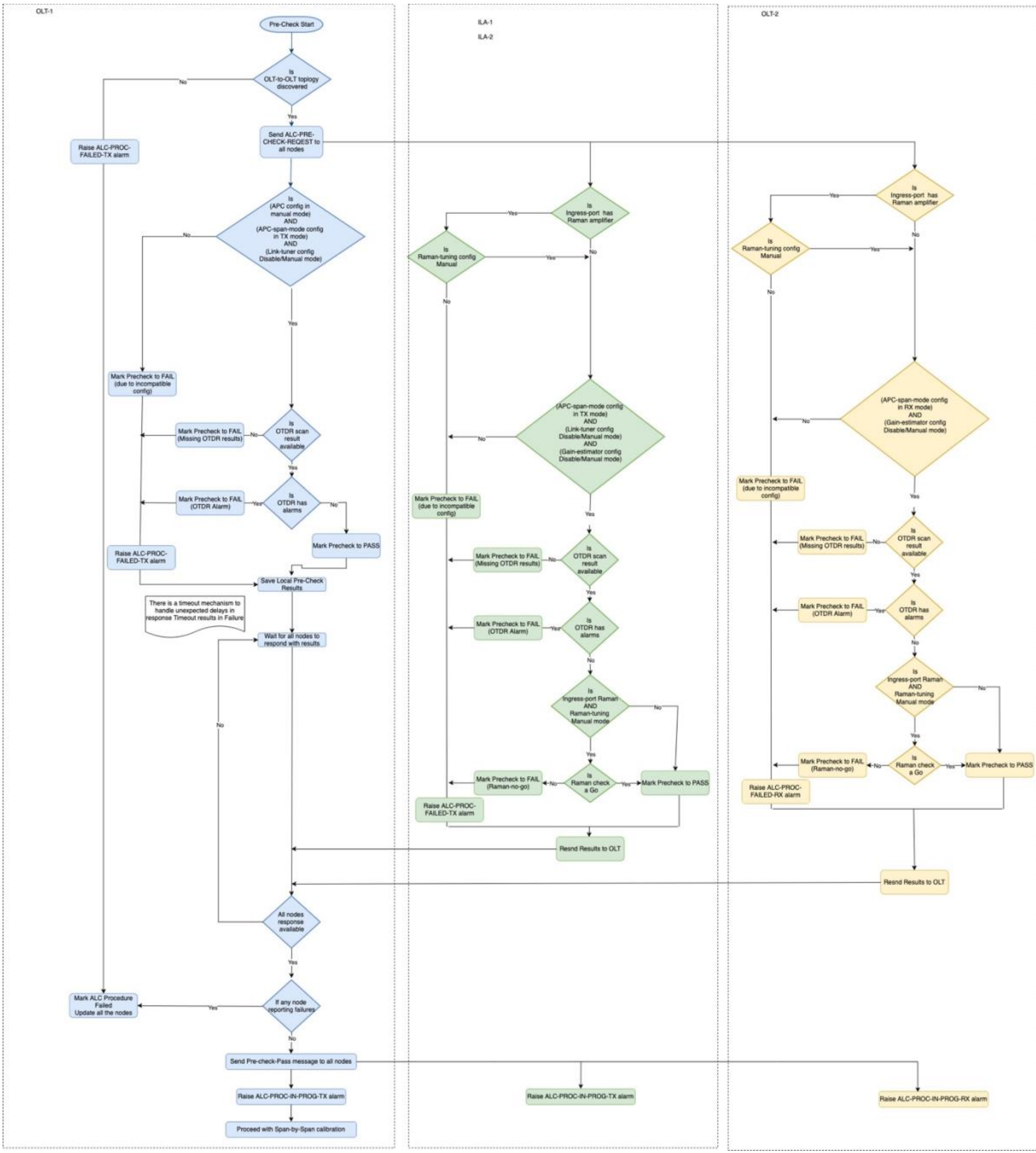
This Phase starts when user triggers the procedure through an action command (either through CLI or any of the manageability interfaces). OLT sends pre-check requests to all nodes (via Application Bus). Each node responds to OLT with the results.

In case of one or more nodes reporting error, ALC procedure is marked as FAILURE.

Below diagram depicts the overall sequence, for the schema mentioned above:



Flow chart of the checks done on each port for the schema mentioned above:



Below are the checks done at each node, for the pre-conditions:

Phase	Condition	Error Code	Scope	Reporting
PRE-CHECK	End-to-end OLT is expected to be discovered on BoL OLT This also covers the, - possible fiber-cuts - missing OSPF configurations - OSC link down etc.	PARTIAL-TOPOLOGY	Domain	ALC-PROC-FAILED-TX alarm on BoL OLT Alarm will be cleared with subsequent ALC retrigger. Information on where the topology is broken to be derived from topology based oper-CLI/model.
PRE-CHECK	All these configurations are meant to enforce MSFT specific behaviour for control loops These are generated from CONP tool Allowed Configuration apc manual apc-span-mode [rx/tx] link-tuner [disable/manual] gain-estimator [disable/manual] raman-tuning [maual] Fiber type [E-LEAF/ SMF/ SMF-28E/ TW-Classic]	INCOMPATIBLE-CONFIG	Domain/Port	ALC-PROC-FAILED-TX alarm on node where incorrect configuration is present. It means, we can have more than one node reporting ALC-PROC-FAILED-TX alarm, depending on where incorrect configurations are present. “show olc alc-local cli” will have details on which configurations are incorrect. Report all configurations that are incorrect (more than one if applicable)
PRE-CHECK	Raman No-go failing due to No-Go evaluation. This evaluation is done based on the latest OTDR scan available for the port. Derived results may or may-not be form baselined OTDR scan results. -	RAMAN-NO-GO	Port	ALC-PROC-FAILED-TX alarm on ports where calibration is on-going.

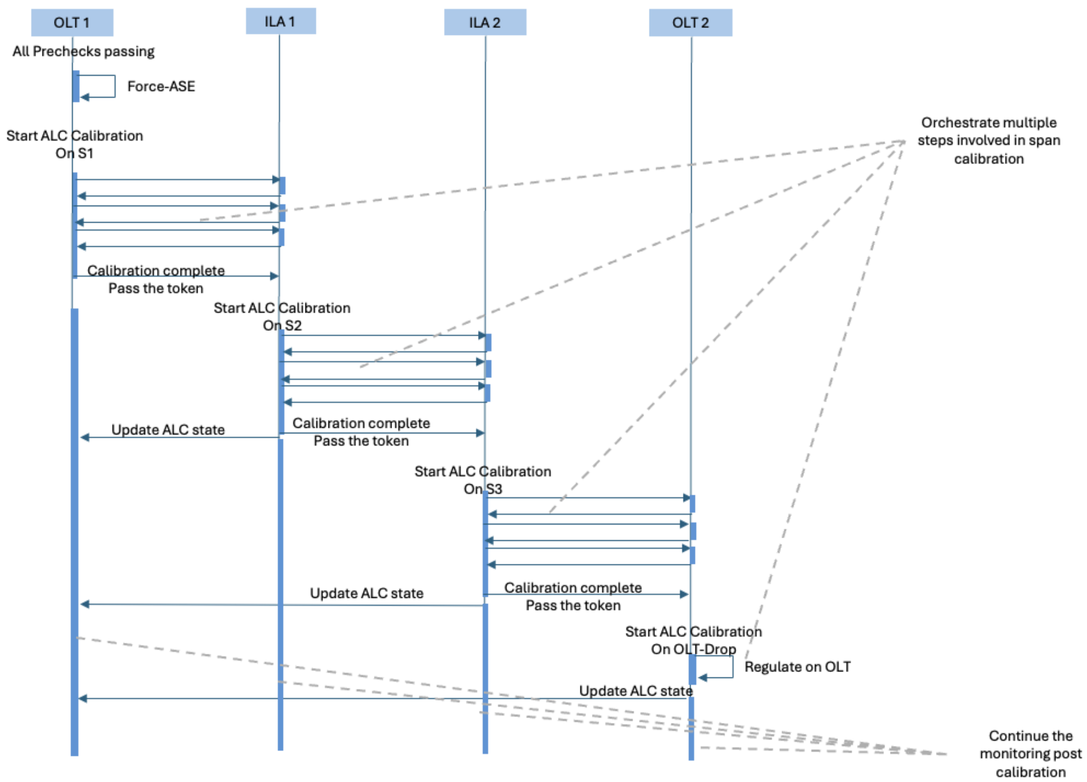
PRE-CHECK	Any ongoing data-path activity. Such as below can result in ALC procedure to fail • OTDR Scan • Raman tuning	CONTROL-LOOP-BLOCKED	Port	ALC-PROC-FAILED-TX alarm where data-path related activity is on-going

6.10.3.2 ALC Calibration

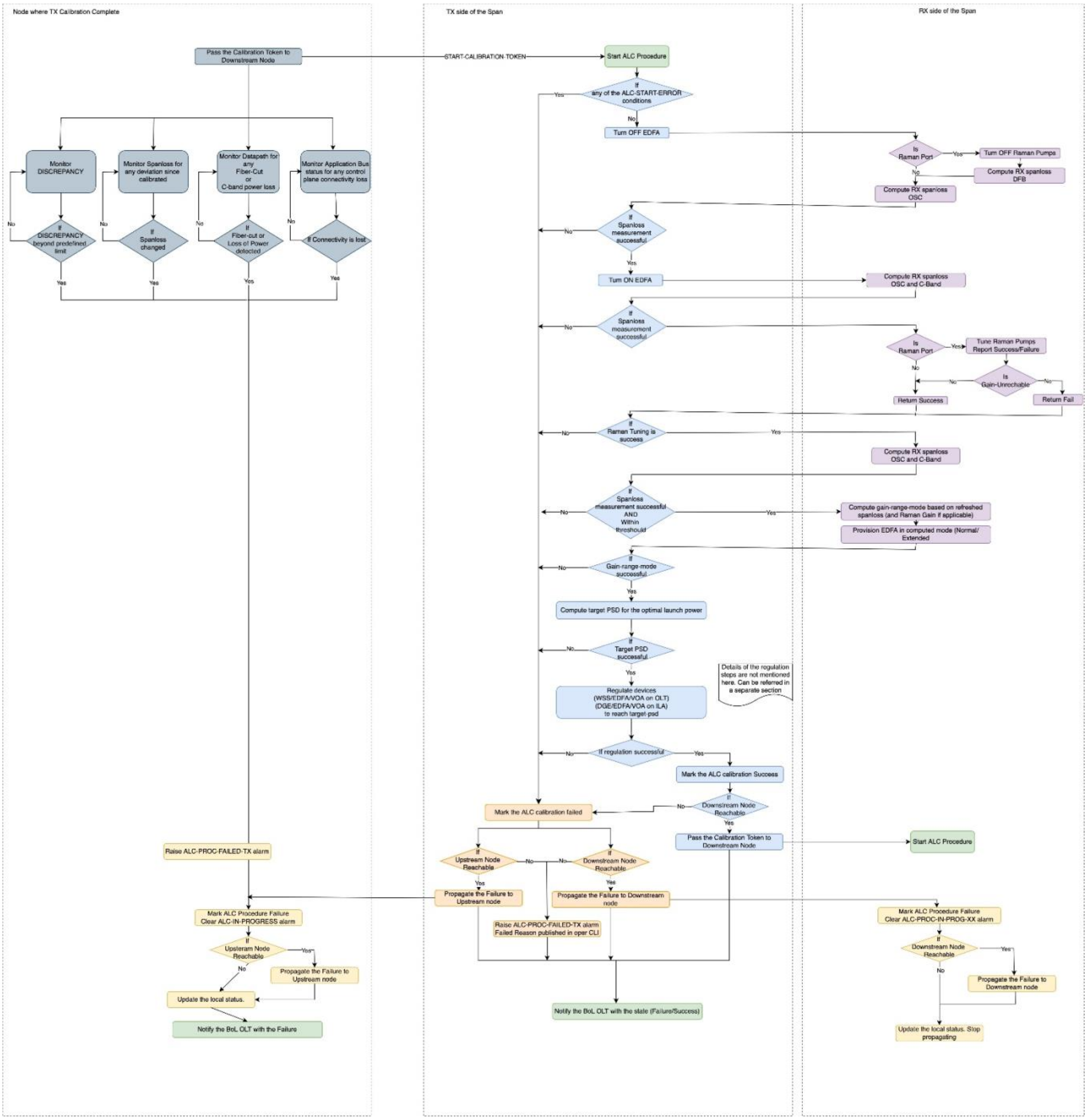
Calibration phase starts when all the prechecks pass on all nodes.

Details of the OLT-ADD/ILA-regulation and OLT-DROP regulation are explained in different section (APC).

Below diagrams focus more on ALC orchestration and different steps involved during bring up of a span:



Below is the Flow Chart of the steps involved in Calibration of specific span:



At the end of the calibration, the values related to calibrated end of the span is baselined. In the topology considered earlier,

At the end of calibration on S1, below parameters get baselined on OLT -1 egress port

ALC baseline timestamp

Device configurations (EDFA Gain/EDFA Tilt/VOA Attn/WSS Attn)

TX PD measurements

TX Spanloss

TX target PSD

TX OCM measurements

At this stage, none of the parameters on ILA – 1 is baselined.

When the calibration is completed on S2, baselining is done in ingress attributes of Side-1 and egress attributes of Side-2.

Device configurations (EDFA Gain/EDFA Tilt/VOA Attn/DGE Attn) on Side-2

Device configuration (EDFA gain range mode) on Side-2 (note, gain range mode selection happens as part of S1 bring up)

TX PD measurements on Side-2

TX Spanloss on Side-2

TX target PSD on Side-2

TX OCM measurements on Side-2

RX PD measurements on Side-1

RX Spanloss on Side-1 (note, this computation is done as part of S1 bring up)

RX OCM measurements on Side-1

On the last OLT, baseline is saved at the end of Drop-side regulation. Below list of parameters get saved in RX baseline

Device configurations (EDFA Gain/EDFA Tilt/WSS Attn)

Device configuration (EDFA gain range mode) on Side-1 (note, gain range mode selection happens as part of S3 bring up)

RX PD measurements on Side-1

RX Spanloss on Side-1 (note, this computation is done as part of S3 bring up)

RX OCM measurements on Side-1

In case where calibration fails in any of the downstream spans, we will have few nodes in the network having baseline updated for the failed calibration run.

For instance, in the topology considered above, if the ALC fails while calibrating S3 for N-th iteration of an ALC run

OLT-1 TX, ILA-1 side-2 will have baselines corresponding to N-th run (with updated baseline timestamps in oper data)

Whereas baselines on ILA-2 TX and OLT-2 RX will correspond to (N-1)-th run

~~Below are few conditions, that can cause ALC to fail~~

This information is already available in previous section so remove this table.

~~Phase~~	~~Condition~~	~~Error Code~~	~~Scope~~	~~Reporting~~
~~CALIBRATION~~	~~Fiber-Cut detected while calibrating~~	~~FIBER-DISCONNECT~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on Upstream node.~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~C-BAND power lost~~	~~C-BAND-POWER-DOWN~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on first node in the direction where power drop is noticed.~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~Failed to reach target Raman gain~~	~~RAMAN-GAIN-NOT-REACHABLE~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on Raman port where tuning failed.~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~Error while computing target PSD~~	~~TARGET-PSD-CMP-ERROR~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on the node for which computation has failed.~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~Error while estimating gain~~	~~GAIN-EST-CMP-ERROR~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on the node for which computation has failed.~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~Spanloss out-of-range~~	~~SPAN-LOSS-OOR~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on the node where calibration is blocked due to OOR~~ ~~Rest of the nodes report failed attempt through an oper CLI~~
~~CALIBRATION~~	~~Regulation failure (to reach target PSD)~~	~~APC-OOR~~	~~Span~~	~~ALC-PROC-FAILED-XX alarm raised on the node where calibration failed due to OOR~~

				~~Rest of the nodes report failed attempt through an oper CLI~~

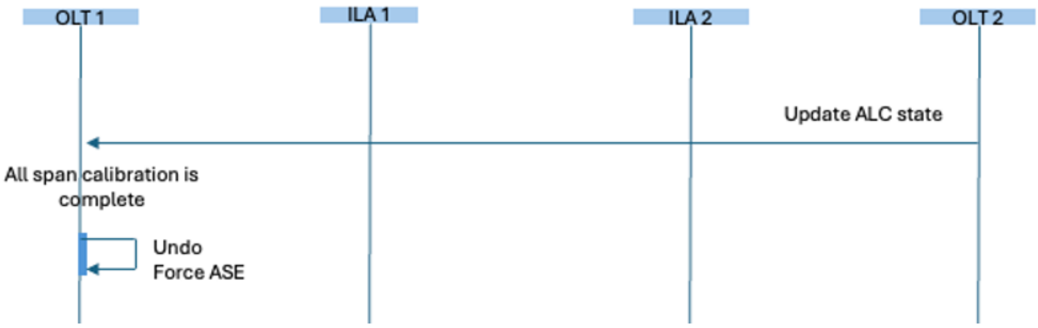
6.10.3.3 ALC Completion

This is the last phase in the ALC procedure. This phase is initiated, when last OLT notifies BoL OLT about successful completion of calibration.

Once BoL OLT receives end-of-calibration from EoL OLT, Force-ASE is undone.

In case the ALC gets terminated, without successful baseline, device config will not match the last-saved baseline. The system remains in an inconsistent state, util ALC runs successfully, and new baseline is saved.

There is no flow chart added here, as it is a simple flow:



6.10.3.4 Span Loss Computation During ALC

Following are steps for computation

1. Span TX side collects and timestamps every 50 msec TX PD measurement for one second and sends these measurements using gRPC messages every one second
2. Span RX side collects and timestamps every 50 sec RX PD measurement and stores in RX buffer that can store last 12 seconds measurement
3. On receiving one second TX measurements (received in gRPC message), TX measurement is stored in TX buffer that can store last 12 seconds measurements
4. TX measurement and RX measurement stability is checked for continuous 10 seconds measurements
5. If TX measurements and RX measurements are stable for 10 seconds with variation of maximum 0.3 dB, average of span loss values corresponding to each of TX measurement and RX measurement is computed. This average span loss value is used for baselining

6.10.3.5 Gain Mode Selection and Power Profile Optimization During ALC Procedure

Power optimization process is used to identify optimum power profile (or, equivalently, the optimum PSD profile) at fiber input maximizing the QoT of channels across C-band. Optimum power profile is used in the second step of the commissioning phase (Automatic Link Calibration process)

Optimization criteria used to define the optimum power profile, respectful of customer requirements, are here summarized:

- Optimum power profile at each fiber input must be automatically and univocally defined, for a given traffic matrix (baud-rate, and consequently spectral density), as a function of fiber type and span loss. Under these constraints, optimum power profile (expressed by means of total power and tilt) is provided by means of lookup tables
- Optimum power profile must optimize the QoT of the link in BoL condition; the same profile must guarantee the performance in EoL. Optimization must be complaint with the following constraints:
  - No changes of total power and tilt at fiber input even in front of span loss variations (set and forget approach)
  - EDFA allowed gain range must be limited to the controlled tilt region
  - Capability of the EDFA’s at the end of each span to compensate up to 3dB of span loss increase without changing the gain operative mode (low gain range or high gain range)
- Non-linear transmission effects used in optimum power profile optimization, must be evaluated via SSFM method in combination with TXP DSP simulator
- At parity inputs, same optimum power profile is expected in case the network is designed with CONP tool and in case it’s calibrated during the commissioning phase (ALC procedure). In the two scenarios span loss is respectively user-provisioned or measured (span loss baseline)

6.10.3.6 LUT Format and Implementation Detail

Below are sample LUT tables for low gain range mode and high gain range mode:

ID	1	2
Tot. Loss	3	5
Ptot	14.56	15.49
Tilt	0.0475	0.0957
Chan Freq	PSD	PSD
191375	-11.04	-10.23
191525	-11.03	-10.21
191675	-11.03	-10.2
191825	-11.02	-10.19
191975	-11.01	-10.17
192125	-11.01	-10.16
192275	-11	-10.14
192425	-10.99	-10.13
192575	-10.98	-10.11
192725	-10.98	-10.1
192875	-10.97	-10.09
193025	-10.96	-10.07
193175	-10.96	-10.06
193325	-10.95	-10.04
193475	-10.94	-10.03
193625	-10.93	-10.01
193775	-10.93	-10
193925	-10.92	-9.98
194075	-10.91	-9.97
194225	-10.91	-9.96
194375	-10.9	-9.94
194525	-10.89	-9.93
194675	-10.88	-9.91
194825	-10.88	-9.9
194975	-10.87	-9.88
195125	-10.86	-9.87
195275	-10.86	-9.86
195425	-10.85	-9.84
195575	-10.84	-9.83
195725	-10.83	-9.81
195875	-10.83	-9.8
196025	-10.82	-9.78
196175	-10.81	-9.77

High Range Gain Mode

ID	1	2	3	4	5	6	7	8	9	10	11	12
Tot. Loss	3	6	9	12	15	18	21	24	27	30	33	36
Ptot	11.56	14.45	16.08	17.28	18.43	19.16	20.12	21.18	21.99	22.53	22.53	22.53
Tilt	0.029	0.093	0.1615	0.2302	0.2977	0.3719	0.4615	0.578	0.6883	0.7772	0.7951	0.809
Chan Freq	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD	PSD
191375	-14	-11.26	-9.8	-8.77	-7.79	-7.25	-6.52	-5.77	-5.26	-4.96	-5.01	-5.05
191525	-13.99	-11.25	-9.78	-8.74	-7.75	-7.2	-6.46	-5.69	-5.16	-4.85	-4.89	-4.93
191675	-13.99	-11.23	-9.75	-8.7	-7.7	-7.14	-6.39	-5.6	-5.05	-4.73	-4.77	-4.81
191825	-13.98	-11.22	-9.73	-8.67	-7.66	-7.08	-6.32	-5.51	-4.95	-4.61	-4.65	-4.69
191975	-13.98	-11.21	-9.7	-8.63	-7.61	-7.03	-6.25	-5.43	-4.85	-4.5	-4.54	-4.57
192125	-13.98	-11.19	-9.68	-8.6	-7.57	-6.97	-6.18	-5.34	-4.74	-4.38	-4.42	-4.44
192275	-13.97	-11.18	-9.66	-8.56	-7.52	-6.92	-6.11	-5.25	-4.64	-4.26	-4.3	-4.32
192425	-13.97	-11.16	-9.63	-8.53	-7.48	-6.86	-6.04	-5.17	-4.54	-4.15	-4.18	-4.2
192575	-13.96	-11.15	-9.61	-8.5	-7.44	-6.81	-5.97	-5.08	-4.43	-4.03	-4.06	-4.08
192725	-13.96	-11.14	-9.58	-8.46	-7.39	-6.75	-5.9	-4.99	-4.33	-3.91	-3.94	-3.96
192875	-13.95	-11.12	-9.56	-8.43	-7.35	-6.69	-5.83	-4.91	-4.23	-3.8	-3.82	-3.84
193025	-13.95	-11.11	-9.53	-8.39	-7.3	-6.64	-5.76	-4.82	-4.12	-3.68	-3.7	-3.72
193175	-13.94	-11.09	-9.51	-8.36	-7.26	-6.58	-5.69	-4.73	-4.02	-3.56	-3.58	-3.6
193325	-13.94	-11.08	-9.49	-8.32	-7.21	-6.53	-5.62	-4.65	-3.92	-3.45	-3.46	-3.47
193475	-13.94	-11.07	-9.46	-8.29	-7.17	-6.47	-5.56	-4.56	-3.81	-3.33	-3.34	-3.35
193625	-13.93	-11.05	-9.44	-8.25	-7.12	-6.42	-5.49	-4.47	-3.71	-3.21	-3.22	-3.23
193775	-13.93	-11.04	-9.41	-8.22	-7.08	-6.36	-5.42	-4.39	-3.61	-3.1	-3.1	-3.11
193925	-13.92	-11.03	-9.39	-8.18	-7.03	-6.3	-5.35	-4.3	-3.5	-2.98	-2.99	-2.99
194075	-13.92	-11.01	-9.36	-8.15	-6.99	-6.25	-5.28	-4.21	-3.4	-2.86	-2.87	-2.87
194225	-13.91	-11	-9.34	-8.12	-6.94	-6.19	-5.21	-4.13	-3.3	-2.75	-2.75	-2.75
194375	-13.91	-10.98	-9.32	-8.08	-6.9	-6.14	-5.14	-4.04	-3.19	-2.63	-2.63	-2.62
194525	-13.91	-10.97	-9.29	-8.05	-6.85	-6.08	-5.07	-3.95	-3.09	-2.52	-2.51	-2.5
194675	-13.9	-10.96	-9.27	-8.01	-6.81	-6.02	-5	-3.86	-2.99	-2.4	-2.39	-2.38
194825	-13.9	-10.94	-9.24	-7.98	-6.77	-5.97	-4.93	-3.78	-2.88	-2.28	-2.27	-2.26
194975	-13.89	-10.93	-9.22	-7.94	-6.72	-5.91	-4.86	-3.69	-2.78	-2.17	-2.15	-2.14
195125	-13.89	-10.91	-9.2	-7.91	-6.68	-5.86	-4.79	-3.6	-2.68	-2.05	-2.03	-2.02
195275	-13.88	-10.9	-9.17	-7.87	-6.63	-5.8	-4.72	-3.52	-2.58	-1.93	-1.91	-1.9
195425	-13.88	-10.89	-9.15	-7.84	-6.59	-5.75	-4.66	-3.43	-2.47	-1.82	-1.79	-1.77
195575	-13.87	-10.87	-9.12	-7.81	-6.54	-5.69	-4.59	-3.34	-2.37	-1.7	-1.67	-1.65
195725	-13.87	-10.86	-9.1	-7.77	-6.5	-5.63	-4.52	-3.26	-2.27	-1.58	-1.55	-1.53
195875	-13.87	-10.84	-9.07	-7.74	-6.45	-5.58	-4.45	-3.17	-2.16	-1.47	-1.43	-1.41
196025	-13.86	-10.83	-9.05	-7.7	-6.41	-5.52	-4.38	-3.08	-2.06	-1.35	-1.32	-1.29
196175	-13.86	-10.82	-9.03	-7.67	-6.36	-5.47	-4.31	-3	-1.96	-1.23	-1.2	-1.17

Span loss entry data:
Optimum PSD's (Ptot_inFiber & tilt) are available for span losses > 3dB up to the max value supported by EDFA's for the considered fiber type. Inside the considered span loss range, optimum PSD are provided with step of 3dB. Regular trend of Ptot_inFiber & tilt vs span loss allows the derivation of optimum Ptot_inFiber & tilt at any span loss with linear interpolation between two adjacent data

EDFA operative mode selection:
For each fiber type, two LUTs are available

- First table for span loss range supported by low gain range mode EDFA
- Second table for span loss range supported by high gain range EDFA

Due to NF profile, low gain range has better performances than high gain range in their overlap region. If compatible with span loss value and EoL margin, low gain range mode must be selected (no gain mode change is allowed from BoL to EoL)

LUT's are used in SW-embedded during Automatic Line Calibration phase to establish the optimum power profile at the input of each span. Inputs for PSD profile selection are

- Measured span loss, i.e. the loss between line TX and line RX ports at the span edges
- Connector losses, as per CONP node configuration download (future enhancement)
- Provisioned fiber type, as per CONP node configuration download
- Channel plan, as per CONP node configuration download (future enhancement)

Output of this process is optimum power profile covering full spectrum at line TX port and gain range mode of the EDFA at the end of the span. These are the inputs for the ALC regulation process i.e. APC

After checking for supported fiber type, following are steps for computing target PSD in TX and EDFA gain mode in RX:

1. Span Loss correction
   This step is described for future enhancement (not yet implemented) as LUT's are computed considering the loss between fiber input and EDFA_RX input but entry data for LUT value selection is the total span loss, $\mathrm{IL_{span}}$, including TX connector loss
2. To neutralize the difference between the reference TX connector loss (used in LUT's generation) and the current TX connector loss (as per CONP provisioning), $\mathrm{IL_{span}}$ entry data is corrected into $\mathrm{IL_{span}^{corrected}}$, to adjust the discrepancy. In case of current TX connector loss equals the reference one, the correction is transparent (that's why it's a future enhancement and the current implementation meets the customer req's, i.e., consider a reference value of TX and RX connector losses)
3. Identification of pertinent LUT
   Fiber type allows the identification of LUT tables to be used for optimum power profile selection, if, for this fiber type, corrected span loss is in the allowed rang
4. Check of span loss compatibility
   LUT's are evaluated for span loss greater than 3dB up to the maximum allowed value that guarantees compatibility with EDFA gain range
5. Optimum power and tilt at fiber input
   After the identification of the LUT's related to the current fiber type, optimum PinFiber and tilt values at fiber input is found (details of this process is described in next paragraph)
6. Scaling of PSD from fiber input to Line-TX
   optimum PinFiber and tilt at fiber input – that was found in LUT based on corrected span loss – is translated in optimum PSD at the line-TX port where optimum power profile is regulated during ALC procedure

Selection of low gain range mode table vs high gain range mode table is determined as mentioned below

I. Low gain mode compatibility
   If span loss value is compatible with the EDFA working in low gain range (that means that the span loss value is inside min and max span loss of low gain range mode table)
   - Low gain range mode LUT is firstly selected for optimum power selection
   - Ptot_inF & tilt are evaluated via linear interpolation of closest adjacent values in the table and scaled at line_TX port, of P@line_TX, via TX connector loss correction
   - P@line_TX is compared with the maximum power allowed at amplifier output and in case it exceeds this threshold, is clamped at the maximum allowed value
   - Expected power at EDFA_RX input, PinEDFA_RX, is computed as a function of clamped P@line_TX and span loss measured baseline, ILspan
II. Low gain mode verification
   To verify the low gain mode is applicable, the behavior from BoL to EoL must be verified: using PinEDFA_RX, that will be constant across the entire operative life of the link thanks to span compensation mechanism, EDFA gain in BoL and EoL is computed and compared with allowed low gain range in tilt-controlled region. If compatible, of P@line_TX and tilt are frozen as optimum power values. If not, high gain mode is checked
III. High gain mode selection and verification
   In case low gain mode is not applicable (failure of steps I. or II.) the same approach is applied to high gain mode LUT. In case of failure, the design of the span cannot be supported, and an alarm is raised

Optimum power profile evaluation P@line_TX and tilt are translated into optimum power profile, for the provisioned channel plan

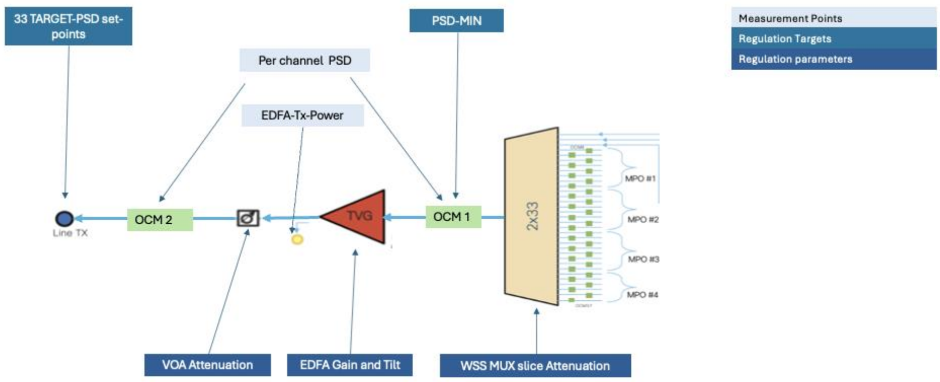
6.10.4 Power Regulation During ALC Procedure

6.10.4.1 OLT-ADD

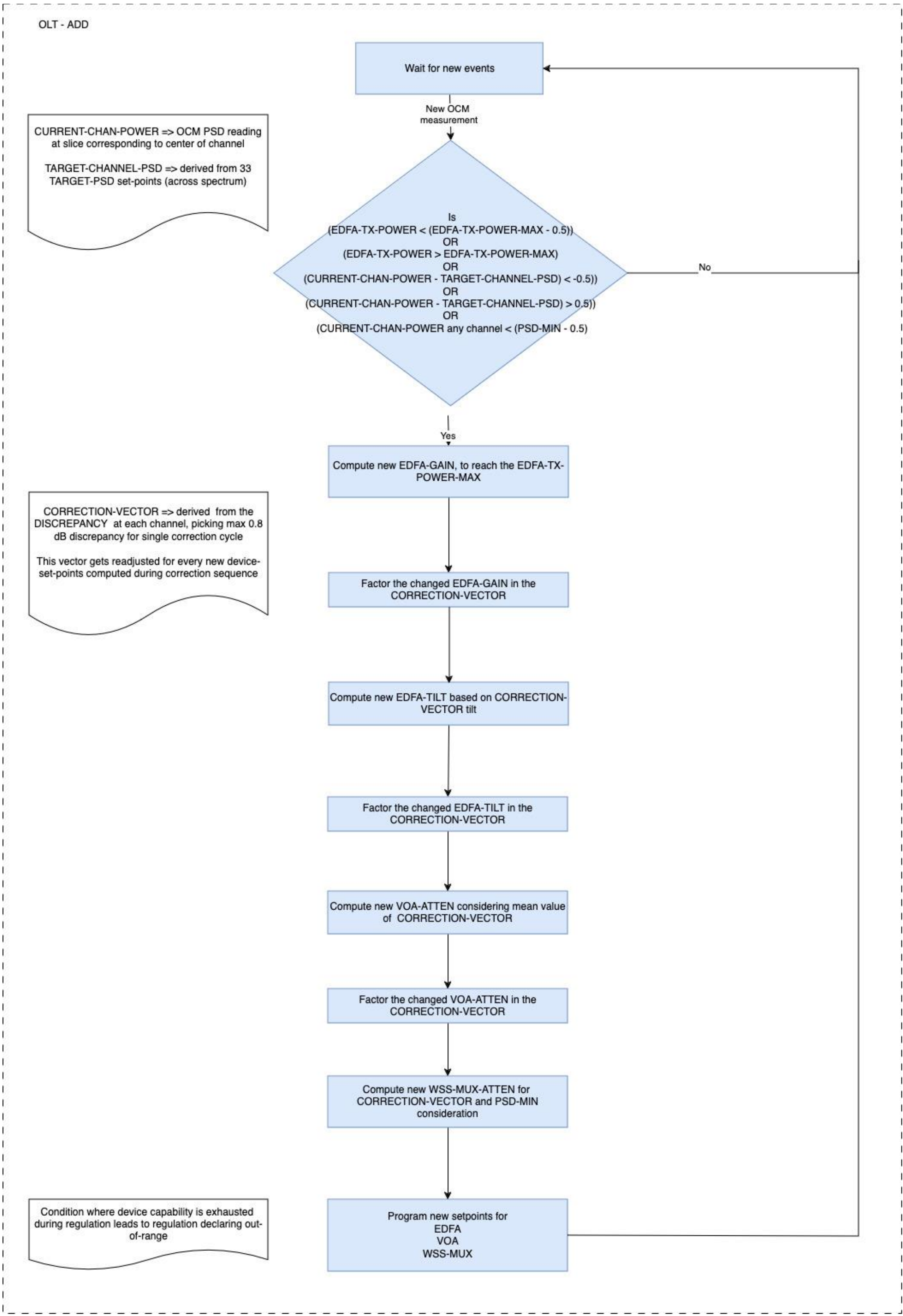
Below diagram illustrates different points of

- Measurements
- Device programming (along with parameters)
- Regulation target

33 TARGET-PSD setpoints is computed by link-simulation during ALC procedure. PSD-MIN is a configuration, coming from CONP.



And On OLT-ADD, Regulation during ALC procedure follows the computation describe in the below diagram:

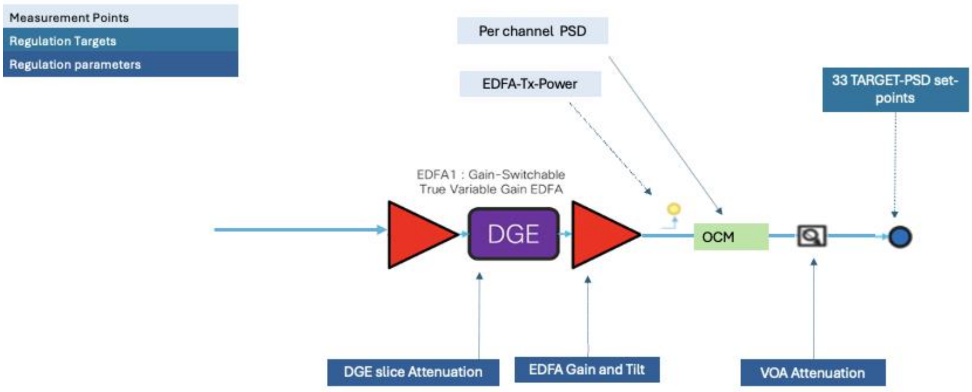

OLT - ADD
Wait for new events
New OCM measurement
CURRENT-CHAN-POWER => OCM PSD reading at slice corresponding to center of channel
TARGET-CHANNEL-PSD => derived from 33 TARGET-PSD set-points (across spectrum)
Is
(EDFA-TX-POWER < (EDFA-TX-POWER-MAX - 0.5))
OR
(EDFA-TX-POWER > EDFA-TX-POWER-MAX)
OR
(CURRENT-CHAN-POWER - TARGET-CHANNEL-PSD) < -0.5))
OR
(CURRENT-CHAN-POWER - TARGET-CHANNEL-PSD) > 0.5))
OR
(CURRENT-CHAN-POWER any channel < (PSD-MIN - 0.5)
No
Yes
Compute new EDFA-GAIN, to reach the EDFA-TX-POWER-MAX
CORRECTION-VECTOR => derived from the DISCREPANCY at each channel, picking max 0.8 dB discrepancy for single correction cycle
This vector gets readjusted for every new device-set-points computed during correction sequence
Factor the changed EDFA-GAIN in the CORRECTION-VECTOR
Compute new EDFA-TILT based on CORRECTION-VECTOR tilt
Factor the changed EDFA-TILT in the CORRECTION-VECTOR
Compute new VOA-ATTEN considering mean value of CORRECTION-VECTOR
Factor the changed VOA-ATTEN in the CORRECTION-VECTOR
Compute new WSS-MUX-ATTEN for CORRECTION-VECTOR and PSD-MIN consideration
Condition where device capability is exhausted during regulation leads to regulation declaring out-of-range
Program new setpoints for
EDFA
VOA
WSS-MUX

6.10.4.2 ILA Regulation

Below diagram illustrates different points of

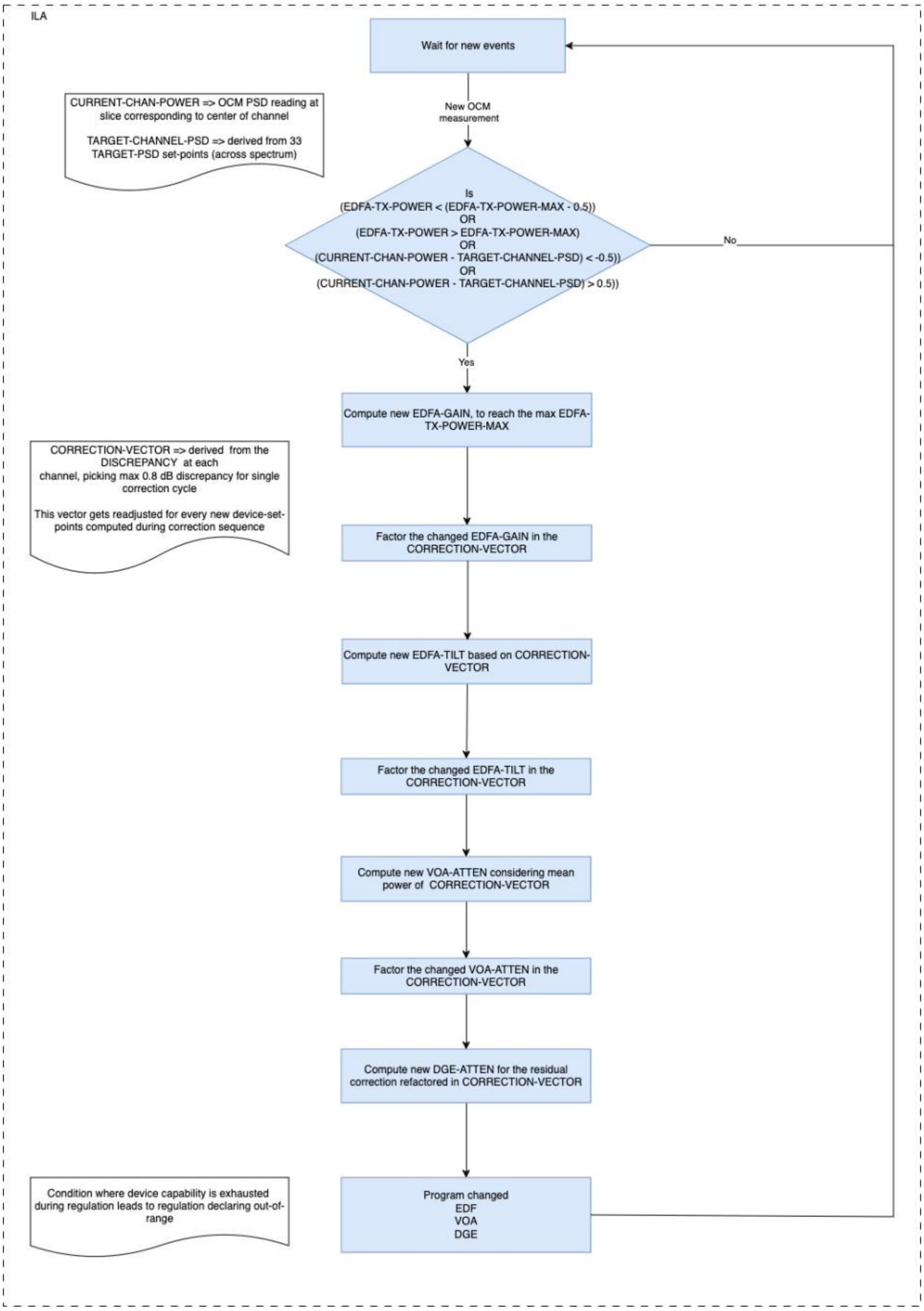
- Measurements
- Device programming (along with parameters)
- Regulation target

It's similar to OLT-ADD, except for PSD-min being not-applicable. DGE device included instead of WSS. 33 TARGET-PSD setpoint is computed by link-simulation logic during ALC procedure.



And On ILA, Regulation during ALC procedure follows the computation describe in the below diagram.

During span-loss compensation, regulation flow on ILA remains the same. Regulation gets triggered, when spanloss change (from last regulation point) is beyond 0.2 dB (default tolerance). However, this tolerance is configurable via CLI.



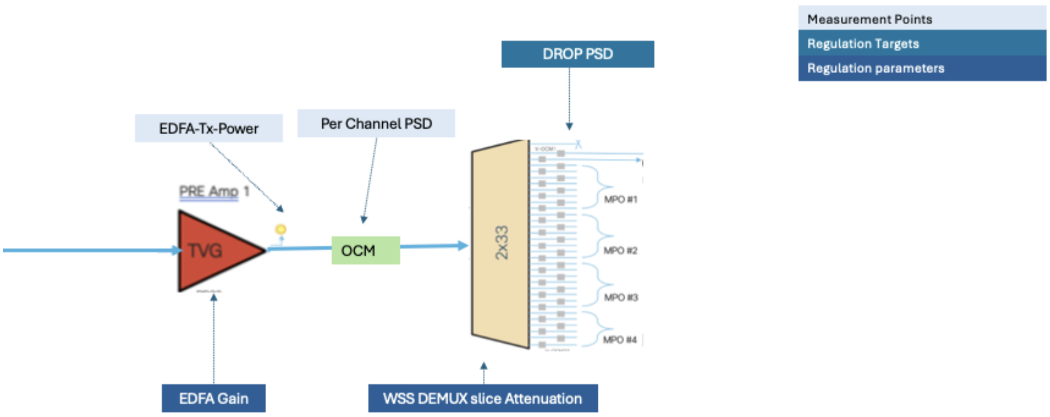
6.10.4.3 OLT-DROP

Below diagram illustrates different points of interest on OLT Drop side.

- Measurements

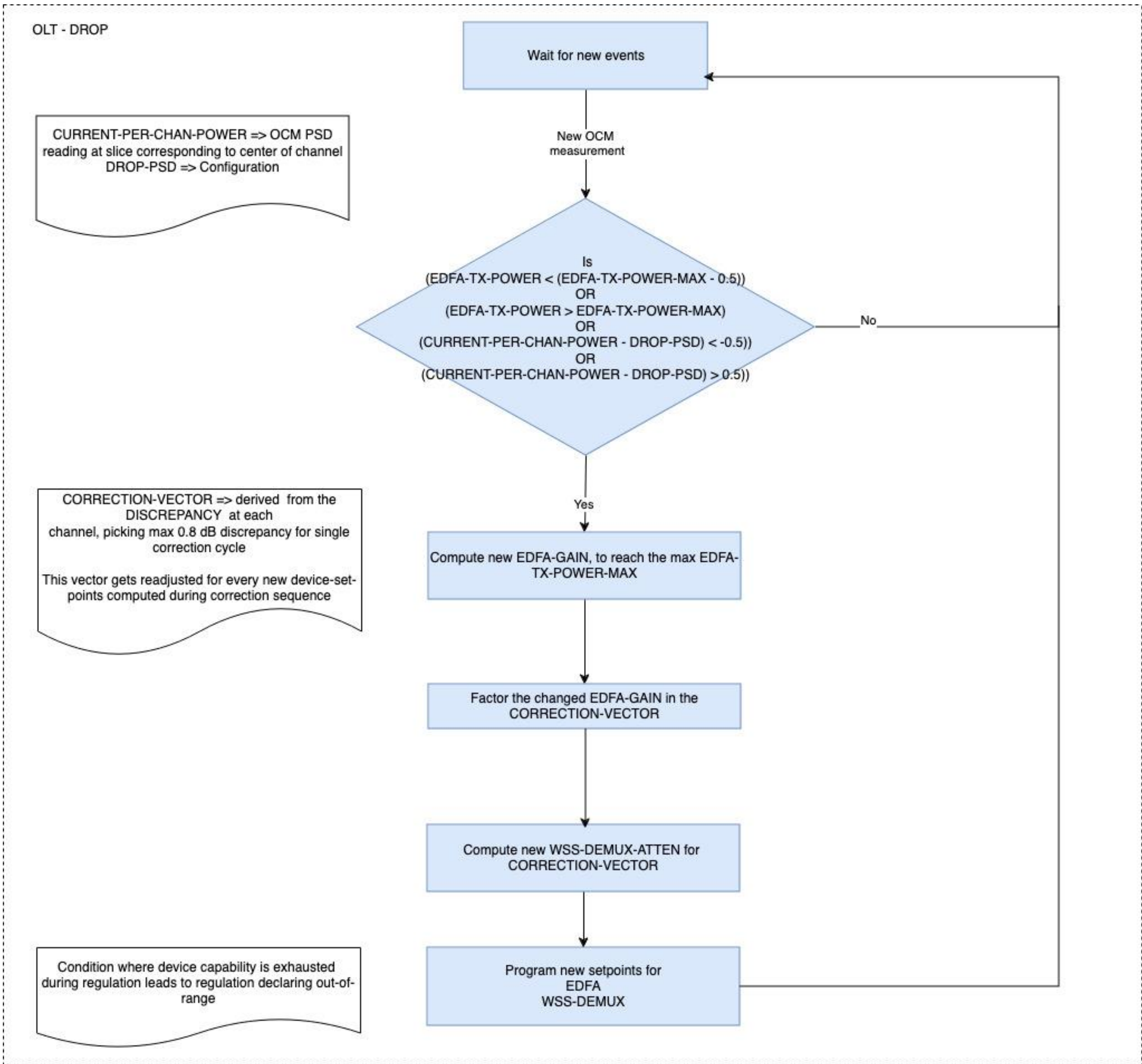
- Device programming (along with parameters)
- Regulation target

VOA device is not present in this direction. EDFA and WSS DEMUX are regulated on OLT Drop side. DROP PSD is a per drop-port configuration.



On OLT Drop side, Regulation during ALC procedure follows the computation describe in the below diagram:

During span-loss compensation, regulation flow on OLT Drop remains the same. Regulation gets triggered, when spanloss change (from last regulation point) is beyond 0.2 dB (default tolerance). However, this tolerance is configurable via CLI.



6.10.4.4 ALC Calibration Reporting

ALC reports the state of the procedure through CLIs (also Netconf models), that indicate status both at node-scope as well as domain-scope. There are also alarms to indicate in-progress and failure states.

List of Alarms associated with ALC procedure

Alarm Tag	Scope	Sev	Domain/Port	Description
ALC-PROC-IN-PROG-TX	Ots R/S/I/P	Minor	Port	Indicate an ongoing ALC procedure in TX direction of port at individual node participating in the procedure.

ALC-PROC-IN-PROG-RX	Ots R/S/I/P	Minor	Port	Indicate an ongoing ALC procedure in RX direction of port at individual node participating in the procedure.
ALC-PROC-FAILED-TX	Ots R/S/I/P	Critical	Port	Indicate failure in ALC procedure in TX direction of port at individual node participating in the procedure.
ALC-PROC-FAILED-RX	Ots R/S/I/P	Critical	Port	Indicate failure in ALC procedure in RX direction of port at individual node participating in the procedure.
ALC-PROC-FAILED	Ots R/S/I/P	Minor	Domain	Indicates failure in ALC procedure on head node.

Format of the domain-scope CLI is as follows

```
show olc alc status Ots R/S/I/P

Controller                : OtsR/S/I/P
ALC Status                : [ IDLE | IN-PROGRESS | FAILED |
[Failed Reason             :  <failure-reason>]
ALC-Procedure started at :  <alc-start timestamp>

Node RID                   : <rid1>
ALC State                  : [COMPLETE | IN-PROGRESS | PRE-CHECK-FAILED | FAILED
| WAITING | TERMINATED]
[Failed Reason              : <failed-reason>]

Node RID                   : <rid2>
ALC State                  : [COMPLETE | IN-PROGRESS | PRE-CHECK-FAILED | FAILED
| WAITING | TERMINATED]
[Failed Reason              : <failed-reason>]
 ..
Node RID                   : <ridN>
ALC State               : [COMPLETE | IN-PROGRESS | PRE-CHECK-FAILED | FAILED |
WAITING | TERMINATED]
[Failed Reason        : <failed-reason>]
```

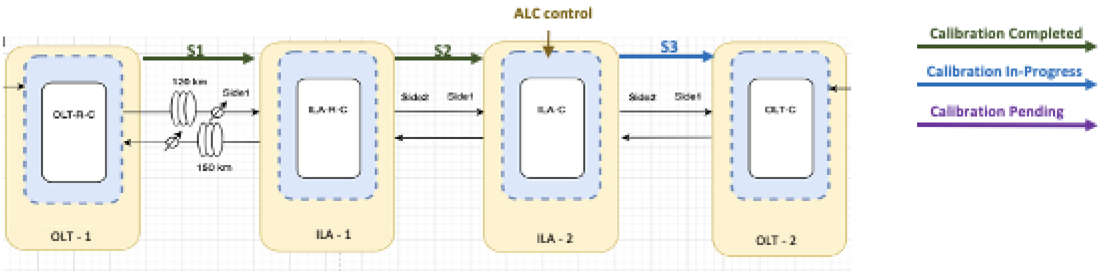
Format of the node-scope CLI is as follows

```
show  olc alc-local status controller <otsR/S/I/P>  [rx/tx]
ALC State                          : [IDLE | COMPLETE | IN-PROGRESS | FAILED |
WAITING | TERMINATED | PRE-CHECK-FAILED]
Failed Reason                      : <Description of the failure(s)>
ALC Calibrations triggered at      : <timestamp when start trigger received for
the port>
```

```
ALC Calibration start timestamp   : <timestamp when calibration starts on the
port>
ALC Baseline at                   : <timestamp when calibration data gets
baselined>
```

ALC State	Description	
IDLE	Default state when there are no operations related to ALC has occurred.	
WAITING	ALC triggered on OLT. But span is yet to be calibrated. All agents move to this state once ALC gets triggered on OLT.	Timestamp corresponding to "ALC Calibrations triggered at :" gets updated at this transition
IN-PROGRESS	Span being calibrated. Applicable on egress port except for the last OLT	Timestamp corresponding to "ALC Calibration start timestamp :" gets updated at this transition
COMPLETE	Span completed successfully. And the config/measurements got calibrated.	Timestamp corresponding to "ALC Baseline at :" gets updated at this transition
PRE-CHECK-FAILED	Failed due to preconditions not met	
FAILED	Span calibration failed due to an error. Error descriptions should clearly state the reason.	"ALC Calibration end timestamp :" timestamp gets updated at this transition
TERMINATED	This state indicates ALC procedure terminated due to calibration failure during the procedure. When a failure is detected on specific span, the failure is propagated to both upstream and downstream. Nodes receiving the failure notification, terminate the ongoing procedure at their respective scope. And mark the state as "TERMINATED"	

Example of states in the topology considered below:



Port	Alarm	Node Status	Domain Status
OLT1 – Side-1	Raise: ALC-PROC-IN-PROG-TX	ALC State : COMPLETED Failed Reason : NA ALC Calibrations triggered at : <n1-t1> ALC Calibration start timestamp : <n1-t2> ALC Baseline at : <n1-t3>	Controller : OtsR/S/I/P ALC Status : IN-PROGRESS ALC-Procedure started at : <n1-t0> Node RID : <rid1> ALC State : COMPLETE Node RID : <rid2> ALC State : COMPLETE Node RID : <rid3> ALC State : IN-PROGRESS Node RID : <rid4> ALC State : WAITING
ILA1 – Side-2	Raise: ALC-PROC-IN-PROG-TX	ALC State : COMPLETED Failed Reason : NA ALC Calibrations triggered at : <n2-t1> ALC Calibration start timestamp : <n2-t2> ALC Baseline at : <n2-t3>	
ILA2 – Side-2	Raise: ALC-PROC-IN-PROG-TX	ALC State : IN-PROGRESS Failed Reason : NA ALC Calibrations triggered at : <n3-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	

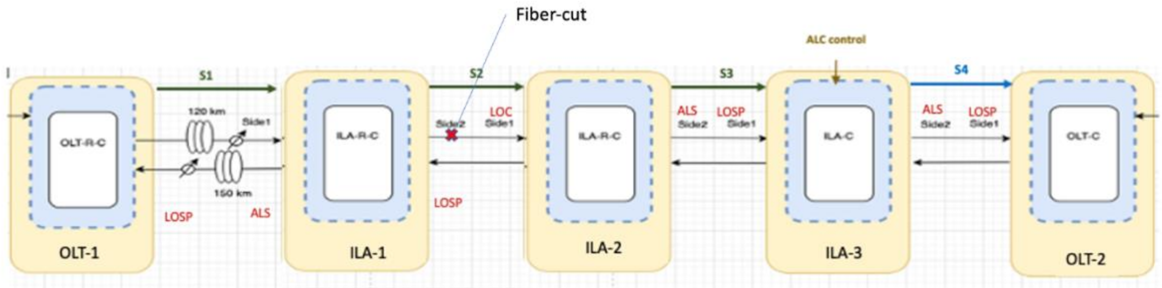
OLT2 – Side-1	Raise: ALC-PROC-IN-PROG-RX	ALC State : WAITING Failed Reason : NA ALC Calibrations triggered at : <n4-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	

6.10.5 ALC Fault Handling and Reporting

6.10.5.1 Fiber Cut

Considering the scenario below, where calibration is complete for first 3 spans, and there is a fiber-cut on S2. Due to safety considerations, EDFA on ILA1 goes down.

ALC software detects this condition and treats this as a failure condition. ILA1 reports the failure with an alarm. Procedure gets terminated on all nodes.



Port	Alarm	Node Status	Domain Status
OLT1 – Side-1	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n1-t1> ALC Calibration start timestamp : <n1-t2> ALC Baseline at : NA	Controller : OtsR/S/I/P ALC Status : FAILED ALC-Procedure started at : <n1-t0> Node RID : <rid1> ALC State : TERMINATED

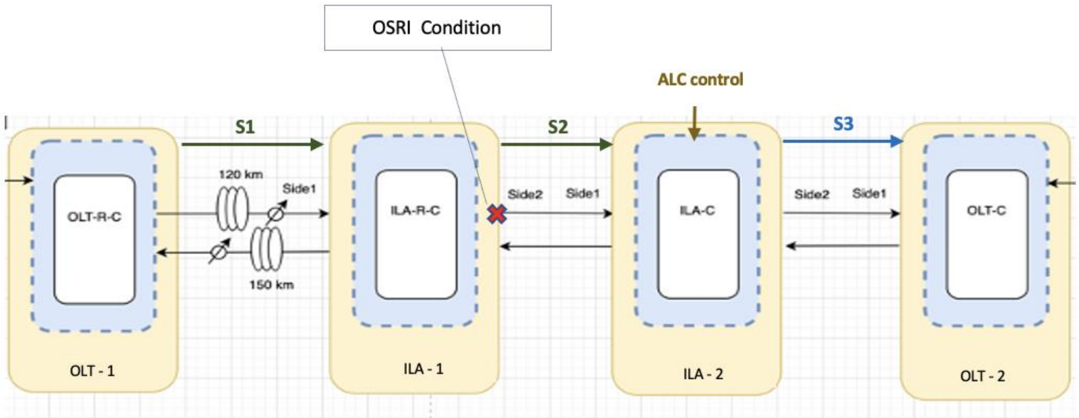
ILA1 – Side-2	Clear: ALC-PROC-IN-PROG-TX Raise: ALC-PROC-FAILED-TX	ALC State : FAILED Failed Reason : Amplifier Shutdown due to safety ALC Calibrations triggered at : <n2-t1> ALC Calibration start timestamp : <n2-t2> ALC Baseline at : NA	Node RID : <rid2> ALC State : FAILED Node RID : <rid3> ALC State : TERMINATED Node RID : <rid4> ALC State : TERMINATED Node RID : <rid5> ALC State : TERMINATED
ILA2 – Side-2	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n3-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	
ILA3 – Side-2	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n4-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	
OLT2 – Side-1	Clear: ALC-PROC-IN-PROG-RX	ALC State : TERMINATED Failed Reason. : Remote Failure ALC Calibrations triggered at : <n5-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	

6.10.5.2 High-BR/OSRI

The second category of failures is when EDFA is down due to other (than fiber-cut) conditions. Conditions such as High-BR and OSRI

Consider the condition described below. Calibration is complete on S1 and S2 and OSRI condition happens on ILA1

ALC will detect this condition and mark the procedure failure (with failed alarm on ILA1) and propagate the failure upstream and downstream.



Port	Alarm	Node status	Domain status
OLT1 – Side-1	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n1-t1> ALC Calibration start timestamp : <n1-t2> ALC Baseline at : NA	Controller : OtsR/S/I/P ALC Status : FAILED ALC-Procedure started at : <n1-t0> Node RID : <rid1> ALC State : TERMINATED
ILA1 – Side-2	Clear: ALC-PROC-IN-PROG-TX Raise: ALC-PROC-FAILED-TX	ALC State : FAILED Failed Reason : Amplifier APR ALC Calibrations triggered at : <n2-t1> ALC Calibration start timestamp : <n2-t2> ALC Baseline at : NA	Node RID : <rid2> ALC State : FAILED Node RID : <rid3> ALC State : TERMINATED Node RID : <rid4> ALC State : TERMINATED
ILA2 – Side-2	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED	

		Failed Reason : Remote Failure ALC Calibrations triggered at : <n3-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	
OLT2 – Side-1	Clear: ALC-PROC-IN-PROG-RX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n4-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	

6.10.5.3 OSC Disconnections

ALC procedure expects the OSC connections to be intact throughout the procedure. All the control flows and orchestration rely on application bus (GRPC connections over OSC) connectivity. Any form of connection loss here is treated as blocking condition for ALC and any ongoing procedure is terminated on such events.

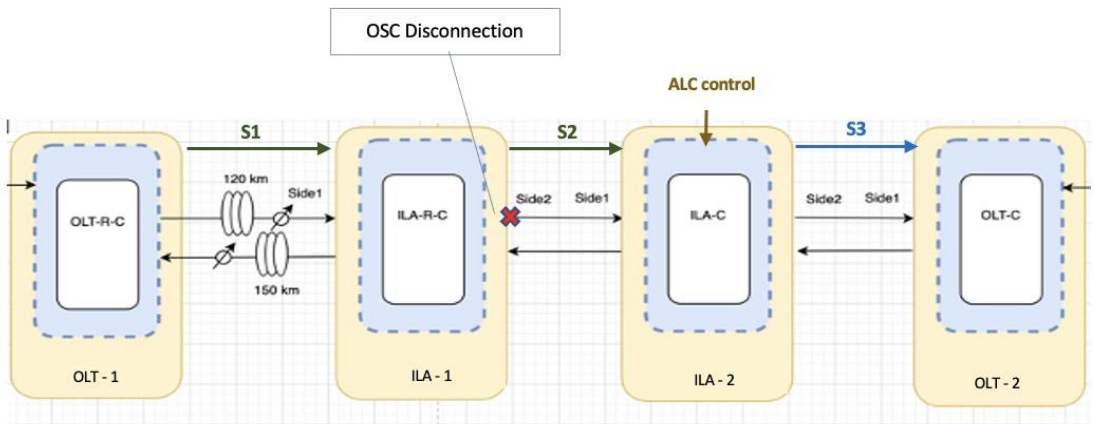
Below are the events that cause OSC disconnections:

RP reload (cold/warm)

Line card reloads (Cold/warm)

OSC down event

Control loop application restart



Port	Alarm	Node Status	Domain Status
OLT1 – Side -1	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n1-t1> ALC Calibration start timestamp : <n1-t2> ALC Baseline at : NA	Controller : OtsR/S/I/P ALC Status : FAILED ALC-Procedure started at : <n1-t0>
ILA1 – Side -2	Clear: ALC-PROC-IN-PROG-TX Raise: ALC-PROC-FAILED-TX	ALC State : FAILED Failed Reason : OSC Disconnected ALC Calibrations triggered at : <n2-t1> ALC Calibration start timestamp : <n2-t2> ALC Baseline at : NA	Node RID : <rid1> ALC State : TERMINATED Node RID : <rid2> ALC State : FAILED
ILA2 – Side -2	Clear: ALC-PROC-IN-PROG-TX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n3-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	Node RID : <rid3> ALC State : TERMINATED Node RID : <rid4> ALC State : TERMINATED
OLT2 – Side -1	Clear: ALC-PROC-IN-PROG-RX	ALC State : TERMINATED Failed Reason : Remote Failure ALC Calibrations triggered at : <n4-t1> ALC Calibration start timestamp : NA ALC Baseline at : NA	

6.11 APC

6.11.1 OLT Add Regulation

6.11.1.1 Channel Startup

High Level Logic:

Configured channels are monitored on input port.

1. When a failed channel is detected on its input port:
   a. power must be above threshold (LOS-P alarm in EXP RX will clear) PSD must be enough to reach PSD_minimum level out of WSS, even setting attenuation to.
   b. In case LOS-P is cleared but power is not enough to reach target, a specific alarm “target power unreachable” is raised.
2. Two consecutive good measurements are needed.
3. WSS is reconfigured with slices assigned to recovering channel on the configured port, attenuation is set to reach target-1dbm.
4. Attenuation ATTwss_slices are calculated considering that:

   PSDexp-rx – ATTwss_slices - ILexp-rx_com-tx + Gbst - ATTvoa = PSDline-tx

   and we want PSDline-tx = PSDtarget_line-tx – ERRORstartup

   ATTwss_slices = PSDexp-rx – (PSDtarget_line-tx - ERRORstartup)– ILexp-rx_com-tx + Gbst - ATTvoa

ERRORstartup is a positive number, so at this stage output power is lower than the target. ERROR takes in account: possible module accuracy on slices (+- 0.5 dB), possible OCM errors (typical value +- 0.5 dBm), possible little changes of input power between OCM acquisition and slices configuration, frequency dependencies of the IL (typ. +- 0.36 db., max +-2 dB). All these issues can have positive or negative effect on power and setting ERROR positive reduces the risk that the errors generate an overshoot.

First power on LINE-TX should have

PSD= PSDtarget_line-tx - ERRORstartup +- 1.36 db.

ERRORstartup is set at 1 db.

Even considering errors, first power is near to target and WSS control can start regulating the channel.

Gbst and PSDtarget_line-tx are calculated considering the position of the channel in the spectrum, target and booster tilt.

Note:
Channels are switched to input port in batch of 10 channels. E.g. if there are 28 channels to be switched to input port, first 10 channels will be switched, followed by next 10 channels, followed by 8 channels in last batch

6.11.1.2 Failed Channel Switch (channel -> ASE switch)

High Level Logic:

1. Channel is considered failed if one of the two conditions are true:
   a. LOS-P is declared on input express port. This is monitored with input OCM.
   b. Target PSD at WSS ouput (PSDmin) is not reachable, even setting attenuation to zero. This condition must be satisfied on two consecutive OCM readings.
2. Slices for the failed channels are routed to ASE source port.

3. Dynamic ASE channel is started as described above.

Above Channel startup logic is used to detect user channel power and trigger a switch from ASE source to configured express port.

Note: Failed channels are switched to ASE all at once to restore total power as soon as possible

6.11.1.3 Hysteresis for Channel Readiness vs Channel Failure

There is 1.5 dB margin between channel being considered ready for channel startup vs channel being considered failed for switching to ASE. E.g. if PSDmin is configured as -22.5 dBm, minimum channel PSD required post WSS (or pre EDFA in other words) with WSS set to 0 dB attenuation is -22.5+1.5 = -21.0 dBm for channel to be considered ready for channel startup. But channel will be considered failed when channel PSD post WSS (with WSS set to 0 dB atten) goes below -22.5 dBm

6.11.1.4 Sensitivity of Failure Detection

Channel failure detection is performed on output port, that can be counterintuitive. The idea is that if a channel at steady state one the control port (input of booster) disappears from one OCM refresh to another, the only reasonable reason is that there is no power on the input of the WSS.

Checking on output port has the advantage that with one OCM sweep all channels are checked, regardless of the input port.

Between a well-installed scenario and a complete failure scenario (where channel power on express port disappears completely), an intermediate scenario in which channel power is below than expected must be managed. In this case, express port is not reporting LOS-P and WSS attenuation is reduced to reach PSDmin target. As described above, switch to ASE happens when the attenuation reaches zero.

In a typical installation, WSS attenuation is about 8 dB so the system can compensate for 8 dB of drop power on express port.

Switch Times:
OCM refresh time on WSS output is about one second, so reaction time in case of failure is about 2 seconds.
OCM refresh time on WSS express ports is about 12 seconds, so presence detection is max 24 seconds, mean 18. Mean total time to switch from ASE to channel port is 20 seconds.

6.11.1.5 WSS Regulation

All amplifiers in the link are driven by span loss change except OLT TX path. For OLT TX path, EDFA gain / tilt and VOA attenuation are not changed after ALC calibration. OLT TX path regulation is performed measuring channel PSD on OCM2

1. OCM2 (line TX OCM) is acquired and it used to calculate the channel error vector. This is the gap, per channel, between channel actual PSD and the target PSD. See Discrepancy calculation logic paragraph below for more details
2. If all values in vector are below 0.5 dBm, regulation is avoided. Cycle goes back to 1
3. Error vector is used to regulate channel attenuation on WSS, basically changing attenuation with the error

6.11.2 ILA / OLT RX Regulation (Span Loss Based Trigger)

ILA regulation / OLT RX regulation is based on ingress span loss change and it regulates EDFA gain and VOA atten to compensate for ingress span loss change

6.11.2.1 Regulation Trigger

Regulation must be triggered if a change of more than 0.2 db from the last ”regulated loss” is detected for 10 secs, +- 1sec. This means that reaction time is going to be in the range 9s -11s

6.11.2.2 Span Loss Change Measurement

Span loss computation requires TX measurement and RX measurement to be synchronous i.e. two measurements to be taken at exactly same time. Each of nodes uses 50 msec timer to take measurement every 50 msec. Timer running on two nodes being independent and nodes can have time offset, it is not possible to have properly synchronized TX measurement and RX measurement. Approach used is to synchronize two nodes using NTP and timestamp each of 50 msec measurements. And use timestamp to align TX measurement and RX measurement

Following are steps for computation

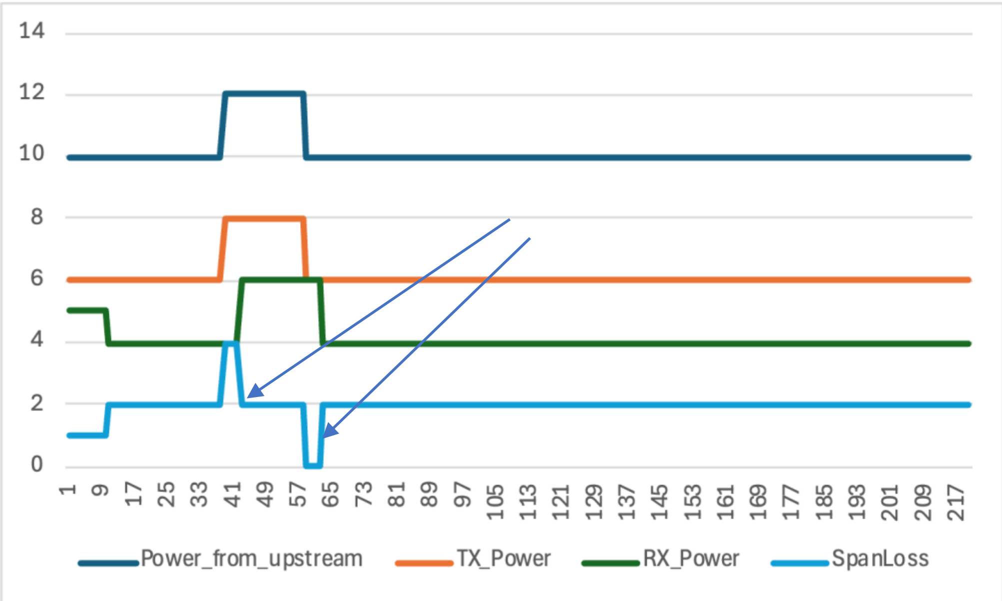
1. Span TX side collects and timestamps every 50 msec TX PD measurement for one second and sends these measurements using gRPC messages every one second
2. Span RX side collects and timestamps every 50 sec RX PD measurement and stores in RX buffer that can store last 12 seconds measurement
3. On receiving one second TX measurements (received in gRPC message), these measurements are stored TX buffer that can store last 12 seconds measurements
4. Span loss computation is triggered every 200 msec. Span loss computation logic performs following steps
    a. Time align TX measurements and RX measurements stored in 12 second buffer. Take RX measurement with timestamp closest to but later than timestamp of TX measurement
    b. Calculate span loss for each of time aligned TX measurement and RX measurement
    c. When span loss change is greater than 0.2 (i.e. span loss increased by more than 0.2 dB or decreased by more than 0.2 dB) for first time, note
        i. First span loss change value in firstSpanLossDeltaValue
        ii. RX measurement timestamp as first span loss change time in firstSpanLossDeltaTime
        iii. Value of computed span loss in firstSpanLossNewVaue
    d. If span loss change for subsequent measurements from stored measurement buffer
        i. Has same sign (i.e. plus for span loss increase and minus for span loss decrease) as first measurement having span loss change greater than 0.2
        ii. Is outside +- 0.2 dB range of last “regulated loss”
        iii. Is lower than firstSpanLossDeltaValue

        set firstSpanLossDeltaValue and firstSpanLossNewValue as per this measurement
    e. If span loss change has same sign and does not go back to +- 0.2 dB range of last “regulated loss” for 10 seconds interval starting from firstSpanLossDeltaTime, firstSpanLossNewValue is used for regulation trigger

6.11.2.2.1 Handling / Ignoring Power Variation From Upstream

Regulation must be triggered on detecting span loss change of more than 0.2 db from the last ”regulated loss” for 10 secs, +- 1s even in presence of power variation from upstream. E.g. span loss change on upstream span will cause power variation in TX measurement and RX measurement for downstream span which is also undergoing span loss change. To cater to this scenario, span loss change computation logic will check for span loss stability check instead of checking stability of TX measurement and RX measurement

Consider below picture where span loss for downstream span increased from 1 dB to 2dB at beginning of interval. After span loss changed, power coming from upstream increased from 10 dB to 12 dB for 1 second. TX node and RX node has 200 msec offset on downstream span. This time offset causes span loss to change to 4 dB for 200 msec, followed by revert to actual span loss value of 2 dB for 800 msec, followed by span loss to change to 0 dB, followed by revert to actual span loss of 2 dB. Span loss stability check will fail due to variation on span loss caused by power variation from upstream. Here, width of not-real span loss change is equal to time offset between nodes. To handle this case, SW will ignore span loss changes with span loss change duration < max time offset between nodes. Max offset between nodes is assumed to be 500 msec



6.11.2.3 Regulation Logic

1. Only EDFA gain and VOA atten are controlled. DGE and tilt are not modified
2. EDFA gain is used to compensate the loss change. If it cannot accommodate the delta, it is set to its limit (e.g. maximum gain) and VOA atten compensate remaining delta
3. New EDFA gain and VOA atten setpoints are calculated considering new span loss value and baselined values viz span loss value, EDFA gain value and VOA atten value
4. All regulations are made in one step and respects HW limits for EDFA gain and VOA atten
5. Computation of EDFA gain and VOA atten is captured below

   deltaLossFromB = newSL – baseSL
   desiredG = baseG + deltaLossFromB
   targetG = max(min(desiredG, maxG), minG)
   residualDeltaG = deltaLossFromB - (targetG - baseG)
   desiredV = baseV – residualDeltaG
   targetV = max(min(desiredV, maxV), min)
   residualError = residualDeltaG – (targetV – baseV)

6. Computed targetG and targetV are used to program HW which typically takes 3-4 seconds to complete and come into effect in terms of changein spectrum

7. Regulation reports APC out of range alarm if EDFA gain min limit is hit or VOA atten max is hit

6.11.2.4 Regulation Escalation

When regulation cannot fully compensate for span loss change due to EDFA gain / VOA atten hitting max / min limit, residual error can be present in compensating for the span loss. Local APC will "ask help" to the following node

1. Residual_error is calculated as captured in previous section. OLT TX is supposed to be always able to reach target, so it will always pass zero as its residual error
2. Residual_error is sent only if it changes more than 0.5 (apc tolerance)
3. Residual error is added to deltaLossFromB and targetG and targetV are computed as captured in previous section
4. This mechanism repeats if downstream node cannot compensate residual_error, it sends its own residual error to the following node
5. Irrespective of local span loss change, downstream node tries to compensate the passed error
6. Eventually, span loss may return to its original value. At that point, the first EDFA will be able to keep the equation in balance, and it will report zero as residual error and subsequent node will recompute targetG, targetV and residual error for downstream node considering new value for residual error coming from upstream node set firstSpanLossDeltaValue and firstSpanLossNewValue as per this measurement set firstSpanLossDeltaValue and firstSpanLossNewValue as per this measurement

6.11.3 Channel Monitoring

APC regulation on ILA / OLT RX is triggered by span loss changes. This should cover most of the causes of wrong power levels.
It is still possible that channels drift away from target without a change in span loss.

System must monitor channel PSD on output and report an alarm if this happens.

Monitoring is very similar to error/regulation vectors calculation in existing implementation:

1. Channel error is calculated accordingly to discrepancy calculation logic.
2. Alarm is raised if error is beyond a threshold. Threshold default is 1 dbm.
3. Alarm has a very long hold-off configurable timer, default 30 seconds.

Note that some maintenance operations (ASE troubleshooting commands) may cause threshold crossing and alarms to be raised. This is expected and tolerated

There are three ranges on the target PSD

+/- 0.5 dbm from target (used by OLT TX regulation)

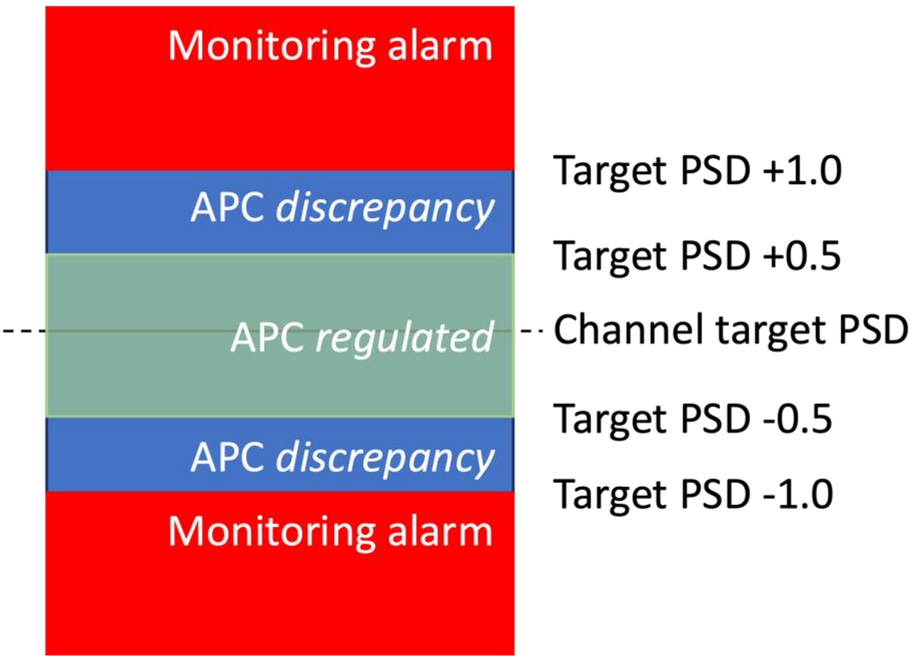
When regulation is triggered, regulation runs until channels are into the +/- 0.5 dBm range from target. Regulation performs little steps toward the target, and when actual psd is into the target range, a final step is performed to the target. A channel into this range is considered *APC regulated*.

+/- 1 dbm from target:

This is the range for channel monitoring feature applicable to OLT TX regulation, ILA regulation and OLT RX regulation. Channels outside this range are notified with an alarm.

There is a gap between first and second borders: channels with psd in [target-1, target-0.5] and [target+0.5, target+1] are candidate for APC regulation, but they are not so out of target to raise the “Target PSD not met” alarm.

In APC *show regulation-info* command, APC candidate channels are marked with *discrepancy* state.
During system lifetime, a channel can move across these borders. The picture below shows the described regions:



6.11.4 Discrepancy Calculation

Several control components are present in the system, and some of them are able to control signal power at pretty granular level: WSS in OLT has 6.25 GHz slices, DGE in ILA has 12.5 GHz. Additionally, PSD configuration requires specific power levels for each zone of the spectrum.

Because of this, discrepancy calculation and its correction must happen at the most granular level possible

6.11.4.1 Actual PSD (PSD_{ACTUAL})

OCM reports raw data as “an array” of values, one per each slice of spectrum. Actual channel PSD is computed taking average PSD of channel slices around centre of channel as per spectral density, E.g. for 32 channel grid with channel width configured as 150 GHz and spectral density being 92%, number of slices considered for channel average PSD computation is 44 slices

6.11.4.2 Configured Channel PSD

PSD is configured as 33 values, dividing the full spectrum in 150 GHz steps.

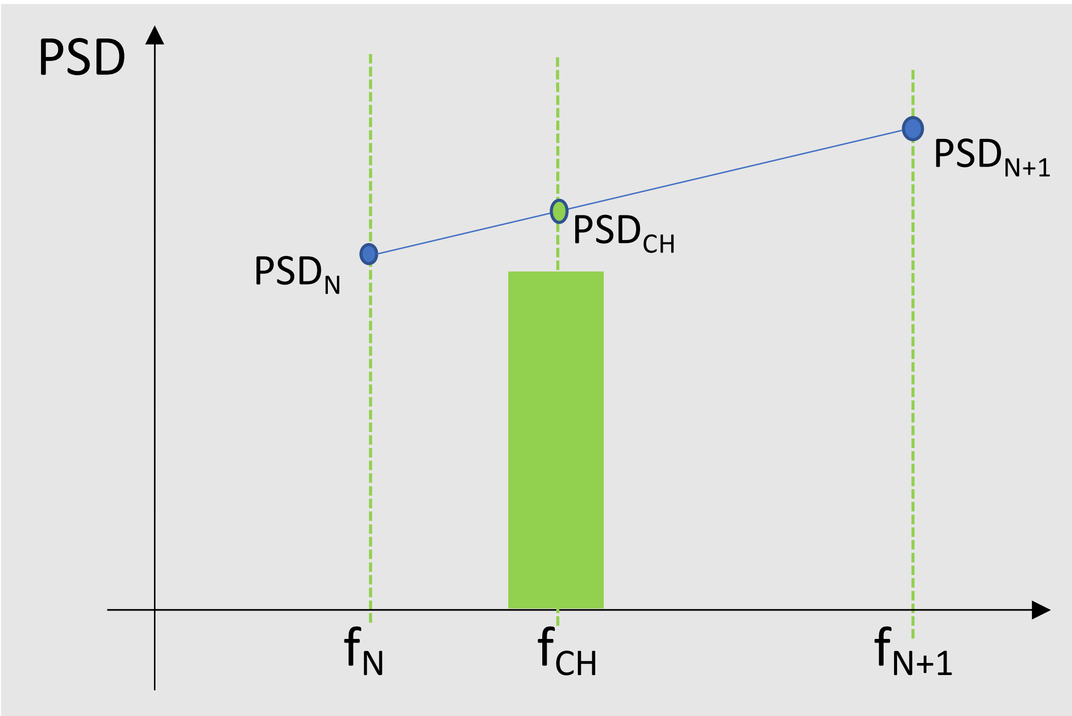
In case channel frequency corresponds to a configured point, that PSD value is used.

If central frequency is not on a configured position, target PSD for a channel is calculated interpolating on the two adjacent steps; consider a channel with frequency f, and PSDi the i-th PSD value:

1. "left" step is step N=(f – base_frequency) / Wstep
2. "right" step is step N+1
3. fN is the frequency where step N is defined
4. PSDch = PSDN + $\frac{PSD_{N+1} - PSD_N}{W_{step}}(f_{CH} - f_N)$

Where:

- Wstep is 150 GHz (the width of the configuration slices)
- base_frequency is 191337.5 GHz
- PSDN is configured PSD of the nearest configured point but less than fCH
- PSDN+1 is configured PSD of the nearest configured point but greater than fCH



6.11.4.3 Discrepancy Calculation Logic

The result of the discrepancy calculation is, per each channel, the difference between the configured PSD and the actual PSD.

Each time discrepancy calculation is required:

- Actual channel PSD PSDACTUAL is calculated:
    - Raw OCM is acquired

  - The list of circuits is used to select the raw data slices to be used to compute PSD_{ACTUAL} for each of channel
  - Result is a list of PSD_{ACTUAL_i}
- Configured channel PSD is calculated:
  - PSD_{TARGET_i} is calculated for channel i:
    - Linear interpolation as in previous paragraph
    - OXC PSD offset is added
- Discrepancy (or error) is one value per channel, calculated as the difference:
    - $PSD_{TARGET\_i} – PSD_{ACTUAL\_i}$

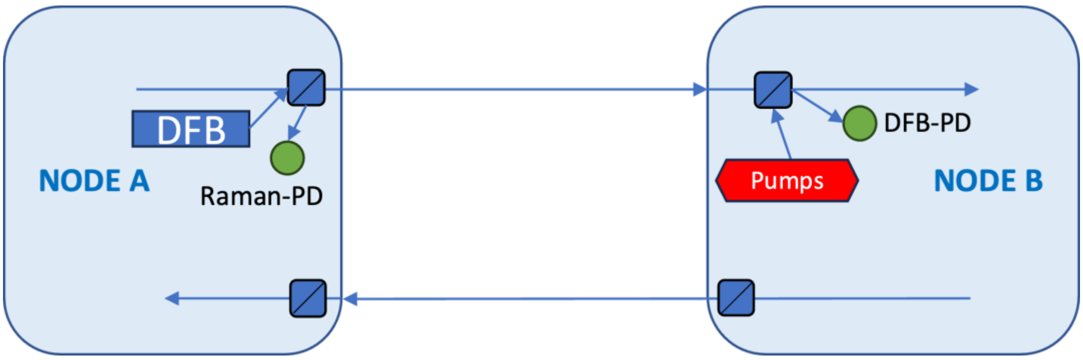
The result is an error value per channel, named CH_ERR(i).

6.12 Raman Tuner

Raman tuning is an embedded procedure that finds the best combination of pump powers to achieve the target Raman gain on the span.

6.12.1 Raman Tuning Procedure

[Theoretical explanation of Raman tuning is explained in a separate document].



Raman tuning is a procedure where the two nodes on a collaborate. This is the high-level sequence of operations:

1. Pumps are shut down on node B.
2. Node A shuts down its payload (launching EDFA is switched off).
3. Node A and B measures loss at pump frequencies and on DFB.
4. On/off Raman gain on DFB per each pump is measured.
5. Node B:
   a) evaluates the measurements.
   b) calculates maximum achievable Raman gain.
   c) generates a set of pump powers to reach the target.

6. A loop is performed:
    a) Actual gain on DFB is measured.
    b) If actual gain is reached (tolerance is 0.5 Db) the loop ends, and tuning is successful.
    c) If not reached, pump powers are adjusted, and another cycle is performed.

CLI Interface

Raman related management is implemented in two places.

Pumps operational data are shown in the line controllers. For example:

```
show controller ots 0/0/0/0 raman-info
```

```
Output example:
        Parameter Statistics:
         ---------------------
         Raman Safety Control mode = auto
         Raman OSRI = OFF
         Raman Force Apr = OFF
         Composite Raman Power = 648.70 mW
         Raman BR Power = -3.70 dBm

         RAMAN Pump Info:
         ---------------------
         Instance        Wavelength(nm)  Power(mW)
          1               1424.00                185.60
          2               1436.00                155.50
          3               1451.00                110.70
          4               1467.00                198.60
          5               1495.00                0.00

         Configured Parameters:
         -------------
         Raman Safety Control mode = auto
         Raman OSRI = OFF
         Raman Force Apr = OFF

         RAMAN Pump Info:
         ---------------------
         Instance        Power(mW)
          1               185.60
          2               155.50
          3               110.70
          4               198.60
```

5 35.00

Config, alarms, PM, TCA are implemented on the same controller.

Raman tuning operation/config data are modelled into the optical-line-control realm.

optical-line-control controller Ots <ctrl-#> raman-tuning enable/disable/manual

This parameter controls when Raman tuning is triggered: respectively "After each fiber cut or on cli request", "never", "only during ALC or on cli request".

optical-line-control controller Ots <ctrl-#> raman-tuning tuning-mode

Cli request command is:

olc start-raman-tuning controller Ots <ctrl-#>

Raman-related configuration for Microsoft installations:
CONP (Design tool) generates a configuration file per node. For Raman based nodes, the config file contains:

1. enabling of raman-turn-up checks. See paragraph above about this feature.
2. Raman-tuning mode set to manual. This makes Raman tuning to run only when triggered by ALC or when started with a troubleshooting command from CLI.

   optical-line-control controller Ots <ctrl-#> raman-tuning manual

3. Raman safety set to "check DFB and OSC LOS for DFB". In this mode, fiber continuity is declared as failed when both DFB and OSC are missing. This detection forces pumps to shut down.
4. Raman tuning procedure to target c-band-only

   optical-line-control controller Ots <ctrl-#> raman-tuning tuning-mode C-band-only

6.12.2 Raman Failure Scenarios

Issue	Symptoms	Alarms	Fix action
Fiber cut	Pumps are down, even though controller are not shut, and no maintenance settings are applied	LOC alarm on the receiving node of the broken span	Fix the fiber cut
Bad/dirty connector	Pumps are down, even though controller are not shut, and no maintenance settings are applied	EBR alarms is raised on the ots line controller where pumps are off.	Clean connector/fix the high reflection
Raman turn-up fails	Pumps are down, even though controller are not shut, and no maintenance settings are applied	RAMAN-TURNUP-FAIL is raised	Verify which event caused the checks to fail, fix it. Alternatively, change relaxation factor in turn-up config

Tuning fails for unreachable gain	Result of raman tuning is "Completed," but ALC fails because target gain is not reached.	Raman-gain-not-reached	Verify concentrated losses, especially near pump connector
Tuning fails for SW error	This can be due to node warm restart; ALC fails	None	
Optical problem during tuning	Optical problem can be fiber cut or fiber bending	ALC fails	Fix the physical problem and restart ALC

.

6.13 Gain Range Selection

The specific gain range for OLT-C PRE-AMP1 and ILA-C shall be selected according with the:

- actual span loss from the span loss verification process
- the optimal PSD at the begin of span defined by the Link Tuner
- the actual Raman Gain from the Raman Tuner (if Raman if present)
- the span EOL margin considered.

The Actual Span Loss is calculated as below

Span_Loss = Verified_Span_Loss if no Raman is present

= Verified_Span_Loss – Target_Raman_Gain + Raman_extra_loss

if Raman is present;

OLT-C PRE

The expected gain in Beginning Of Life condition is calculated considering the PRE output setpoint and the optimal PSD defined by the LinkTuner at the beginning of the span:

Gain_BOL = PSD_Setpoint[COM-RX-1] – PSD_Setpoint[LINE-TX](@Span_begin) + Span_Loss;

The expected gain in End Of Life condition is defined as

Gain_EOL = Gain_SOL + EOL_margin;

OLT-C PRE gain ranges:

Range#1: 12 ~ 22dB flat; it can be extended up to 25dB with up to 2.4dB tilt

Range#2: 20 ~ 35dB flat; it can be extended up to 28dB with up to 2.4dB tilt

The OLT-C PRE gain range shall be selected with the following rules

- if Gain_EOL ≤ 22dB => Range1
- if Gain_EOL > 22dB but Gain_BOL ≤ 21dB => Range1
- if Gain_BOL > 21dB or Gain_EOL > 25dB => Range2

ILA-C

The expected gain in Beginning Of Life condition is calculated considering the ILA-C output setpoint and the optimal PSD defined by the LinkTuner at the beginning of the span:

Gain_BOL = PSD_Setpoint[LINE-TX|VOA-LINE=0] – PSD_Setpoint[LINE-TX](@Span_begin) + Span_Loss;

The expected gain in End Of Life condition is defined as

Gain_EOL = Gain_SOL + EOL_margin;

ILA gain ranges:

- Range#1: 8 ~ 20dB flat; it can be extended up to 23dB with up to 2.4dB tilt
- Range#2: 16 ~ 33dB flat; it can be extended up to 36dB with up to 2.4dB tilt

The ILA-C gain range shall be selected with the following rules

- if Gain_EOL ≤ 19dB => Range1
- if Gain_EOL > 19dB but Gain_BOL ≤ 17dB => Range1
- if Gain_BOL > 17dB or Gain_EOL > 22dB => Range2

6.14 OSC Behaviour During the Reloads

6.14.1 Line Card Warm Reload (Non Traffic impact Reload)

During the LC Warm Reload, the Line card moves out of Operational State and Back to Operational State when the reload is completed.

Due to this, the interfaces present in the software are deleted & recreated.

This will result in S/W Stack to Completely Remove the interfaces and recreate them.

This results in OSPF topology break with peer OLT/ILA devices. Hence the OLC process (Optical Line Control Application) removes FSM data on local node.

In addition, APC local regulation information on local node will not be available till LC does not move back to Operational State. Immediate downstream node will lose connectivity with this node and will raise “APC blocked in TX direction” alarm in case of ILA / “APC blocked in RX direction” alarm in case of tail node OLT

This operation **will not** have any impact to Optical Data Path. Hence there will not be any LOS alarm on the OSC/OTS controllers

Also, it is important to note that

6.14.2 RP (controller) Card Reload (both Warm Reload and Cold Reload) (Non-Traffic impact Reload)

During the Controller card Reload, the control plane will go down as the RP is the one handles the control plane updates.

Similar to the LC warm reload case, there is no impact to the Optical Datapath. However, the control plane updates cannot be processed until the RP is back in action.

During this duration, there will be APC blocked alarms on the neighbour nodes. However, no LOS alarm on OSC/OTS controllers as the optical datapath is uninterrupted.

until LC does move to Operational state after RP comes up, APC local regulation information on local node will not be available. Immediate downstream node will lose connectivity with this node and will raise “APC blocked in TX direction” alarm in case of ILA / “APC blocked in RX direction” alarm in case of tail node OLT

6.15 Auto Line Shutoff (ALSO) – EDFA Safety

Optical transmission devices must comply to safety regulation regarding optical signals.

1010 complies to several safety regulations.

Considering these regulations:

1. ADD/DROP ports have a low power signal, that doesn’t require shutdown mechanism.
2. Ports transmitting into spans require check of fibre continuity and shut off in case the span to the other end is interrupted. Note that this shut off can be partial, so that power is reduced to a level safe compatible with an open connection (always accordingly to the regulations).

Requirements for such a mechanism are:

1. Intervention time. This is the maximum time elapsed between span cut and shut off (or reduction) of the signals transmitted on it. 1010 has target of 100 ms.
2. Reliability, measured in FIT. Because this requirement is very stringent, SW usage must be avoided to detect a cut and drive the relevant action.

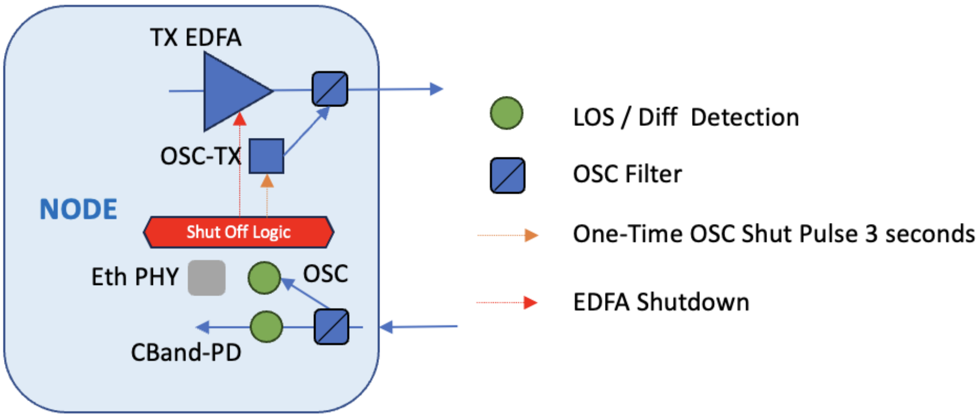
6.15.1 EDFA Shutoff Logic

Each bidirectional port facing a span (ots controller 0/0/0/0 on OLT, ots controller 0/0/0/0 and 0/0/0/2 on ILA) implement this logic:

1. C-band signal on RX side is monitored and checked against LOS-P threshold. Raise time is 50 msec.
2. OSC is monitored with differential threshold (see below). Raise time is 50 msec.
3. If both signals are detected as failed, fiber cut on the RX direction is declared.
4. LOC alarm is raised. This demotes C-band and OSC alarms. Threshold crossing and combinatory logic are implemented in a FPGA component (shut off logic in the picture below)
5. OSC TX direction is shut off and back on for period of 3 seconds. ALS (Automatic Laser Shutdown) alarm is raised.
6. The shut off and on of OSC TX direction is needed to Shut Down EDFA on both end of fibers for Uni-Directional fiber cut.

7. C-band TX EDFA (egress amplifier on OTS controller) is shut off. ALS is raised.

Shutting off only when both received signals are absent increase reliability of the mechanism, so that a RX fiber cut is declared only when ALL input signals are down. If far end node stops transmitting one of the two, this is not mistaken as a fiber cut and traffic is not brought down.



6.15.2 Turn ON logic

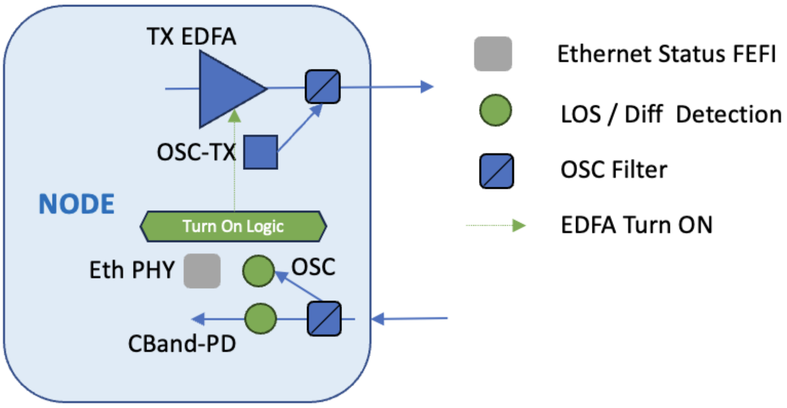
Turn On of EDFA will done post bidirectional fiber connectivity check.

Bidirectional Fiber Connectivity check done using the condition check

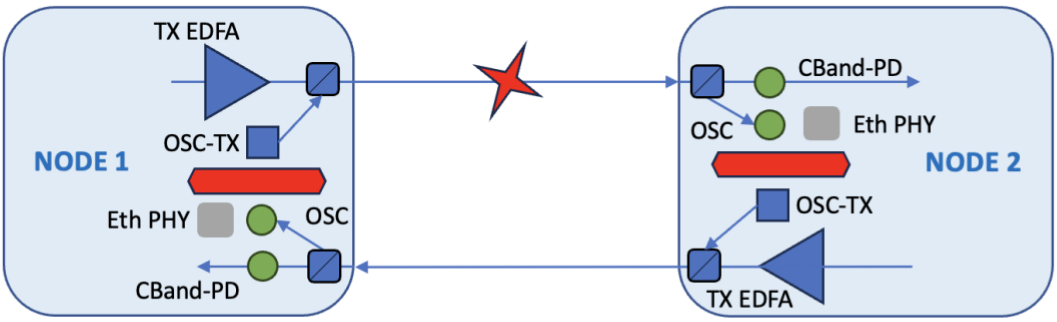
1. OSC differential threshold to be Above threshold.
2. Ethernet PHY No FEFI Alarm Present

The above conditions are checked for period of 20 seconds to Turn ON the EDFA. Implementation is done in SW, Logic in picture below

EDFA Does not Turn Up when Node is in Headless mode.

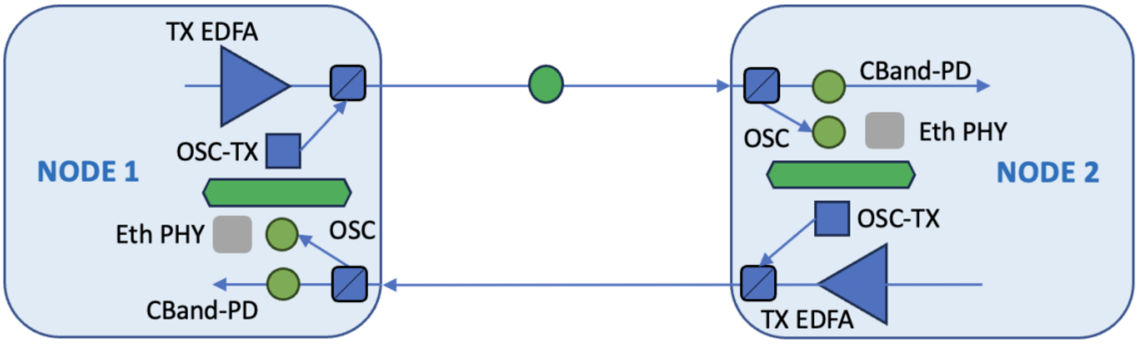


6.15.3 Uni-directional Fiber Cut Scenario



Notes	NODE 1					NODE 2				
	OSC LOS	C LOS	Eth FEFI	ALS	OSC OFF	OSC LOS	C LOS	Eth FEFI	ALS	OSC OFF
Before event	0	0	0	NO	NO	0	0	0	NO	NO
N2: Fiber Cut C, OSC LOS Detected	0	0	0	NO	NO	1	1	0	NO	NO
N2: OSC OFF, ALS 3 Sec Timer Start	0	0	0	NO	NO	1	1	0	YES	YES
N1: C, OSC LOS Detected	1	1	0	NO	NO	1	1	0	YES	YES
N1: OSC OFF, ALS 3 Sec Timer Start	1	1	0	YES	YES	1	1	0	YES	YES
N2: 3 Sec Timer Expired OSC ON	1	1	0	YES	YES	1	1	0	YES	NO
N1: OSC LOS Clear, ETH FEFI Detected	0	1	1	YES	YES	1	1	0	YES	NO
N1: 3 Sec Timer Expired OSC ON	0	1	1	YES	NO	1	1	0	YES	NO

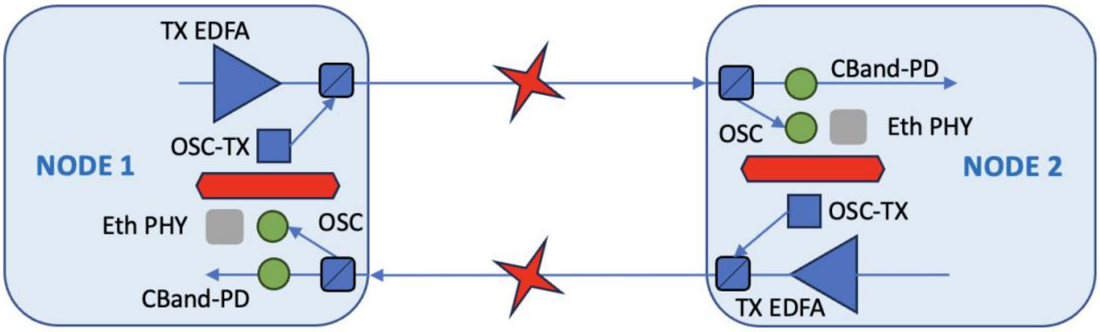
Uni-Directional Fiber Cut Repair



In the Above Scenario a Uni-Directional Fiber Cut has been Repaired below is the Sequence of Events.

Notes	NODE 1					NODE 2				
	OSC LOS	C LOS	Eth FEFI	ALS	OSC OFF	OSC LOS	C LOS	Eth FEFI	ALS	OSC OFF
Before event	0	1	1	YES	NO	1	1	0	YES	NO
N2: Fiber Repair OSC LOS Cleared 20 Second Timer Start	0	1	1	YES	NO	0	1	0	YES	NO
N1: FEFI Clear 20 Second Timer Start	0	1	0	YES	NO	0	1	0	YES	NO
N2: 20 Second Timer Expires ALS Disable	0	1	0	YES	NO	0	1	0	NO	NO
N1: C LOS Cleared	0	0	0	YES	NO	0	1	0	NO	NO
N1: 20 Second Timer Expires ALS Disable	0	0	0	NO	NO	0	1	0	NO	NO
N2: C LOS Cleared	0	0	0	NO	NO	0	0	0	NO	NO

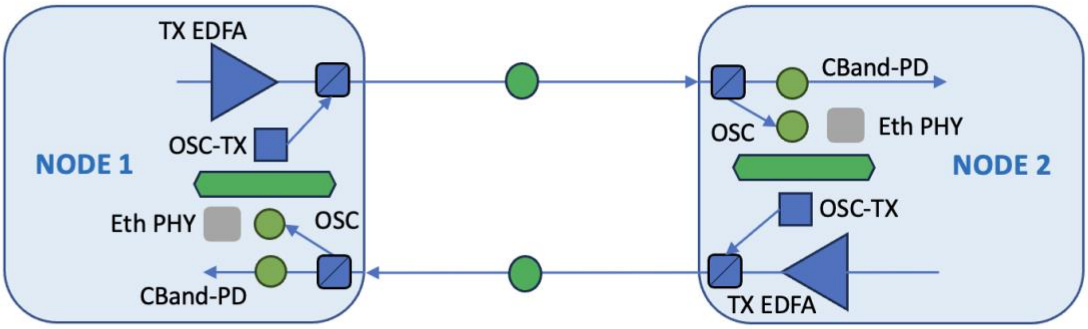
6.15.4 Bidirectional Fiber Cut Scenario



In this scenario both directions are broken by the same event. Of course, the reaction of the single nodes is the same: when no signal is present on RX direction, TX signals are shut off. The result is the same as before: Both nodes have TX off, and with LOS Event on OSC and C-Band.

Bidirectional Fiber Cut Repair

In this scenario both directions fiber cut gets repaired. The sequence of events remains the same of the Node 2 in the uni-directional fiber cut repair illustration, but happens on both nodes 1 and 2.



6.15.5 ALSO Alarm

"EGRESS-AUTO-LASER-SHUT" alarm is raised on Line OTS Controller of ILA / OLT for ALS Condition action on the EDFA

"EGRESS-AMPLI-LASER-OFF" alarm is raised on Line OTS Controller of ILA / OLT for power at the input to EDFA below threshold

"INGRESS-AMPLI-LASER-OFF" alarm is raised on Line OTS Controller of OLT for power at the input of EDFA below threshold

"LOC" alarm is raised on Line OTS Controller of ILA/OLT in event of Fiber-Cut

"LOS-P" alarm is raised on OTS controller when input power at the port is below threshold

"LOS-P" alarm is raised on OSC controller when input power at the Optical Service Channel is below threshold

All the alarms have a default Declare Soak of 2.5 seconds

To prevent alarm flap conditions for Uni-Directional fiber cut the Declare Soak of LOC at OTS controller & LOS-P OSC Controller has been customized to 3.5 seconds

6.16 OTDR

6.16.1 HW Design Considerations

The OTDR component is embedded in the OLT and ILA C-Band line card (any design variant, with or without Raman amplification).

A single OTDR component scans all the LINE ports of the line-card (2x for OLT, 4x for ILA), by means of an optical switch. Therefore, it is not possible to scan two fibers simultaneously for the same line card.

The OTDR performance specifications and all the considerations reported in this document apply to both OLT and ILA.

The distance between the OTDR and the line port of the Line card (including the possible presence of the Raman module) is measured during production and taken into account by the OTDR SW, in order to "mask" the reflections and losses internal to the line-card.

6.16.2 SOR File

6.16.3 Recommended SOR File Viewer

Viavi Fiber cable 2:

https://www.viavisolutions.com/en-us/free-trial-fibertrace-2-and-fibercable-2-reporting-software

6.16.4 Event Classification

Events can be:

- R: Reflective (like connectors)

- NR: Non-reflective (like attenuators)

Events that have both nature (i.e. a reflective and an attenuating part), are reported as two separate events with same location in the summary table.

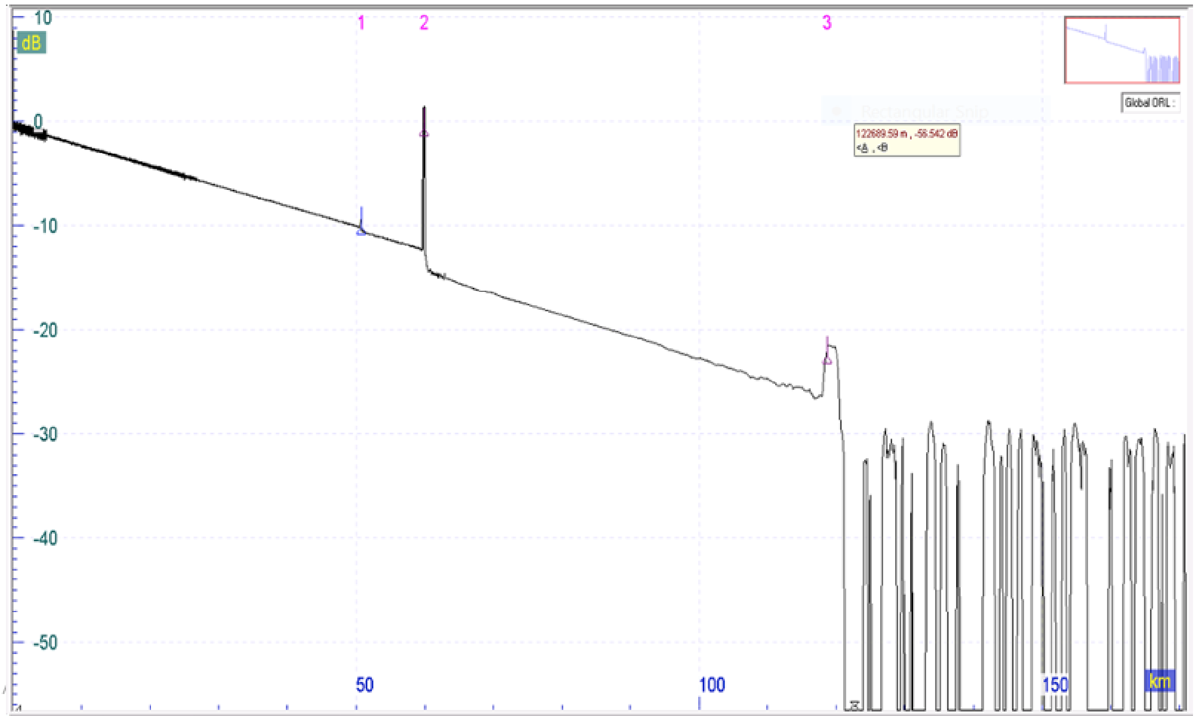
If the reflection part exceeds a pre-defined threshold, the event is also marked with "ER" (excessive Refection).

If the event is also identified to be the End of the Fiber (see 6.16.5), it is also marked with "FE"

Here below an example of the Event Table reported in teh XR CLI and corresponding OTDR trace extracted from SOR file:

Event Type Legend: NR:Non-Reflective R:Reflective FE:Fiber-End ER:Excess-Reflection

Event#	Detected Event(s)	Location(km)	Accuracy(m)	Magnitude(dB)	Attenuation/km(dB)
1	NR	0.0000	2.00	0.45	0.00
2	NR	50.7051	52.70	0.39	0.19
3	R	59.8477	61.84	-21.20	0.20
4	NR	59.8477	61.84	2.14	0.20
5	R FE	118.5395	120.53	-34.12	0.20
6	NR FE	118.5395	120.53	24.06	0.20



6.16.5 End of Fiber Detection

NCS1K-OTDR adopts two criteria for EOF detection. The EOF is detected if one or both of the following criteria are satisfied:

1. a NR event with Loss > EOF Threshold
2. last reflection event located outside of the 23.8 dB measurement range (but still within the 28.8 Dynamic Range)

the EOF Threshold is user configurable, with a default value of 5dB.

For MSFT application, the EOF threshold is configured with the value 99dB through CONP generated XML file, thus effectively disabling the EOF detection feature.

6.16.6 Event Thresholds

The table below summarizes the event measurable range, the default event threshold, and the “excessive reflection” threshold.

Type	Min detectable	Threshold	Excessive alarm	Max detectable		
Reflection	-50 dB	-40 dB	-20 dB	-20 dB		
Loss	0.2 dB	0.35 dB	-	99dB(*)		

(*) degradation of the loss measurement accuracy is expected for values above 5dB

OTDR Alarm Thresholds:

For OTDR-ABS-ATTENUATION-EXCEEDED alarms default threshold is +5 dB. And it is configurable from 0.5 to 99 dB.

For MSFT, this threshold will be set to 99 dB through CONP generated XML file.

For OTDR-ABS-REFLECTANCE-EXCEEDED alarms default threshold is -20 dB. And it is configurable from -50 to -10 dB.

For MSFT, this threshold will be set to -20 dB through CONP generated XML file.

For OTDR-ABS-ORL-EXCEEDED alarms default threshold is +10 dB. And it is configurable from 10 to 60 dB.

For MSFT, this threshold will be set to 27 dB through CONP generated XML file.

6.16.7 Total ORL

ORL is defined as Optical Return Loss, i.e. the sum of all the detected reflected events, considering the fiber attenuation, and excluding Rayleight scattering. It is calculated as per following formula:

$$ORL = 10 * \log\left(\sum 10^{(refl. + Fiber\ Loss\ )/10}\right)$$

As an example, assuming 2 reflective events:

- R1: -40 dB @ 10km (assume fiber loss =-2 dB),

- R2: -50 dB @ 40Km (assume fiber loss =- 8 dB),

Then the Total ORL is:

ORL = 10*log10(10^(((-40)+(-2))/10) + 10^(((-50)+(-8))/10)) = 10*log((10^(-4.2) +10^(-5.8)) = -41.89 dB.

6.16.8 Auto-Mode

With Auto Mode, the OTDR will perform 4 independent measurements with 20ns / 200ns/ 2us/ 20us pulse width, and ~160 Km sampling distance.

The event detection algorithm is then processing the 4 traces independently; the detected events are then compared and merged into a single event set.

The 4 ODTR traces are also processed, and “stitched” together to form a single OTDR trace.

The stitching algorithm calculates the end point of each trace based on the different noise level, then stitch the traces at the measurement range end point position.

As a result, the stitching point is not always at the same position: it varies depending on actual fiber conditions and the consequent noise level. Generally speaking, the loss range depends on the pulse width as per following table:

Pulse Width	Loss Range	Notes	Reflective Dead Zone (mt)	Attenuation Dead Zone (mt)
20 ns	0 to ~-4 dB	Net loss, excluding the loss internal to the line card	Typical: 3m, Max: < 5m	Max: < 20m
200 ns	~-4 dB to ~-8 dB		Typical: 21m, Max: < 25m	Max: < 40m
2 us	~-8 dB to ~-18 dB		Typical: 201m, Max:<205m	Max: < 290m
20 us	> ~-18 dB		Typical: 2001m, Max:<2005m	Max: < 3020m

The table above also shows Typical and Maximum Dead Zone in the four regions, as a result of the different pulse width:

Reflective dead zones are referred to <-40dB reflection events.

The resulting trace has a total number of about 44864 data points, covering about 171 Km. The trace resolution depends on the distance from the OTDR, as per following table:

Distance (2)	Approx. Resolution (1)	Number of Points	Number of Averages (3)
0 – 25 km	65 cm	38’232	30’000
25 – 50 km	520 cm	4’779	10’000
50 – 75 km	2600 cm	908	10’000
75 km – 171 km	10790 cm	909	10’000

(1): Approximate figures: actual resolution depends on fiber refractive index, and on the OTDR sampling clock.

(2): Excluding actual offset distance between OTDR component and NCS1010 LINE ports (5m to 20m).

(3): Approximate figures

Below is measurement time breakdown (in sec) :

Auto mode:

Pulse width	TEC stabilize	Scan	Data process

20ns	5	51	4
200ns	5	17	4
2us	5	17	4
20us	5	17	4

Total: ~138s. Data process time is variable number based on fiber conditions

For Data transfer time between line card and module, it is estimated as ~ 2 seconds for events data and SOR files.

6.16.9 Expert Mode

When in expert mode, the following parameters are user configurable:

PARAMETER	Unit	Min Setpoint	Max Setpoint	Default	Step
OTDR Expert Scan Pulse Width	nSec	5	20000	20	See par. below
OTDR Expert Scan Time	Sec	30	180	60	1 sec
OTDR Expert Scan Capture Start	cm	0	10000000	0	1 cm
OTDR Expert Scan Capture End	cm	0	15000000	15000000	1 cm

6.16.10 Expert Pulse Width

Pulse Width can be varied among the following pre-defined values:

5ns, 10ns, 20ns, 100ns, 200ns, 1us, 2us, 10us, 20us.

Note that the XR CLI interface also accepts intermediate values (say, 23ns), but these are then rounded to the next pre-defined value by the OTDR software.

The settable minimum pulse is 5ns. however, settings < 20ns are not recommended for stable use, since dynamic range is heavily impacted and almost no range for events calculation.

6.16.11 Scan Time

Scan time setting, together with Scan Capture End setting, has effect on the averaging time, i.e. the number of scans the OTDR performs to build the OTDR trace. The longer the scan time, the higher the number of averages, and the lower is the trace noise, especially in the region close to the Dynamic Range limit.

Shorter *Capture End* setting and longer Scan Time setting will help OTDR to achieve higher dynamic range for the selected pulse width.

Software can take the setting from 0 to 180s for expert mode. Nevertheless, OTDR module's Firmware limits the minimum measurement time as 20s, since below this value the noise of the OTDR trace becomes excessive.

With 180s Scan Time and 150km Capture End, the number of averaging is 70'000 ~ 80'000 samples.

The actual number is reported in the SOR file.

6.16.12 Capture Start / End

Capture Start and Capture End define the interval for OTDR acquisition.

Note that maximum Capture End is limited to 150 km, to guarantee sufficient margin against OTDR maximum acquisition range (~ 170km) for internal calculation purpose.

Capture End affects the actual Trace Resolution and number of points, as per the following table:

Distance	Trace Resolution	Number of Points
0 – 25 km	65 cm	38’232
25 – 50 km	520 cm	4’779
50 – 75 km	2600 cm	908
75 km – 150 km	10790 cm	807

As a consequence, here below the number of trace points with different setting of Expert Scan Capture End:

Capture End setting	Number of Trace Point
25 km	38’232
50 km	38’232 + 4779 = 43’011
150 km	38’232 + 4779 + 908 + 807 = 44’726

Capture Start doesn’t affect the parameters of the OTDR acquisition but truncates the trace when transferring data.

6.16.13 Multi-Region Mode

When in Multi-Region mode, the OTDR performs three consecutive scans with pulses of pre-defined widths, optimized for Central Office, Short and Long Range distances.

At the end of the multiple scans, the measured data are reported in three separate table of events in the CLI, and similarly three SOR files are stored in the controller memory.

The following table defines the 3 regions, and the OTDR settings adopted for each scan.

Note that the OTDR Scan Range is always covering the full 0 to 150 km range. This is also reflected in the saved SOR files.

On the contrary, the OTDR events reported in the Table of events in the CLI only include those within the Distance Range.

Region	Distance Range	Pulse width	Event Dead Zone	Attenuation Dead Zone	Capture start	Capture end	Dynamic Range	Measurem. Range
Office	0 to 8 Km	20 ns	5m	15 m	0	150 km	4dB	2 dB
Short	8 to 32 Km	1 us	105m	150 m	0	150 km	16dB	11 dB
Long	32 to 150 Km	20 us	2.05 Km	3.5 Km	0	150 km	28.8dB	24 dB

The Otdr scan-mode command allows to select the ‘multi-region’ option value, with ‘auto’ mode being the default:

```
controller ots 0/0/0/0 otdr scan-mode [expert, multi-region]
```

Similarly to ‘auto’ mode, the OTDR scan in Multi-Region mode is triggered by the following events:
- auto-scan enable
- Fiber cut/restore (when auto-scan is anabled)
- User Trigger request via CLI.

6.16.13.1 Results Examples

The following are the three tables exported in the CLI:

The `show cmd` displays in the same report the 3 separated event lists (one for each region)

Each list shall report only the events within that region Distance Range, while sor files shall report the data of the full scan

```
RP/0/RP0/CPU0: #sh controller ots 0/0/0/0 otdr-info tx
Mon Jul 15 16:18:40.544 UTC

        Scan Direction: TX
        Scan Status: Data Ready
        Scan Region: Office(8 km)

        Scan Region: Office(8 km)
        Optical Return Loss: 37.0 dB
        SOR file: /harddisk:/otdr/site1_OTDR_Ots0_0_0_0_TX_office_region_20240715-161144.sor
        Total Events detected: 2
        Scan Timestamp: Mon Jul 15 16:11:44 2024 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End  ER:Excess-Reflection EA:Excess-Attenuation
        Event#      |  Detected Event(s)        |  Location(m)      |  Accuracy(m)      |  Magnitude(dB)    |  Attenuation/km(dB)
        1           |  NR                       |  6.5600           |  2.00             |  1.79             |  0.00
        2           |  NR                       |  24.8600          |  2.02             |  1.87             |  0.00

        Scan Region: Short(32 km)
        Optical Return Loss: 45.0 dB
        SOR file: /harddisk:/otdr/site1_OTDR_Ots0_0_0_0_TX_short_region_20240715-161144.sor
        Scan Timestamp: Mon Jul 15 16:11:44 2024 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End  ER:Excess-Reflection EA:Excess-Attenuation

        Scan Region: Long(150 km)
        Optical Return Loss: 48.0 dB
        SOR file: /harddisk:/otdr/site1_OTDR_Ots0_0_0_0_TX_long_region_20240715-161144.sor
        Total Events detected: 4
        Scan Timestamp: Mon Jul 15 16:11:44 2024 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End  ER:Excess-Reflection EA:Excess-Attenuation
        Event#      |  Detected Event(s)        |  Location(m)      |  Accuracy(m)      |  Magnitude(dB)    |  Attenuation/km(dB)
        1           |  R                        |  56578.6800       |  58.57            |  -34.56           |  0.18
        2           |  NR                       |  56578.6800       |  58.57            |  1.05             |  0.18
        3           |  R                        |  113778.0200      |  115.77           |  -37.72           |  -0.22
        4           |  NR                       |  113778.0200      |  115.77           |  4.90             |  -0.22
```

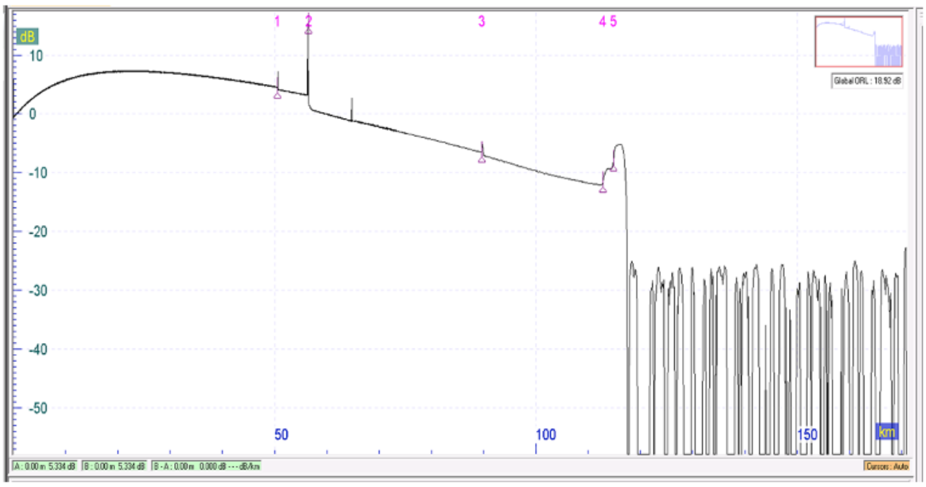
6.16.14 About the use of OTDR with Raman Amplified Spans

The following paragraphs provide the technical background around known use limitations in Raman amplified links.

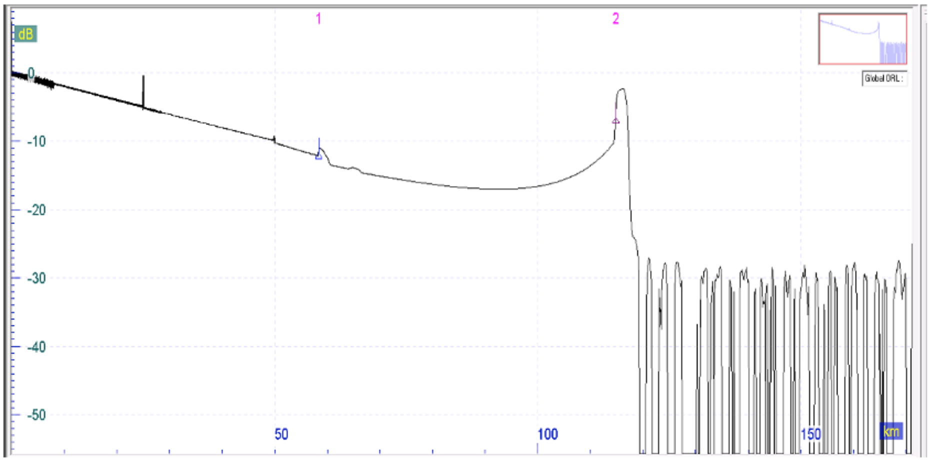
6.16.15 Effect of Raman Amplification

The presence of Raman amplification over the fiber inspected by the OTDR causes the amplification of the OTDR pulse at different distances, and the resulting characteristic shape of the OTDR trace.

The trace below provides an example for OTDR pulse co-propagating with Raman pumps, i.e. OTDR scanning the LINE-RX port. The trace shows a “hill” in the first 50km approximately:



Conversely, the trace below refers to the OTDR pulse counter-propagating with Raman pumps, i.e. OTDR scanning the LINE-TX port. In this case the Raman amplification has effect in the last 50 km approximately:

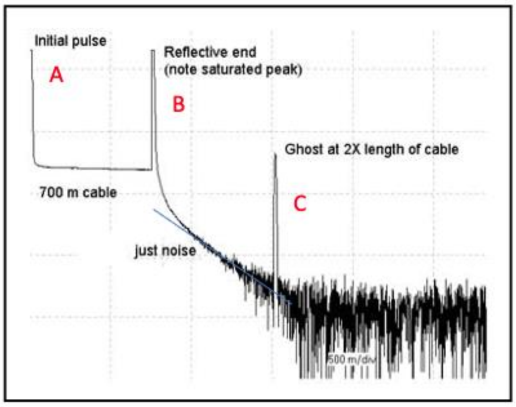


6.16.16 Ghost Events

Ghost reflection is a common phenomenon caused by two or more high reflection events.

As shown in the chart below, the OTDR pulse bounces between reflection A and reflection B and generates a fake 3rd reflection C, at the Position_C = Position_B + (Position_B – Position_A).

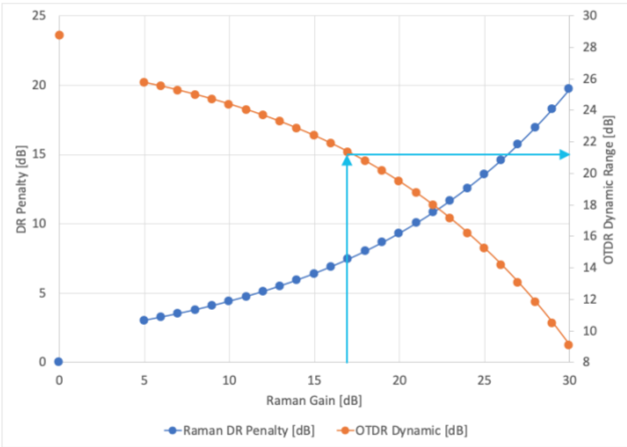
Ghost reflections may get even worse in case additional high reflection events are present, as the effects combine. Any unwanted source reflection should be prevented with proper cleaning of all the optical connections.



The effect of Ghost reflection can be emphasized by the presence of Raman amplification, which makes the back-travelling pulse stronger, thus enabling multiple replica of the same event before the pulse power falls below the detector noise floor. This is particularly evident in case of OTDR co-propagating with the Raman pumps.

6.16.17 Dynamic Range (DR) Penalty

In presence of Raman amplification of the line, a noise contribution affecting the OTDR is the Raman ASE.
The Raman ASE is a broadband noise extending over the C- and L- bands, and partially in the adjacent wavelength regions, including the one occupied by the OTDR.
The optical power of the Raman ASE that falls within the OTDR detector's bandwidth (~ 1518nm +/-2nm) represents a noise floor that reduces the actual Dynamic Range of the OTDR.
As the power of the Raman ASE increases with the Raman Gain, the OTDR DR Penalty and consequently the actual OTDR DR also depend on the Raman Gain, with an approximate rule reported in the following chart.

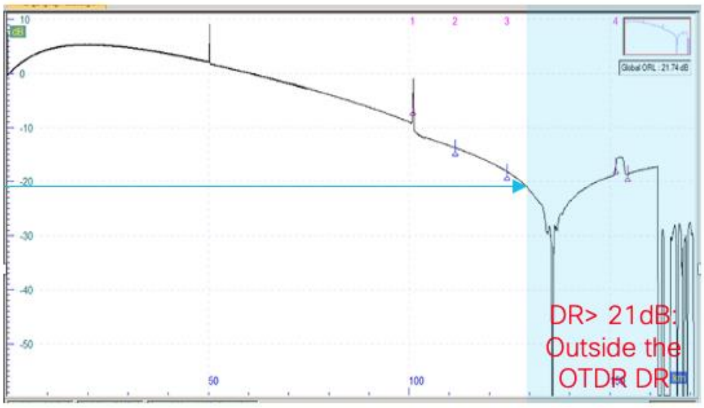


In the example above, a Raman Gain of ~ 17dB introduces a DR Penalty of ~ 8dB. Consequently, the OTDR DR is reduced from the max value (28.8dB in the absence of Raman) to ~ 21dB.
Note that this is true only in case the OTDR propagates in the same direction as the Raman pump (OTDR scanning at the LINE-RX connector), as in this position Raman ASE power at has the maximum value. On the other side, with OTDR counter-propagating with the Raman Pumps (i.e. OTDR scanning at the LINE-TX connector), the effect of the Raman are negligible, as the Raman ASE is attenuated by the fiber loss.

6.16.18 Trace Distortion

Due to the DR penalty described in the previous paragraph, the OTDR trace may result distorted in the following scenario:
- OTDR co-propagating with Raman pumps (OTDR scanning at LINE-RX connector)
- Long span reach, close to the max dynamic range of the OTDR (28.8dB)

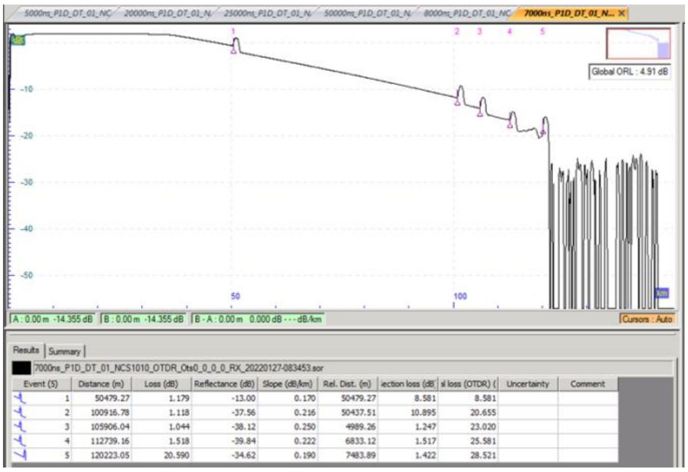
The chart below provides an example of the trace distortion. In this case the Raman is set to 17dB, and the Span Reach is ~ 150km (~ 30dB). As explained, the Raman ASE reduces the OTDR DR to ~ 21dB; as a consequence, outside this DR, the OTDR trace should be considered not valid.



6.16.19 Input Saturation

In Specific cases, the Raman Gain can bring the OTDR receiver to saturate. This may occur in case of:
- OTDR co-propagating with Raman pumps (OTDR scanning at LINE-RX connector)
- Excessive Raman Gain, or Raman pumps manually configured (without Automatic Raman Tuner)

In this case, the received power could be higher than the maximum allowed. The effect of this condition is that the reported OTDR power “clamps” to the max value, and consequently a portion of the OTDR trace is distorted to a horizontal line.



Event (5)	Distance (m)	Loss (dB)	Reflectance (dB)	Slope (dB/km)	Rel. Dist. (m)	ection loss (dB	al loss (OTDR) (	Uncertainty	Comment
1	50479.27	1.179	-13.00	0.170	50479.27	8.581	8.581		
2	100916.78	1.118	-37.56	0.216	50437.51	10.895	20.655		
3	105906.04	1.044	-38.12	0.250	4989.26	1.247	23.020		
4	112739.16	1.518	-39.84	0.222	6833.12	1.517	25.581		
5	120223.05	20.590	-34.62	0.190	7483.89	1.422	28.521		

6.16.20 OTDR Software Workflow

6.16.20.1 OTDR Start & Stop using CLI Interface

OTDR scan can be triggered and aborted individually on Tx or Rx fiber of any line side.

```
otdr-start controller ots R/S/I/P tx|rx

otdr-stop controller ots R/S/I/P tx|rx
```

6.16.20.2 OTDR: Negotiated Scan

Two OTDR scans may run at the same time on the same fiber disturbing each other. To avoid scan clash, before starting an OTDR scan, the node checks with the peer that a scan is not already in place on the same fiber. This feature is commonly called "negotiated scan".

This negotiated scan applies both the manual and auto-scan and needs the support of the OSC communication channel.

The user can force the manual scan to run even when the comms channel is not up and running with the force option:

```
otdr-start controller ots 0/0/0/0 tx|rx force
```

6.16.20.3 Starting OTDR Scan on the TX:

```
RP/0/RP0/CPU0:ILA-4#otdr-start controller Ots 0/0/0/0 Tx

Wed Feb 14 14:33:30.297 IST

OTS OTDR Scan Started at TX
```

6.16.20.4 Status Check

```
RP/0/RP0/CPU0:ILA-4#show controllers Ots 0/0/0/0 otdr-info Tx

Wed Feb 14 14:34:16.826 IST

        Scan Direction: TX

        Scan Status: Measuring

        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
```

6.16.20.5 Scan completed and Data Processing in Progress

```
RP/0/RP0/CPU0:ILA-4#show controllers Ots 0/0/0/0 otdr-info Tx

Wed Feb 14 14:35:24.958 IST

        Scan Direction: TX

        Scan Status: Data Processing
```

```
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
```

OTDR scan can have following status:

```
Unknown                          When scan never run after a reload

Stopped                          When scan is aborted

Measuring                        When OTDR measurement is ongoing

Data Processing                  When OTDR measurement data is being processed

Data Ready                       When OTDR results are available

Error                           This identifies an error during the scan and
it’s not expected in normal working scenarios]

Waiting Span Reservation         waiting remote OTDR lock
```

In addition, these other error status details may be displayed in case of a manual scan with error

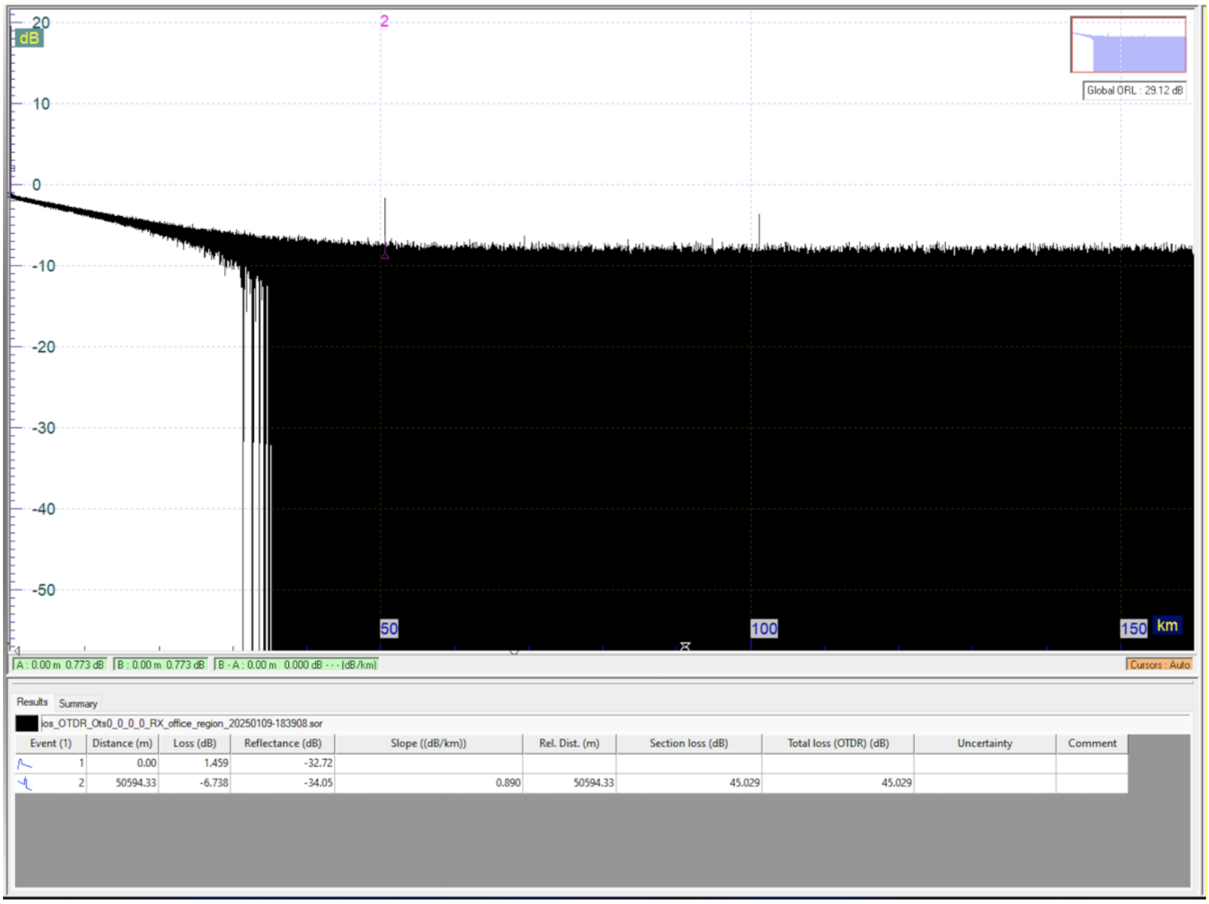
```
Timeout                          scan (manual) did not complete within the
expected timeout

Communication Failed             not able to reserve the span due to link down

Local Resource Not Available     local resource (otdr equipment) busy

Span Reservation Failed          remote resource busy

Scan Not Allowed                 scan can’t be started (i.e. Raman pumps on)
```

6.16.20.6 Final Status along with Event Table

```
RP/0/RP0/CPU0:ios#sh controllers ots 0/0/0/0 otdr-info rx
Thu Jan  9 18:46:05.971 UTC

        Scan Direction: RX
        Scan Status: Data Ready
        Scan Region: Office(8 km)
        Optical Return Loss: 30.0 dB
        SOR file:
/harddisk:/otdr/ios_OTDR_Ots0_0_0_0_RX_office_region_20250109-183908.sor
        Total Events detected: 2
        Scan Timestamp: Thu Jan  9 18:39:08 2025 UTC

        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
```

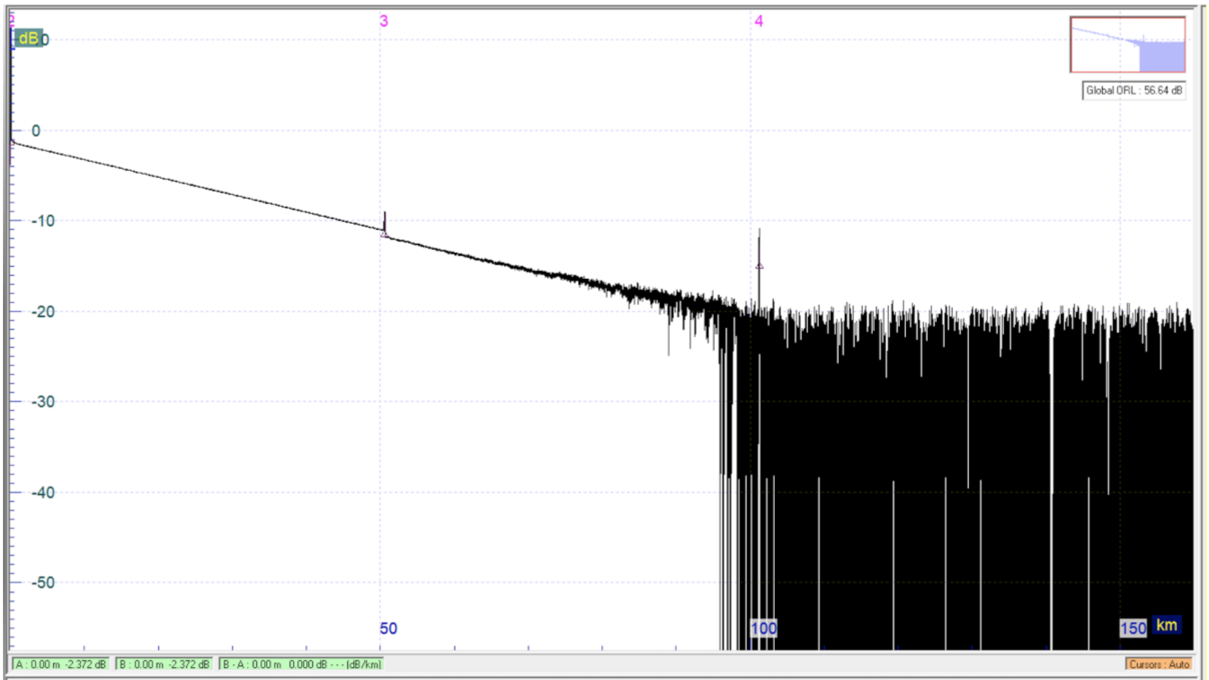
```
        Event#       |  Detected Event(s)        |  Location(m)       |
Accuracy(m)      |  Magnitude(dB)    |  Attenuation/km(dB)
        1            |  R                        |  0.0000            |  2.00
|  -32.72          |  0.00
        2            |  NR                       |  0.0000            |  2.00
|  1.46            |  0.00
        Scan Region: Short(32 km)
        Optical Return Loss: 56.0 dB
        SOR file: /harddisk:/otdr/ios_OTDR_Ots0_0_0_0_RX_short_region_20250109-
183908.sor
        Scan Timestamp: Thu Jan  9 18:39:08 2025 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
        Scan Region: Long(150 km)
        Optical Return Loss: 51.0 dB
        SOR file: /harddisk:/otdr/ios_OTDR_Ots0_0_0_0_RX_long_region_20250109-
183908.sor
        Total Events detected: 3
        Scan Timestamp: Thu Jan  9 18:39:08 2025 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
        Event#       |  Detected Event(s)        |  Location(m)       |
Accuracy(m)      |  Magnitude(dB)    |  Attenuation/km(dB)
        1            |  NR                       |  51443.8100        |  53.44
|  0.72            |  0.19
        2            |  R                         |  101243.6600       |  103.24
|  -28.84          |  0.21
```

<u>Office Region OTDR scan</u>



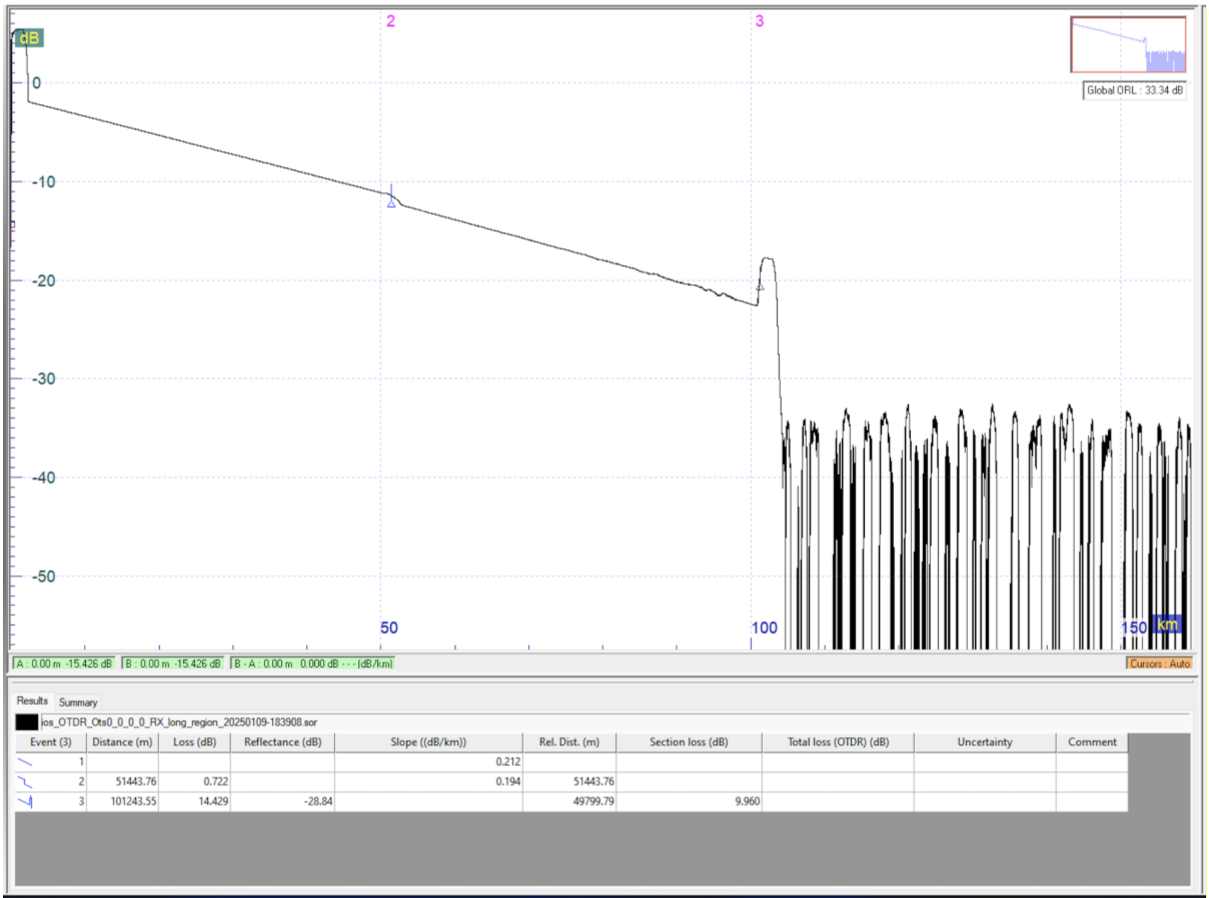
Event (1)	Distance (m)	Loss (dB)	Reflectance (dB)	Slope ((dB/km))	Rel. Dist. (m)	Section loss (dB)	Total loss (OTDR) (dB)	Uncertainty	Comment
1	0.00	1.459	-32.72						
2	50594.33	-6.738	-34.05	0.890	50594.33	45.029	45.029		

<u>Short Region OTDR Scan</u>



Event (4)	Distance (m)	Loss (dB)	Reflectance (dB)	Slope ((dB/km))	Rel. Dist. (m)	Section loss (dB)	Total loss (OTDR) (dB)	Uncertainty	Comment
1				1.619					
2	124.15	3.800		0.191	124.15				
3	50605.44	0.665	-49.60		50481.29	10.096			
4	101218.72	5.837	-42.35		50613.28	10.123			

Long Region OTDR Scan



6.16.20.7 OTDR Results

OTDR results are displayed in XR CLI as shown above.

SOR file generated by the device is stored in the hard disk at this location: `/harddisk:/otdr/`

```
RP/0/RP0/CPU0:ios#run
Tue Jan  7 15:25:24.824 UTC
[node0_RP0_CPU0:~]$cd /harddisk\:/otdr/
[node0_RP0_CPU0:/harddisk:/otdr]$ls -ltr | grep <date>
-rw-rw-rw-, 1 root iosxr 490374 Jan 09 18:39
ios_OTDR_Ots0_0_0_0_RX_office_region_20250109-183908.sor
-rw-rw-rw-, 1 root iosxr 490374 Jan 09 18:39
ios_OTDR_Ots0_0_0_0_RX_short_region_20250109-183908.sor
-rw-rw-rw-, 1 root iosxr 490374 Jan 09 18:39
ios_OTDR_Ots0_0_0_0_RX_long_region_20250109-183908.sor
```

SOR file name format is as follows: `hostname_OTDR_OtsR_S_I_P_Direction_Region_Timestamp`

6.16.20.8 Stopping OTDR Scan on the TX

The OTDR scan can be stopped using the below CLI interface and the status can be queried

```
RP/0/RP0/CPU0:ILA-4#otdr-stop controller Ots 0/0/0/0 Tx
Wed Feb 14 14:36:47.134 IST
OTS OTDR Scan Stopped at TX

RP/0/RP0/CPU0:ILA-4#show controllers Ots 0/0/0/0 otdr-info Tx
Wed Feb 14 14:36:54.810 IST
        Scan Direction: TX
        Scan Status: Stopped
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-End
ER:Excess-Reflection EA:Excess-Attenuation
```

***NOTE**: Same sequence can be followed for the RX direction also*

6.16.20.9 OTDR Start & Stop on Dfferent Ports and Direction

OTDR can be started or stopped on each of the following ports and directions:

At OLT Line-Tx

```
otdr-start controller Ots 0/0/0/0 Tx
show controllers Ots 0/0/0/0 otdr-info Tx
otdr-stop Controller Ots 0/0/0/0 Tx
```

At OLT Line-Rx

```
otdr-start Controller Ots 0/0/0/0 Rx
show Controllers Ots 0/0/0/0 otdr-info Rx
otdr-stop controller Ots 0/0/0/0 Rx
```

At ILA SIDE-1 Line-Tx

```
otdr-start controller Ots 0/0/0/0 Tx
show controllers Ots 0/0/0/0 otdr-info Tx
otdr-stop controller Ots 0/0/0/0 Tx
```

At ILA SIDE-1 Line-Rx

```
otdr-start controller Ots 0/0/0/0 Rx
show controllers Ots 0/0/0/0 otdr-info Rx
otdr-stop controller Ots 0/0/0/0 Rx
```

At ILA SIDE-2 Line-Tx

```
otdr-start controller Ots 0/0/0/2 Tx
show controllers Ots 0/0/0/2 otdr-info Tx
otdr-stop controller Ots 0/0/0/2 Tx
```

At ILA SIDE-2 Line-Rx

```
otdr-start controller Ots 0/0/0/2 Rx
show controllers Ots 0/0/0/2 otdr-info Rx
otdr-stop controller Ots 0/0/0/2 Rx
```

6.16.20.10 OTDR: Modes of Operation

By default, OTDR works in ‘auto’ mode. It can be set to expert or multi-region mode by using config command below.

CONP generates an xml including the scan-mode setting in multi-region.

```
RP/0/RP0/CPU0:ios(config)#controller ots 0/0/0/0 otdr scan-mode ?
  expert        Configure OTDR Scan Mode to Expert
  multi-region  Configure OTDR Scan Mode to Multi-region
```

OTDR gives flexibility to configure back-scattering & refractive-index for each direction independently.

```
RP/0/RP0/CPU0:ios(config)#controller ots 0/0/0/0 otdr rx ?
  auto              OTDR Rx auto configuration
  back-scattering   Configure OTDR Rx Back Scattering (Value in 0.01 dB)
  expert            OTDR Rx expert configuration
  refractive-index  Configure OTDR Rx Refractive Index (Value in 0.000001)

RP/0/RP0/CPU0:ios(config)#controller ots 0/0/0/0 otdr tx ?
  auto              OTDR Tx auto configuration
  back-scattering   Configure OTDR Tx Back Scattering (Value in 0.01 dB)
  expert            OTDR Tx expert configuration
  refractive-index  Configure OTDR Tx Refractive Index (Value in 0.000001)

 back-scattering is configurable from -90 dB to -70 dB with default as -81.87 dB
 refractive-index is configurable from 1.0000 to 2.0000 with default as 1.4682
```

6.16.20.11 OTDR: Alarm Threshold Configuration

OTDR gives flexibility to configure event thresholds for each direction independently. These setting are valid for both the scan done in 'auto' o 'multi-region' mode.

```
RP/0/RP0/CPU0:ios(config)#controller Ots 0/0/0/0 otdr rx auto ?
  end-of-fiber-loss-threshold   Configure OTDR Rx End of Fiber Loss Threshold (Value in 0.1 dB)
  excess-attenuation-threshold  Configure OTDR Rx Excess Attenuation Threshold (Value in 0.1 dB)
  excess-orl-threshold          Configure OTDR Rx Excess Optical Return Loss Threshold (Value in 0.1 dB)
  excess-reflection-threshold   Configure OTDR Rx Excess Reflection Threshold (Value in dB)
  raman-setpoint                Configure OTDR Rx Raman Setpoint  (Value in 0.1 dB)
  reflectance-threshold         Configure OTDR Rx Reflectance Threshold  (Value in dB)
  splice-loss-threshold         Configure OTDR Rx Splice Loss Threshold  (Value in 0.001 dB)
```

```
RP/0/RP0/CPU0:ios(config)#controller Ots 0/0/0/0 otdr tx auto ?
  end-of-fiber-loss-threshold    Configure OTDR Tx End of Fiber Loss Threshold
(Value in 0.1 dB)
  excess-attenuation-threshold   Configure OTDR Tx Excess Attenuation Threshold
(Value in 0.1 dB)
  excess-orl-threshold            Configure OTDR Tx Excess Optical Return Loss
Threshold (Value in 0.1 dB)
  excess-reflection-threshold    Configure OTDR Tx Excess Reflection Threshold
(Value in dB)
  raman-setpoint                 Configure OTDR Tx Raman Setpoint  (Value in 0.1
dB)
  reflectance-threshold          Configure OTDR Tx Reflectance Threshold  (Value
in dB)
  splice-loss-threshold          Configure OTDR Rx Splice Loss Threshold  (Value
in 0.001 dB)


excess-reflection-threshold      is configurable from -50 dB to -10 dB with
default as -20 dB
reflectance-threshold            is configurable from -50 dB to -10 dB with
default as -40 dB
splice-loss-threshold            is configurable from -0.2 dB to 5 dB with
default as -0.35 dB
excess-attenuation-threshold     is configurable from 0.5 dB to 99 dB with
default as 5 dB
end-of-fiber-loss-threshold      is configurable from 0.5 dB to 99 dB with
default as 5 dB
raman-setpoint      is configurable from 0 dB to 17 dB with default as 0 dB (not
used in this rel)
```

OTDR gives flexibility to configure following parameter in **expert mode** for each direction independently.

```
RP/0/RP0/CPU0:ios(config)#controller ots 0/0/0/0 otdr rx expert ?
  capture-end    Configure OTDR Rx Capture End (Value in cm)
  capture-start  Configure OTDR Rx Capture Start (Value in cm)
  pulse-width    Configure OTDR Rx Pulse Width (Value in nano seconds)
  scan-duration  Configure OTDR Rx Scan Duration (Value in seconds)

RP/0/RP0/CPU0:ios(config)#controller ots 0/0/0/0 otdr tx expert ?
  capture-end    Configure OTDR Tx Capture End (Value in cm)
  capture-start  Configure OTDR Tx Capture Start (Value in cm)
  pulse-width    Configure OTDR Tx Pulse Width (Value in nano seconds)
  scan-duration  Configure OTDR Tx Scan Duration (Value in seconds)


capture-start       is configurable from 0 to 10000000 cm with default as 0 cm
```

```
capture-end          is configurable from 0 to 15000000 cm with default as 15000000
cm
pulse-width          is configurable from 5 ns to 20000 ns with default as 20 ns
scan-duration              is configurable from 0 to 180 seconds with default as
60 seconds
```

6.16.20.12 OTDR Auto-scan

When OTDR auto-scan feature is enabled, OTDR scan will be automatically started for an Span Fault and Span Restore events.

Span Fault

In case of a Span Fault the fiber cut can be on a single fiber direction or on both:

- On Unidirectional fiber cut the broken fiber is scanned on both RX and TX direction by the NE and FE nodes, while the other fiber is scanned on TX only direction.
- On Bidirectional fiber cut the two fibers are scanned both on RX and TX directions.

OTDR autoscan is automatically executed w/o negotiation in case of fiber cut (service channel cannot work)

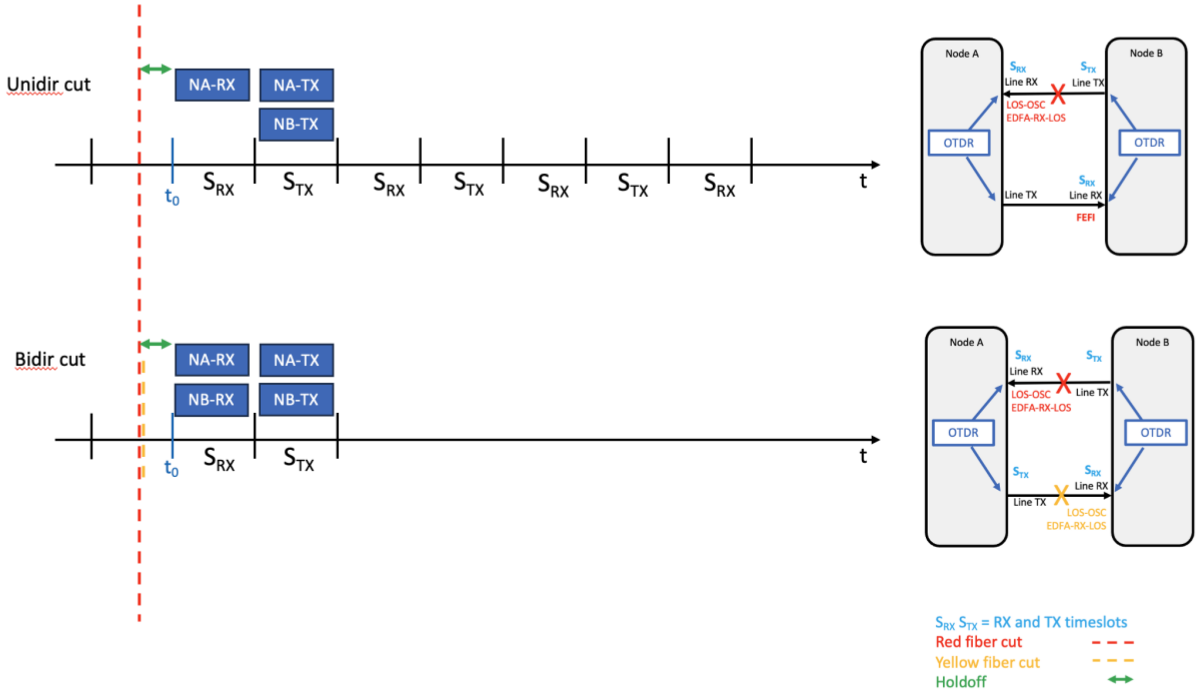
OTDR Scan on Span Down: Timeslot approach

In case of unidir or bidir fiber cut (Span Down event) the OTDR scan is done using RX/TX time-slot approach (see next figure).

- Two different RX and TX timeslots are defined starting after a span down detection (plus an additional holdoff time). No communication is required between the 2 nodes
- Timeslot duration is defined basing on scan duration (Draco OTDR scan should be done by specs within 180 secs so timeslot can be ~4 minutes)
- OTDR scan RX can only be executed inside an RX timeslot. Same for TX scan.
- In case of a fiber cut, if the fiber is repaired before the scan completed, the time-slot implementation avoids the risk that the 2 nodes can run the OTDR on the same fiber even for short time (before the OTDR scan is stopped on repaired fiber RX side)
- In normal condition the OTDR scan on a span is completed in 2 timeslots

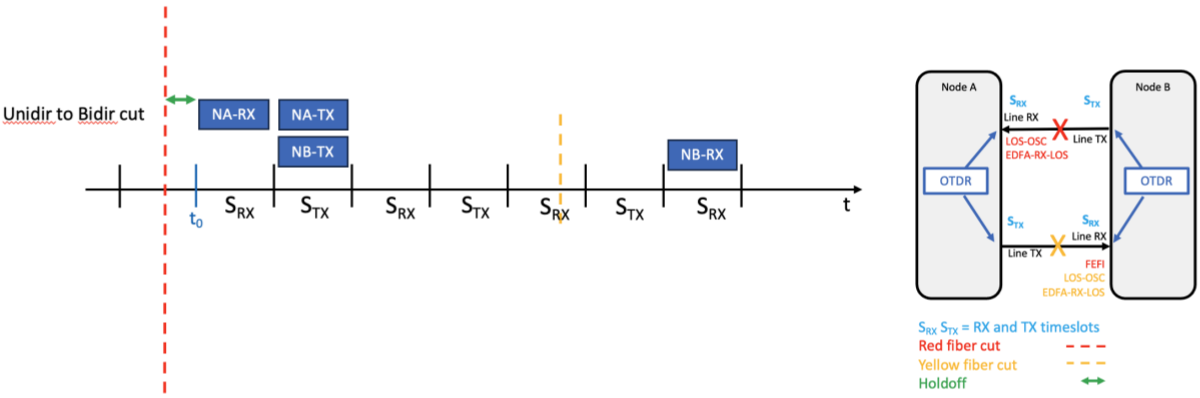
The time slots have the same duration, and they are assigned to RX and TX directions alternatively with the same order on both NE and FE nodes.

The following picture shows the Timeline for the OTDR automatic scans in case of bidirectional and unidirectional fiber cuts.



If a scan cannot be completed inside the assigned TS or the scan execution failed for any reason, the execution is rescheduled at the next available TS for that port/direction.

Note:
With reference to the example into the picture below please note that there is an initial unidir cut that after a certain time (long enough to complete all the unidir scans) becomes a bidir cut; in this case the only node detecting a change is the Node B and so the only possible action is to start an additional NodeB Rx scan since on the Node A none change can be detected to trigger a new NodeA TX scan.



Span Restore
In case of a Span Restore, whatever it has been the fiber cut on a single or both directions, the scan is done on both RX and TX for both the fibers. Scan is done negotiated to avoid probing collision between NE and FE nodes executing the OTDR scan on the same fiber.

If change in span status (up/down) is detected while auto-scan is happening, the ongoing scan will be aborted and new auto-scan will be triggered
OTDR auto-scan will lock OTDR resource to avoid trigger of scan by user request.

OTDR auto-scan would wait if scan triggered by user request is ongoing.

CLI to configure OTDR auto scan:

```
RP/0/RP0/CPU0:ios(config)#optical-line-control Controller Ots 0/0/0/0
RP/0/RP0/CPU0:ios(config-olc-ots)#otdr auto-scan enable
RP/0/RP0/CPU0:ios(config-olc-ots)#commit

RP/0/RP0/CPU0:ios(config)#optical-line-control Controller Ots 0/0/0/0
RP/0/RP0/CPU0:ios(config-olc-ots)#otdr auto-scan disable
RP/0/RP0/CPU0:ios(config-olc-ots)#commit
```

6.16.20.13 Trigger for OTDR Auto-scan

Following are triggers for OTDR auto-scan on non-Raman span

- Transition of auto-scan feature from Disable to Enable via configuration

  When auto-scan enable:

  - Fiber cut (SPAN-DOWN)
  - Fiber restore (SPAN-UP)
  - LC cold reload [TA reset] or LC OIR
  - Reload location all
  - Device power cycle
  - Administrative shutdown/no shutdown of both far end Line OTS and OSC controller [Ots-0/ Ots-2, Osc-0/ Osc-2]

OTDR auto-scan triggers a scan on SPAN-UP and SPAN-DOWN only if all of these controllers/interfaces on the local node are in no shut:

- Ots controller
- Osc controller
- GigabitEthernet interface
- DFB controller

In case one of the above controllers is moved in shutdown during a scan, that running scan will be stopped and scan will move the state Completed with error.

Following are additional triggers for OTDR scan on Raman span

- DFB LOS
- If auto-scan not enabled, the transition of raman turn up feature from Disable to Enable (when Raman pumps are OFF) is a trigger for an OTDR scan

An OTDR auto-scan can start only if all these controllers on the local node are in no shut:

- DFB controller

6.16.20.14 OTDR Auto-scan Results

In addition to the OTDR scan events that can be seen with the above-mentioned command:

```
show controller Ots 0/0/0/0 otdr-info Tx
```

the auto-scan has some additional info that can be seen with the:

```
RP/0/RP0/CPU0:maserati-1r-1-olt-c#sh olc otdr-status [controller Ots0/0/0/0]
[details]
Wed Jan  8 20:20:46.590 UTC

Controller                          : Ots0/0/0/0
OTDR Auto-scan Status               : COMPLETED
Auto-scan Rx Start Time             : 2025-01-08 08:44:51
Rx Status Detail                    : Completed on Span Up
Auto-scan Tx Start Time             : 2025-01-08 08:47:15
Tx Status Detail                    : Completed on Span Up
Raman Turn Up Fiber Check           : NA
Optical Span Status                 : Up
Trigger Event                       : Span Restore
```

Where:

`OTDR Auto-scan Status: [RUNNING|COMPLETED|DISABLED|IDLE|NA|FAILED]`

it shows the status of the overall autoscan that may have involved both RX and TX direction or RX only depending on the trigger event

`Auto-scan xx Start Time:  it’s the start time of the OTDR scan on RX or TX direction`

`xx Status Detail: [NA / “Waiting for OTDR Resource” / “Starting on Span Up in less than 'x' minutes” / “Starting on Span Down in less than 'x' minutes” / “Waiting Span Reservation”/ “Waiting Scan Completion on Span Up” / “Waiting Scan Completion on Span Down” / “Completed on Span Up” / “Completed on Span Down” / “Failed to Complete” [**] / “Failed due to Timeout”[**] / “Stopped”[**]`

```
/ "OTDR Resource Not Available" [**]/ "Span Reservation Failed"[**] /
"Communication Failed"[**]]
(**) in case one of this value the auto-scan will retry after a timeout
```

it's the status detail of the RX or TX direction scan status

Status Details (Anomalous conditions)	Description
<Stopped>	Last scan has been stopped.
<Failed due to Timeout>	Scan cannot be completed within the expected time.
<Communication Failed>	Not able to reserve the span due to communication channel failures.
<OTDR Resource Not Available>	Local OTDR resource busy.
<Span Reservation Failed>	Remote resource busy.
<Failed to Complete>	The OTDR scan on the Module completed with an ERROR code

Raman Turn Up Fiber Check: It reports the result of the GO/NO-GO check. This is not applicable for no raman span

```
Optical Span Status : [Up|Tx Down|Down|NA]
```

'Down' is shown on a node where an RX LOS has been detected and so this node shall run both RX and TX scan

'TX Down' is shown on a node where NO RX LOS has been detected but the indication of a fiber cut on the other direction (FEFI) has been received that is triggering scan only on TX

```
Trigger Event: [Manual|Span Restore|Span Fault|NA]
```

It specifies the event type that triggered the OTDR scan

In case 'details' option is done on the show command, these 3 additional fields are shown reporting these info related to the last completed auto-scan run.

```
Last Raman Turn Up Scan Time        : NA
Last Raman Turn Up Fiber Check      : NA
Last Trigger Event                  : NA
```

6.16.20.15 OTDR Baseline

The OTDR Baseline feature saves an OTDR scan as a reference for future comparison with next scan executed on the same optical span.

It is automatically activated once the auto-scan is enabled (CONP generates an XML with auto-scan enable at the end of provisioning).

At the completion of an auto-scan, if the scan completed successfully and none of these condition are present, the results (sor file and event list) are saved as baseline:

- No LOC alarm
- No Excess-Reflection OTDR alarm

The baseline is stored per port/direction providing OTDR Scan information such as, the scan timestamp, the SOR Filename, the ORL and the detected events.

To see the baseline results the show CLI command has been extended with a new flag 'baseline'

```
sh controller ots 0/0/0/0 otdr-info rx/tx baseline
```

In addition, in case the user wants to save a new baseline (that is to save the results of the latest OTDR scan as a Baseline), a new CLI command has been defined.

```
otdr-save-baseline controller ots 0/0/0/0 rx|tx
```

6.17 Default State of Ports on the Line Cards

The OLT Add-Drop Ports Modelled as controller `OTS 0/0/0/2-33` and CCMD-16 Controllers `OMS 0/<slot>/0/0`, `OCH 0/<slot>/0/1-16` come up in Automatic In-Service by Default. Any Fault Get Raised a Condition not as Alarm.

All Conditions is captured under "`show alarms brief card location 0/RP0/CPU0 conditions`"

Optionally the Ports that are Not used can be put to Shutdown state via below configuration.

```
Iosxr(config)#controller [OTS | OMS | OCH] R/S/I/P shutdown
```

6.17.1 Raman-turn-up Checks (OTDR go/no-go)

[Checks and rules are described in a separate document]

Raman pump powers can be very high, and a mechanism to avoid connectors/junctions damages is required. OTDR is used to assess the concentrated losses on the line, especially near the raman pumps, and to decide if pumps can be turned on or kept off.

Raman go/nogo check is performed at installation time and after every span repair; this is the typical loop:

1. Pumps are off (by default system starts from a fiber cut/everything down scenario).
2. Continuity checks are performed. The sequence proceeds only when loop is closed.
3. If Raman is installed, RX span is measured with OTDR. If OTDR auto-scan on fiber repair is enabled, only one scan is performed.
4. Event list is evaluated accordingly to the rules described in the shared document.
5. If checks succeed, pumps are enabled and reach their target power.

User interface/CLI

CLI config to enable/disable the feature:

```
optical-line-control controller ots <ctrl-#> otdr raman-turn-up
<enable/disable>
```

CLI config to set relaxation factor:

```
optical-line-control controller ots <ctrl-#> otdr raman-turn-up relaxation-
factor <0-100>
```

Turn-up results: alarm "*RAMAN-TURNUP-FAIL - Raman Pumps Turnup Fail*" is raised if check failed.

Check results are embedded in regular `show otdr` command:

```
show controllers ots <ctrl-#> otdr-info rx
```

Each blocking event is marked, and the risk factor of the event is shown.

If relaxation factor is changed the events are immediately re-evaluated. If the new factor would make checks fail but pumps are on, they are not turned down.

6.18 OSC

6.19 Raman Safety Control Algorithm

6.19.1 Raman Safety Overview

This chapter describes the Automatic Laser Shutdown feature of the Raman pumps.

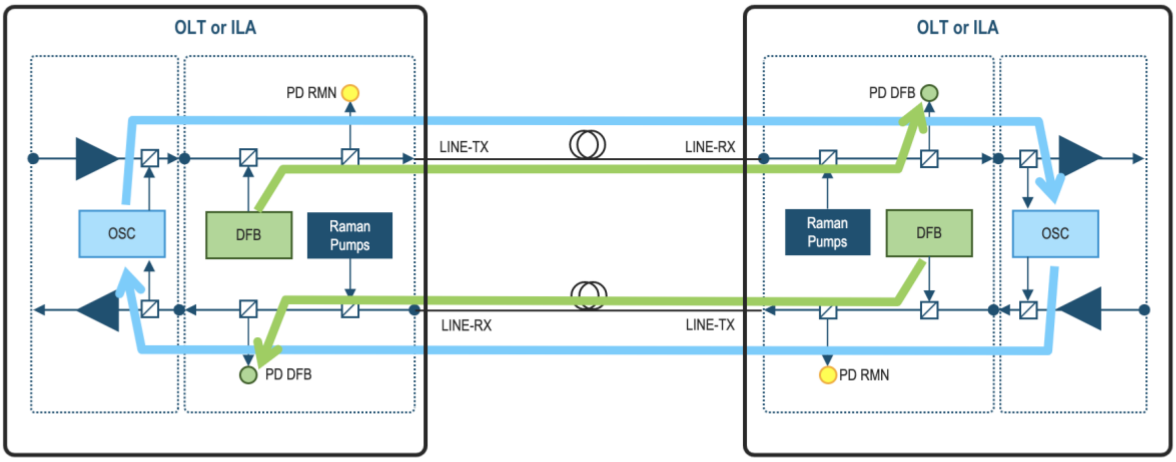
The Raman ALS is based on the detection of two independent probing signals:

- The Optical Service Channel (OSC), operating at 1510 nm
- A dedicated probing CW signal, named “DFB” in this document, operating at 1568.77nm

Both signals are co-propagating with the payload, and counter-propagating with the Raman pumps.

The Received power and the “OSNR” of both signals are continuously monitored by dedicated photodiodes, and the received values are compared with Fail Thresholds.

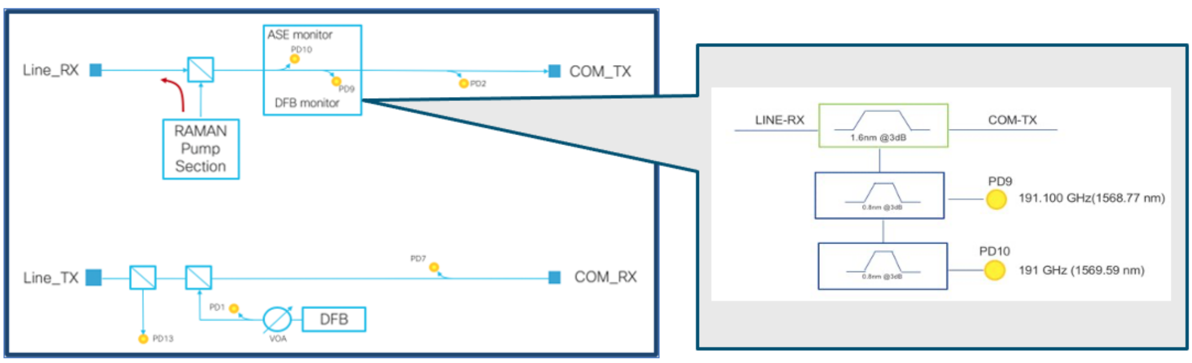
The monitoring of the signal “OSNR” (namely, OSC_Diff and DFB_Diff in the rest of the document) becomes necessary in Raman applications due to the In-band ASE generated by the Raman pump; more about it in the following paragraphs.



6.19.2 Probe Photodetectors

The presence of each probing signal, OSC and DFB, is monitored by means of two independent photodiodes.

Consider the diagram below, which provides a detail of the DFB detectors in the Raman module:



- Photodiode #9 is monitoring the received power probe signal

- Photodiode #10 is monitoring the received power of the ASE adjacent to the probe signal

The difference between the two readings provides an indication of probe "OSNR":

DFB_Diff = DFB_Received_Power – ASE_Received_Power = PD9 – PD10

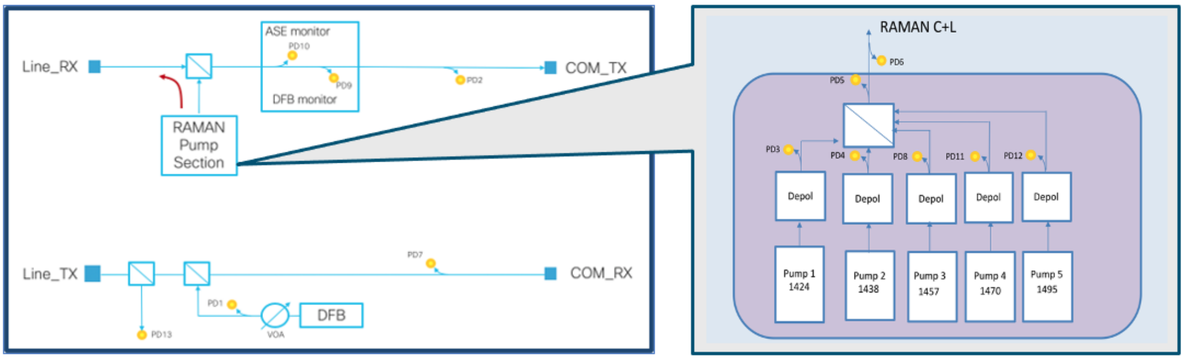
In case of fiber cut, while the power of the Raman ASE can be sufficient to light up PD9, making difficult to define a suitable fail threshold, the value of DFB_Diff drops to 0dB, a condition that can be safely detected through threshold crossing.

Similar detection scheme is implemented for the OSC signal.

OSC_Diff = OSC_Received_Power – ASE_Received_Power

6.19.3 Raman Back-Reflection Detection

The optical diagram below highlights how the back-reflection monitor is implemented:



- Photodiode#5 measured the aggregated Raman Pump power injected in line at LINE_RX connector.

- Photodiode#6 measures the reflect power, still at LINE_RX connector.

Raman Back Reflection is defined as the difference between the two photodiodes:

RAMAN_BR = Reflected_Power – Transmitted_power = PD6 – PD5

6.19.4 Raman ALS Triggers

The Automatic Laser Shutdown of the Raman pumps is activated in any of the following cases:

- Detection of Loss of Continuity of the line (e.g., a fiber cut).
- Significant drop of the received power of the probe signal (OSC and DFB), e.g. in case of the output fiber being accidentally bended.
- Excessive line-card connector Back-Reflection, like in case of open connector or significantly contaminated.

The following table provides a comprehensive summary of the ALS conditions:

Raman ALS is triggered if any of the following is true:	Condition	Notes
Loss of Continuity	DFB_Diff_Fail AND OSC_Diff_Fail	DFB_Diff_Fail: DFB_DIff < 8dB OSC_Diff_Fail: OSC_DIff < 8dB
Drop in Received power	DFB_Drop AND OSC_Drop	DFB_Drop: DFB_Power (Baseline – Current) > 10dB OSC_Drop: OSC_Power (Baseline – Current) > 10dB
Excessive Back-Reflection	RAMAN_BR_Fail	RAMAN_BR_Fail: Reflected power – Transmitted power > -17dB

6.19.5 Threshold Setting at Installation

Default threshold values of DFB-Diff, OSC-Diff and RAMAN_BR are compatible with the supported span reach, and do not require fine-tuning in field.

On the contrary, the threshold of DFB_Drop and OSC_Drop depends directly on the working conditions (span loss and Raman Gain) and should be provisioned by the user during installation.

Here below the suggested procedure:

The values of the Factory Default thresholds (< -40dBm) do not to prevent the fisrt Raman turn-up

Once Raman tuning procedure has completed, user shall record the received power of DFB and OSC: this represent the day-0 baseline, against which variations are monitored.

Fail thresholds should be set typically 10dB lower than the baseline value:
DFB_Power_Fail = DFB_RX_Baseline – 10dB
OSC_Power_Fail = OSC_RX_Baseline – 10dB

6.20 Optical Return Loss and Auto Power Reduction Feature (including alarm)

Optical Return Loss Computation Detailed in Section 10.12.7 Total ORL. The ORL measured is available in OTDR Scan Data CLI interface presented below:

```
RP/0/RP0/CPU0:OLT-1#sh controllers OTS 0/0/0/0 otdr-info rx
Mon Feb  5 21:15:12.372 IST
         Scan Direction: RX
         Scan Status: Data Ready
         Optical Return Loss: 40.0 dB
         SOR file: /harddisk:/otdr/OLT-1_NCS1010_OTDR_Ots0_0_0_0_RX_20240201-
215505.sor
         Total Events detected: 5
```

```
        Scan Timestamp: Thu Feb  1 21:55:05 2024 UTC
        Event Type Legend:  NR:Non-Reflective  R:Reflective  FE:Fiber-
End  ER:Excess-Reflection EA:Excess-Attenuation
        Event#       |  Detected
Event(s)        |  Location(m)      |  Accuracy(m)      |  Magnitude(dB)    |  Atte
nuation/km(dB)
        1           |  NR                        |  4.4000           |  2.00
      |  0.72             |  0.00
        2           |  R                         |  50494.4600       |  52.49
      |  -30.51           |  0.19
        3           |  NR                        |  50494.4600       |  52.49
      |  1.15             |  0.19
        4           |  R
FE                   |  100997.5900     |  102.99          |  -
27.75          |  0.19
```

ORL Exceeding threshold Raise Following Alarm: OTDR-ABS-ORL-EXCEEDED-RX/ OTDR-ABS-ORL-EXCEEDED-TX. Default Threshold : 10 dB

APR (Automation Power Reduction) is used at start-up during Back Reflection check. After Power On or after Shutdown, (after Card_ready time at Power On / immediately, after shutdown), the Line Card Module will check the APS condition. If APS condition is false, the EDFA will turn on and permanently stay in APR mode, while Back Reflection is not above fail high threshold. In APR, the EDFA operates in Constant Output Power mode. While in APR, the Output Power setpoint shall be default +8dBm. APR condition can be set even when the APS condition is true, by Configuring the Below Command on IOSXR.

```
RP/0/RP0/CPU0:OLT-1(config)#controller OTS 0/0/0/0 egress-ampli-force-apr on

RP/0/RP0/CPU0:ILA-1(config)#controller OTS 0/0/0/0 egress-ampli-force-apr  on
RP/0/RP0/CPU0:ILA-1(config)#controller OTS 0/0/0/2 egress-ampli-force-apr on
```

Alarm Raised when EDFA Set in APR Mode : EGRESS-AUTO-POW-RED

Alarm Raised when EDFA detects high back reflection: HIGH-TX-BR-PWR

6.21 Target Control and Related Alarms

6.21.1 OLC: SPANLOSS CLI & ALARMS

6.21.2 Span-loss operational cli : "*show olc span-loss*"

For EDFA-only Node (24.4.15)

```
RP/0/RP0/CPU0:NCS1020_P1B_06#show olc span-loss
Thu Jan 23 17:48:43.525 IST

Controller                                   : Ots0/0/0/0
Neighbour RID                                : 24.1.1.7
Rx Span Loss                                 : 12.63 dB
Rx OSC Span Loss                             : 13.93 dB
Rx Signal Span Loss                          : 12.64 dB
Rx Span Loss (with pumps off)                : NA
Estimated Rx Span Loss                       : NA
Tx Span Loss                                 : 11.75 dB
Tx OSC Span Loss                             : 12.74 dB
Tx Signal Span Loss                          : 11.84 dB
Tx Span Loss (with pumps off)                : NA
Estimated Tx Span Loss                       : NA
```

6.21.2.1 Span-loss config cli – Threshold Configuration

This will come from CONP. An example given in case if user prefers to change it later to new value.

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#min-baseline-deviation 5
(config-olc-ots)#max-baseline-deviation 35
(config-olc-ots)#commit
```

6.21.2.2 Alarm Related to Span-loss

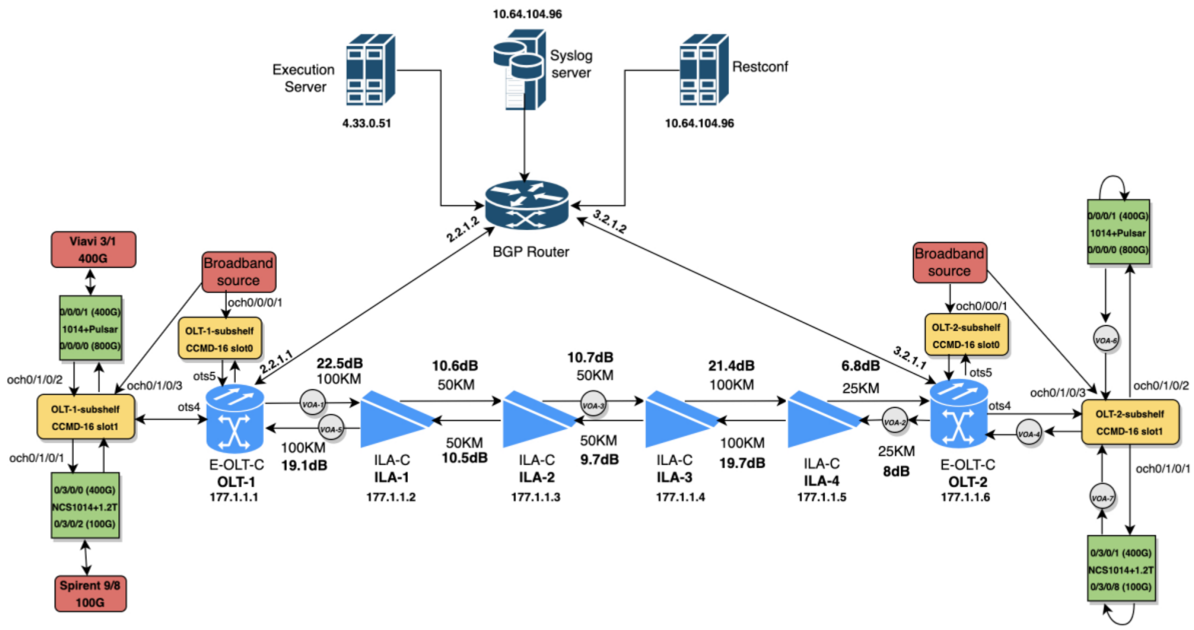
“show alarms brief system active | Include Span Loss”

The Span-loss Out of Range alarm is raised when the measured span loss is crossed minimum or maximum threshold

```
show alarms brief system active | include Span Loss

0/0/NXR0        Minor        Software        12/18/2023 01:30:59
IST    Ots0/0/0/0 - Rx span loss deviated from baseline
```

6.21.3 OLC: APC CLI

6.21.3.1 APC operational CLI




```
RP/0/RP0/CPU0:OLT-1#show olc apc
Fri Feb  9 23:07:08.234 IST
Controller        : Ots0/0/0/0
APC Status        : MANUAL
```

<u>On OLT</u>

```
RP/0/RP0/CPU0:OLT-1#show olc apc-local
Fri Feb  9 23:07:11.510 IST
Controller :  Ots0/0/0/0
Tx Status : SPAN-MODE
Rx Status : SPAN-MODE
```

<u>On ILA</u>

```
RP/0/RP0/CPU0:ILA-1#show olc apc-local
Fri Feb  9 23:08:05.021 IST
Controller :  Ots0/0/0/0
Tx Status : SPAN-MODE
Controller :  Ots0/0/0/2
Tx Status : SPAN-MODE
```

6.21.3.2 APC operational cli – PSD profile

“show olc apc-local target-psd-profile"

- PSD profile cli display the PSD and the respective frequency range:
- If link tuner is active the CLI output indicates the same under “Target PSD source”
- If link tuner is DISABLED, the Target PSD source indicates “**Configuration”**

```
RP/0/RP0/CPU0:OLT-1#show olc apc-local target-psd-profile
Fri Feb  9 23:09:33.060 IST
Controller          : Ots0/0/0/0
Target PSD source   : Link Tuner
      ---------------------------------------------------------------------------------
Setpoint                Frequency                         Target PSD
                          (THz)                         (dBm/12.5 GHz)
----------------------------------------------------------------------------
---
01                    191.375000                           -6.2
02                    191.525000                           -6.1
03                    191.675000                           -6.1
04                    191.825000                           -6.0
05                    191.975000                           -5.9
06                    192.125000                           -5.9
07                    192.275000                           -5.8
08                    192.425000                           -5.7
09                    192.575000                           -5.6
10                    192.725000                           -5.6
11                    192.875000                           -5.5
12                    193.025000                           -5.4
13                    193.175000                           -5.3
14                    193.325000                           -5.3
15                    193.475000                           -5.2
16                    193.625000                           -5.1
17                    193.775000                           -5.1
18                    193.925000                           -5.0
19                    194.075000                           -4.9
20                    194.225000                           -4.8
21                    194.375000                           -4.8
22                    194.525000                           -4.7
23                    194.675000                           -4.6
24                    194.825000                           -4.5
25                    194.975000                           -4.5
26                    195.125000                           -4.4
27                    195.275000                           -4.3
28                    195.425000                           -4.3
29                    195.575000                           -4.2
30                    195.725000                           -4.1
31                    195.875000                           -4.0
32                    196.025000                           -4.0
33                    196.175000                           -3.9
```

6.21.3.3 APC operational cli – Tx Direction

“show olc apc-local regulation-info controller ots 0/0/0/0 tx”

```
RP/0/RP0/CPU0:OLT-1#show olc apc-local regulation-info controller ots 0/0/0/0 tx
Fri Feb  9 23:22:55.222 IST
Controller                                  : Ots0/0/0/0
Domain Manager                              : NA
Mode                                        : Span-Mode APC
Status                                      : IDLE
Direction                                   : Tx
PSD Minimum                                 : -22.5 (dBm/12.5 GHz)
Gain Range                                  : Normal
Last Correction                             : 2024-02-09 15:42:54
```

```
Last Span-Loss Input                       : NA
Last Span-Loss Input Timestamp             : NA
Residual Discrepancy from Previous Node    : NA
Residual Discrepancy Input Timestamp       : NA
Span-Loss Correction Threshold             : 0.2 dB
Correction Tolerance                       : 0.5 dB
```

Device Parameters		Min	Max	Configuration	Operational
Egress Ampli Gain (dB)	:	16.0	30.0	18.7	18.7
Egress Ampli Tilt (dB)	:	-5.0	4.2	-2.3	-2.3
Tx Ampli Power (dBm)	:	-	23.0	-	22.7
Tx VOA Attenuation (dB)	:	0.0	15.0	2.1	2.1
Egress WSS/DGE Attenuation (dB)	:	0.0	25.0	-	-

Channel Center Frequency (THz)	Channel Width (GHz)	Channel ID	Channel Source	Spectrum Slice Num	Ampli-Input PSD (dBm/12.5 GHz)	Target PSD (dBm/12.5 GHz)	Current PSD (dBm/12.5 GHz)	Discrepancy (dB)	Channel Slice Attn Config (dB)
191.425000	150.00	1	OCh	29	-21.2	-6.2	-6.3	0.1	12.8
191.575000	150.00	2	OCh	77	-21.3	-6.1	-6.1	0.0	10.0
191.725000	150.00	3	OCh	125	-21.5	-6.1	-6.1	0.0	9.9
191.875000	150.00	4	OCh	173	-21.5	-6.0	-6.0	0.0	9.6
192.025000	150.00	5	OCh	221	-21.5	-5.9	-5.9	0.0	9.6
192.175000	150.00	6	OCh	269	-21.6	-5.9	-5.9	0.0	9.7
192.325000	150.00	7	OCh	317	-21.6	-5.8	-5.8	0.0	9.7
192.475000	150.00	8	OCh	365	-21.5	-5.7	-5.7	0.0	9.4
192.625000	150.00	9	OCh	413	-21.4	-5.6	-5.6	0.0	9.0
192.775000	150.00	10	OCh	461	-21.5	-5.6	-5.6	0.0	8.9
192.925000	150.00	11	OCh	509	-21.5	-5.5	-5.5	0.0	8.6
193.075000	150.00	12	OCh	557	-21.5	-5.4	-5.4	0.0	8.4
193.225000	150.00	13	OCh	605	-21.4	-5.3	-5.3	0.0	8.3
193.375000	150.00	14	OCh	653	-21.5	-5.3	-5.4	0.1	8.3
193.525000	150.00	15	OCh	701	-21.4	-5.2	-5.2	0.0	8.2
193.675000	150.00	16	OCh	749	-21.3	-5.1	-5.1	0.0	7.8
193.825000	150.00	17	OCh	797	-21.5	-5.1	-5.1	0.0	7.8
193.975000	150.00	18	OCh	845	-21.3	-5.0	-5.0	0.0	7.5
194.125000	150.00	19	OCh	893	-21.4	-4.9	-4.9	0.0	7.7
194.275000	150.00	20	OCh	941	-21.5	-4.8	-4.9	0.0	11.5
194.425000	150.00	21	OCh	989	-21.4	-4.8	-4.8	0.0	7.8
194.575000	150.00	22	OCh	1037	-21.5	-4.7	-4.8	0.1	8.0
194.725000	150.00	23	OCh	1085	-21.4	-4.6	-4.6	0.0	7.9
194.875000	150.00	24	OCh	1133	-21.3	-4.5	-4.5	0.0	7.7
195.025000	150.00	25	OCh	1181	-21.4	-4.5	-4.5	0.0	7.3
195.175000	150.00	26	OCh	1229	-21.4	-4.4	-4.3	0.0	6.7
195.325000	150.00	27	OCh	1277	-21.5	-4.3	-4.3	0.0	6.3
195.475000	150.00	28	OCh	1325	-21.7	-4.3	-4.3	0.0	5.9
195.625000	150.00	29	OCh	1373	-21.8	-4.2	-4.2	0.0	5.5
195.775000	150.00	30	OCh	1421	-22.1	-4.1	-4.1	0.0	5.3
195.925000	150.00	31	OCh	1469	-22.3	-4.0	-4.0	0.0	5.8
196.075000	150.00	32	OCh	1517	-22.4	-4.0	-4.0	0.0	6.5

```
ASE - Noise Loaded Channel

OCh - Optical Channel
```

6.21.3.4 APC operational cli – Rx Direction

"show olc apc-local regulation-info controller ots 0/0/0/0 rx"

```
RP/0/RP0/CPU0:OLT-1#show olc apc-local regulation-info controller ots 0/0/0/0
rx

Fri Feb  9 23:25:28.815 IST

Controller                                 : Ots0/0/0/0

Domain Manager                             : NA

Mode                                       : Span-Mode APC

Status                                     : IDLE

Direction                                  : Rx

PSD Minimum                                : NA

Gain Range                                 : Extended

Last Correction                            : 2024-02-09 21:20:36

Last Span-Loss Input                       : 19.8 dB

Last Span-Loss Input Timestamp             : 2024-02-09 18:46:31

Residual Discrepancy from Previous Node    : 0.0 dB
```

```
Residual Discrepancy Input Timestamp      : 2024-02-09 21:33:33
Span-Loss Correction Threshold            : 0.2 dB
Correction Tolerance                      : 0.5 dB

  Device Parameters                         Min          Max          Configuration            Operational
=============================================================================================================
  Ingress Ampli Gain (dB)            :      20.0         38.0         25.1                     25.1
  Ingress Ampli Tilt (dB)            :      -5.0         5.0          -0.4                     -0.4
  Rx  Ampli Power (dBm)              :       -           25.0          -                       24.9
  Rx  VOA Attenuation (dB)           :      0.0          0.0          0.0                      0.0
  Ingress WSS/DGE Attenuation (dB)   :      0.0          25.0          -                        -

  Channel Center    Channel     Channel     Channel     Spectrum       Ampli-Input      Target          Current         Discrepancy     Channel Slice
    Frequency        Width        ID        Source      Slice Num         PSD             PSD             PSD                           Attn Config
      (THz)          (GHz)                                            (dBm/12.5 GHz) (dBm/12.5 GHz)  (dBm/12.5 GHz)        (dB)            (dB)
=========================================================================================================================================================
   191.425000       150.00       1          -            29            -25.9           -9.5            -9.5            0.0             4.6
   191.575000       150.00       2          -            77            -25.6           -17.0           -16.9           -0.1            12.7
   191.725000       150.00       3          -            125           -26.2           -17.0           -17.1           0.0             12.2
   191.875000       150.00       4          -            173           -25.4           -17.0           -16.8           -0.1            12.6
   192.025000       150.00       5          -            221           -26.1           -17.0           -17.1           0.0             12.2
   192.175000       150.00       6          -            269           -25.6           -17.0           -16.8           -0.2            12.4
   192.325000       150.00       7          -            317           -26.2           -17.0           -17.2           0.1             12.2
   192.475000       150.00       8          -            365           -25.4           -17.0           -16.8           -0.1            12.6
   192.625000       150.00       9          -            413           -26.2           -17.0           -17.2           0.2             12.3
   192.775000       150.00       10         -            461           -25.7           -17.0           -16.9           0.0             12.5
   192.925000       150.00       11         -            509           -26.0           -17.0           -17.1           0.0             12.4
   193.075000       150.00       12         -            557           -25.5           -17.0           -16.9           -0.1            12.7
   193.225000       150.00       13         -            605           -25.9           -17.0           -17.0           0.0             12.5
   193.375000       150.00       14         -            653           -25.5           -17.0           -16.9           -0.1            12.7
   193.525000       150.00       15         -            701           -25.8           -17.0           -16.9           -0.1            12.4
   193.675000       150.00       16         -            749           -25.5           -17.0           -17.1           0.0             12.9
   193.825000       150.00       17         -            797           -25.9           -17.0           -17.1           0.1             12.5
   193.975000       150.00       18         -            845           -25.4           -17.0           -17.1           0.0             12.9
   194.125000       150.00       19         -            893           -25.8           -17.0           -16.9           -0.1            12.4
   194.275000       150.00       20         -            941           -25.7           -9.5            -9.4            -0.1            4.7
   194.425000       150.00       21         -            989           -25.7           -17.0           -16.8           -0.2            12.4
   194.575000       150.00       22         -            1037          -26.0           -17.0           -17.1           0.1             12.5
   194.725000       150.00       23         -            1085          -25.9           -17.0           -16.9           -0.1            12.4
   194.875000       150.00       24         -            1133          -26.1           -17.0           -17.0           0.0             12.4
   195.025000       150.00       25         -            1181          -25.8           -17.0           -17.0           0.0             12.7
   195.175000       150.00       26         -            1229          -26.3           -17.0           -17.0           0.0             12.0
   195.325000       150.00       27         -            1277          -26.0           -17.0           -17.0           0.0             12.3
   195.475000       150.00       28         -            1325          -26.2           -17.0           -16.9           0.0             12.0
   195.625000       150.00       29         -            1373          -25.8           -17.0           -17.2           0.1             12.7
   195.775000       150.00       30         -            1421          -26.0           -17.0           -17.1           0.1             12.5
   195.925000       150.00       31         -            1469          -26.1           -17.0           -17.0           0.0             12.6
   196.075000       150.00       32         -            1517          -26.0           -17.0           -16.9           0.0             12.8
```

ASE - Noise Loaded Channel

OCh - Optical Channel

APC config manual/enable/disable:

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#apc manual ----> Change this to enable/disable to
Enable/Disable APC
(config-olc-ots)#commit
```

APC PSD config of 33 slices:

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#psd 1 -30
(config-olc-ots)#psd 2 -50
(config-olc-ots)#psd 3 -40
(config-olc-ots)#!
(config-olc-ots)#!
(config-olc-ots)#psd 33 -70
```

```
(config-olc-ots)#commit
```

APC Drop-PSD config:

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/4
(config-olc-ots)#drop-psd  -50
```

APC PSD-min config

Default PSD min is -24dBm

```
RP/0/RP0/CPU0:OLT-1(config)#optical-line-control controller ots 0/0/0/0
RP/0/RP0/CPU0:OLT-1(config-olc-ots)#psd-min ?
  <-400,+230>  Enter the psd in range -40.0 dBm per 12.5 GHz to 23.0 dBm per
12.5 GHz in increments of 0.1 dBm per 12.5 GHz.
RP/0/RP0/CPU0:OLT-1(config-olc-ots)#psd-min -220
RP/0/RP0/CPU0:OLT-1(config-olc-ots)#commit
```

APC Pause-APC config

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#apc-pause ---> no apc-pause to remove
(config-olc-ots)#commit
```

6.21.4 OLC: APC Alarms

Taken from different nodes to show the possible alarms. This doesn't mean all these alarms will co-exist. Blocked alarm will mask the Out-of-Range alarm for example.

Alarm Name	Alarm Description	Severity
APC blocked in TX direction	APC-BLOCKED-TX	Minor
APC blocked in RX direction	APC-BLOCKED-RX	Minor
APC Reached out-of-range condition in TX direction	APC-OUT-OF-RANGE-TX	Minor
APC Reached out-of-range condition in RX direction	APC-OUT-OF-RANGE-RX	Minor
Rx span loss deviated from baseline	SPAN-LOSS-BASELINE-DEVIATION-OUT-OF-RANGE	Minor
APC Target PSD not met in TX direction	APC-TARGET-PSD-NOT-MET-TX	Minor

APC Target PSD not met in RX direction	APC-TARGET-PSD-NOT-MET-RX	Minor

6.21.5 OLC: RAMAN TUNING CLI

6.21.5.1 Raman Tuning Enable/Disable

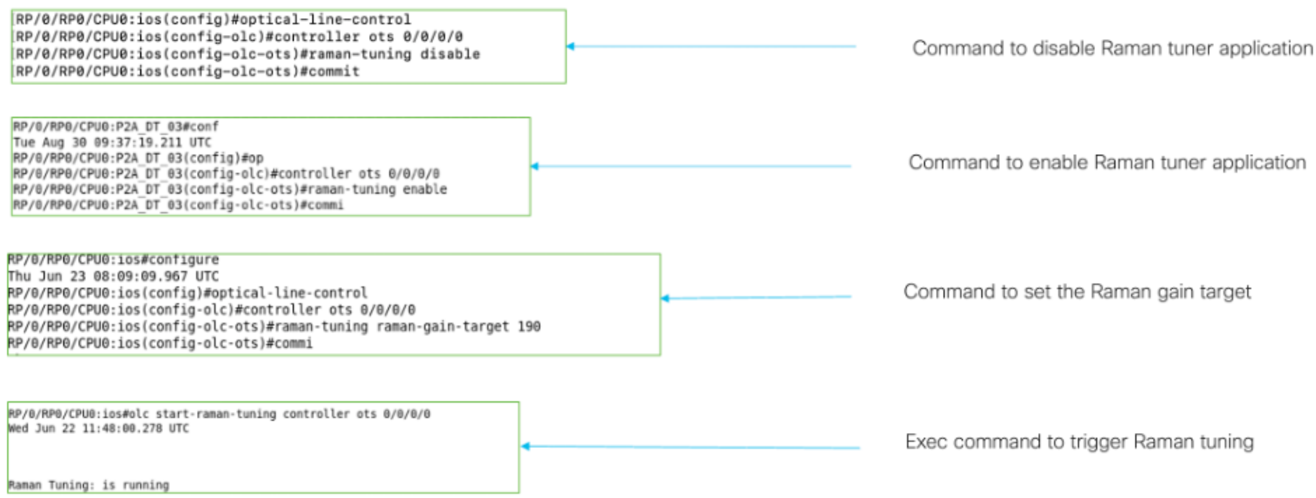
```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#raman-tuning disable (Use enable to re-enable the Raman Tuning)
(config-olc-ots)#commit
```

6.21.5.2 Raman Gain Target Config

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#raman-tuning raman-gain-target 190
(config-olc-ots)#commit
```

6.21.5.3 CLI to Force Raman Tuning

"olc start raman-tuning controller ots 0/0/0/0"



6.21.5.4 Raman Tuning Operational CLI for OLT-C-R ILA-C-R & ILA-C-2R

"show olc raman-tuning"

```
RP/0/RP0/CPU0:ios#show olc raman-tuning
Thu Jun 23 12:12:39.161 UTC

Controller                       : Ots0/0/0/0
Raman-Tuning Status              : TUNED
Tuning Complete Timestamp        : 2022-06-23 12:09:39
Estimated Max Possible Gain      : 19.8 dB
Raman Gain Target                : 15.8 dB
Gain Achieved on Tuning Complete : 15.6 dB
```

Raman Tuner output in ILA-C-2R node

```
RP/0/RP0/CPU0:ios#show olc raman-tuning
Wed Jun 22 08:18:20.090 UTC

Controller                       : Ots0/0/0/0
Raman-Tuning Status              : TUNED
Tuning Complete Timestamp        : 2022-06-21 06:01:52
Estimated Max Possible Gain      : 21.5 dB
Raman Gain Target                : 16.0 dB
Gain Achieved on Tuning Complete : 16.0 dB


Controller                       : Ots0/0/0/2
Raman-Tuning Status              : TUNED
Tuning Complete Timestamp        : 2022-06-20 09:20:20
Estimated Max Possible Gain      : 21.8 dB
Raman Gain Target                : 16.0 dB
Gain Achieved on Tuning Complete : 15.4 dB
```

6.21.6 OLC: RAMAN TUNING ALARMS

```
RP/0/RP0/CPU0:ios#show alarms brief system active | include Raman
Wed Jun 22 11:55:22.167 UTC
0/0/NXR0        Major        Software        06/22/2022 11:47:31 UTC    Ots0/0/0/0 - Raman Tuning procedure is running
```

Alarm is declared while Raman tuning is initiated and is in progress.
Alarm will clear once the Raman tuner completes tuning

```
RP/0/RP0/CPU0:ios#show alarms brief system active | include Raman
Wed Jun 22 11:57:11.892 UTC
0/0/NXR0        NotAlarmed   Software        06/22/2022 11:57:06 UTC    Ots0/0/0/0 - Raman Tuning procedure has failed
```

Alarm is declared when Raman Tuner run is BLOCKED due to issue in a span like High BR/fiber fail/DFB fail etc
Alarm will clear once the user clears the issue blocking Raman tuner run.

```
RP/0/RP0/CPU0:ios#show alarms brief system active | inc Raman
Thu Jun 23 08:18:04.525 UTC
0/0/NXR0        NotAlarmed   Software        06/23/2022 08:17:30 UTC    Ots0/0/0/0 - Raman Tuning Gain Unreachable
```

Alarm is declared when Raman Tuner cannot achieve the target gain set by user or the algorithm itself
For the alarm to declare, the difference between the Raman Gain Target and Gain Achieved should be > 3.5dB
Alarm will clear once the difference comes below 3dB

6.21.7 OLC: Link Tuner & Gain Estimator CLI

6.21.7.1 Link Tuner Operational CLI

"`show olc link-status`*" (*) and for more details "*`show olc link-status details`*"(*)*

```
RP/0/RP0/CPU0:NCS1020_P1D_04#show olc link-status
Thu Jan 23 18:21:30.322 IST

Controller              : Ots0/0/0/0
Status                  : OPERATIONAL
Last Update             : 2025-01-23 16:25:27

Node RID 24.1.1.1
-------------------------------------
                                C-Band
Controller                   Ots0/0/0/0
Link Tuner Status                MANUAL
Tx Ampli Power (dBm)               22.4
-------------------------------------
PSD (dBm/12.5 GHz)          Single Band
Average                            -6.5

Node RID 24.1.1.2
-------------------------------------
                                C-Band
Controller                   Ots0/0/0/2
Link Tuner Status                MANUAL
Gain Estimator Status            MANUAL
Tx Ampli Gain Mode             Extended
Tx Ampli Power (dBm)               22.2
-------------------------------------
PSD (dBm/12.5 GHz)          Single Band
Average                            -4.1

Node RID 24.1.1.3
-------------------------------------
                                C-Band
Controller                   Ots0/0/0/2
Link Tuner Status                MANUAL
Gain Estimator Status            MANUAL
Tx Ampli Gain Mode             Extended
Tx Ampli Power (dBm)               23.0
-------------------------------------
PSD (dBm/12.5 GHz)          Single Band
Average                            -4.1

Node RID 24.1.1.4
-------------------------------------
                                C-Band
Controller                   Ots0/0/0/2
Link Tuner Status                MANUAL
Gain Estimator Status            MANUAL
Tx Ampli Gain Mode               Normal
Tx Ampli Power (dBm)               23.0
-------------------------------------
PSD (dBm/12.5 GHz)          Single Band
Average                            -4.1

Node RID 24.1.1.5
-------------------------------------
                                C-Band
Controller                   Ots0/0/0/0
Gain Estimator Status            MANUAL
Rx Ampli Gain Mode               Normal
```

6.21.7.2 Link Tuner Operational CLI

"`show olc link-tuner`"

```
RP/0/RP0/CPU0:NCS1020_P1D_04#show olc link-tuner
Thu Jan 23 18:21:42.938 IST
Controller           : Ots0/0/0/0
Config Mode          : MANUAL
Link Tuner Status    : IDLE
Last PSD computation: 2025-01-23 16:59:23
----------------------------------------------------------------------
Single Band
----------------------------------------------------------------------
Setpoint             : Computed PSD
                      (dBm/12.5 GHz)
----------------------------------------------------------------------
01                    -7.4
02                    -7.3
03                    -7.3
04                    -7.2
05                    -7.2
06                    -7.1
07                    -7.1
08                    -7.0
09                    -7.0
10                    -6.9
11                    -6.8
12                    -6.8
13                    -6.7
14                    -6.7
15                    -6.6
16                    -6.6
17                    -6.5
18                    -6.5
19                    -6.4
20                    -6.4
21                    -6.3
22                    -6.3
23                    -6.2
24                    -6.2
25                    -6.1
26                    -6.1
27                    -6.0
28                    -5.9
29                    -5.9
30                    -5.8
31                    -5.8
32                    -5.7
33                    -5.7
```

6.21.7.3 Gain Estimator Operational CLI - Agent

“show olc gain-estimator”

```
RP/0/RP0/CPU0:NCS1020_P1B_06#show olc gain-estimator
Thu Jan 23 18:13:11.844 IST
Controller                        : Ots0/0/0/0
Config Mode                       : MANUAL
Ingress Gain Estimator Status     : IDLE
Ingress Estimated Gain            : 20.1 dB
Ingress Estimated Gain Mode       : Extended
Ingress Gain Estimation Timestamp : 2025-01-21 14:28:30
```

Gain Estimator Status:

- IDLE - Gain estimator was able to compute and configure gain & gain mode
- DISABLED – Gain estimator is disabled
- BLOCKED – Gain estimator is blocked due to pre-condition not met

Gain Estimator Configuration

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)# gain-estimator manual (use disable to disable the link tuner)
(config-olc-ots)#commit
```

6.21.7.4 OLC: Link Tuner & Gain Estimator

Link Tuner Enable/Disable:

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#link-tuner manual (use disable to disable the link tuner)
(config-olc-ots)#commit
```

Parameter Config

```
(config)#optical-line-control
(config-olc)#controller ots 0/0/0/0
(config-olc-ots)#fiber-type ? --> It will list the Options for different fibers
(config-olc-ots)#connector-loss tx ? --->It will list the options for TX range
(config-olc-ots)#connector-loss rx ? ---> It will list the options for RX range
(config-olc-ots)#link-tuner spectrum density ?
(config-olc-ots)#commit
```

```
RP/0/RP0/CPU0:NCS1020_P1D_04(config)#optical-line-control
RP/0/RP0/CPU0:NCS1020_P1D_04(config-olc)#controller Ots 0/0/0/0
RP/0/RP0/CPU0:NCS1020_P1D_04(config-olc-ots)#fiber-type ?
  E-LEAF       Type E-LEAF
  FREE-LIGHT   Type FREE-LIGHT
  METRO-CORE   Type METRO-CORE
  SMF          Type SMF
  SMF-28E      Type SMF-28E
  TERA-LIGHT   Type TERA-LIGHT
  TW-Classic   Type TW-Classic
  TW-RS        Type TW-RS
  TW-Reach     Type TW-Reach
  TW-minus     Type TW-minus
  TW-plus      Type TW-plus
  ULL-SMF28    Type ULL-SMF28

RP/0/RP0/CPU0:NCS1020_P1D_04(config)#optical-line-control
RP/0/RP0/CPU0:NCS1020_P1D_04(config-olc)#controller Ots 0/0/0/0
RP/0/RP0/CPU0:NCS1020_P1D_04(config-olc-ots)#link-tuner spectrum-density ?
  <1-100>  Enter spectrum density in range 1 to 100 in increments of 1
```

6.22 Channel Groups and Management

Channel Creation – Configuration CLI

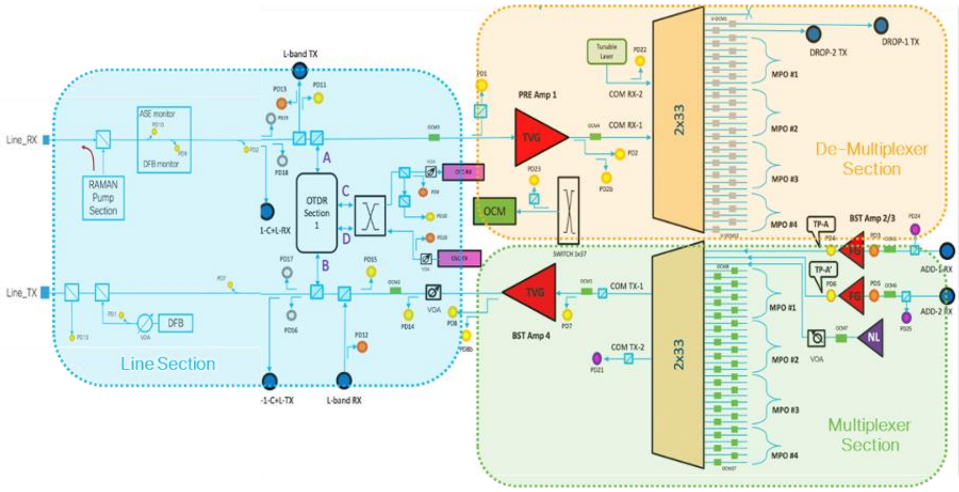
Configuring Channel & Associating to an ID

Channel ID: 1 | Channel: 191.375 Thz

```
hw-module location 0/0/NXR0
 terminal-ampli
  grid-mode flex
   channel-id 1 centre-freq 191.375 width 75
```

Create Cross Connect

```
controller Ots-Och0/0/0/0/1
 add-drop-channel Ots-Och0/0/0/31/1
```



Detailed Explanation: https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/77x/configuration/guide/b-ncs1010-dathpath-config-guide/m-ots.html

6.23 Connection Validation

Connection Validation: OLT to CCMD

Purpose

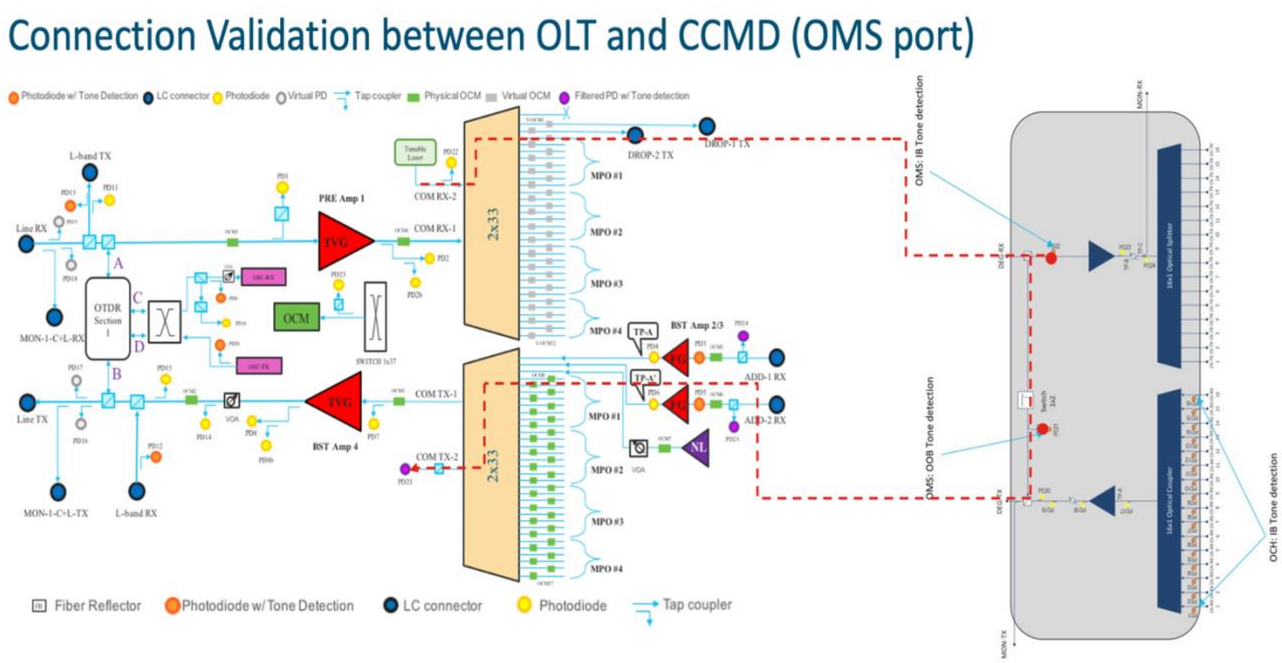
- Validate the connection between OLT and CCMD-16 module to avoid mis-cabling during node installation.

- Supports both OOB and IB tone detection
- CV uses low frequency ON/OFF modulation tone signal at OOB(191.175GHz) or IB frequency.

How it works?

1. Apply the tone related configuration on OLT add/drop OTS controller and corresponding CCMD OMS controller
2. Start tone pattern generation on OLT add/drop OTS controller
3. Start tone pattern detection on CCMD OMS controller
4. Start tone pattern detection on OLT add/drop OTS controller
5. Use tone-info command to check for successful connection verification on CCMD OMS or OLT OTS controller
6. Stop tone pattern detect on CCMD OMS controller
7. Stop tone pattern detect on OLT add/drop OTS controller
8. Stop tone pattern generation on OLT add/drop OTS controller

DETAILED DESCRIPTION (reference):
https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/77x/configuration/guide/b-ncs1010-dathpath-config-guide/m-verify-connection.html



CV from OLT to CCMD

Document link : [MSFT_ConnectionVerification.pptx]()

On OLT NODE:

```
RP/0/RP0/CPU0:(config)#controller ots 0/0/0/4
RP/0/RP0/CPU0:(config-Ots)#tone-rate 25
RP/0/RP0/CPU0:(config-Ots)#tone-frequency 191.175   ( OOB frequency )
RP/0/RP0/CPU0:(config-Ots)#tone-pattern abcd1234
RP/0/RP0/CPU0:(config-Ots)#commit
```

On CCMD NODE

```
RP/0/RP0/CPU0:(config)#controller oms 0/1/0/0
RP/0/RP0/CPU0:(config-Oms)#tone-rate 25
RP/0/RP0/CPU0:(config-Oms)#tone-pattern-expected abcd1234
RP/0/RP0/CPU0:(config-Oms)#tone-detect-oob
RP/0/RP0/CPU0:(config-Oms)#commit
```

On OLT NODE start the TONE Generation:

```
RP/0/RP0/CPU0:#tone-pattern controller ots 0/0/0/4 start
Tue May 10 11:37:51.597 UTC
Tone pattern started
```

On CCMD NODE, Start TONE detection:

```
RP/0/RP0/CPU0:#tone-pattern-detect controller oms 0/1/0/0 start
Tue May 10 11:38:03.775 UTC
Tone pattern detect started
```

On CCMD NODE : Query the Tone status

```
RP/0/RP0/CPU0:#show controllers oms 0/1/0/0 tone-info
Tue May 10 11:41:18.847 UTC
Tone Info:
Tone Rate : 25 bits/second
Tone Pattern Expected(Hex value) : abcd1234
Tone Pattern Received(Hex value) : abcd1234
Tone Detected OOB :  Enabled
Detection State: Success
```

CV from CCMD to OLT

On CCMD NODE Stop the TONE Detection

```
RP/0/RP0/CPU0:#tone-pattern-detect controller oms 0/1/0/0 stop
Tue May 10 11:50:36.185 UTC
Tone pattern detect stopped
```

On OLT NODE Stop the TONE Generation

```
RP/0/RP0/CPU0:#tone-pattern controller ots 0/0/0/4 stop
```

```
Tue May 10 11:50:45.837 UTC
```

Tone pattern stopped On OLT NODE:

```
RP/0/RP0/CPU0:(config)#controller ots 0/0/0/4
RP/0/RP0/CPU0:(config-Ots)#tone-rate 25
RP/0/RP0/CPU0:(config-Ots)#tone-frequency 191.175   ( OOB frequency )
RP/0/RP0/CPU0:(config-Ots)#tone-pattern abcd1234
RP/0/RP0/CPU0:(config-Ots)#tone-pattern-expected abcd1234
RP/0/RP0/CPU0:(config-Ots)#tone-detect-oob
RP/0/RP0/CPU0:(config-Ots)#commit
```

On OLT NODE start the TONE Generation:

```
RP/0/RP0/CPU0:#tone-pattern controller ots 0/0/0/4 start
Tue May 10 11:37:51.597 UTC
```

Tone pattern started

On OLT NODE, Start TONE detection:

```
RP/0/RP0/CPU0:#tone-pattern-detect controller ots 0/0/0/4 start
Tue May 10 11:38:03.775 UTC
```

Tone pattern detect started

On OLT NODE detect the Tone Status

```
RP/0/RP0/CPU0:#show controllers ots 0/0/0/4 tone-info
Tue May 10 11:41:18.847 UTC
Tone Info:
Tone Rate : 25 bits/second
Tone Pattern Expected(Hex value) : abcd1234
Tone Pattern Received(Hex value) : abcd1234
Tone Detected OOB :  Enabled
```

Detection State: Success

On OLT NODE Stop the TONE Detection

```
RP/0/RP0/CPU0:#tone-pattern-detect controller ots 0/0/0/4 stop
Tue May 10 11:50:36.185 UTC
```

Tone pattern detect stopped

On OLT NODE Stop the TONE Generation

```
RP/0/RP0/CPU0:#tone-pattern controller ots 0/0/0/4 stop
Tue May 10 11:50:45.837 UTC
```

Tone pattern stopped

6.24 Alarm Correlation and Hierarchy

The Slides are updated in the SharePoint : 7.11.1_MSFT_OLS_Alarm_Propagation&Hierarchy_v2_Nov29.pptx

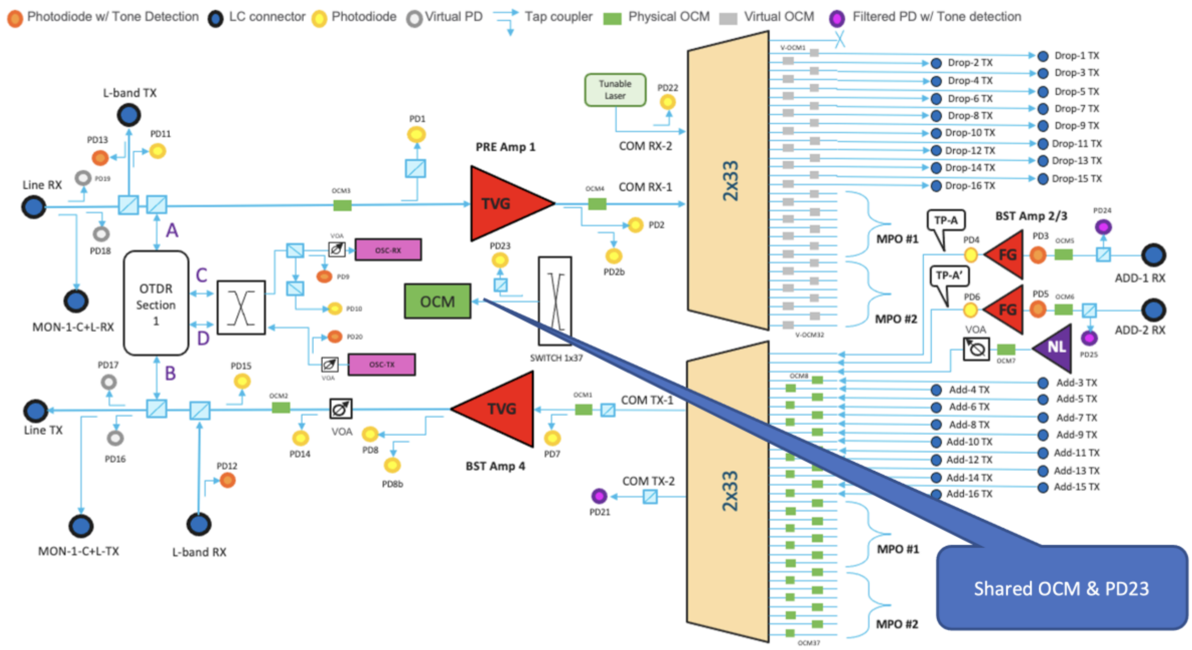
6.25 Spectrum Analyzer Support (from OCM)

CLI Command to check OCM reading of a controller

Command to check OCM per 3.25GHz slice on a given controller.
Output shown here is specific to controller 0/0/0/0

```
RP/0/RP0/CPU0:#show controllers ots 0/0/0/0 spectrum-info
Tue May  9 09:35:34.143 UTC

 Spectrum Slices spacing          :            3.125 GHz
 Spectrum Slices Range            :            1 - 1548
 Slice start wavelength           :            1566.82 nm
 Slice start frequency            :            191337.50 GHz

 Spectrum power information :
 Rx power :
 ---------------------------------------------------------------------------------
 spectrum-slice num                       Rx-power values (dBm)
 ---------------------------------------------------------------------------------
   1 - 12          -27.4  -24.9  -23.4  -22.5    -22.1  -22.0  -22.0  -22.1    -22.1  -22.1  -22.1  -22.2
  13 - 24          -22.2  -22.3  -22.3  -22.3    -22.2  -22.3  -22.8  -23.9    -25.6  -28.2  -30.4  -29.6
  25 - 36          -27.2  -25.2  -23.9  -23.1    -22.7  -22.5  -22.4  -22.3    -22.2  -22.2  -22.2  -22.2
  37 - 48          -22.2  -22.2  -22.3  -22.4    -22.7  -23.3  -24.3  -25.9    -28.1  -29.7  -28.4  -26.0
  49 - 60          -24.1  -22.9  -22.4  -22.3    -22.4  -22.4  -22.4  -22.4    -22.3  -22.3  -22.2  -22.2
  61 - 72          -22.2  -22.2  -22.1  -22.1    -22.0  -21.8  -21.7  -22.0    -22.6  -23.6  -24.2  -23.9
  73 - 84          -23.2  -22.6  -22.4  -22.5    -22.6  -22.6  -22.6  -22.6    -22.5  -22.4  -22.4  -22.3
  85 - 96          -22.3  -22.3  -22.2  -22.2    -22.1  -21.9  -21.9  -22.2    -23.3  -25.1  -28.1  -32.6
  97 - 108         -36.5  -37.6  -35.7  -31.9    -28.1  -25.4  -23.7  -22.7    -22.3  -22.2  -22.2  -22.2
 109 - 120         -22.2  -22.2  -22.2  -22.2    -22.2  -22.1  -22.0  -21.9    -22.3  -23.2  -24.9  -27.7
 121 - 132         -32.0  -36.6  -40.1  -41.9    -88.8  -88.8  -88.8  -88.8    -88.8  -88.8  -88.8  -88.8
 133 - 144         -88.8  -88.8  -88.8  -88.8    -88.8  -88.8  -88.8  -88.8    -42.0  -39.7  -36.1  -31.6
 145 - 156         -27.8  -25.1  -23.5  -22.5    -22.2  -22.1  -22.2  -22.3    -22.3  -22.3  -22.3  -22.3
 157 - 168         -22.3  -22.3  -22.3  -22.2    -22.2  -22.3  -22.7  -23.8    -25.5  -28.1  -31.0  -30.9
 169 - 180         -28.2  -25.7  -24.0  -22.9    -22.5  -22.3  -22.3  -22.4    -22.4  -22.3  -22.3  -22.3
 181 - 192         -22.3  -22.3  -22.4  -22.4    -22.3  -22.4  -22.8  -23.8    -25.5  -28.0  -30.5  -30.1
 193 - 204         -27.5  -25.3  -23.8  -22.9    -22.5  -22.5  -22.5  -22.5    -22.5  -22.4  -22.4  -22.4
 205 - 216         -22.4  -22.4  -22.4  -22.4    -22.4  -22.4  -22.9  -24.0    -25.7  -28.4  -31.2  -30.8
 217 - 228         -28.0  -25.5  -23.9  -22.9    -22.5  -22.4  -22.5  -22.5    -22.5  -22.6  -22.6  -22.5
 229 - 240         -22.5  -22.5  -22.4  -22.4    -22.3  -22.3  -22.8  -23.8    -25.6  -28.2  -30.7  -30.2
 241 - 252         -27.6  -25.3  -23.7  -22.8    -22.5  -22.4  -22.5  -22.6    -22.6  -22.6  -22.6  -22.6
 253 - 264         -22.6  -22.6  -22.6  -22.6    -22.6  -22.7  -23.2  -24.3    -26.0  -28.5  -30.7  -29.9
 265 - 276         -27.2  -25.0  -23.6  -22.8    -22.5  -22.4  -22.5  -22.5    -22.5  -22.6  -22.6  -22.6
 !
 !
 1453 - 1464        -21.9  -21.9  -21.9  -21.9    -21.8  -22.0  -22.7  -23.9    -26.0  -28.9  -30.7  -29.1
 1465 - 1476        -26.4  -24.3  -23.0  -22.2    -22.0  -21.9  -21.9  -22.0    -22.0  -22.0  -22.0  -22.0
 1477 - 1488        -22.0  -22.1  -22.0  -22.0    -22.0  -22.2  -22.9  -24.3    -26.5  -29.4  -31.0  -29.1
 1489 - 1500        -26.4  -24.5  -23.3  -22.7    -22.5  -22.5  -22.5  -22.5    -22.4  -22.4  -22.4  -22.4
 1501 - 1512        -22.4  -22.4  -22.4  -22.4    -22.4  -22.6  -23.3  -24.7    -26.9  -29.9  -31.2  -29.0
 1513 - 1524        -26.3  -24.4  -23.2  -22.6    -22.4  -22.5  -22.5  -22.5    -22.5  -22.5  -22.5  -22.5
 1525 - 1536        -22.5  -22.4  -22.4  -22.3    -22.3  -22.6  -23.4  -24.9    -27.4  -31.2  -35.7  -39.2
 1537 - 1548        -41.0  -41.8  -88.8  -88.8    -88.8  -88.8  -88.8  -88.8    -88.8  -88.8  -88.8  -88.8
 ---------------------------------------------------------------------------------
 Tx power :
 ---------------------------------------------------------------------------------
 spectrum-slice num                       Tx-power values (dBm)
 ---------------------------------------------------------------------------------
   1 - 12          -10.9   -8.3   -6.7   -5.8     -5.5   -5.4   -5.4   -5.4     -5.4   -5.4   -5.5   -5.5
  13 - 24           -5.5   -5.5   -5.6   -5.7     -5.7   -5.8   -6.4   -7.5     -9.3  -12.1  -14.5  -13.5
  25 - 36          -10.6   -8.4   -7.0   -6.2     -5.8   -5.7   -5.7   -5.6     -5.6   -5.6   -5.5   -5.5
  37 - 48           -5.4   -5.4   -5.6   -5.8     -6.0   -6.4   -7.3   -8.7    -10.8  -12.8  -11.9   -9.4
  49 - 60           -7.6   -6.4   -5.9   -5.9     -6.0   -6.0   -6.1   -6.0     -6.0   -5.9   -5.8   -5.7
  61 - 72           -5.7   -5.7   -5.6   -5.5     -5.4   -5.0   -4.5   -4.2     -4.6   -5.4   -6.5   -7.2
  73 - 84           -6.8   -6.1   -5.7   -5.7     -5.8   -5.9   -5.9   -5.8     -5.8   -5.7   -5.6   -5.6
  85 - 96           -5.6   -5.6   -5.5   -5.4     -5.3   -5.2   -5.2   -5.4     -6.2   -7.7  -10.0  -13.7
  97 - 108         -17.9  -19.4  -17.9  -13.9    -10.2   -7.8   -6.3   -5.5     -5.3   -5.3   -5.3   -5.4
 109 - 120          -5.4   -5.4   -5.3   -5.3     -5.2   -5.2   -5.2   -5.2     -5.7   -6.7   -8.5  -11.3
 121 - 132         -15.9  -20.7  -23.7  -25.1    -25.7  -26.1  -26.3  -26.5    -26.7  -26.8  -26.9  -27.0
 133 - 144         -27.0  -27.0  -27.0  -26.9    -26.8  -26.6  -26.1  -25.2    -23.8  -21.4  -18.1  -13.4
 145 - 156          -9.8   -7.5   -6.1   -5.3     -5.1   -5.0   -5.1   -5.1     -5.1   -5.1   -5.1   -5.0
 157 - 168          -5.0   -5.0   -5.0   -5.0     -5.1   -5.3   -5.9   -7.1     -8.9  -11.6  -14.3  -13.2
 169 - 180         -10.1   -7.8   -6.2   -5.4     -5.0   -5.0   -5.0   -5.0     -5.0   -4.9   -4.9   -4.9
 181 - 192          -5.0   -5.0   -5.0   -4.9     -4.9   -5.1   -5.6   -6.7     -8.5  -10.9  -13.6  -13.1
 193 - 204         -10.2   -8.0   -6.4   -5.6     -5.3   -5.2   -5.2   -5.2     -5.1   -5.1   -5.0   -5.0
 205 - 216          -5.0   -5.0   -4.9   -4.8     -4.8   -5.1   -5.6   -6.8     -8.7  -11.2  -13.6  -12.5
 217 - 228          -9.7   -7.5   -6.1   -5.3     -5.0   -4.9   -4.9   -4.9     -4.9   -4.9   -4.9   -4.9
 229 - 240          -4.9   -4.8   -4.8   -4.7     -4.6   -4.7   -5.3   -6.4     -8.3  -10.8  -12.6  -11.4
 241 - 252          -8.9   -6.9   -5.6   -4.9     -4.7   -4.7   -4.8   -4.8     -4.9   -4.9   -4.8   -4.8
 253 - 264          -4.8   -4.8   -4.8   -4.7     -4.6   -4.8   -5.4   -6.6     -8.6  -11.1  -13.3  -12.2
 265 - 276          -9.4   -7.1   -5.7   -4.9     -4.6   -4.6   -4.6   -4.7     -4.7   -4.7   -4.7   -4.7
 277 - 288          -4.7   -4.7   -4.8   -4.7     -4.7   -4.9   -5.5   -6.7     -8.7  -11.3  -13.6  -12.2
 !
 !
 1453 - 1464         -0.7   -0.7   -0.8   -0.7     -0.6   -0.8   -1.5   -2.7     -4.9   -7.9   -9.9   -8.3
 1465 - 1476         -5.4   -3.2   -1.8   -1.0     -0.7   -0.6   -0.6   -0.6     -0.6   -0.6   -0.6   -0.7
 1477 - 1488         -0.7   -0.7   -0.7   -0.7     -0.6   -0.8   -1.6   -2.9     -5.1   -8.2   -9.8   -7.7
 1489 - 1500         -4.8   -2.8   -1.5   -0.9     -0.7   -0.7   -0.7   -0.7     -0.7   -0.7   -0.6   -0.6
 1501 - 1512         -0.5   -0.5   -0.5   -0.4     -0.4   -0.7   -1.6   -3.1     -5.4   -8.6  -10.0   -7.7
 1513 - 1524         -4.9   -2.9   -1.7   -1.1     -1.0   -1.1   -1.1   -1.1     -1.1   -1.1   -1.1   -1.1
 1525 - 1536         -1.1   -1.1   -1.1   -1.0     -0.9   -1.2   -2.0   -3.5     -6.1  -10.4  -15.3  -18.7
 1537 - 1548        -20.9  -22.2  -23.0  -23.4    -23.7  -23.8  -24.0  -24.0    -24.1  -24.1  -24.2  -24.2
```

6.26 Optical Line Terminal – Optical Channel Monitor & Photo Diode Scheduler



The picture above depicts OCM (Optical Channel Monitor) and PD23, are Shared devices across the entire hardware. There are 37 Different Monitoring points for the OCM device across the entire terminal line card block depicted as Green Blocks. The Monitoring points are identified as OCM1, OCM2 … OCM37. There are 4 OCM points on the left hand Side of 2x33 MUX/DMX WSS, they are Numbered as OCM1, OCM2, OCM3, OCM4. There are 33 OCM points on the Add Port Right Hand Side of 2x33 MUX WSS device, OCM5, OCM6, … OCM37. There are Virtual OCM points V-OCM1, V-OCM2, ..V-OCM32 at the Right of 2x33 DMX WSS device. As depicted in the design above OCM Device and PD23 monitoring is controlled via a common switch.

The shared OCM Device & PD23 has a customizable scheduler that allows the Cisco S/W to Control OCM Points & PD23 Scan Order as per need. Cisco software uses a Dynamic Scan Order based on the active cross connections on COM port of the terminal line card.

OCM1, OCM2, OCM4 Monitoring points that are used for govern the Amplifier , WSS regulation and Channel Failure Monitoring used for Noise Loading function are scanned more frequently than the OCM & PD23 monitoring points that are used for PM & Alarm Monitoring, The COM side OCM points are scanned at next level of priority, COM side OCM points without any cross connections are scanned at the lowest priority. Based on tests, OCM1, OCM2, OCM4 Monitoring points are scanned every ~1 second, COM port OCM points with active cross connects are scanned ~1 second if there only one port with cross connection, ~2 second if there are two port with cross connection, ~3 second if there are three port with cross connection.

6.27 CLIs References for New Features

Feature	Config CLI	Show/Exec CLI

An alarm must be raised when channel is replaced by ASE and vice-versa	None	Alarms: CHANNEL-NOISE-LOADED
Fast refresh the PD and document refresh times for OCM, PD for MSFT to correlate	None	No new CLI. Standard PM CLIs will be used here
FAST APC	optical-line-control controller ots0/0/0/0 apc-span-mode-tx optical-line-control controller ots0/0/0/0 apc-span-mode-rx optical-line-control controller ots0/0/0/0 apc-alarm-hold-off-timer <> • Range : 1 s to 1800 s optical-line-control controller ots0/0/0/0 apc-span-loss-correction-threshold Tx <> • Range : 2 to 200 in increments of 0.1 dB optical-line-control controller ots0/0/0/0 apc-span-loss-correction-threshold Rx <> • Range : 2 to 200 in increments of 0.1 dB	"show olc apc" show olc apc-local regulation-info"
Auto-OTDR must before EDFA/Raman span is up; decide Raman turn up	optical-line-control **controller ots 0/0/0/0** **otdr** **raman-turn-up <enable/disable>** A command to configure OTDR Raman turn-up feature: **optical-line-control** **controller ots 0/0/0/0** **otdr** **raman-turn-up protection-level <0,100>**	**Show CLI** A command to show the Raman turn-up status (go/no-go) and critical events: show olc otdr-status **controller ots 0/0/0/0 [details]** **Exec CLI** A command to force the turn up of Raman Pumps skipping the OTDR RX scan check **olc otdr force-raman-turn-up controller ots 0/0/0/0**

		A command to retrigger the OTDR RX scan and Raman turn-up re-evaluation **olc otdr start-raman-turn-up controller ots 0/0/0/0**
Auto-OTDR must at failures and after recovery	Command to enable/disable the OTDR auto-scan feature: **optical-line-control** **controller ots 0/0/0/0** **otdr** **auto-scan <enable/disable>**	Command to show the OTDR status: **show olc otdr-status controller ots 0/0/0/0 [details]**
Raman tuning shall be run before ALC is triggered on day-1; frozen later till fiber cut and reset	**optical-line-control** **controller ots 0/0/0/0** **raman-tuning manual**	**show olc raman-tuning** **show olc raman-tuning details**
Remote Console for ILA	None	Action CLI# remote-connect <destination mac> | <dest_host> [<verbose>]
Raman Dual Safety	**Config CLI:** Config # controller ots 0/0/0/0 raman-safety-trigger include-osc-osnr-los raman-safety-trigger include-dfb-los raman-safety-trigger include-osc-los	
ALC	**Config CLI** optical-line-control controller ots 0/0/0/0 link-tuner manual gain-estimator manual apc manual apc apc-span-mode TX	**Exec CLI** olc alc-start controller ots R/S/I/P olc alc-terminate controller ots R/S/I/P **Oper CLI**

	apc apc-span-mode RX	Show olc alc status controller ots R/S/I/P Show olc alc-local status controller ots R/S/I/P

6.27.1 CCMD Command Reference

Parameter	XR CLI	Comments
EDFA-ADD Control mode	Controller Oms R/S/I/P egress-ampli-mode power-control	Default mode is gain-control. User can change the mode to power-control using this command. User can remove the configuration to revert to gain-control mode.
EDFA-ADD Power	controller Oms R/S/I/P egress-ampli-power <val in 0.1 dBm>	Target output Power configuration for EDFA-ADD. Default value will be applied as per info model if not configured.
EDFA-ADD Gain Range	Controller Oms R/S/I/P egress-ampli-gain-range <normal | extended>	EDFA-ADD Gain range selection (COM Tx). Default is 'Normal'.
EDFA-ADD Gain	controller Oms R/S/I/P egress-ampli-gain <val in 0.1 dB>	EDFA-ADD Gain configuration. Default value will be applied as per info model if not configured.
EDFA-DROP control mode	Controller Oms R/S/I/P ingress-ampli-mode power-control	Default mode is gain-control. User can change the mode to power-control using this command. The config needs to be removed to revert to gain-control mode.
EDFA-DROP Power	controller Oms R/S/I/P ingress-ampli-power <val in 0.1 dBm>	Target Power configuration for EDFA-DROP. Default value will be applied as per info model if not configured.
EDFA-DROP Gain	controller Oms R/S/I/P ingress-ampli-gain <val in 0.1 dB>	EDFA-DROP Gain configuration. Default value will be applied as per info model if not configured.
VoA Attenuation	controller Oms R/S/I/P tx-voa-attenuation <val in 0.1 dB>	VoA attenuation at COM-Tx and Rx. Default value will be applied as per info model if not configured.

	rx-voa-attenuation <val in 01. dB>	
Shutdown (COM Port)	controller Oms R/S/I/P shutdown	COM Tx and Rx ports are put in OOS. This will turn-off the EDFA devices on both COM-Tx and COM-Rx ports and respective alarms will be masked. Default is "unshut".
Shutdown (Ch Ports)	controller Och R/S/I/P shutdown	No-op (behavior is same as Sirius-OLT Com ports)

Parameter	XR CLI	Comments
Photo Diodes (COM Port)	**OMS Controller** Tx Power Rx Power	Rx Power = Inband + OOB (same as Sirius passives)
Photo Diodes (CH Ports)	**Och Controller** Tx Power Rx Power	Tx power will be derived from total Tx power measured before the splitter section (i.e., Tx power per Ch port = Total drop power / 16)
Amplifier Parameters	**OMS Controller** Egress Ampli Mode Egress Ampli Gain range Egress Ampli Gain Egress Ampli Power Egress Ampli BR Egress Ampli BR Power Egress Ampli BR Ratio Ingress Ampli Mode Ingress Ampli Gain Ingress Ampli Power	
VoA Parameters	OMS Controller: Tx Voa Attenuation Rx Voa Attenuation	

Parameter	XR CLI	Comments
Tone detection Parameters (COM port)	controller Oms R/S/I/P tone-detect-oob tone-rate <val in bps> tone-pattern-expected <Hex val>	Default is in-band. Default Tone-rate will be picked from info-model if not configured. Tone-pattern-expected is mandatory config for Tone-detection. Note: the switch on the OOB loopback path is open by default. It is closed when tone-detect-oob is configured for the first time. It will stay in closed state (regardless of the presence of tone-detect-oob config) until the LC module is cold reset.
Tone detection Parameters (Channel ports)	controller Och R/S/I/P tone-rate <val in bps> tone-pattern-expected <Hex val>	

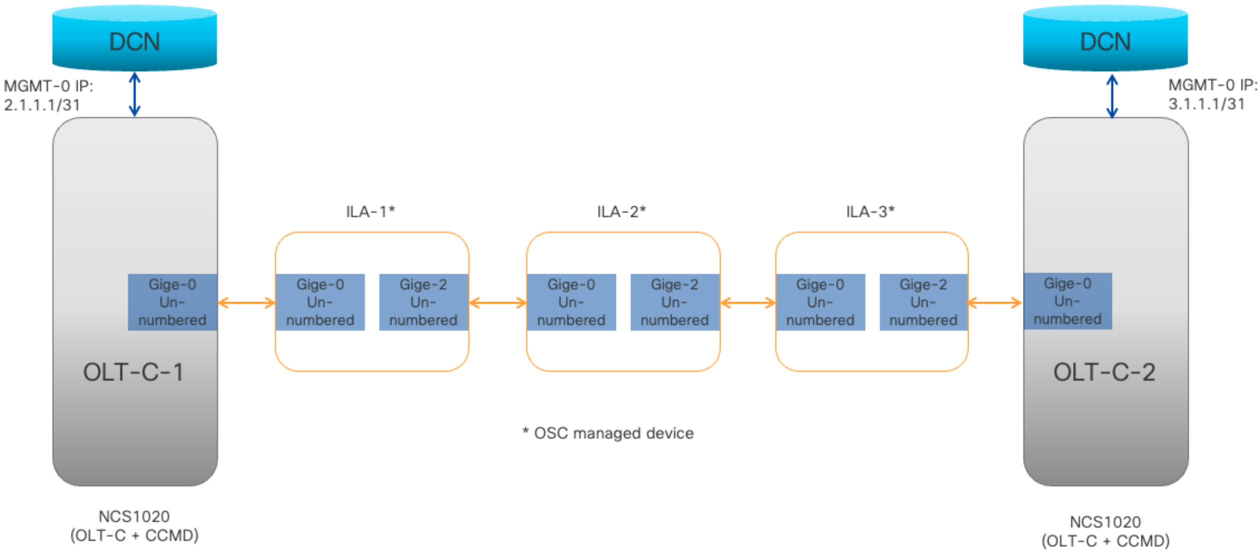
Parameter	XR CLI	Comments
Tone detection (OMS)	Tone Rate Tone Pattern Expected(Hex value) Tone Pattern Received(Hex value) Tone Detected OOB Detection State	
Tone detection (Och)	Tone Rate Tone Pattern Expected(Hex value) Tone Pattern Received(Hex value) Detection State	

Parameter	XR CLI	Comments
Tx Low threshold (COM port)	controller Oms R/S/I/P tx-low-threshold <val in 0.1 dBm>	Tx-Low-Pwr Alarm (COM-Tx port)
Rx Low threshold	controller Oms R/S/I/P	LOS-P alarm (COM-Rx port)

(COM port)	rx-low-threshold <val in 0.1 dBm>	
Tx Low threshold (CH port)	controller Och R/S/I/P tx-low-threshold <val in 0.1 dBm>	Tx-Low-PWR alarm (CH-Tx port)
Rx Low threshold (CH port)	controller Och R/S/I/P rx-low-threshold <val in 0.1 dBm>	LOS-P (CH-Rx port)
BR High Threshold	Controller oms R/S/I/P egress-ampli-br-high-threshold <val in 0.1 dBm>	BR ratio to declare HI-TX-BR-PWR alarm.

7 Platform Software

7.1 Day-0 Turn Up



OLT-C-1	**ILA-C1**	**ILA-C2**	**ILA-C3**	**OLT-C-2**

```
Upon receiving the box from Manufacturing and booted, User will see the below
    prompt. The HW will come up with no configs preloaded.
    Username and password must be created before access.

    !!!!!!!!!!!!!!!!!!!! NO root-system username is configured. Need to
    configure root-system username. !!!!!!!!!!!!!!!!!!!!

             --- Administrative User Dialog ---

      Enter root-system username: cisco
      Enter secret:
      Enter secret again:
    Use the 'configure' command to modify this configuration.
    User Access Verification

    Username:
```

Static Route: router static address-family ipv4 unicast 0.0.0.0/0 2.1.1.2				**Static Route: router static address-family ipv4 unicast 0.0.0.0/0 3.1.1.2**
eBGP: route-policy pass-all pass end-policy router bgp 1 bgp router-id 1.1.1.1 address-family ipv4 unicast redistribute ospf 1 route-policy pass-all ! neighbor 2.1.1.2 remote-as 100 address-family ipv4 unicast route-policy pass-all in route-policy pass-all out				**eBGP:** route-policy pass-all pass end-policy router bgp 1 bgp router-id 1.1.1.5 address-family ipv4 unicast redistribute ospf 1 route-policy pass-all ! neighbor 3.1.1.2 remote-as 100 address-family ipv4 unicast route-policy pass-all in route-policy pass-all out

iBGP : route-policy pass-all pass end-policy router bgp 1 bgp router-id 1.1.1.1 address-family ipv4 unicast redistribute ospf 1 route-policy pass-all ! neighbor 2.1.1.2 remote-as 1 address-family ipv4 unicast next-hop-self				**iBGP :** route-policy pass-all pass end-policy router bgp 1 bgp router-id 1.1.1.5 address-family ipv4 unicast redistribute ospf 1 route-policy pass-all ! neighbor 3.1.1.2 remote-as 1 address-family ipv4 unicast next-hop-self
OSPF: router ospf 1 distribute link-state router-id 1.1.1.1 network point-to-point default-information originate area 0 interface Loopback0 ! interface GigabitEthernet0/0/0/0	**OSPF:** router ospf 1 distribute link-state router-id 1.1.1.2 network point-to-point area 0 interface Loopback0 ! interface GigabitEthernet0/0/0/0 interface GigabitEthernet0/0/0/2	**OSPF:** router ospf 1 distribute link-state router-id 1.1.1.3 network point-to-point area 0 interface Loopback0 ! interface GigabitEthernet0/0/0/0 interface GigabitEthernet0/0/0/2	**OSPF:** router ospf 1 distribute link-state router-id 1.1.1.4 network point-to-point area 0 interface Loopback0 ! interface GigabitEthernet0/0/0/0 interface GigabitEthernet0/0/0/2	**OSPF:** router ospf 1 distribute link-state router-id 1.1.1.5 network point-to-point default-information originate area 0 interface Loopback0 ! interface GigabitEthernet0/0/0/0

Loopback, GE Unnumbered and Mgmt and LLDP on OSC interface Loopback0 ipv4 address 1.1.1.1 255.255.255.255 interface GigabitEthernet0/0/0/0 ipv4 point-to-point ipv4 unnumbered Loopback0 lldp enable no shut interface mgmt 0/rp0/cpu0/0 ipv4 address 2.1.1.1/30 no shut interface MgmtEth0/RP0/CPU0/1 ipv4 address 192.168.1.1 255.255.255.252 no shut	**Loopback, GE** Unnumbered and LLDP on OSC interface Loopback0 ipv4 address 1.1.1.2 255.255.255.255 interface GigabitEthernet0/0/0/0 ipv4 point-to-point ipv4 unnumbered Loopback0 lldp enable no shut interface GigabitEthernet0/0/0/2 ipv4 point-to-point ipv4 unnumbered Loopback0 no shut	**Loopback, GE** Unnumbered and LLDP on OSC interface Loopback0 ipv4 address 1.1.1.3 255.255.255.255 interface GigabitEthernet0/0/0/0 ipv4 point-to-point ipv4 unnumbered Loopback0 lldp enable no shut interface GigabitEthernet0/0/0/2 ipv4 point-to-point ipv4 unnumbered Loopback0 no shut	**Loopback, GE** Unnumbered, LLDP on OSC interface Loopback0 ipv4 address 1.1.1.4 255.255.255.255 interface GigabitEthernet0/0/0/0 ipv4 point-to-point ipv4 unnumbered Loopback0 lldp enable no shut interface GigabitEthernet0/0/0/2 ipv4 point-to-point ipv4 unnumbered Loopback0 no shut	**Loopback, GE** Unnumbered and Mgmt interface Loopback0 ipv4 address 1.1.1.5 255.255.255.255 interface GigabitEthernet0/0/0/0 ipv4 point-to-point ipv4 unnumbered Loopback0 lldp enable no shut interface mgmt 0/rp0/cpu0/0 ipv4 address 3.1.1.1/30 no shut interface MgmtEth0/RP0/CPU0/1 ipv4 address 192.168.1.1 255.255.255.252 no shut
NTP: ntp server A.B.C.D	**NTP:** ntp server 1.1.1.1	**NTP:** ntp server 1.1.1.1	**NTP:** ntp server 1.1.1.1	**NTP:** ntp server A.B.C.D
SSH config: ssh server rate-limit 600 ssh server	**SSH config:** ssh server rate-limit 600 ssh server	**SSH config:** ssh server rate-limit 600 ssh server	**SSH config:** ssh server rate-limit 600 ssh server	**SSH config:** ssh server rate-limit 600 ssh server session-limit

session-limit 110 ssh server v2 ssh server netconf vrf default	session-limit 110 ssh server v2 ssh server netconf vrf default	session-limit 110 ssh server v2 ssh server netconf vrf default	session-limit 110 ssh server v2 ssh server netconf vrf default	110 ssh server v2 ssh server netconf vrf default
Show Commands				
RP0/CPU0:PROD3#show route ipv4 Mon Apr 24 16:26:22.211 UTC Codes: C - connected, S - static, R - RIP, B - BGP, (>) - Diversion path D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP i - ISIS, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area,	RP0/CPU0:PROD2#show route ipv4 Mon Apr 24 16:27:19.400 UTC Codes: C - connected, S - static, R - RIP, B - BGP, (>) - Diversion path D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP i - ISIS, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area,			RP/0/RP0/CPU0:PROD1#show route ipv4 Mon Apr 24 21:57:45.856 IST Codes: C - connected, S - static, R - RIP, B - BGP, (>) - Diversion path D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2 E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP i - ISIS, L1 - IS-IS level-1, L2 - IS-IS level-2 ia - IS-IS inter area, su - IS-IS summary null, * - candidate

su - IS-IS summary null, * - candidate default U - per-user static route, o - ODR, L - local, G - DAGR, l - LISP A - access/subscriber, a - Application route M - mobile route, r - RPL, t - Traffic Engineering, (!) - FRR Backup path Gateway of last resort is 2.1.1.2 to network 0.0.0.0 S* 0.0.0.0/0 [1/0] via 2.1.1.2, 00:07:21 L 1.1.1.1/32 is directly connected, 5d00h, Loopback0 O 1.1.1.2/32 [110/2] via 1.1.1.2, 00:03:18, GigabitEthernet0/0/0/0 O 1.1.1.3/32 [110/3] via 1.1.1.2, 00:00:29, GigabitEther	su - IS-IS summary null, * - candidate default U - per-user static route, o - ODR, L - local, G - DAGR, l - LISP A - access/subscriber, a - Application route M - mobile route, r - RPL, t - Traffic Engineering, (!) - FRR Backup path Gateway of last resort is 1.1.1.3 to network 0.0.0.0 O*E2 0.0.0.0/0 [110/1] via 1.1.1.3, 00:01:31, GigabitEthernet0/0/0/0 [110/1] via 1.1.1.1, 00:01:31, GigabitEthernet0/0/0/2 O 1.1.1.1/32 [110/2] via 1.1.1.1, 00:04:17, GigabitEthernet0/0/0/2 L 1.1.1.2/32 is directly connected,			default U - per-user static route, o - ODR, L - local, G - DAGR, l - LISP A - access/subscriber, a - Application route M - mobile route, r - RPL, t - Traffic Engineering, (!) - FRR Backup path Gateway of last resort is 3.1.1.2 to network 0.0.0.0 S* 0.0.0.0/0 [1/0] via 3.1.1.2, 03:39:48 O 1.1.1.1/32 [110/3] via 1.1.1.2, 00:01:57, GigabitEthernet0/0/0/0 O 1.1.1.2/32 [110/2] via 1.1.1.2, 00:01:57, GigabitEthernet0/0/0/0 L 1.1.1.3/32 is directly connected, 00:02:06, Loopback0 C 3.1.1.0/30 is directly connected, 09:30:23, MgmtEth0/RP0/CPU0/2 L 3.1.1.1/32 is directly connected,

net0/0/0/0 C 2.1.1.0/30 is directly connected, 5d00h, MgmtEth0/RP0/CPU0/2 L 2.1.1.1/32 is directly connected, 5d00h, MgmtEth0/RP0/CPU0/2 B 4.33.0.0/16 [20/0] via 2.1.1.2, 04:09:43 C 10.127.60.0/24 is directly connected, 3d03h, MgmtEth0/RP0/CPU0/0 L 10.127.60.123/32 is directly connected, 3d03h, MgmtEth0/RP0/CPU0/0 C 192.168.1.0/30 is directly connected, 3d02h, MgmtEth0/RP0/CPU0/1 L 192.168.1.1/32 is directly connected, 3d02h, MgmtEth0/RP0/CPU0/1	00:04:20, Loopback0 O 1.1.1.3/32 [110/2] via 1.1.1.3, 00:01:31, GigabitEthernet0/0/0/0			09:30:23, MgmtEth0/RP0/CPU0/2 B 4.33.0.0/16 [20/0] via 3.1.1.2, 04:11:07 C 10.127.60.0/24 is directly connected, 09:30:23, MgmtEth0/RP0/CPU0/0 L 10.127.60.219/32 is directly connected, 09:30:23, MgmtEth0/RP0/CPU0/0 C 192.168.1.0/30 is directly connected, 09:30:23, MgmtEth0/RP0/CPU0/1 L 192.168.1.1/32 is directly connected, 09:30:23, MgmtEth0/RP0/CPU0/1 RP/0/RP0/CPU0:PROD1#

RP/0/RP0/CPU0:PROD3#show ntp status Mon Apr 24 21:59:52.962 IST Clock is synchronized, stratum 3, reference is 4.33.0.51 nominal freq is 1000000000.0000 Hz, actual freq is 88388421.6878 Hz, precision is 2**24 reference time is E7F10EDD.AABA5D4F (19:51:17.666 IST Mon Apr 24 2023) clock offset is 11.412 msec, root delay is 4.296 msec root dispersion is 127.89 msec, peer dispersion is 6.39 msec loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.0000103137 s/s system poll interval is 512, last update was 7715 sec	RP/0/RP0/CPU0:PROD3#show ntp status Mon Apr 24 21:59:52.962 IST Clock is synchronized, stratum 3, reference is 4.33.0.51 nominal freq is 1000000000.0000 Hz, actual freq is 88388421.6878 Hz, precision is 2**24 reference time is E7F10EDD.AABA5D4F (19:51:17.666 IST Mon Apr 24 2023) clock offset is 11.412 msec, root delay is 4.296 msec root dispersion is 127.89 msec, peer dispersion is 6.39 msec loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.0000103137 s/s system poll interval is 512, last update was 7715 sec			RP/0/RP0/CPU0:PROD1#show ntp status Mon Apr 24 21:59:52.962 IST Clock is synchronized, stratum 3, reference is 4.33.0.51 nominal freq is 1000000000.0000 Hz, actual freq is 88388421.6878 Hz, precision is 2**24 reference time is E7F10EDD.AABA5D4F (19:51:17.666 IST Mon Apr 24 2023) clock offset is 11.412 msec, root delay is 4.296 msec root dispersion is 127.89 msec, peer dispersion is 6.39 msec loopfilter state is 'CTRL' (Normal Controlled Loop), drift is 0.0000103137 s/s system poll interval is 512, last update was 7715 sec ago authenticate is disabled

ago authenticate is disabled	ago authenticate is disabled			

7.2 Timing

The NTP protocol is supported, and the configuration part is captured in the Day-0 config table in Section-1 of this Platform Software.

7.3 Communications

The eBGP is supported on the management port. LLDP is supported both for Management port (to discover the peer devices in the DCN) and in OSC to discover the peer amplifier/terminal sites

Also, OSC used OSPF for internal topology discovery.

Configuration is captured in the Day-0 config table

7.4 Security

The security protocols requested by Microsoft will be supported.

Also, Cisco support Mutual TLS Authentication for grpc and streaming telemetry.9.7

PORT STATE SERVICE VERSION

830/tcp open ssh (protocol 2.0)

| ssh2-enum-algos:

| **kex_algorithms: (8)**

| curve25519-sha256

| curve25519-sha256@libssh.org

| ecdh-sha2-nistp256

| ecdh-sha2-nistp384

| ecdh-sha2-nistp521

| diffie-hellman-group16-sha512

| diffie-hellman-group14-sha1

| diffie-hellman-group14-sha256

| **server_host_key_algorithms: (8)**

| ecdsa-sha2-nistp256

| ecdsa-sha2-nistp384

| ecdsa-sha2-nistp521

| ssh-ed25519

| ssh-rsa

| rsa-sha2-256

| rsa-sha2-512

| ssh-dss

| **encryption_algorithms: (6)**

| chacha20-poly1305@openssh.com

| aes128-ctr

| aes192-ctr

| aes256-ctr

| aes128-gcm@openssh.com

| aes256-gcm@openssh.com

| **mac_algorithms: (3)**

| hmac-sha2-512

| hmac-sha2-256

| hmac-sha1

| compression_algorithms: (2)

| none

|_ zlib@openssh.com

| fingerprint-strings:

| NULL:

|_ SSH-2.0-OpenSSH_8.0 PKIX[12.1]

7.5 SNMP Support

Below are the MIBs that are supported in OLS and TXP. More details are in : SNMP MIB Support

MIBS for OLS	MIBS for TXP
ENTITY-MIB	ENTITY-MIB
CISCO-ENTITY-SENSOR-MIB	CISCO-ENTITY-SENSOR-MIB
CISCO-IF-EXTENSION-MIB	CISCO-IF-EXTENSION-MIB

CISCO-ENTITY-ASSET-MIB	CISCO-ENTITY-ASSET-MIB
CISCO-PROCESS-MIB	CISCO-PROCESS-MIB
CISCO-SYSTEM-MIB	CISCO-SYSTEM-MIB
CISCO-SYSLOG-MIB	CISCO-SYSLOG-MIB
CISCO-ALARM-MIB	RMON2-MIB
CISCO-OTS-MIB	CISCO-OTS-MIB
Cisco-OLC-MIB	CISCO-ALARM-MIB
LLDP-MIB	LLDP-MIB
IP-MIB	HC-RMON-MIB
SNMPv2-MIB	CISCO-OPTICAL-MIB
	IP-MIB
	SNMPv2-MIB

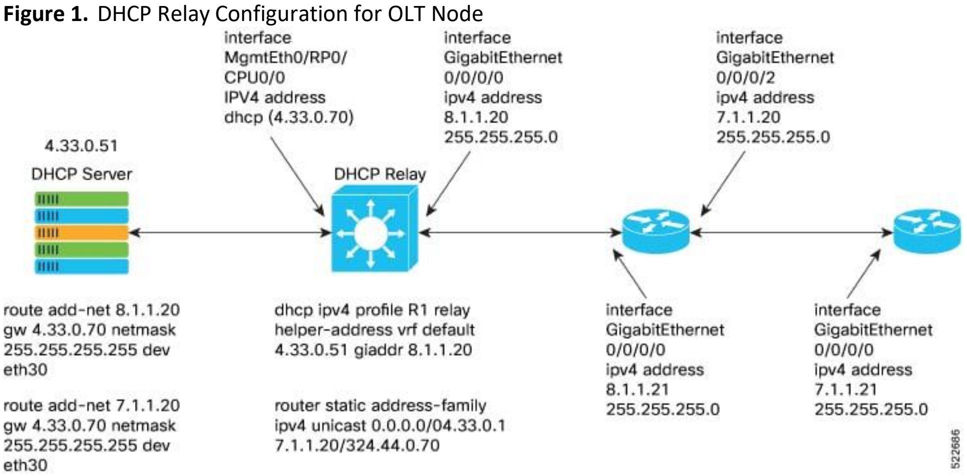
7.6 ZTP

NCS101x family support ZTP configuration. Note that for the ILA the OLT will be used as DHCP relay to relay the DHCP request coming from the ILA side to reach the proper DHCP server. This config needs to be applied to the OLT before the ILA ZTP can work.

The config for OLT DHCP relay is reference below

The OLT node must be configured with the DHCP management connection to manage the ILA node remotely over OSC interface.

Figure 1. DHCP Relay Configuration for OLT Node



Following is the sample DHCP relay configuration for the OLT gateway node:

```
RP/0/RP0/CPU0:P2B_DT_02#sh running-config int mgmtEth 0/RP0/CPU0/2
Thu Jun  9 06:37:59.071 UTC
interface MgmtEth0/RP0/CPU0/2
 ipv4 address 192.168.1.1 255.255.255.252
!

RP/0/RP0/CPU0:P2B_DT_02#

RP/0/RP0/CPU0:P2C_DT_02#

RP/0/RP0/CPU0:P2B_DT_02#sh running-config dhcp ipv4
Thu Jun  9 06:28:51.879 UTC
dhcp ipv4
 profile R1 relay
  helper-address vrf default 10.4.33.51 giaddr 10.8.1.20
 !
 interface GigabitEthernet0/0/0/0 relay profile R1
!
```

In the above sample CLI,

- **10.4.33.51** is the DHCP server IP address
- **10.8.1.20** is the OSC interface IP address that going to ILA node from OLT node
- **0/0/0/0** is the interface number
- **R1** is the profile

Detail configuration for the ZTP can be found at this public link

https://www.cisco.com/c/en/us/td/docs/optical/ncs1010/77x/configuration/guide/b-ncs1010-system-setup-guide/m-bring-up-ncs1010.html

Code	DHCP Option	Description
60	vendor-class-identifier	**Is Option 60 included with vendor class? (vendorID, ModelID)?** Yes
61	dhcp-client-identifier	Request sent with Serial No. or Mac address EX: hardware ethernet 68:9e:0b:b8:6f:ad ; option dhcp-client-identifier "FCB2437B05P" ;

77	user-class	Option 77 is used to config or load an image. An example is given below.
		
		host cisco-rp0 {
		  hardware ethernet e4:c7:22:be:10:ba;
		  fixed-address 172.30.12.54;
		  if exists user-class and option user-class = "xr-config" {
		    filename = "http://172.30.0.22/scripts/cisco-rp0_ztp.sh";
		  }
		}

7.7 SW Upgrade

SW Upgrade

Detailed MOP for Software upgrade is captured in the link : OLS 2.0 software upgrade MOP.docx

7.8 Licensing

Licensing will be disabled for MSFT configs. The complete guide on how Licensing works is captured in : Msft-NCS1010-smartlicensing.pptx

7.9 Alarms and Alarm Correlation and Hierarchy

The List of alarms and its correlation and hierarchy is captured in PPT and given in the soft link : Alarm Guides

All the line side alarm (list given below) are following a soak time of 2.5 sec before raising and 10 sec before clearing except the LOC (Loss of Continuity), OSC LOS-P and DFB-LOS-P. These alarms will have soak time of 33 second before raising and clearing.

Rx-LOS-P

TX-POWER-FAIL-LOW

EGRESS-AUTO-LASER-SHUT

RAMAN-AUTO-LASER-SHUT

EGRESS-AMPLI-GAIN-HIGH/LOW

INGRESS-AMPLI-GAIN-HIGH/LOW

HIGH-RX-BR-PWR

HIGH-TX-BR-PWR

Receive Channel Power Below Minimum Power Spectral Density

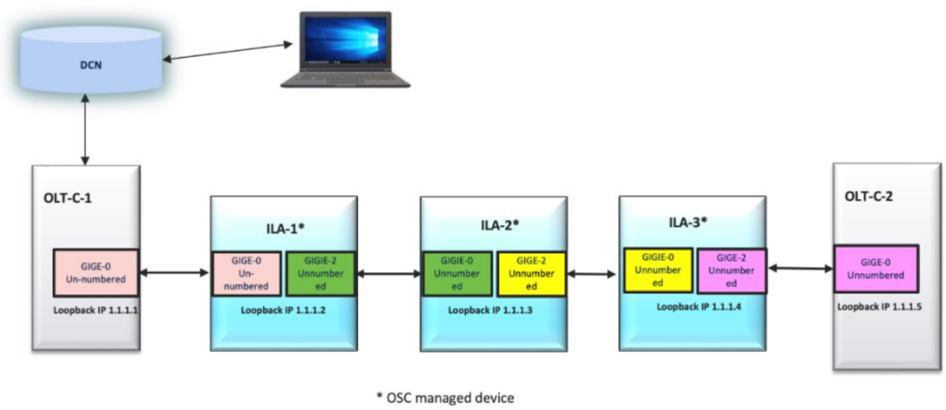
All the other alarms such as control loop, otdr, raman etc are instantaneous raise and clear (without any soak)

7.10 Log Collection

The CLI based log collection is shown below (using the command "show tech-support ncs10xx detail). The file will be saved in the below location " /harddisk:/showtech/"

```
RP/0/RP0/CPU0:NCS1020_P1B_DT_10#show tech ncs10xx detail Fri Jan 17 10:05:43.988
IST ++ Show tech start time: 2025-Jan-17.100544.IST ++ Fri Jan 17 10:05:45 IST 2025
Waiting for gathering to complete
.....................................................................................................................................................................................................
......................................................................................................................... Fri Jan 17 10:22:17 IST 2025
Compressing show tech output Show tech output available at 0/RP0/CPU0 :
/harddisk:/showtech/showtech-NCS1020_P1B_DT_10-ncs10xx-2025-Jan-17.100544.IST.tgz
++ Show tech end time: 2025-Jan-17.102229.IST ++
```

7.11 Software Download Characterization



With an image size of 1.4G, the characterization data stands as below

Build	Telemetry	Size	Operation	Gateway	1st Hop	2nd Hop	3rd Hop	4th Hop
7.10.1	10sec	1405MB	Parallel download	34s	6m 43s	9m 45s	11m 13s	11m 59s
7.10.1	10sec	1405MB	Sequential	22s	3m	3m 17s	3m 23s	3m 40s

With a 5 nodes topology shown above,

- By parallel download, to complete download on all the nodes, it takes 12 mins.
- By One at a time, the final node software download completion ~ 12 mins.
- So overall time did not differ much. But there are advantages on serial download as the OSC link is not stressed so much compared to the parallel download.

Cisco Recommendations:

- Download of software: One node at a time
- In case of Dual Gateway scenario, one download via each GNE can be carried out

7.12 ACL (Access Control List)

Cisco supports the Access control list with the below configuration (provided as an example, more details can be provided based on the requirement)

For example, find the config below, to allow ssh only from specific source:
Here, the SSH will be allowed only from source `4.33.0.51`

```
RP/0/RP0/CPU0:P2C_DT_02#sh access-lists
Fri Dec  8 09:05:12.998 IST
ipv4 access-list test3
2 permit tcp host 4.33.0.51 host 4.33.0.90 eq ssh
3 deny tcp any any eq ssh
12 deny ipv4 any any (88 matches)

RP/0/RP0/CPU0:P2C_DT_02#sh running-config int mgmtEth 0/RP0/CPU0/0
Fri Dec  8 09:12:48.711 IST
interface MgmtEth0/RP0/CPU0/0
ipv4 address 4.33.0.90 255.255.255.0
ipv4 access-group test3 ingress
!

RP/0/RP0/CPU0:P2C_DT_02#sh running-config ssh
Fri Dec  8 09:13:25.723 IST
ssh server rate-limit 600
ssh server session-limit 110
ssh server v2
ssh server vrf default ipv4 access-list test3
ssh server netconf vrf default
```

<u>To block a specific port (example port 2000 to be blocked)</u>

```
RP/0/RP0/CPU0:P2C_DT_02#sh access-lists
Fri Dec  8 13:12:12.186 IST
ipv4 access-list test2000
10 permit ipv4 any any
20 deny tcp any any eq 2000

RP/0/RP0/CPU0:P2C_DT_02#conf
Fri Dec  8 13:12:59.910 IST
RP/0/RP0/CPU0:P2C_DT_02(config)#int mgmtEth 0/RP0/CPU0/0
RP/0/RP0/CPU0:P2C_DT_02(config-if)#ipv4 access-group test2000 in
RP/0/RP0/CPU0:P2C_DT_02(config-if)#commit
Fri Dec  8 13:13:27.725 IST
RP/0/RP0/CPU0:P2C_DT_02(config-if)#
```

7.13 Monitoring and Planning tools

CONP (Cisco Optical Network Planner) will be used for the network planning. Details are stored in the SharePoint
MSFT_CONP.pdf

7.14 Cisco Process Manager Theory

- The Process Manager is the central authority responsible for running and terminating XR processes. It initially activates only a core set of router processes on the box, creates additional processes on user request, and restarts crashed processes without having to reload the network device.
- All processes in XR architecture with a few exceptions are restart able.
- Architecturally, none of the process restarts MUST disrupt forwarding. This needs more explanation:
    - If one or multiple processes crash, forwarding should continue.
    - Some processes are designated as mandatory, i.e. they must be up and running in the system ALL the time. These can go down, but if they restart soon and work fine, the system is good. But if these continue to go through a restart churn, then after 5 restarts, then the VM/LXC/Card on which they are running would be brought down.
    - If a non-mandatory process crashes, it is respawned immediately for 5 times. Beyond that the process is put into slow restart meaning it will be respawned after 120 secs for every exit and respawn will continue forever.

7.15 Configuring AAA services

Authentication commands are used to verify the identity of a user or principal. Authorization commands are used to verify that an authenticated user (or principal) is granted permission to perform a specific task.

Accounting commands are used for logging of sessions and to create an audit trail by recording certain user- or system-generated actions.

1) Configure Users, Taskgroups, and Usergroups

a) Each user is identified by a username that is unique across the administrative domain and should be made a member of at least one user group.

i) A username user1 is created for login purposes, a secure login password is assigned, and user1 is made a root-lr usergroup

username user1 secret lab group root-lr exit

ii) A user group named priv5 is created, which will be used for users authenticated using the TACACS+ method and whose entry in the external TACACS+ daemon configuration file has a privilege level of 5.

usergroup priv5 taskgroup operator exit

iii) Verification

To verify the configured username details, use “show run aaa”

b) At least one root system user account must be created during router setup. Multiple root system users can exist.

c) User groups that are created in an external server are not related to the user group concept that is used in the context of local AAA database configuration on the router. The management of external TACACS+ server or RADIUS server user groups is independent, and the router does not recognize the user group structure.

d) The Cisco software provides a collection of user groups whose attributes are already defined. The predefined Usergroups are as follows:

cisco-support: This group is used by the Cisco support team.

maintenance: Has the ability to display, configure and execute commands for network, files and user-related entities.

netadmin: Has the ability to control and monitor all system and network parameters.

provisioning: Has the ability to display and configure network, files and user-related entities.

read-only-tg: Has the ability to perform any show command, but no configuration ability.

retrieve: Has the ability to display network, files and user-related information.

root-lr: Has the ability to control and monitor the specific secure domain router.

sysadmin: Has the ability to control and monitor all system parameters but cannot configure network protocols.

serviceadmin: Service administration tasks, for example, Session Border Controller (SBC).

e) The following predefined task groups are available for administrators to use, typically for initial configuration:

cisco-support: Cisco support personnel tasks maintenance: Maintenance team tasks

netadmin: Network administrator tasks

operator: Operator day-to-day tasks (for demonstration purposes)

provisioning: Provisioning team tasks

retrieve: Retrieve team tasks

root-lr: Secure domain router administrator tasks

sysadmin: System administrator tasks

serviceadmin: Service administration tasks, for example, SBC

2) TACACS+

a) Configuring TACACS Server

```
tacacs-server host host-name port port-number
```

In the following example, we see two TACACS server configurations

```
tacacs-server host 10.20.17.1 port 49
key 7 abc
timeout 10
!
tacacs-server host 10.20.17.2 port 49
key 7 DEF
timeout 10
!
```

b) To display information about the TACACS+ servers that are configured in the system use "show tacacs" command

c) Grouping TACACS Servers

A TACACS+ server group named TACACS-DEFAULT is created and an already configured TACACS+ server is added to it.

```
aaa group server tacacs+ TACACS-DEFAULT
server 10.20.17.1
server 10.20.17.2
(Optional) vrf vrf-id exit
```

3) AAA Method Lists

a) Authentication configuration uses method lists to define an order of preference for the source of AAA data, which may be stored in a variety of data sources. You can configure authentication to define more than one method list and applications (such as login) can choose one of them. For example, console ports may use one method list and the vty ports may use another. If a method list is not specified, the application tries to use a default method list.

The following examples specifies a method list called VTY-DEFAULT that uses the list of all configured TACACS+ servers under the group TACACS-DEFAULT for AAA services. If that method fails, the local username database method is used for authentication.

aaa authentication login VTY-DEFAULT group TACACS-DEFAULT local

aaa accounting exec VTY-DEFAULT start-stop group TACACS-DEFAULT none

aaa accounting commands VTY-DEFAULT start-stop group TACACS-DEFAULT none

aaa authorization exec VTY-DEFAULT group TACACS-DEFAULT local none

4) Applying AAA in both Console and VTY ports

The following configuration shows, for line template vty, VTY-DEFAULT is the method lists used for authentication, authorization, and accounting:

```
vty-pool default 0 29 line-template VTY-DEFAULT
line template VTY-DEFAULT
accounting exec VTY-DEFAULT
accounting commands VTY-DEFAULT
authorization exec VTY-DEFAULT
authorization commands VTY-DEFAULT
login authentication VTY-DEFAULT
timestamp
exec-timeout 10 0
transport input ssh
transport output none
line console
accounting exec VTY-DEFAULT
accounting commands VTY-DEFAULT
authorization exec VTY-DEFAULT
authorization commands VTY-DEFAULT
login authentication VTY-DEFAULT
timestamp
exec-timeout 10 0
transport input telnet ssh
transport output none
!
```

7.16 Syslogs

System Logging (Syslog) is the standard application used for sending system log messages. Log messages indicate the health of the device and point to any encountered problems or simplify notification messages according to the severity level. The IOS XR router sends its syslog messages to a syslog process. By default, syslog messages will be sent to the console terminal. But syslog messages can be sent to destinations other than the console such as the logging buffer, syslog servers, and terminal lines.

1) Configuring Logging to the Logging Buffer

This example shows the configuration for sending syslog messages to the logging buffer. The size of the logging buffer is configured as 3000000 bytes.

```
RP/0/RP0/CPU0:OLT# configure
RP/0/RP0/CPU0:OLT(config)# logging buffered 3000000
RP/0/RP0/CPU0:OLT(config)# commit
```

2) Configuring Logging to a Remote Server

This option will send the syslog messages to an external syslog server by specifying the ip address or hostname of the syslog server using the logging command. Also, you can configure the syslog facility in which syslog messages are send by using the logging facility command.

This example shows the configuration for sending syslog messages to an external syslog server. The ip address 10.127.60.137 is configured as the syslog server.

```
RP/0/RP0/CPU0:OLT(config)#  logging 10.127.60.137 vrf default severity
all port default
RP/0/RP0/CPU0:OLT(config)#  logging source-interface Loopback0
RP/0/RP0/CPU0:OLT(config)#  logging hostnameprefix OLT-1
RP/0/RP0/CPU0:OLT(config)#  commit
```

3) Sending Syslog Messages to an SNMP server

This example shows the configuration for sending syslog messages to an SNMP server. The logging trap command is used to limit the logging of messages sent to the snmp servers based on severity.

```
Router# configure
Router(config)# snmp-server traps syslog
Router(config)# logging trap warnings
Router(config)# commit
```

4) Logging Timestamps

By default, time stamps are enabled for syslog messages. Time stamp is generated in the month day HH:MM:SS format indicating when the message was generated.

This example shows how to configure or modify the timestamp for syslog and debugging messages:

```
service timestamps log uptime
service timestamps log datetime localtime msec show-timezone
service timestamps debug datetime localtime msec show-timezone year
```

5) Saving the Syslogs into a File

As per current design, the syslog from XR software will not persist for RP reload, Software upgrade and Power cycle scenarios. However, MSFT needs the syslogs to be persistent for such reloads. Cisco has an option of saving the logs in a file in live manner in real time.

The option discussed below allows the user to save the syslog in to a disk location which can be referred in the event of reload of RP or Software upgrade.

This is a configuration command.

```
RP/0/RP0/CPU0(config)#logging file syslog.log path /var/log/ maxfilesize 11200
severity debugging
RP/0/RP0/CPU0(config)#commit
```

Various fields in the given CLI config above

syslog.log à This is a file name user provided. It can be any name (user choice). This file will be permanent in the harddisk until user removes it or node goes to factory default

/var/log/ à this is the path in which the files will be stored

11,200 à is the max size of the file.

debugging à severity of the logging. Debugging is the lowest severity which will cover all severity (list of all different options are given below).

Example for different severity options that can be saved is given below.

User can choose the different severity starting from "emergencies" (severity=0) to "debugging" (severity=7).

Whenever user choses a severity, for example warning, then software will store logs of sev-4, sev-3, sev-2, sev-1 and sev-0.

When user choose "debugging" à This will capture all the severities which is super set.

In the example given above, we shared the severity of "debugging" which will make sure all the syslogs are stored in the file.

```
RP/0/RP0/CPU0:OLT-1(config)#logging file syslog.log path /var/log/ ?
  local-accounting  Store only the command accounting logs
  maxfilesize       Set max file size
  severity          Set severity level
  <cr>
RP/0/RP0/CPU0:OLT-1(config)#logging file syslog_file.log path /var/log/
severity ?
  alerts         Immediate action needed           (severity=1)
  critical       Critical conditions               (severity=2)
  debugging      Debugging messages                (severity=7)
  emergencies    System is unusable                (severity=0)
  error          Error conditions                  (severity=3)
  info           Informational messages            (severity=6)
  notifications  Normal but significant conditions (severity=5)
  warning        Warning conditions                (severity=4)
```

This command performs the following:

- Whenever a new syslog is generated in the system, the same will be saved instantaneously into the file mentioned in the CLI (in this case syslog.log).
- This file will be located in the path mentioned in the CLI (in this case /var/log)
- This file saves syslog up to size specified in the CLI (in this case it is 10MB)can be retrieved/viewed anytime
- Once it reaches 10MB, it will be compressed and backed-up (last 2 files are preserved always)
- Since this file is stored in the persistent memory (/var/log) , this file will persist across RP reloads, Software upgrades and Power cycles.
- User can always open the file from mentioned location for processing the syslogs which we present before reloading.

How to Read the File ?

The files can be accessed by accessing the `/var/log` from linux

```
RP/0/RP0/CPU0:OLT-1#run à go into linux shell
Mon Feb  5 15:06:11.731 IST
[node0_RP0_CPU0:~]$cd /var/log à access the /var/log folder
[node0_RP0_CPU0:/var/log]$ls -lrt | grep syslog.log
-rw-rw-rw-.   1 root  iosxr            3772928 Feb  5 15:06 syslog.log

RP/0/RP0/CPU0:OLT-1#run
Tue Feb  6 12:25:21.755 UTC
[node0_RP0_CPU0:/misc/scratch]$cd /var/log
```

Here we can view the file (the filename which is used in the config command) using the vi or cat options

As a part of the test, we reloaded the RP at “Jan 31 16:15:56”.

As you can see, the events from pre/post reload is saved in the file (post reload logs are from Jan 31 16:18:46).

Snippet from the syslog file from `/var/log/` location

”

RP/0/RP0/CPU0:Jan 31 16:14:52.214 UTC: config[67328]: %MGBL-CONFIG-6-DB_COMMIT : Configuration committed by user 'cisco'. Use 'show configuration commit changes 1000000449' to view the changes.
RP/0/RP0/CPU0:Jan 31 16:14:53.816 UTC: config[67328]: %MGBL-SYS-5-CONFIG_I : Configured from console by cisco on vty0 (4.33.0.51)
RP/0/RP0/CPU0:Jan 31 16:15:11.648 UTC: smartlicserver[353]: %LICENSE-SMART_LIC-2-PLATFORM_ERROR : Smart Licensing has encountered an internal software error. Contact TAC: The platform provided UDI list has invalid values: ; udi_pid is empty
RP/0/RP0/CPU0:Jan 31 16:15:11.648 UTC: smartlicserver[353]: %LICENSE-SMART_LIC-2-PLATFORM_ERROR : Smart Licensing has encountered an internal software error. Contact TAC: The platform provided UDI list has invalid values: ; udi_pid is empty
RP/0/RP0/CPU0:Jan 31 16:15:56.731 UTC: shelfmgr_exec_cli[68416]: %PLATFORM-SHELFMGR-6-USER_OP : User root requested 'graceful card reload' of 0/RP0/CPU0
RP/0/RP0/CPU0:Jan 31 16:15:56.735 UTC: smartlicserver[353]: %LICENSE-SMART_LIC-2-PLATFORM_ERROR : Smart Licensing has encountered an internal software error. Contact TAC: The platform provided UDI list has invalid values: ; udi_pid is empty
RP/0/RP0/CPU0:Jan 31 16:15:56.738 UTC: processmgr[51]: %OS-SYSMGR-6-INFO : Received request for graceful go-down from shelfmgr. Reload Reason:User initiated card reload. Timeout 55
RP/0/RP0/CPU0:Jan 31 16:15:56.738 UTC: processmgr[51]: %OS-SYSMGR-6-INFO : Prepared RMF to reboot
RP/0/RP0/CPU0:Jan 31 16:15:57.921 UTC: obflmgr[313]: %PLATFORM-OBFL-6-INFO : Unmounted OBFL directory for 0/Rack
RP/0/RP0/CPU0:Jan 31 16:15:58.521 UTC: obflmgr[313]: %PLATFORM-OBFL-6-INFO : Unmounted OBFL directory for 0/RP0/CPU0

RP/0/RP0/CPU0:Jan 31 16:15:58.960 UTC: processmgr[51]: %MGBL-SCONBKUP-6-INTERNAL_INFO : Reload debug script successfully spawned
RP/0/RP0/CPU0:Jan 31 16:16:25.961 UTC: processmgr[51]: %OS-SYSMGR-6-INFO : sysmgr_audit_app_tier: ack not received for sysmgr shutdown event from :emsd(1110)
RP/0/RP0/CPU0:Jan 31 16:16:27.289 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9992]: Received signal 15; terminating.
RP/0/RP0/CPU0:Jan 31 16:16:27.489 UTC: shelfmgr[329]: %PLATFORM-SHELFMGR-4-CARD_RELOAD : Reloading 0/RP0/CPU0: User initiated card reload
RP/0/RP0/CPU0:Jan 31 16:18:46.837 UTC: ospf[1036]: %ROUTING-OSPF-6-HA_INFO : Process 1: OSPF process initialization complete
RP/0/RP0/CPU0:Jan 31 16:18:46.881 UTC: ospf[1036]: %ROUTING-OSPF-5-HA_NOTICE : Process 1: Signaled PROC_AVAILABLE
RP/0/RP0/CPU0:Jan 31 16:18:50.248 UTC: emsd[1110]: %MGBL-EMS-6-EMSD_SERVICE_START : emsd service start
RP/0/RP0/CPU0:Jan 31 16:18:54.296 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9800]: Server listening on 0.0.0.0 port 22.
RP/0/RP0/CPU0:Jan 31 16:18:54.296 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9800]: Server listening on :: port 22.
RP/0/RP0/CPU0:Jan 31 16:18:54.916 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9800]: Received signal 15; terminating.
RP/0/RP0/CPU0:Jan 31 16:18:55.003 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9883]: Server listening on 0.0.0.0 port 830.
RP/0/RP0/CPU0:Jan 31 16:18:55.003 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9883]: Server listening on :: port 830.
RP/0/RP0/CPU0:Jan 31 16:18:55.003 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9883]: Server listening on 0.0.0.0 port 22.
RP/0/RP0/CPU0:Jan 31 16:18:55.003 UTC: ssh_syslog_proxy[1192]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : sshd[9883]: Server listening on :: port 22.
RP/0/RP0/CPU0:Jan 31 16:18:56.055 UTC: smartlicserver[353]: %LICENSE-SMART_LIC-2-PLATFORM_ERROR : Smart Licensing has encountered an internal software error. Contact TAC: The platform provided UDI list has invalid values: ; udi_pid is empty
RP/0/RP0/CPU0:Jan 31 16:18:56.334 UTC: ifmgr[201]: %PKT_INFRA-LINK-5-CHANGED : Interface PTP0/RP0/CPU0/0, changed state to Administratively Down
RP/0/RP0/CPU0:Jan 31 16:18:56.334 UTC: ifmgr[201]: %PKT_INFRA-LINK-5-CHANGED : Interface PTP0/RP0/CPU0/1, changed state to Administratively Down
RP/0/RP0/CPU0:Jan 31 16:18:56.336 UTC: cfgmgr-rp[366]: %MGBL-CONFIG-6-OIR_RESTORE : Configuration for node '0/RP0/0' has been restored.
RP/0/RP0/CPU0:Jan 31 16:18:56.393 UTC: ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface MgmtEth0/RP0/CPU0/0, changed state to Down
RP/0/RP0/CPU0:Jan 31 16:18:56.393 UTC: ifmgr[201]: %PKT_INFRA-LINEPROTO-5-UPDOWN : Line protocol on Interface MgmtEth0/RP0/CPU0/0, changed state to Down
RP/0/RP0/CPU0:Jan 31 16:18:56.393 UTC: ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface MgmtEth0/RP0/CPU0/1, changed state to Down

7.17 Configuration Management

Configuration History, change inspection and Rollback

NCS1010/1020 equipment share the same configuration management used by all device based on IOS-XR platform. The device configuration is based on uman readable CLI text and is stored in the device filesystem in a fully versioned way with configuration history tracking.

The system maintains this configuration history up to 100 configuration change in the past life of the device.

It is possible to inspect the list of configuration operation ("commit") applied in the past using the command "show configuration commit list" like in the following example:

```
RP/0/RP0/CPU0:ILA-1#show configuration commit list
Wed Jun 19 12:31:49.948 UTC
SNo. Label/ID              User      Line                Client      Time Stamp
~~~~ ~~~~~~~~              ~~~~      ~~~~                ~~~~~~      ~~~~~~~~~~
1    1000000111            cisco     vty0:node0_RP0_CPU  CLI         Mon Jun 10
13:23:13 2024
2    1000000110            cisco     vty0:node0_RP0_CPU  CLI         Mon Jun 10
13:23:03 2024
```

```
3     1000000109            cisco    vty0:node0_RP0_CPU  CLI         Wed Jun  5
06:52:03 2024
4     1000000108            cisco    vty1:node0_RP0_CPU  CLI         Wed Jun  5
06:30:27 2024
5     1000000107            cisco    vty1:node0_RP0_CPU  CLI         Wed Jun  5
06:04:16 2024
6     1000000106            cisco    vty0:node0_RP0_CPU  CLI         Tue Jun  4
07:45:29 2024
7     1000000105            cisco    vty1:node0_RP0_CPU  CLI         Mon Jun  3
07:24:48 2024
8     1000000104            cisco    vty0:node0_RP0_CPU  CLI         Thu May 30
16:27:21 2024
9     1000000103            cisco    vty0:node0_RP0_CPU  CLI         Fri May 24
08:55:35 2024
10    1000000102            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
13:41:39 2024
11    1000000101            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
13:24:07 2024
12    1000000100            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
13:19:55 2024
13    1000000099            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
13:12:16 2024
14    1000000098            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
12:15:05 2024
15    1000000097            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
12:14:33 2024
16    1000000096            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
12:11:49 2024
17    1000000095            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
08:58:09 2024
18    1000000094            cisco    vty0:node0_RP0_CPU  CLI         Thu May 23
08:55:48 2024
19    1000000093            cisco    netconf             YANG Frame  Fri May 17
11:59:06 2024
20    1000000092            cisco    netconf             YANG Frame  Fri May 17
11:49:10 2024
21    1000000091            cisco    netconf             YANG Frame  Fri May 17
11:40:19 2024
22    1000000090            cisco    vty0:node0_RP0_CPU  CLI         Fri May 17
11:39:51 2024
23    1000000089            cisco    vty0:node0_RP0_CPU  CLI         Fri May 17
09:35:18 2024
24    1000000088            cisco    vty0:node0_RP0_CPU  CLI         Fri May 10
15:47:46 2024
25    1000000087            cisco    vty0:node0_RP0_CPU  CLI         Fri May 10
15:47:32 2024
26    1000000086            cisco    vty0:node0_RP0_CPU  CLI         Wed May  8
15:24:43 2024
```

```
27   1000000085           cisco    vty0:node0_RP0_CPU  CLI         Wed May  8
15:23:43 2024
28   1000000084           cisco    netconf             YANG Frame  Wed May  8
15:21:57 2024
29   1000000083           cisco    vty0:node0_RP0_CPU  CLI         Wed May  8
15:20:51 2024
30   1000000082           cisco    con0_RP0_CPU0       CLI         Wed May  8
15:16:26 2024
31   1000000081           cisco    con0_RP0_CPU0       CLI         Wed May  8
14:26:32 2024
32   1000000080           SYSTEM   con0_RP0_CPU0       Setup Dial  Wed May  8
14:20:03 2024
RP/0/RP0/CPU0:ILA-1#
```

The field in this output are explained in the following table:

Field	Description
SNo.	Serial number of the commit entry.
Label/ID	If a label was assigned to a commit, the first 10 characters of the label display; otherwise, the autogenerated commit ID displays.
User	User who executed the commit.
Line	Line in which the user session was established. In some cases, this field may display "UNKNOWN" or "SYSTEM". These fields indicate that an internal commit was made by the system.
Client	The management interface used to make the commit.
Time Stamp	Time and date when the commit was executed.

Every change operation is identified by a unique ID that let the user inspect the specific change applied during that specific configuration session. The command to use to show the specific commit changes is “sh configuration commit changes <ID>”

```
RP/0/RP0/CPU0:ILA-1#sh configuration commit changes 1000000109
Wed Jun 19 12:49:19.166 UTC
!! Building configuration...
!! IOS XR Configuration 24.2.1.32I
interface GigabitEthernet0/0/0/0
 description "Expected OLT-1-B"
!
interface GigabitEthernet0/0/0/2
 description "Expected ILA-2"
```

```
!
end
RP/0/RP0/CPU0:ILA-1#
```

Is also possible to group and show the configuration changes done by multiple configuration sessions by using the "last" or "since" modifier of the command. For example:

```
RP/0/RP0/CPU0:ILA-1#sh configuration commit changes last 3
Wed Jun 19 12:55:17.685 UTC
!! Building configuration...
!! IOS XR Configuration 24.2.1.32I
hw-module location 0/0/NXR0
 inline-ampli
  grid-mode flex
   no channel-id 1 centre-freq 196.075 width 150.0
   channel-id 1 centre-freq 191.425 width 150.0
  !
 !
!
interface GigabitEthernet0/0/0/0
 description "Expected OLT-1-B"
!
interface GigabitEthernet0/0/0/2
 description "Expected ILA-2"
!
end

RP/0/RP0/CPU0:ILA-1#sh configuration commit changes since 1000000109
Wed Jun 19 12:55:17.685 UTC
!! Building configuration...
!! IOS XR Configuration 24.2.1.32I
hw-module location 0/0/NXR0
 inline-ampli
  grid-mode flex
   no channel-id 1 centre-freq 196.075 width 150.0
   channel-id 1 centre-freq 191.425 width 150.0
  !
 !
!
interface GigabitEthernet0/0/0/0
 description "Expected OLT-1-B"
!
```

```
interface GigabitEthernet0/0/0/2
 description "Expected ILA-2"
!
end
RP/0/RP0/CPU0:ILA-1#
```

Since the device is maintains all the configuration sessions change it is possible to rollback any specific single change, the last n changes or all the changes from a specific ID (included or not). The following example show how to use the “rollback configuration change …” command to perform this operation.

```
RP/0/RP0/CPU0:ILA-1#rollback configuration to 1000000110
Wed Jun 19 13:33:20.330 UTC

Loading Rollback Changes.
Loaded Rollback Changes in 1 sec
Committing.
1 items committed in 1 sec (0)items/sec
Updating.
Updated Commit database in 1 sec
Configuration successfully rolled back 2 commits.
RP/0/RP0/CPU0:ILA-1#

Or

RP/0/RP0/CPU0:ILA-1#rollback configuration last 2
Wed Jun 19 13:33:55.480 UTC

Loading Rollback Changes.
Loaded Rollback Changes in 1 sec
Committing.
1 items committed in 1 sec (0)items/sec
Updating.
Updated Commit database in 1 sec
Configuration successfully rolled back 2 commits.
RP/0/RP0/CPU0:ILA-1#

Rollback operations are recorded as well as configuration changes, with a
dedicated Client field set as “Rollback”:

RP/0/RP0/CPU0:ILA-1#show configuration commit list
Wed Jun 19 13:35:35.150 UTC
SNo. Label/ID              User      Line                Client      Time Stamp
~~~~ ~~~~~~~~              ~~~~      ~~~~                ~~~~~~      ~~~~~~~~~~
```

```
1     1000000112            cisco     vty0:node0_RP0_CPU  Rollback    Wed Jun 19
13:33:20 2024
2     1000000111            cisco     vty0:node0_RP0_CPU  CLI         Mon Jun 10
13:23:13 2024
3     1000000110            cisco     vty0:node0_RP0_CPU  CLI         Mon Jun 10
13:23:03 2024
4     1000000109            cisco     vty0:node0_RP0_CPU  CLI         Wed Jun  5
06:52:03 2024
5     1000000108            cisco     vty1:node0_RP0_CPU  CLI         Wed Jun  5
06:30:27 2024
[…]
```

Configuration update during SW upgrade

In same SW upgrade path it may happen that the new software version may apply automatic change to the configuration. This may be due to new feature introduction and in general for configuration CLI change across the two software version.

When this happens during the upgrade, a related system initiated (Client field show as SYSTEM) configuration change line will appear in the configuration commit list at the first boot of the new software.

The user can inspect the change applied by the system related to the upgrade by using the same "show configuration change" command with the ID of the system-initiated configuration change. If the system is going to remain with the new software it is strongly suggested to not rollback these changes, since configuration change during the upgrade are applied only when mandatory and required.

In the case the user may decide to rollback (downgrade) to the previous software version for any reason, the new configuration lines introduced by the new software version (if present) may fail when booting back in the old software. This can be inspected using the command "show configuration failed startup" executed after the software downgrade.

If this happens the system will raise an alarm indicating that the configuration is in inconsistent state:

```
RP/0/RP0/CPU0:Jun 11 05:52:32.731 UTC: cfgmgr-rp[207]: %MGBL-CONFIGCLI-3-
BATCH_CONFIG_FAIL : 2 config(s) failed during startup. To view failed config(s)
use the command - "show configuration failed startup"
RP/0/RP0/CPU0:Jun 11 05:52:32.737 UTC: cfgmgr-rp[207]: %MGBL-CONFIG-3-
INCONSISTENCY_ALARM : A configuration inconsistency alarm has been raised.
Configuration commits will be blocked until 'clear configuation inconsistency'
command has been run to synchronize persistent configuration with running
configuration.
RP/0/RP0/CPU0:Jun 11 05:52:32.740 UTC: cfgmgr-rp[207]: %PKT_INFRA-FM-2-
FAULT_CRITICAL : ALARM_CRITICAL :CFGMGR-CONFIG-INCONSISTENCY :DECLARE
:0/RP0/CPU0:
```

In this condition the system do not allow any additional configuration change until the inconsistency is resolved. If the user tries to configure the device the following message is shown:

```
RP/0/RP0/CPU0:P2A_DT_08#conf
Mon Jun 10 07:54:25.894 UTC
This SDR's running configuration is inconsistent with persistent configuration.
```

```
No configuration commits for this SDR will be allowed until a 'clear
configuration inconsistency' command is performed.
RP/0/RP0/CPU0:P2A_DT_08(config)#
```

The user have to clear the configuration inconsistency using the “'clear configuration inconsistency” command as suggested by the error message.

In general, the failed configurations are due to new feature introduced in the new software version that do not apply to the old one, so the failure are harmless to the system. Anyway, is possible to rollback the configuration to the ID in the configuration history that is just before the upgrade system-initiated config change. In this way both the software and the configuration are rolled back to the same history point before the upgrade.

Configuration Backup

Manual backup

It is possible for the user to manually backup the running configuration both locally and remotely using the copy command by using “running-config” as source file and a local or remote location as destination file:

```
RP/0/RP0/CPU0:ILA-1#copy running-config ?
  WORD        Copy to file
  config:     Copy to config: file system
  disk0:      Copy to disk0: file system
  ftp:        Copy to ftp: file system
  harddisk:   Copy to harddisk: file system
  http:       Copy to http: file system
  https:      Copy to https: file system
  rootfs:     Copy to rootfs: file system
  scp:        Copy to scp: file system
  sftp:       Copy to sftp: file system
  tftp:       Copy to tftp: file system

RP/0/RP0/CPU0:ILA-1#copy running-config scp://test@10.58.230.32/ila1.cfg
Thu Jun 20 11:30:57.500 UTC
Destination file name (control-c to cancel): [ila1.cfg]?
.311 lines built in 1 second
Password:
nvgen-22496-_proc_22496_fd_96                100% 7327     1.3MB/s   00:00
RP/0/RP0/CPU0:ILA-1#
```

Automatic backup

Is also possible to configure an automatic configuration backup that performs a local or remote (depending on the destination definition) backup of the config on every committed configuration change. This can be archived with the following configuration section:

```
RP/0/RP0/CPU0:OLT-1-B#sh run configuration commit auto-save
Thu Jun 20 12:42:38.574 UTC
configuration commit auto-save
 maximum 20
 filename sftp://test@10.58.230.32://home/test/auto-cfg-backup/olt1.cfg
 password encrypted encryption-default 044A1B11002445
 timestamp
 wait-time days 0 hours 0 minutes 1 seconds 0
!
```

In this case the configuration is auto-saved on the remote sftp server, adding the timestamp to the filename and maintaining up to 20 backup file. The auto-save has a configured wait time (1 minute in this example) to avoid to have multiple backup in case of back to back fast config change commit. The backup is triggered after “wait-time” w/o change from the last commit.

The following syslog show the tracking of a configuration change and the subsequent connection to the server for the auto-save operation. The connection to the server is executed twice, the first one to check if the history rotation (“maximum 20”) require deleting old configuration, the second connection to actually save the current config

```
RP/0/RP0/CPU0:Jun 20 12:42:28.263 UTC: config[66629]: %MGBL-SYS-5-CONFIG_I : Configured from console by cisco on vty0 (10.228.192.145)

RP/0/RP0/CPU0:OLT-1-B#RP/0/RP0/CPU0:Jun 20 12:42:57.149 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22880]: Warning: Permanently added '10.58.230.32' (ECDSA) to the list of known hosts.

RP/0/RP0/CPU0:Jun 20 12:42:57.336 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22880]: SSH Client successfully established session as test to 10.58.230.32

RP/0/RP0/CPU0:Jun 20 12:42:57.490 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22880]: SSH Client terminated session as test to 10.58.230.32

RP/0/RP0/CPU0:Jun 20 12:42:59.664 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22973]: Warning: Permanently added '10.58.230.32' (ECDSA) to the list of known hosts.

RP/0/RP0/CPU0:Jun 20 12:42:59.844 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22973]: SSH Client successfully established session as test to 10.58.230.32

RP/0/RP0/CPU0:Jun 20 12:42:59.988 UTC: ssh_syslog_proxy[1191]: %SECURITY-SSHD_SYSLOG_PRX-6-INFO_GENERAL : ssh_csm[22973]: SSH Client terminated session as test to 10.58.230.32
```

After the auto-save operation the server folder contain the auto-saved configuration files.

```
[test@mnz-dt-pxe01 ~]$ ls -l /home/test/auto-cfg-backup/
total 12
-rw------- 1 test test 11213 Jun 20 14:42 olt1.cfg.autosave.0.ts.Thu_Jun_20_12-42-57_532_UTC
[test@mnz-dt-pxe01 ~]$
```

7.18 Disaster Recovery (CPU Replacement)

NCS1K is a single RP platform, but it has an additional Chassis-based SSD (solid state drive). Without the redundancy offered by dual RPs, it is desirable to be able to quickly recover to a functional state in the event of either RP corruption or replacement.

To achieve this, the chassis SSD is used to store a backup of the running software image and configuration, enabling the RP to be quickly rebooted from this backup if necessary.

NOTE:

The SSD on the Chassis is removeable/replaceable in NCS1020 and NCS1014 while it is non-removable in NCS1010.

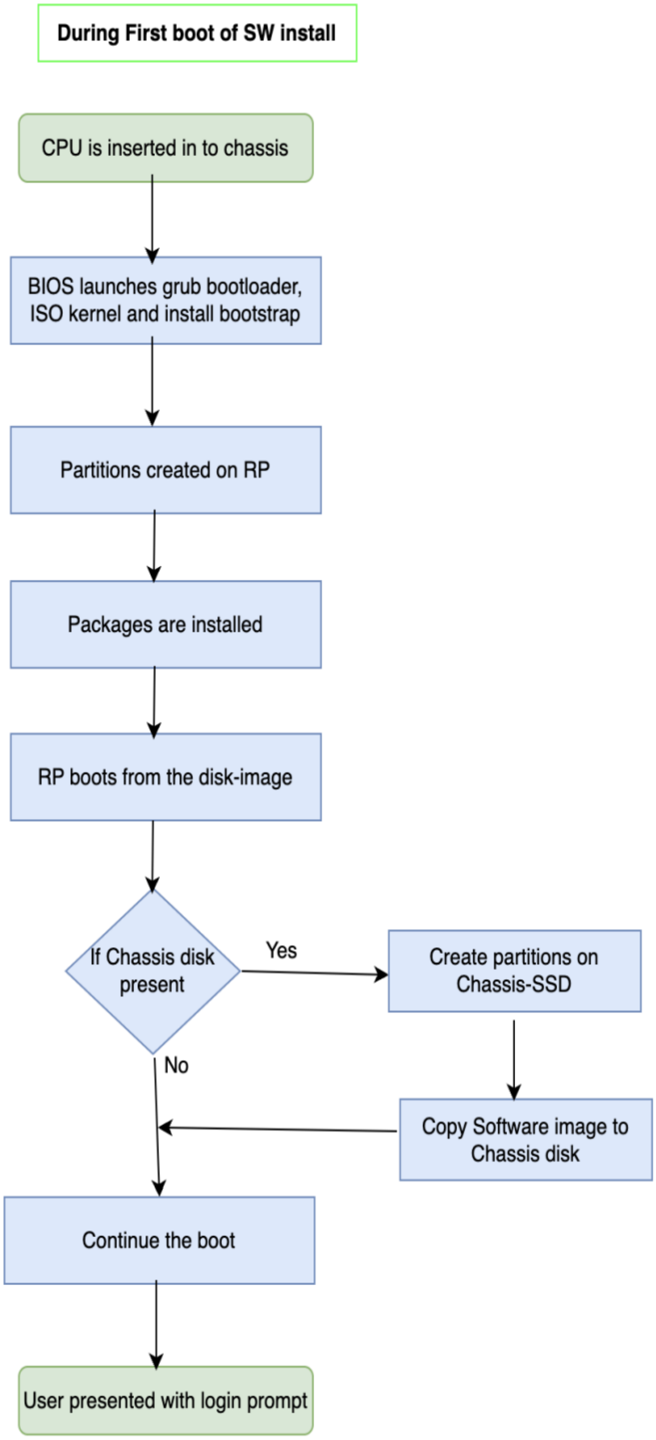
In normal operating conditions, both the RP and Chassis SSDs are in sync with respect to the Software Image (only Current/Active Software) and the configurations present in the system.

When both the RP and Chassis SSD are present and valid, the Chassis-SSD is marked as priority/master except two conditions captured below

- In case of the Chassis-SSD content corrupted (refer alarm section for details), the RP-SSD will be marked as preferred/master
- In the event of Chassis-SSD RMA, the Chassis-SSD will be shipped empty and in such cases the RP-SSD will be marked as master

During very-first time boot

- The BIOS launches the grub bootloader and ISO kernel, and the Install bootstrap script is triggered
- Partition sizes are determined, and partitions are created on the RP
- Packages are installed from the ISO repository
- Once setup is complete, the RP reboots and boots from disk, the newly installed software.
- During disk boot, the chassis SSD is partitioned.
    - If a DR disk is present, then partition sizes are retrieved from the disk layout specification, and the chassis partitions created and formatted. Partition creation is done regardless of the presence of existing partitions on the chassis SSD.
    - If the DR disk is not present, the boot continues by skipping the backup operations. There will be an alarm raised indicating the backup software is unavailable "DISASTER_RECOVERY_UNAVAILABLE".
- After successful creation of partitions, the software image is copied to the chassis SSD.



During the RP boot

Several checks are performed during disk-boot, to verify whether the chassis SSD software is in a valid state or needs repopulating, or whether the RP needs repopulating from the chassis SSD. The flow is as follows:

NOTE:

The Cookie is a hash of the standard cookie (calculated from the list of installed packages), together with EFI partition contents, DRI, ztp, and label.

Upon power on/inserted into the chassis, the RP boots from the image stored in the RP disk

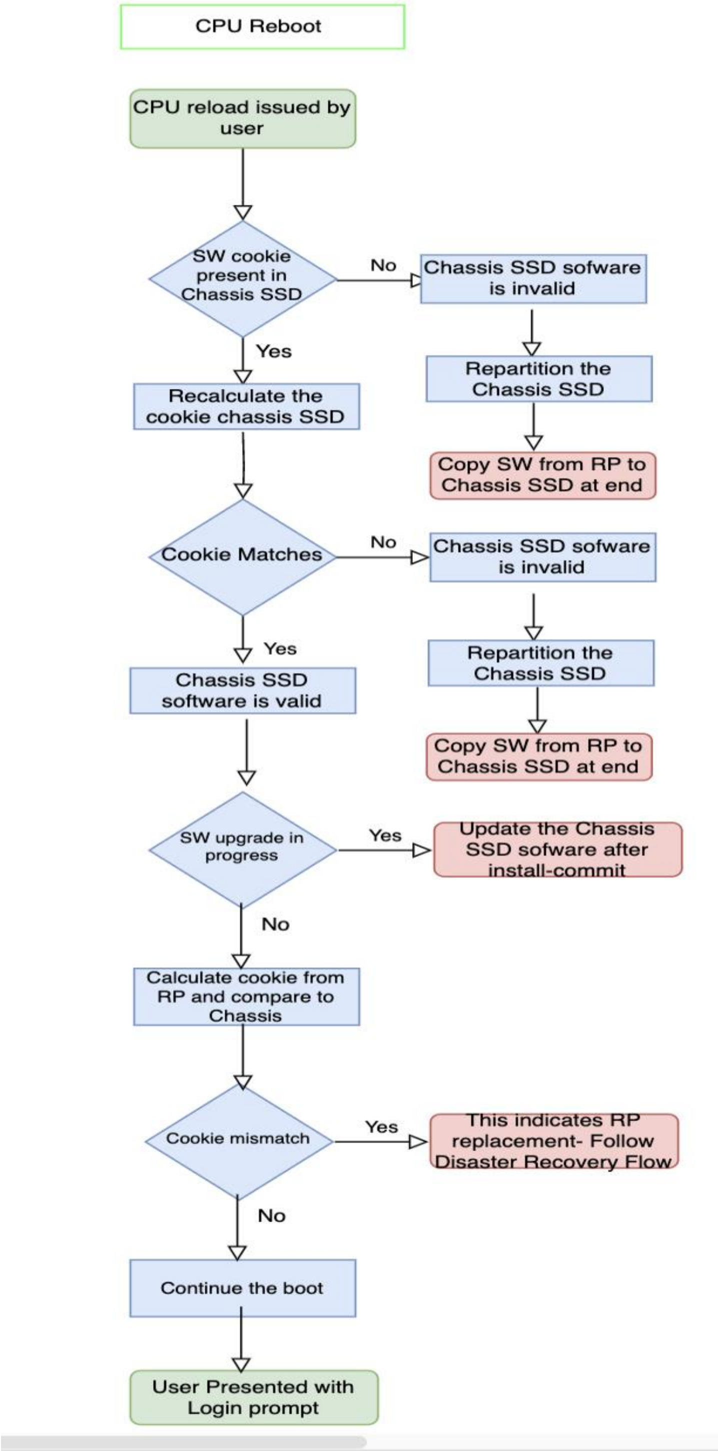
1. Check for the presence of the software cookie on the chassis SSD. If this is absent, the chassis SSD software is invalid.
    a. Expected to be hit for the case of chassis replacement (RMA), in which the chassis SSD is empty on disk-boot.

    Example logs:

    ```
    [   42.601210] xrnginstall[3131]: 2024-06-19 20:36:48.056 IST: xrinstall: Mounting DR partitions /dev/sdb1 /dev/dr-vg/data-lv
    [   42.640926] xrnginstall[3142]: 2024-06-19 20:36:48.108 IST: xrinstall: No disaster recovery software cookie present at /mnt/dr_disk/data/dr-cookie
    ```
2. If invalid, the chassis SSD is repartitioned. A resync from the RP will be triggered on Orchestrator startup.
3. If the software cookie is present, recalculate the cookie from the software on the chassis disk, and compare to the stored cookie. If there is a mismatch, then the chassis SSD software is invalid, and the repartition flow (step 3) is triggered.
4. If all the above checks passed, then the chassis SSD has a valid set of backup software, which can be used to repopulate the RP if needed.

    Example Logs

    ```
    [   47.555422] xrnginstall[3212]: 2024-06-19 15:08:19.031 UTC: xrinstall: Checking software on DR disk /dev/sdb
    [   47.573587] xrnginstall[3216]: 2024-06-19 15:08:19.039 UTC: xrinstall: Mounting DR partitions /dev/sdb1 /dev/dr-vg/data-lv
    [   47.602748] xrnginstall[3226]: 2024-06-19 15:08:19.079 UTC: xrinstall: Calculating disaster recovery cookie for DR disk software using v3 algorithm
    [   47.633504] xrnginstall[3266]: 2024-06-19 15:08:19.111 UTC: xrinstall: Setting repo_path to /mnt/dr_disk/data/repo/ /mnt/dr_disk/data/partner_install_internal_repo/ /mnt/dr_disk/data/owner_install_internal_repo/
    [   47.671086] xrnginstall[3283]: 2024-06-19 15:08:19.149 UTC: xrinstall: Calculating disaster recovery cookie with files: /mnt/dr_disk/efi/EFI/Cisco_DR/LockDown.efi /mnt/dr_disk/efi/EFI/Cisco_DR/bootx64.efi /mnt/dr_disk/data/dri.iso /mnt/dr_disk/efi/EFI/BOOT/grub.cfg /mnt/dr_disk/efi/EFI/BOOT/grub.cfg.signature
    ```
5. If a software upgrade is in progress, then a mismatch between RP and chassis SSD software is expected, and the next step is bypassed; the chassis SSD software will be updated on install-commit.
6. Calculate the software cookie from the software on the RP and compare to the chassis cookie. If there is a mismatch (and no software upgrade in progress), this indicates RP replacement. The Disaster Recovery method is called here. Refer “Disaster Recovery” section
7. Otherwise, proceed with the standard boot flow.



NOTE:
RP and CPU are used interchangeably in this section.

Disaster Recovery Boot

During the RP boot process, if the cookie mismatch between RP and Chassis software is detected (Step-7 in the RP boot process above), marked in **Orange** below the RP will be set to disaster recovery boot (i.e, booting the software image from the Chassis-SSD) and CPU will load the image from Chassis-SSD (aka, Disaster Recovery boot) marked in **Green** below

At the end of the boot, the RP will be loaded with image from Chassis-SSD and the configurations will be copied to RP

```
[   52.712650] xrnginstall[4777]: 2024-06-19 22:15:11.172 IST: xrinstall:
Calculating disaster recovery cookie for RP software
[   52.739557] xrnginstall[4796]: 2024-06-19 22:15:11.199 IST: xrinstall:
Setting repo_path to
/var/opt/cisco/iosxr/install/mirror/iosxr_install_internal_repo/
/var/opt/cisco/iosxr/install/mirror/partner_install_internal_repo/
/var/opt/cisco/iosxr/install/mirror/owner_install_internal_repo/
[   52.775831] xrnginstall[4801]: 2024-06-19 22:15:11.236 IST: xrinstall:
Calculating disaster recovery cookie with files:
/boot/efi/EFI/BOOT/LockDown.efi /boot/efi/EFI/BOOT/bootx64.efi
/opt/cisco/disaster_recovery/dri.iso /opt/cisco/disaster_recovery/grub.cfg
/opt/cisco/disaster_recovery/grub.cfg.signature
[   52.810992] xrnginstall[4805]: md5sum: /opt/cisco/disaster_recovery/dri.iso:
No such file or directory
[   52.827529] xrnginstall[4809]: 2024-06-19 22:15:11.264 IST: xrinstall:
Verifying RPM set
[   62.178174] xrnginstall[6392]: 2024-06-19 22:15:20.637 IST: xrinstall:
Calculated RP cookie as 96f204fb920817f0685aae3e8e77cf7d
[   62.197940] xrnginstall[6396]: 2024-06-19 22:15:20.644 IST: xrinstall: RP
cookie does not match DR cookie 9fd83763085e14ca79754aefe4f73d7e
[   62.240420] xrnginstall[6407]: 2024-06-19 22:15:20.700 IST: xrinstall: RP
software 24.2.1.32I does not match disaster recovery software 24.2.1.32I-GISO
[   62.261020] xrnginstall[6411]: 2024-06-19 22:15:20.706 IST: xrinstall:
Triggering disaster recovery boot
…
  Booting `Install IOS-XR'

Booting from disaster recovery image..
Loading Kernel..
Verifying /boot/bzImage...
/boot/bzImage verified
….
2024-06-19 16:48:10.818 UTC: xrinstall: Populating RPM repository with RPMs
from the DRI
```

Alarms indicating the problems with Backup

In the event of the SSD Disk access error, system will raise: SSD Access Error

In the event of the image file corrupted, system will raise: DISASTER_RECOVERY_UNAVAILABLE.

In case of software image corrupted scenario on Chassis-SSD, the system will attempt to auto-recover the image as a part of the regular audit that runs on every 12 hours. In that case, the software from RP will be copied to Chassis-SSD and the alarm will be cleared if the recovery is successful.

This alarm will also raise during the Software upgrade until the install-commit is performed, indicating that the CPU and Chassis disk are in different software.

NOTE:

During Software Upgrade, the CPU will copy the new image to Chassis SSD only upon commit is issued.

RP replacement scenario

In the event of a faulty RP card RMA, the flow is as follows:

System is running with Chassis-SSD plugged in and user connected to CPU Console (optional):

- Replacement RP running with different SW & Configuration compared to previously running RP
  1. The user removes the OLD CPU and plug-in a new CPU. Step 2 to Step 5 doesn't require any user intervention and is handled automatically.
  2. CPU starts boot the image from the local disk
  3. During the boot process, the CPU SW cookie will be compared with Chassis-SSD SW cookie
  4. In case of mismatch, the Disaster Recovery boot will be automatically initiated (Refer Section: Error! Reference source not found.)
  5. After approximately 20 to 30 mins (depends on FPDs that are needed to be auto-upgraded on the new CPU), the system will be ready for user login
  6. User can login using the same username/password which was configured earlier
  7. User can verify that the system is back in same SW version that was running earlier, exact same configuration is reapplied, and the traffic runs error free. The entire operation is Non-Traffic-Affecting in nature.

- Replacement RP having same SW except configuration compared to previously running RP
  1. The user removes the OLD RP and plug-in a new RP. Step 2 to Step 6 doesn't require any user intervention and is handled automatically.
  2. RP starts boot the image from the local disk
  3. During the boot process, the RP SW cookie will be compared with Chassis-SSD SW cookie
  4. In this case as SW is same as previous RP, both RP and Chassis cookie will match

5. SW from RP will continue to boot, before all applications start an additional check is done if the 'CPU-ID' is same as the old RP or different. This CPU-ID is unique to every Intel CPU, this will not match.
6. This condition enforces to re-apply the configuration and checkpoint data from Chassis SSD to RP-SSD. This is primarily done as RP and Chassis SW cookie matches, but RP CPU-ID and Chassis CPU-ID doesn't match.
7. User can login using the same username/password which was configured earlier
8. User can verify that the system is back in same SW version that was running earlier, exact same configuration is reapplied, and the traffic runs error free. The entire operation is Non-Traffic-Affecting in nature.

NOTE:

The Disaster recovery will only restore the active SW image and configurations. However, any files such as image, show-tech logs etc are kept in /harddisk:/ of the CPU will not be backed-up or restored.

Chassis SSD replacement scenario (NCS1014 & NCS1020)

In the event of a faulty Chassis-SSD, the flow is as follows:

System will raise the alarm indicating the access error to SSD or DISASTER RECOVERY UNAVAILABLE.

Once user has the replacement SSD,

1. User removes the old Chassis-SSD (unscrew the SSD from the front of NCS1020 and rear in case of NCS1014)
2. Insert the new Chassis-SSD
3. System will recognize the new SSD and necessary partitions will be created
4. Then the SW image and Configs will be backed up
5. The alarms will be cleared at the successful sync of the software and config from CPU

Configuration and Checkpoint data backup to Chassis SSD

Configurations and critical system checkpoint data are primarily stored in RP SSD where XR is running from. These data are monitored with the help of Linux services, and it's backed up to chassis SSD as and when a change is detected from the primary store (RP SSD).

7.19 Log Archiving

Different applications generate different types of files like debug logs, operating data and many more. At times, these files grow bigger and could consume entire disk space over time if not monitored. In Cisco products we would have two kinds of files/logs created

i. System generated
ii. User generated

Proposals and explanation:
We have different methods and features to alert, monitor and archive, remove disk files which are growing and consuming disk space beyond a threshold. Below is one example of a threshold crossing alarm on a monitored disk. This is an alert only message and doesn't make any automated corrective action

Syslog:
HA-HA_WD-4-DISK_WARN: A monitored device / (rootfs:/) is above 80% utilization. Current utilization = 94.
As the user is alerted with this kind of syslog, the user can take appropriate corrective action to mitigate the disk utilization warning condition. In our devices we leverage 'logrotate' utility to monitor and archive to local disk and remove files which meets the logrotate configured criteria.

1. **System Generated Files**
   Files generated by the system autonomously fall under this category, these are spread across different mount points of the system like '/var/log', '/harddisk/:'. These files could be of different extensions based on content of the data and its application which generated it. These files include .log, .sor, etc.
   While we have existing system configuration which takes care of monitoring several types of files, we are not monitoring .sor file in current SW.

2. **User Generated Files**
   Files which are created with the help of some debug dump logging CLI like collection of traces on demand, collection of show-tech on demand fall under this category. There could also be instances where user copies different .iso file probably for software upgrade and .rpm files probably to install a bug-fix SMU and there could be more such files which user can copy to a partition which is recommended for user's usage – '/harddisk:'
   User generated files are owned by the user, and it's not recommended to delete/remove them with an automated utility, As this file is generated/created by a user and the tool doesn't have any intelligence on why such file was created by the user and why it's retained for X amount of time/day.
   Hence, for such user-generated files, once these files are deemed unnecessary, we recommend that the user delete them or wait for the HA-HA_WD-4-DISK_WARN syslog message to appear, which will notify the user to take appropriate action.

7.20 Remote Console

In many deployment scenarios, an ILA node may not have a console server, or an Ethernet DCN network connected to it. The only way to access these ILA nodes is through the OSC channel and by using SSH to connect to the ILA node via this channel. For SSH operations, the remote ILA node's XR software must be functioning properly to accept incoming SSH sessions. There may be situations where the remote ILA node's RP software is not working correctly and is inaccessible through the OSC channel. To overcome this limitation and allow users to access the remote ILA node for debugging and troubleshooting, remote console access is enabled. This feature allows a user with access to a functioning OLT node to reach the target ILA node through the OSC channel, enabling connection to the 'console' and access to BIOS/XR via the OSC channel. This facilitates debugging issues in the remote node and eliminates the need for someone to travel and physically connect a console cable to any console server available in the lab for debugging.

User can use this command to get details about the neighbour “show remote-connect neighbours”

```
Ex:
RP/0/RP0/CPU0:PROD3#sh remote-connect neighbours
Wed Sep 18 13:12:49.995 IST
Remote console neighbour details
Records : 2

Interface               ChassisId       Mac                 Hostname
MgmtEth0/RP0/RCOM0/0    FCB2626B0QB     98:a2:c0:1c:91:d7   PROD1
MgmtEth0/RP0/RCOM0/0    FCB2626B0Q9     98:a2:c0:1c:90:6f   PROD2
RP/0/RP0/CPU0:PROD3#
```

User can connect to the remote/target using hostname or MAC information of the target node. This data can be gathered either through above CLI or from their inventory or configurations.
Command to connect to remote node : “remote-connect <hostname|mac>”

```
Ex:
RP/0/RP0/CPU0:R1#remote-connect ?
hostname  Set hostname of the remote node to connect(cisco-support)
mac       Set remote console MAC address of the node to connect(cisco-support)
RP/0/RP0/CPU0:R1#remote-connect hostname PROD1 ?
timeout  Set timeout for session(cisco-support)
verbose  Enable verbose logging(cisco-support)
<cr>
RP/0/RP0/CPU0:R1#
```