TJ1600 Product Family

6.x Feature Description Guide

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Revision history

Version	Document ID and issue date	Updates
4.0	170-DOC000196-E Issue date: 30-Dec-2022	• Updated GMPLS section • Updated AGG200: AGG200:HCPSLine22 - feature table and AGG200G - HCPSLine12/24/25/26/27/28 feature table
3.0	170-DOC000195-E Issue date: 02-Sep-2022	• OTDR feature details added in Key features section • Card population rule table updated with OTDR details • OTN Cross Connect Capacity updated • HCPSLine22- OTN FEC summary and HCPSLine22- feature table information added
2.1	170-DOC000192-E Issue date: 13-June-2022	Added HCPSLine33 and HCPSLine34 card in Hardware section
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1.0	170-DOC000180-E Issue date: 30-Jan-2022	Standard Release

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1 Document overview

This document describes the features and capabilities of the TJ1600 product family.

1.1 Target audience

This guide is intended for network planners and system administrators to know the most important features of the product.

1.2 Chapter organization

This document is organized as follows:

Chapter	Scope
TJ1600 product family	This chapter covers product family overview and key features.
TJ1600 platform capabilities	This chapter summarizes card population rule and software feature support.
SDH	This chapter summarizes the SDH features.
OTN	This chapter summarizes the OTN features.
DWDM	This chapter summarizes the DWDM features.
Ethernet	This chapter summarizes the Ethernet features.
DCN	This chapter summarizes the DCN features.
GMPLS	This chapter summarizes the GMPLS features.
System	This chapter summarizes the System features.
Security	This chapter summarizes the Security features.

1.3 Additional resources

For more information on TJ1600 product family, refer to the following guides:

Document name and version	Description
TJ1600 Product Family Hardware Description Guide v4.0	This document provides information on hardware configuration, limitations, and the physical characteristics of the hardware platforms.
TJ1600 Product Family Installation and Commissioning Guide v3.1	This document details the procedures to install the product and to initially configure it to the point of verifying its appropriate operation in the network.

Document name and version	Description
TJ1600 Product Family 6.x User Interface Guide v4.0	This document provides steps on how to provision and monitor the node using node user interface.
TJ1600 Product Family 6.x L2 User Interface Guide v4.0	This document introduces and orients service providers to the content, function, and organization of the user interface supported on the carrier Ethernet card.
TJ1600 Product Family 6.x Alarm Clearing Procedure Guide v4.0	This document provides the list of alarms, causes, and the procedure to clear the alarm.

2 TJ1600 product family

TJ1600 is a comprehensive metro aggregation and metro core solution, which is deployed in various configurations such as PTN aggregation/core or hybrid NG-SDH and OTN aggregation/core configurations or NG-OTN/SDH/SONET ADM/MADM/DX/DWDM configurations. It supports multi-chassis options of converged packet optical transport products that support GE, SDH, SONET, OTN, FC clients. The product provides a diverse range of data and circuit interfaces in one of the highest densities in products of its class.

Digital cross-connect at fine granularity and data switching functionality along with the modular nature of the interfaces provide carriers with very flexible options for configuring the product in networks.

2.1 Key specifications

Table 1: Key specifications of TJ1600

Specifications	TJ1600-2	TJ1600-6	TJ1600-11		
Controller card	OAMC01	OSMC01	XCC04	XCC03	OSMC01
No of Service slots	2	4	9	9	9
SDH Cross Connect Capacity	Not supported	Not supported	240+120(HO+LO)/ 640G (HO)	320+20(HO+LO)/360G (HO)	Not supported
OTN Cross Connect Capacity	200G/320G/ 400G	200G/320G/ 400G	640G/ 900G	Not supported	Not supported
SDH Line Cards	Not supported	Not supported	Supported	Supported	Not supported
Packet Line Cards	Not Supported	Not Supported	Supported	Supported	Not supported
OTN Transponder/ Muxponder Line cards	Supported	Supported	Supported	Supported	Supported
DWDM Cards	Supported	Supported	Supported	Supported	Supported
Multi-Shelf (maximum of 8 shelfs)	Supported	Supported	Supported	Supported	Supported
OTN Line rates supported	OTU2/OTU2e/OTU1f/OTU4/OTUC1 to OTUC6				
Client type supported	STM1/STM4/STM16/STM64/1GE/10GE/40GE/100GE/1GFC/2GFC/ 4GFC/8GFC/12GFC/16GFC/32GFC				
ODU connections supported	ODU0/ODU1/ODU2/ODU2e/ODUFlex/ ODU3/ODU4			Not supported	Not supported

Table 1: Key specifications of TJ1600

Specifications	TJ1600-2	TJ1600-6	TJ1600-11		
VC connection supported	Not supported	Not supported	VC12/VC3/ VC4/VC4-4c/VC4-16c/VC4-64c	Not supported	Not supported
SDH GMPLS	Not supported	Not supported	Supported	Supported	Not supported
OTN GMPLS	Supported	Supported	Supported	Not supported	Not supported
WDM GMPLS	Supported	Supported	Supported	Supported	Supported
Synchronization	Not applicable	Not applicable	STM Port, BITS, and SyncE	STM Port, BITS, and SyncE	Not applicable

NOTE 1: HCPXCC04/HCPXCC03 cards do not support as slave shelf. In TJ1600-2, multi-shelf is supported in 1600-2 chassis only.

NOTE 2: The TJ1600-2/TJ1600-6 in 200G mode does not support ODU3/ODU4 connections. The1600-2/TJ1600-6 in 400G mode does not support ODU0/ODU1/ ODUFlex/ODU3 connections.

NOTE 3: SDH GMPLS is not supported for VC12/VC3.

NOTE 4: The TJ1600-2 is supported as ILA only in WDM GMPLS network.

2.2 Key features

- **Network evolution:** Allows network designers to use the most cost effective transport technologies for each service type. Networks designers are constantly looking to drive the lowest cost per bit for transport while providing high reliability. Leveraging the advantages of statistical multiplexing while minimizing the number of protocol layers used at each node helps to minimize costs.
- **One device for packet, TDM, and DWDM:** Balances packet and TDM transport in a unique way. Its hybrid architecture allows for three configurations:
  - TDM with packet transport
  - Hybrid TDM
  - Packet transport and all DWDM optical transport using the same hardware, software, and features

  This flexibility creates a unique opportunity for network designs by allowing every service to be optimized based upon the service requirements, not the limitations of a particular transport technology. In addition, reduces operations costs by having a

single platform for all services requirements preventing the need for multiple devices at any site.

- **Flexible packet and TDM switching:** Adapts to changes in service types and bandwidth with a scalable Packet switch provisioned separately from the TDM switch.

- **Services optimization:** Services can be matched to the best transport technology whether it is maximizing efficiency with stat- muxing, reducing costs by using OTN switching to by-pass routers, maximizing fiber utilization with DWDM or minimizing latency with optical / OTN switching.

- **Optimizing packet to DWDM inter-working:** Uses a unique blend of technologies including 10GE interfaces to provide the lowest cost Packet to DWDM inter-working. With OTN wrappers and direct interconnection between Packet and TDM switches to simplify router by-pass in regional / long haul networks. Lower packet transport costs: The TJ1600 optimizes 1G, 10G and 100G transport by using OTN switching to efficiently pack and route traffic through the network. The use of OTN switching also reduces the complexity of the Packet network by offloading high bandwidth services directly onto the OTN/DWDM optical layer.

- **Greater DWDM reach:** Optimized fiber utilization using the latest technology for reliable transport in metro, regional, and long haul networks.

- **SONET/SDH/front-haul:** Provides reliability and performance expected of the transport network; exceptional performance, deterministic routes, predictable latency, low protection switch times, and easy network planning.

- **MPLS-TP:** MPLS label based connection oriented Ethernet allows packet traffic to be easily and precisely routed through the network. Provides MPLS-TP based pseudowires for traffic engineered flows on trunks, which optimizes the network by providing the right amount of control. The cost benefits of stat-muxing are combined with traffic engineering and capacity planning to lower CAPEX by right sizing the network. OPEX reductions come through faster provisioning, robust protection and quicker root cause analysis during failures. With mesh protection capabilities, latency and protection switch times are minimized.

- **Network management:** With Tejas NMS, network evolution is much easier to manage. The point and click technologies for packet, SONET/SDH, OTN, and DWDM traffic allow for more accurate service designs, more efficient routing, and better fault correlation. Accurate alarming and **fault to affected service mapping** enables fault resolution prioritization. Enhanced network element backups and simple remote software upgrades reduce operational costs while enhancing reliability. NMS server redundancy and geographical diversity ensures faster disaster recovery.

- **Advanced Ethernet features:** Provides best in class packet switching to create networks with the highest performance. Ingress rate limiting prevents any one service/application from congesting/choking the network. Each packet is classified so that the appropriate network policies (like prioritization and scheduling) can be applied. Eight CoS queues and scheduling algorithms ensure that there are sufficient options available to manage the data traffic efficiently. This feature supports sub 50ms protected packet rings for greater resiliency, multiple ringlets, and multiple ring topologies.

- **Ethernet OAM:** Supports real-time monitoring of end-to-end circuits, connections or trunks enabling quick detection and isolation of faults to a particular subnet, trunk, link or node. Supports BFD based Fault OAM and ping/traceroute at tunnel/ pseudowire level. It also supports MPLS-TP based performance OAM for MPLS-TP based PW services. For.1q/.1ad based MEF services, PM counters are supported.

- **ASON and WSON GMPLS control plane:** With Tejas Network’s ITU-T G.8080 based GMPLS control plane software, highly resilient networks with multiple levels of protection can be created with ease. The TJ1600 platform supports 1+Reroute

and 1+1+ Reroute options by implementing standard protocols. Tejas GMPLS control plane enables this capability for OTN (L1) as well as DWDM (L0) enabling most flexible and resilient optical network deployments.

- **Flexible network architectures:** Powered with flexible architecture that allows to build the network best suited for all services linearly for rapid deployment such as hub and spoke for cost effective build outs at the edge of the network, ring and ringlet for high utilization and resiliency, meshed for low latency and flexible protection. This is achieved with a unique combination of functionality including the ability for traffic to be switched at Packet TDM or the optical layer depending on service requirements.

- **OTDR:** Optical Time Division Reflectometry (OTDR) is used to detect link degradation and faults over user-defined spans and thresholds. It returns high-resolution fault location measurements to user, which can be further analyzed to pin point exact fault location. This helps to rectify network fault quickly and efficiently minimizing the network downtime. The OTDR hardware can have multiple OTDR scanning ports which can be independently configured to perform measurements in service with no impact to the DWDM traffic. The OTDR hardware can be used in multiple span scenarios such as:
  - Making measurements from both sides or from single side based on the link length and network requirement.
  - In the direction of DWDM traffic or opposite to DWDM traffic.
  - Along with RAMAN amplified link.

3 TJ1600 product family capabilities

This section covers hardware and software capabilities in TJ1600 product families.

3.1 Software

The software provides user interface for configuring and managing the system. Following table summarizes the features supported across various platforms.

NOTE: This guide provides information about the software features supported in 6.x releases. To know about the features supported in the specific 6.x release, refer to the respective Customer Release Notes (CRN).

Table 2: Supported software

Group feature	Specific feature	Supported		
		TJ1600-2	TJ1600-6	TJ1600-11
SDH	Protections	No	No	Yes
	Ethernet over SDH	No	No	Yes
OTN	Protections	Yes	Yes	Yes
	Link integrity	Yes	Yes	Yes
	Idle frame	Yes	Yes	Yes
	Local fault/ Remote fault	Yes	Yes	Yes
	Regenerator Port Pairing (RPP)	Yes	Yes	Yes
DWDM	Protections	No	Yes	Yes
	APC/APB	No	Yes	Yes
	Amplifiers	Yes	Yes	Yes
Ethernet	VLAN	No	Yes	Yes
	ETH services	No	Yes	Yes
	Protections	No	Yes	Yes
	MPLS-TP	No	Yes	Yes
	ETH OAM	No	Yes	Yes
	QOS	No	Yes	Yes
	LLDP	No	Yes	Yes
	BPDU-Tunneling	No	Yes	Yes
	Port mirroring	No	Yes	Yes

Table 2: Supported software

Group feature	Specific feature	Supported		
		TJ1600-2	TJ1600-6	TJ1600-11
DCN	ECC	No	No	Yes
	GCC	Yes	Yes	Yes
	OSC	Yes	Yes	Yes
	External management	No	Yes	Yes
	OSPF	Yes	Yes	Yes
	VLAN management	No	Yes	Yes
	Proxy ARP	Yes	Yes	Yes
GMPLS	-	Yes	Yes	Yes
System	Automatic Laser Shutdown	Yes	Yes	Yes
	10G/100G/200G Transmission System	Yes	Yes	Yes
	Multi-shelf (Master-Slave)	Yes	Yes	Yes
	Dynamic license	Yes	Yes	Yes
	Loopback	Yes	Yes	Yes
	SNMP	Yes	Yes	Yes
	Synchronization	No	No	Yes
	Security	Yes	Yes	Yes
	NTP	Yes	Yes	Yes

3.2 Hardware

The following card population table summarizes the various cards/modules and the slot distribution for the TJ1600 product family.

NOTE: This guide provides information about the hardware features supported in 6.x releases. To know about the features supported in the specific 6.x release, refer to the respective Customer Release Notes (CRN).

Table 3: Card population rule

Tributary card/ Controller card	Card Population			
	TJ1600-2 (OAMC)	TJ1600-6 (OSMC01)	TJ1600-11	
			OSMC01	HCPXCC04
OAMC	5	NA	NA	NA
OSMC01	NA	9, 10	5, 6	NA
HCPXCC04	NA	NA	NA	5, 6
HCPSLine01	NA	NA	NA	1 to 4 and 7 to 11
HCPULine01	NA	NA	NA	1 to 4 and 7 to 11
HCPSLine03	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine08	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine12	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine20	NA	NA	NA	1 to 4 and 7 to 11
HCPSLine22	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine24	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine25	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine26	1, 2	1 to 4	1 to 3 and 7 to 10	1 to 3 and 7 to 10
HCPSLine27	1, 2	1 to 4	1 to 3 and 7 to 10	1 to 3 and 7 to 10
HCPSLine28	1,2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPSLine31	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
HCPSLine32	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
HCPSLine33	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
HCPSLine34	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
CEF-5	NA	2 to 4	1 to 4 and 7 to 11 (One mesh switch in either 2, 3, 4 or 8, 9, 10)	1 to 4 and 7 to 11 (One mesh switch in either 2, 3, 4 or 8, 9, 10)
DWDM Cards				
OFA	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
ROADM-2-C-50G	1,2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
ROADM-4-C-50G	1,2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
ROADM-8-C-50G	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
OPM-C-2/OPM-C-4/ OPM-C-FLEX	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11

Tributary card/ Controller card	Card Population			
	TJ1600-2 (OAMC)	TJ1600-6 (OSMC01)	TJ1600-11	
			OSMC01	HCPXCC04
FPU01/FPU02	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
VOA	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OADM-1-D and OADM-4-D	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
MDU-8-D	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
MDU-16-D	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
MDU-16CL-C-50G	2	2 to 4	2 to 4 and 8 to 11	2 to 4 and 8 to 11
ILU-C-50G	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
ILU-C-100G	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPADP01	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPADP02	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPADP03	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
HCPADP04	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDR-2	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDR-4	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDR-8	2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDRF-2	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDRF-4	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11
OTDRF-8	1, 2	1 to 4	1 to 4 and 7 to 11	1 to 4 and 7 to 11

NOTE 1: PSCM, DCM, OFA-C-S26-FG/OFA-C-S23-FG, ORA, MDU40E-D, MDU40O-D, MDU-64-C-75G, and MDU-96-C-50G are standalone units and not installed on the chassis. Therefore, no slot numbers for these cards.

OSCF-S and OSCF-D modules are plugged into the OFA card. Therefore, no slot numbers mentioned for these cards.

NOTE 2: Active adapter cards are not supported in **Slot 1** of TJ1600-2.

NOTE 3: HMON supports provided for HCPSLine03/08/20/22.

4 SDH

Synchronous Digital Hierarchy (SDH) provides mapping, muxing (byte interleaved TDM), and framing to mainly carry PDH and Ethernet traffic. Overhead bytes ensure the management of payload and pointers allow dynamic allocation of payload in STM frame with which justification can be done under specified limit.

The SDH is supported in accordance with ITU-T G.841.

4.1 EoS

Ethernet over SDH (EoS) provides a simple, flexible and cost-effective solution to customers offering Ethernet based services. An EoS transport solution fundamentally addresses the following key issues:

- LCAS
- VCAT
- GFP-F
- AN
- LI
- Flow control
- Differential delay

4.1.1 LCAS

Link Capacity Adjustment Scheme (LCAS) is specified by ITU-T G.7042 and is a protocol for a standard based hitless scheme to increase or decrease the capacity of a VCAT link between the sources (Transmitter) and sink (Receiver). The LCAS uses a control packet within the H4 byte for High Order and within the Z7/K4 byte for low order links.

4.1.2 VCAT

Virtual Concatenation (VCAT) is specified by ITU-T G.7043 and enables end-to-end connections that precisely match the client requirements without wasting bandwidth. High-order VCAT provides a 155Mb/s (AU-4) resolution. The VCG members need not be in adjacent channels and can take different paths through the network, so ingress and egress elements must be able to tolerate up to 64ms of differential delay between VCG members.

4.1.3 GFP-F

Generic Frame Procedure - Framed (GFP-F) is specified by ITU-T G.7041. It encapsulates bursty client traffic such as Ethernet and also RPR. The received client signal frame is mapped in its entirety into one GFP frame. GFP-F works relative to client frame boundaries (For example, 1 SONET frame per GFP-F frame).

4.1.4 AN

Auto Negotiation (AN) is to negotiate and select a common speed and mode of communication between two link partners.

4.1.5 LI

Link Integrity (LI) or point to point communication, a live feature checks end-to-end (client to client) integrity of the link and if there is a breach of integrity anywhere in the link, then forcefully the health client sides are made down.

4.1.6 Flow control

Rate shaping mechanism to avoid packet drops.

4.1.7 Differential delay

Differential delay measures the difference in time among the channels of a multi-channel with respect to the maximum differential delay allowed for a signal to arrive at its destination. In practice, the maximum amount of differential delay that can be compensated is implementation specific. VCAT allows that channel to be temporarily removed from the data carrying channels.

NOTE: The TJ1600 product family supports a differential delay of 64ms.

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5 OTN

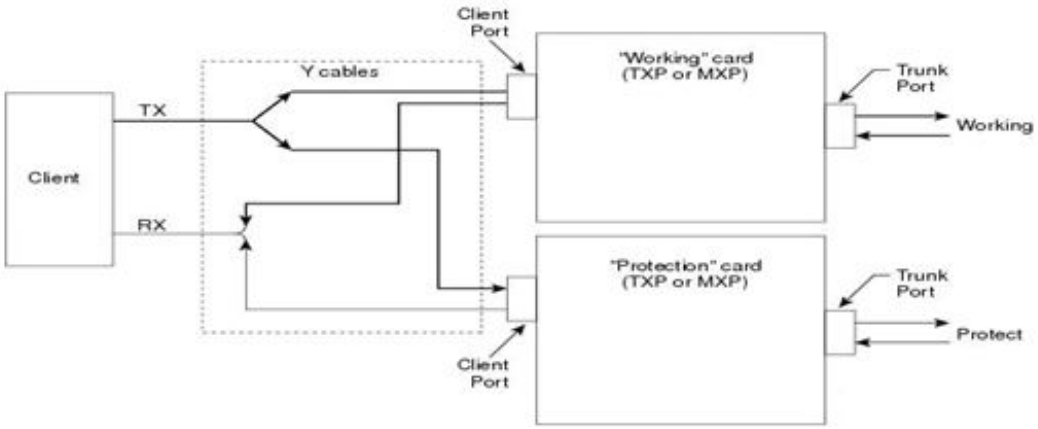
This chapter covers prominent OTN features supported on TJ1600 product family.

The OTN provides transmission, multiplexing, routing, management, supervision, and protection of client services based on the optical channels. The main feature of the OTN is the transmission and configuration of any digital signals which are irrelevant to client's customized features.

5.1 OTN Protections

- **Inherent protection:** This protection uses the dual fed and selective receiving function of the electrical layer ODU cross-connections. The protection switching is triggered by defects detected at the ODUk layer (for example, server layer trail and server/ODUk adaptation function).
- **Non-intrusive protection:** This protection use the dual fed and selective receiving function of the electrical layer ODU cross-connections. The protection switching is triggered by a non-intrusive monitor of the ODUk/ODUj trail.
- **Client non-intrusive:** This protection uses the dual fed and selective receiving function of the electrical layer ODU cross-connections to protect SDH/ETH/FC services at the client side within or across line cards. For faults on client side, uni-directional protection switching occurs.
- **Y-cable protection**: The Y-cable splits the client optical signal (from router or other device) and feeds it to two different clients on transponder or muxponder cards. In other directions, it combines the signal received from work and protect client ports. Here, the node takes decision of which client to send the signal towards client interface that is at a time one of the client laser will be ON and other client laser will be in OFF state. The work and protect client laser is controlled for protection switching based on network side faults. The following figure shows how the near-end and the far-end jointly protect against defects when configured from west to east.

Figure 1: Y-cable protection



- **Compound link SNC group inherent:** Protect ODU is non-channelized at the time of provisioning and the work ODU is channelized. On protection creation, the protect ODU will automatically get channelized. This monitoring type is allowed at ODUk level only and not at ODUj level. Supported only on 1+1 without APS bytes architecture with unidirectional switching mode.

5.2 Link integrity

Allows to detect faults along the end-to-end Ethernet transport connection. When Link integrity is enabled, the following faults forces the Ethernet port laser to go down.

- Near-end Ethernet link failure
- SDH/OTN link failures
- CSF/Far-end Ethernet link failure

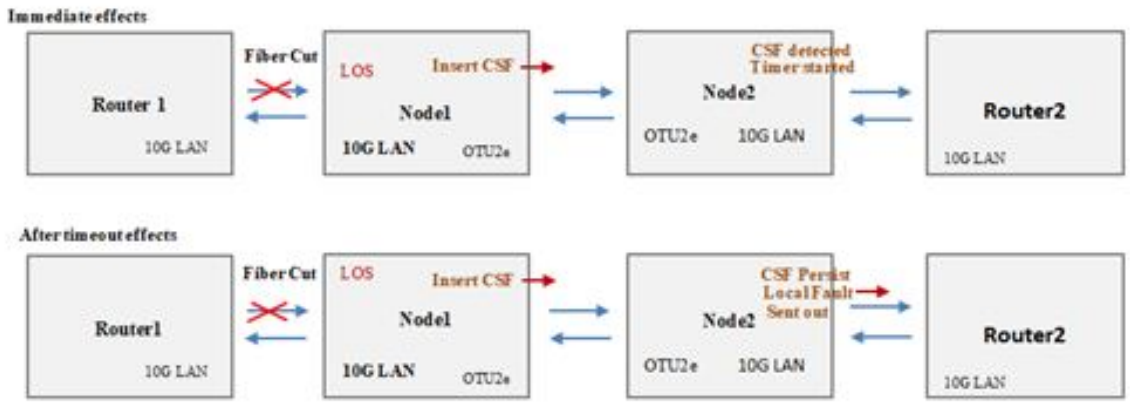
5.3 Idle frame

This frame is also known as control frame and consists of only a core header field with no payload area. When idle frame is enabled, the Ethernet ports emit idle frames for a predetermined amount of time in response to OTN network problems.

Idle frames are dummy frames added to the transmission link to prevent flapping of client devices due to network faults. This is a useful feature to enable and configure when the network is designed with protection in lower layers such as OTN, DWDM. One may like to prevent the flapping of end client device during the momentary link down happening during the switching event between active to stand-by path in the network. The Idle frame insertion helps in pumping in dummy frames during this momentary glitch which in turn results in end device not seeing the faults and thus remaining active and not triggering a switching or flapping.

Enabling/disabling idle frames is a user defined parameter. It is set at each client interface/port on the selected hardware/ports where the feature is supported. You have flexibility to define the idle frame timer which acts as a watch-dog to insert the idle frames from the trigger till the timer runs out. The post timer expiry, the idle frames are stopped from being injected into the transmission link. Any fault that continues past the idle frame timer value will therefore be reported to end devices, indicating a transmission link error.

Figure 2: Timed link fault action



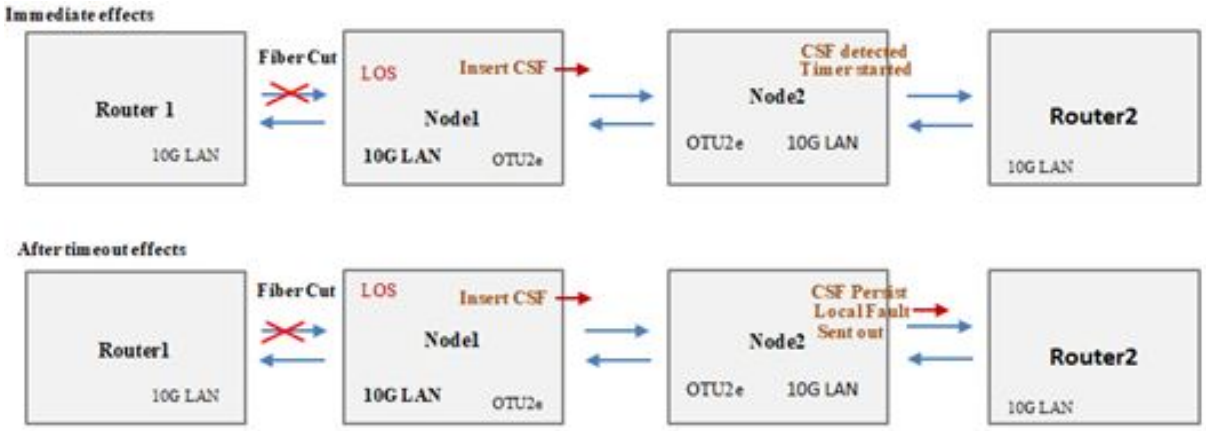
NOTE: Idle frame is supported only for 10GE (only BMP mapping) clients with Timing transparent mapped (TTM).

5.4 Local fault/Remote fault

In OTN network, for client/line side faults, after receiving alarm on client ODUk, the corresponding Ethernet client sends **Local Fault** signal to the near end connected router port and far end router receives **Remote Fault**. After fault restores, client stops sending **Local Fault** signal.

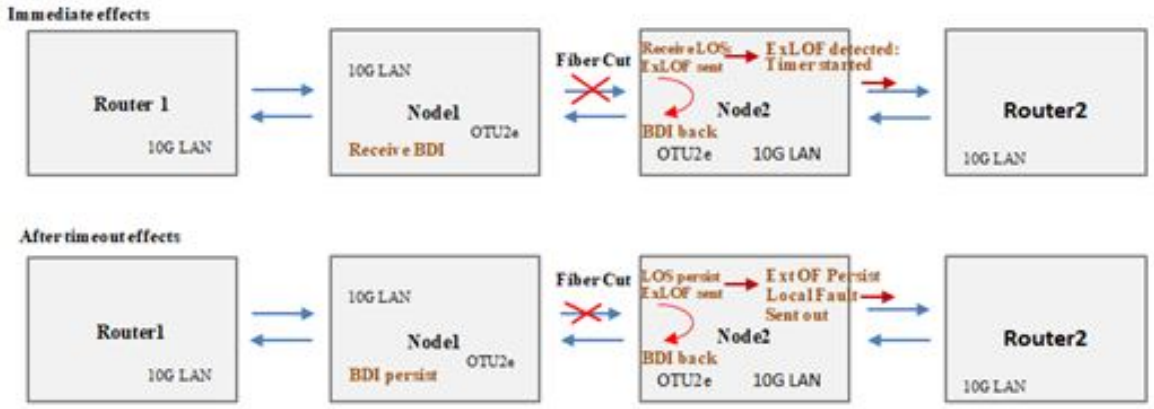
Scenario 1:

Figure 3: Link fault action along with the timer-1



Scenario 2:

Figure 4: Link fault action along with timer-2



NOTE: Local fault or remote fault is supported only for 10GE clients with Timing Transparent mapped (TTM).

5.5 RPP

The Regenerators Port Pairing (RPP) in the link, if fault occurs on one side other side line port still transmits power. The far end node if any optical line protections (OLP/FPU) configured that will not get loss of signal (LOS) and switching will not happen and traffic goes down. With this feature, if any fault received in regenerators one port, other port turns off the laser. Now, far end node receive LOS and protection switches to other path.

NOTE: RPP is supported only on transponder mode.

5.6 NPP

The Network Port Protection (NPP) uses the dual feed and selective receiving function of the electrical layer. The ODU cross-connections to protect OTN line side within same line card. For faults on line side, uni-directional protection switching occurs.

NOTE 1: NPP is supported only in transponder mode.

NOTE 2: Inherent protection, non-intrusive protection, and NPP are supported only for OTN ports.

5.7 FEC

The Forward Error Correction (FEC) enables the detection and correction of errors in an optical link. FEC has proved to be efficient in correcting a very high number of errors in transmission due to noise or other impairments present in high-capacity transmissions thus improving the signal to noise ratio of the signal.

For ITU G.709 the FEC code used is a Reed-Solomon RS (255,239)

For OTU2/OTU2e, GFEC (RS) and EFEC types are supported.

For OTU4 (non-coherent CFP), only GFEC (RS) is supported.

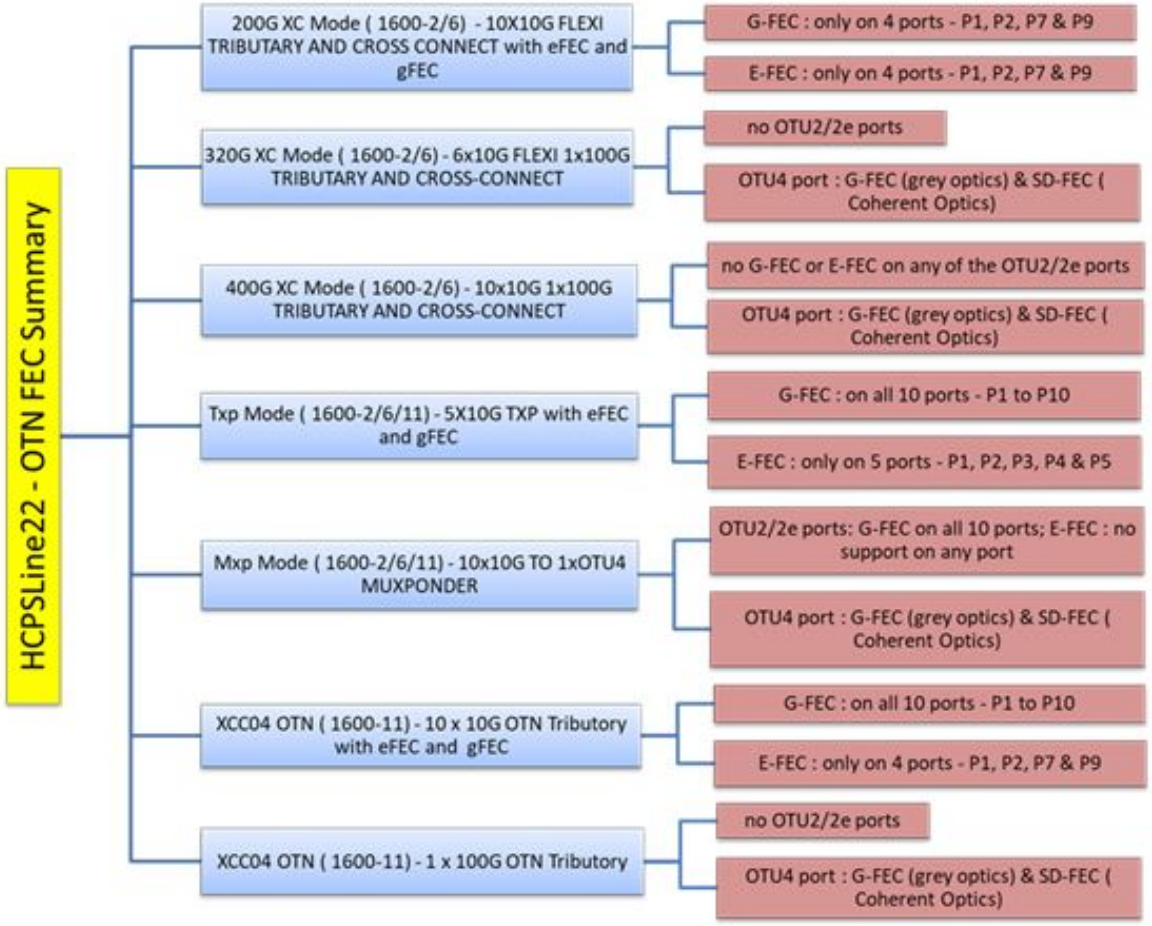
For OTU4/OTUCk (coherent CFP/CFP2), HDFEC, SDFEC, SDFEC-ND, SCFEC and Transparent are supported.

NOTE: Pre FEC SD alarm supported on OTU4/OTUC1/OTUC2 port.

5.8 HCPSLine22 - OTN FEC summary

The HCPSLine22 OTN FEC summary is as follows:

Figure 5: HCPSLine22 OTN FEC summary



5.8.1 AGG200:HCPSLine22 – feature table

The HCPSLine22 feature table provides port details for supported features.

Figure 6: AGG200: HCPSLine22- Feature Table

Features	Type-2SR 200GXC	Type-6SR 200GXC	Type-2SR/6SR 320GXC	Type-2SR/6SR 400GXC	Type-11SR(XCC04) 10x10G TRIB	Type-2/6/11SR TXP	Type-2/6/11SR MXP
10GE-BMP ODU2e	P1-P10	P1-P10	P1-P6	P1-P10	P1-P10	P6-P10	P1-1P0
10GE GFP-F ODU2	P3 & P10	P3 & P10	P3	NA	P3 & P10	P10	P3
10GE GFP-F ODUFlex	P3 & P10	P3 & P10	P3	NA	P3 & P10	NA	NA
10GE WAN	NA	NA	P1-P6	P1-P10	NA	NA	NA
10GE WAN PHY Termination	NA	NA	P5	P6 & P8	NA	NA	NA
STM64	P1-P10	P1-P10	P1-P6	P1-P10	P1-P10	P6-P10	P1-1P0
STM64 WAN PHY Termination	NA	NA	NA	NA	P4 & P8	P6-P10	P3,P4 & P5
STM1/STM4/STM16	P1-P10	P1-P10	P1-P6	NA	NA	NA	NA
1GE-SFP	P1-P10	P1-P10	P1-P6	NA	NA	NA	NA
1GE-COPPER SFP	P1-P10	P1-P10	P1-P6	NA	NA	NA	NA
1GFC/2GFC	P1-P10	P1-P10	P1-P6	NA	NA	NA	NA
4GFC	P1-P10	P1-P10	P1-P5	NA	NA	NA	NA
8GFC-ODU2	P1-P10 (GFEC mode)	P1-P10 (GFEC mode)	P1-P5	P1-P10	P1-P10 (GFEC mode)	P6-P10	NA
8GFC-ODUFlex.7TS	P1-P10 (GFEC mode)	P1-P10 (GFEC mode)	P1-P5	NA	NA	NA	NA
12GFC-ODU2e	NA	NA	P4	P7 & P9	NA	NA	NA
12GFC-ODU1f	NA	NA	NA	NA	NA	P6-P10	NA
Idle Frame-10GE BMP	P1-P10	P1-P10	P1-P6	P1-P10	P1-P10	P6-P10	P1-P10
Idle Frame-1GE	NA	NA	NA	NA	NA	NA	NA
Idle Frame-1GFC/2GFC	NA	NA	NA	NA	NA	NA	NA
Idle Frame-4GFC	P4,P5,P6,P8	NA	P1 & P2	NA	NA	NA	NA
Idle Frame-8GFC	P4,P5,P6,P8	NA	P4 & P5	NA	NA	NA	NA
Idle Frame-12GFC	NA	NA	NA	NA	NA	NA	NA
OTU2/OTU2e-GFEC	P1,P2,P7,P9	P1,P2,P7,P9	NA	NA	P1-P10	P1-P10	P1-P10
OTU2/OTU2e-EFEC	P1,P2,P7,P9	P1,P2,P7,P9	NA	NA	P1,P2,P7,P9	P1-P5	NA
OTU4-Grey CFP-GFEC on OTU Port	NA	NA	P11	P11	NA	NA	P11
OTU4-Coherent CFP-HD/SD-FEC on CFP	NA	NA	P11	P11	NA	NA	P11
PreFEC SD alarm-OTU2/OTU2e	P1,P2,P7,P9	P1,P2,P7,P9	NA	NA	P1-P10	P1-P10	P1-P10
PreFEC SD alarm-OTU4(Grey CFP)	NA	NA	NA	NA	NA	NA	NA
PreFEC SD alarm-OTU4(Coherent CFP)	NA	NA	P11	P11	NA	NA	P11

5.8.2 AGG200G - HCPSLine12/24/25/26/27/28 feature table

Figure 7: AGG200G- HCPSLine12/24/25/26/27/28 Feature Table

Features	HCPSLine12	HCPSLine24	HCPSLine25	HCPSLine26	HCPSLine27	HCPSLine28
100GE GMP ODU4	P2	P4	NA	NA	P2&P3	P2&P3
100GE GFP F ODU4	P2	P4	NA	NA	P2&P3	P2&P3
100GE GFP F ODUFlex	P2	NA	NA	NA	P2&P3	NA
40GE BMP ODU4	P2&P3	NA	NA	NA	NA	NA
40GE GFP F ODU4	P2&P3	NA	NA	NA	NA	NA
40GE GFP F ODUFlex	P2&P3	NA	NA	NA	NA	NA
10GE BMP ODU2e	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
10GE GFP F ODU2	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
10GE GFP F ODUFlex	NA	NA	NA	NA	NA	NA
10GE WAN	NA	NA	NA	NA	NA	NA
10GE WAN PHY Termination	NA	NA	NA	NA	NA	NA
STM64	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
STM1/STM4/STM16	NA	NA	NA	NA	NA	NA
1GE/1GFC/2GFC	NA	NA	NA	NA	NA	NA
4GFC	NA	NA	NA	NA	NA	NA
8GFC ODU2	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
8GFC ODUFlex.7TS	NA	NA	NA	NA	NA	NA
12GFC ODU2e	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
12GFC ODU1f	NA	NA	NA	NA	NA	NA
16GFC	P5,P7,P9,P11	NA	NA	P5,P7,P9,P11	P5,P7,P9,P11	NA
32GFC	P4&P8	NA	NA	P4&P8	P4&P8	NA
Idle Frame 100GE GMP	P2	P4	NA	NA	P2&P3	P2&P3
Idle Frame 40GE BMP	P2&P3	NA	NA	NA	NA	NA
Idle Frame 10GE BMP	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
Idle Frame 8GFC	NA	NA	NA	NA	NA	NA
Idle Frame 12GFC	P4 P13	NA	P11 P20	P2 P21	P4 P13	NA
Idle Frame 16GFC	NA	NA	NA	NA	NA	NA
Idle Frame 32GFC	NA	NA	NA	NA	NA	NA
OTU2/OTU2e GFEC	P4 P13	NA	P1 P20	P2 P21	P4 P13	NA
OTU2/OTU2e EFEC	P4 P13	NA	P1 P20	P2 P21	P4 P13	NA
OTU4 Grey QSFP28 GFEC on OTU Port	P2	NA	NA	NA	P2&P3	P2&P3
OTU4 Grey CFP GFEC on OTU Port	P1	P1& P4	NA	NA	NA	P1&P4
OTU4 Coherent CFP HD/SD FEC	P1	P1& P4	NA	NA	NA	P1&P4
OTUC1/OTUC2 Coherent CFP2 HD/SD FEC	NA	NA	NA	P1	P1	NA
PreFEC SD alarm OTU2/OTU2e	P4 P13	NA	P1 P20	P2 P21	P4 P13	NA
PreFEC SD alarm OTU4(Grey QSFP28/CFP)	NA	NA	NA	NA	NA	NA
PreFEC SD alarm OTU4/OTUC1/OTUC2 (Coherent CFP/CFP2)	P1	P1& P4	NA	P1	P1	P1&P4

5.9 Single Fiber/Uni-directional Crossconnects (100G Network)

Single fiber solution is a special case of optical communication transmission which uses single fiber strand for bidirectional traffic transmission as against the traditional approach of fiber strand pair.

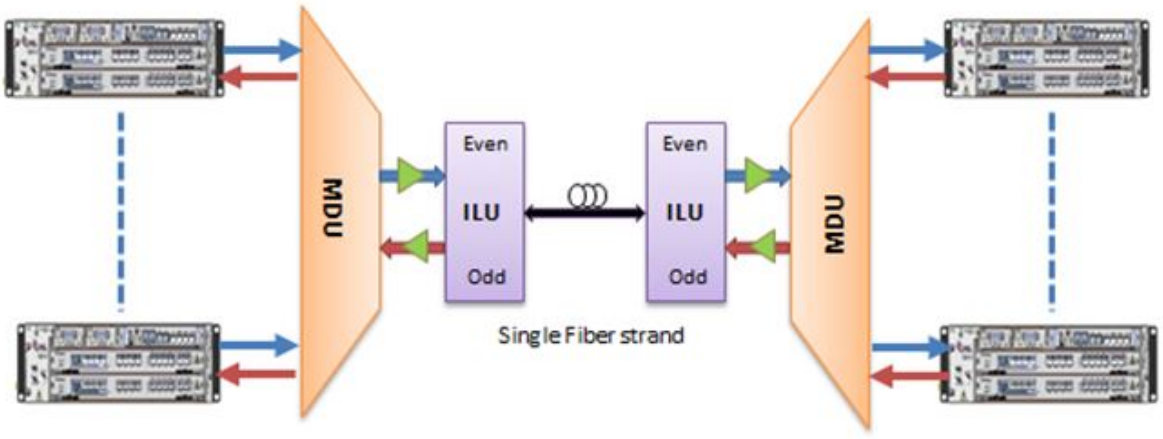
It has functional edge in networks or topologies where fiber core availability is scarce.

This has a large economic impact on carriers, dark fiber providers and enterprises where the cost of ownership or leasing out costs are enormous.

Using an uni-directional cross-connection feature of OTN DXC in TJ1600-2/TJ1600-6/ TJ1600-11, we achieve the single fiber solution.

The solution is transparent to the client interface type and support SDH, SONET, SAN, Ethernet, OTN clients in the single fiber solution.

Figure 8: Single Fiber solution overview



NOTE 1: On the TJ1600-2/6 400GXC node, unidirectional cross connect is supported.

NOTE 2: Uni-directional cross connect with ODU-SNCP protection is supported.

NOTE 3: Uni-directional cross connect with Y-cable protection is supported.

6 DWDM

This chapter covers the prominent DWDM protection features, APC, and Amplifiers supported on TJ1600 product family.

6.1 DWDM protections

6.1.1 Lambda protection

This protection uses the dual fed and selective receiving function of the optical layer Lambda (wavelength) cross-connections. The protection switching is triggered by defects detected at the OPM for individual or at the amplifier for multiplexed channels. OPM is mandatory for Lambda protection.

6.1.2 FPU protection

The FPU is used for optical layer protections and the protection switching is based on the received power. In the Tx side, the optical power is split into 50% on both work and protect. In the Rx side, there is a switch which is selective receive. This supports only unidirectional switching. FPU is used in following types of protections:

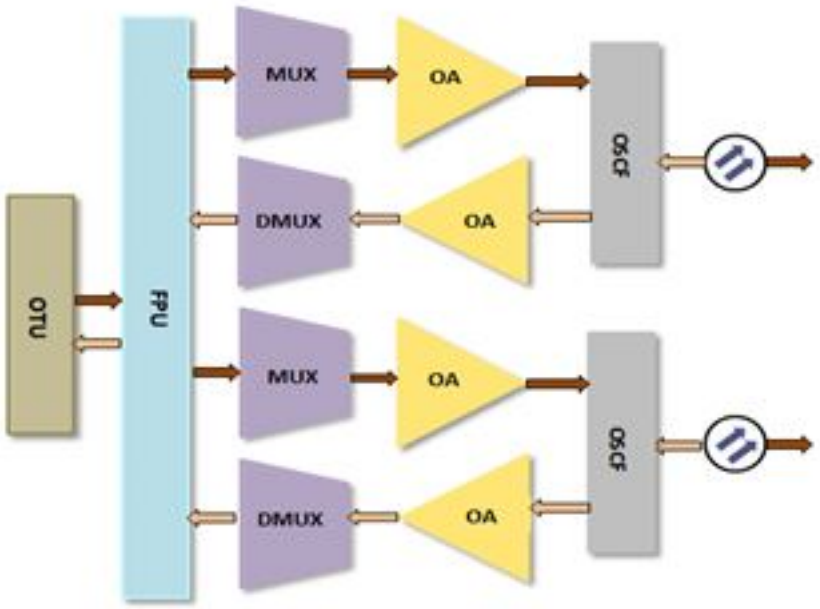
- 1+1 Intra channel protection (OCH)
- 1+1 Intra board protection (OMS)
- 1+1 Optical line protection (OTS)

Note: FPU switching is based on OTUk/ODUk alarms.

6.1.2.1 1+1 Intra channel protection (OCH)

Line-side protection protects the OCH service on single channels and optical-layer boards such as multiplexer/demultiplexer boards and boards at OLA sites.

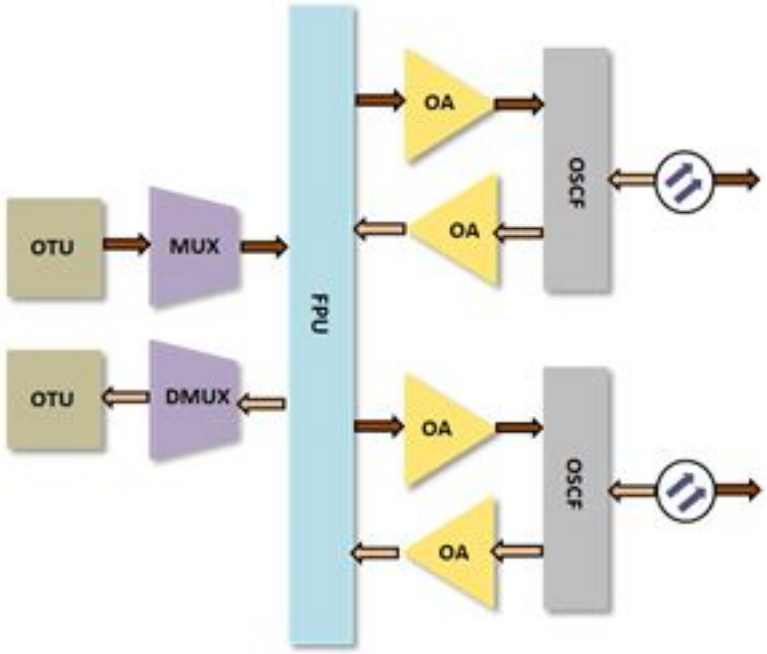
Figure 9: 1+1 Intra channel protection (OCH)



6.1.2.2 1+1 Intra board protection (OMS)

This protects the fibers and amplifier cards between two add/drop sites.

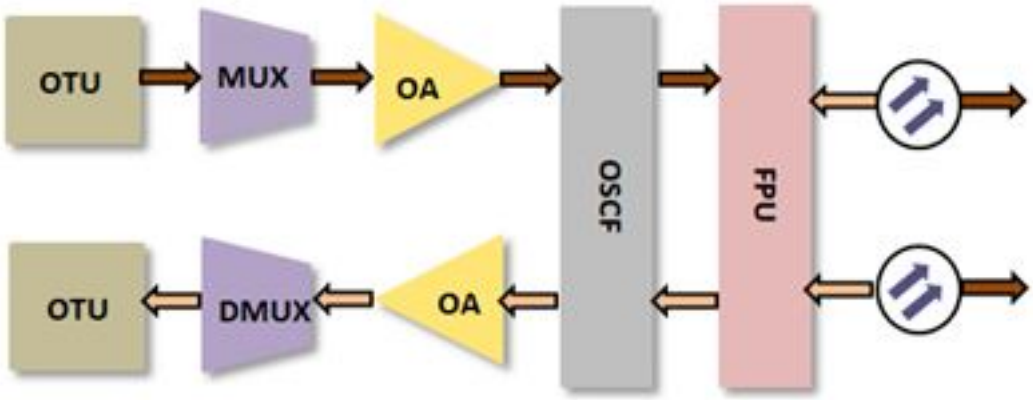
Figure 10: Intra board protection (OMS)



6.1.2.3 1+1 Optical line protection (OTS)

This protects the fibers between two adjacent sites.

Figure 11: 1+1 Optical line protection (OTS)



6.2 APC/APB

Optical power control maintains optical transmission performance by controlling the inconsistent power across DWDM channels. The VOAs perform the channel power balancing.

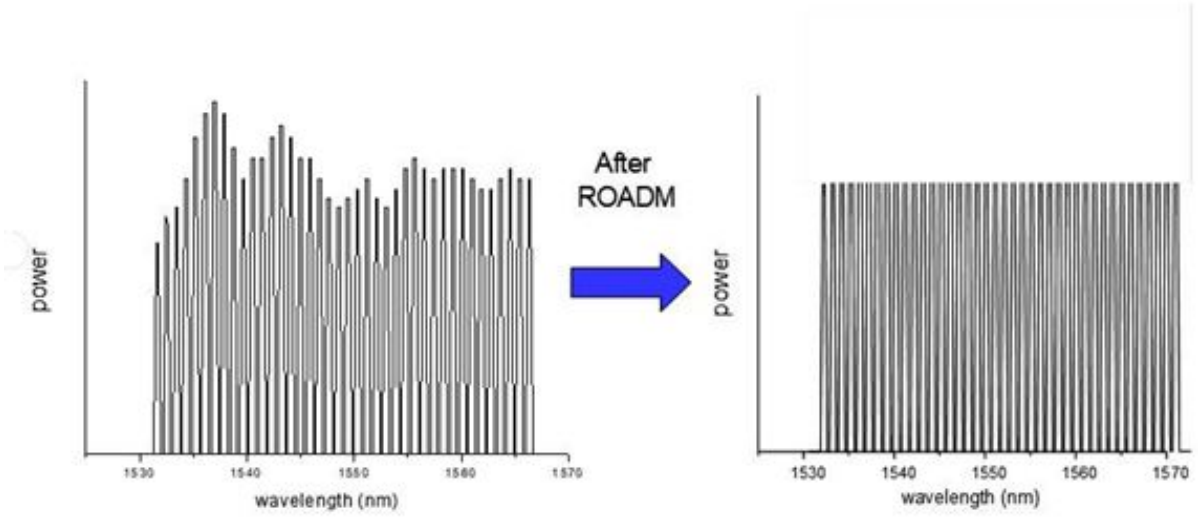
By enabling Automatic power balancing, the power can be controlled automatically or manually in these channels.

Power inconsistency in channels can be because of the following:

- Variations of output power between transceivers.
- Wavelength dependent Insertion loss variations of DWDM components.
- Gain variations and gain tilt in optical amplifiers.

The following figure shows the power variations in WSS after configuring Optical power control:

Figure 12: Power balanced output

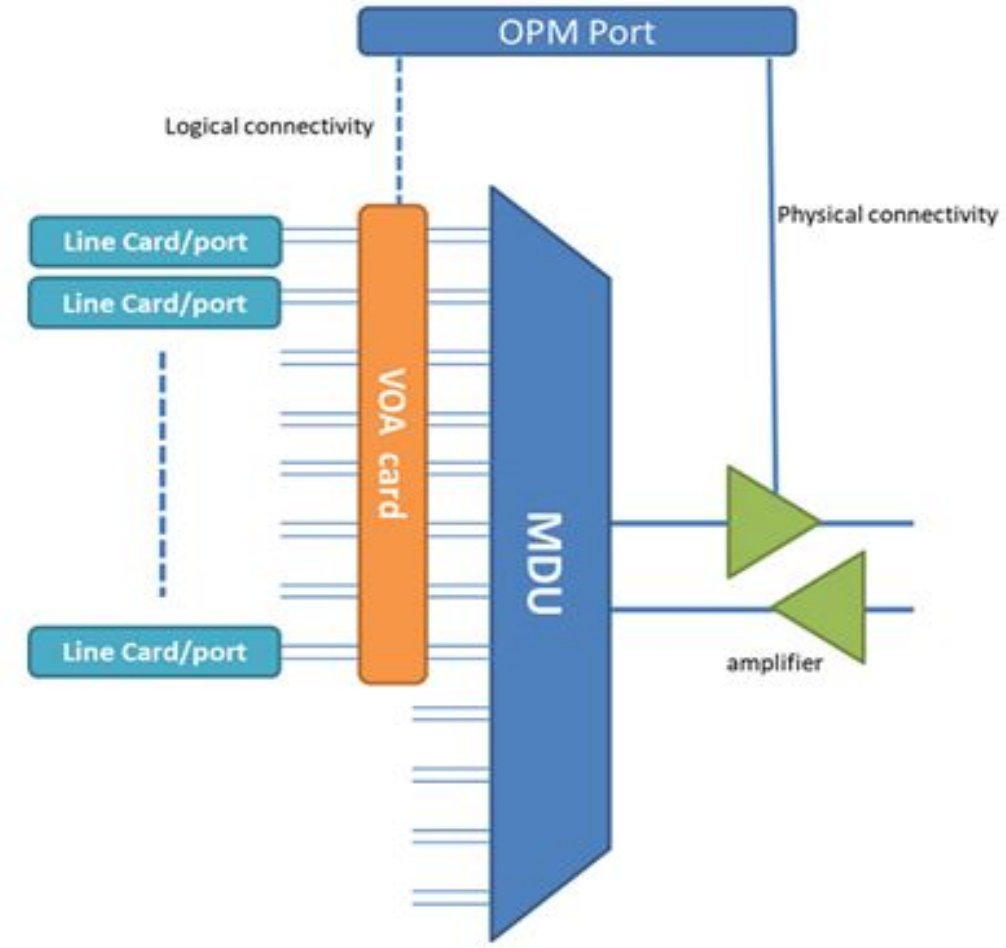


Optical Power control is achieved by following:

6.2.1 APC with VOA

OPM card uses the node logic to establish control loop between the VOA card and Monitor port of amplifier and power balance the individual channels at the amplifier output.

Figure 13: APC with VOA

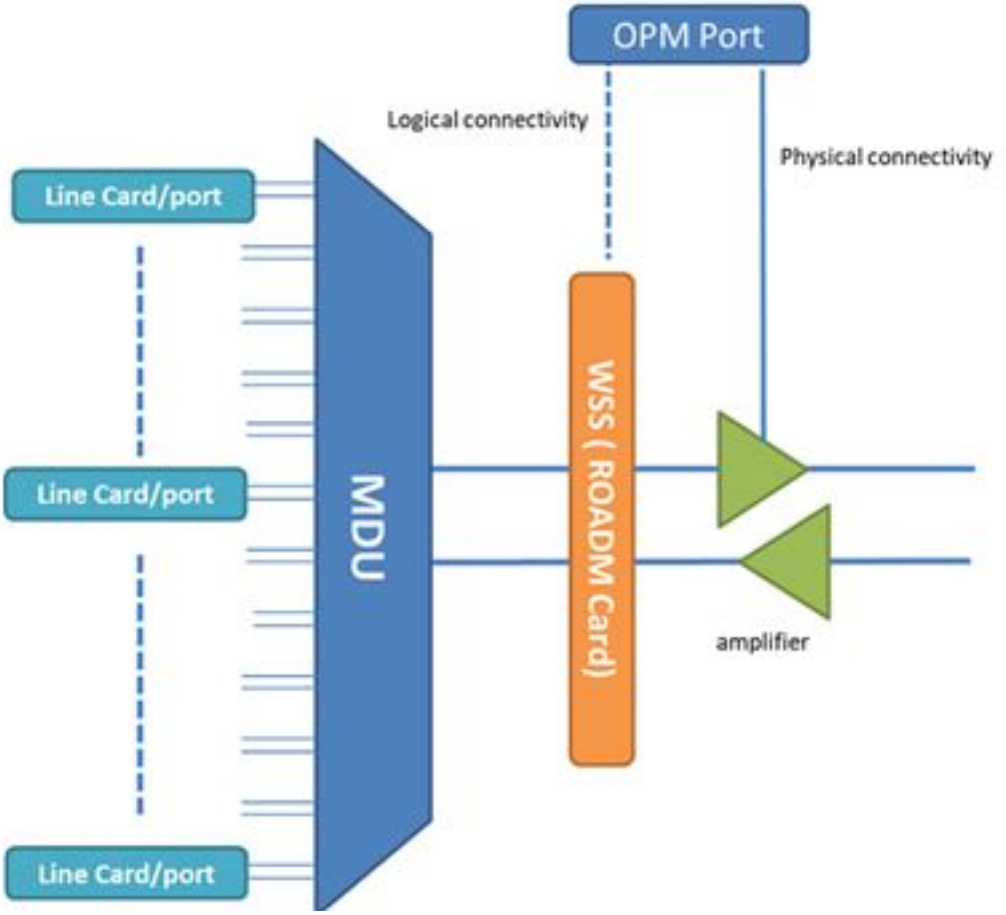


NOTE: Port connect is mandatory between VOA port and add/drop port of the Mux/ Demux for APC with VOA.

6.2.2 APC with WSS

OPM card uses the node logic to establish control loop between the WSS and Monitor port of amplifier and power balance the individual channels at the amplifier output.

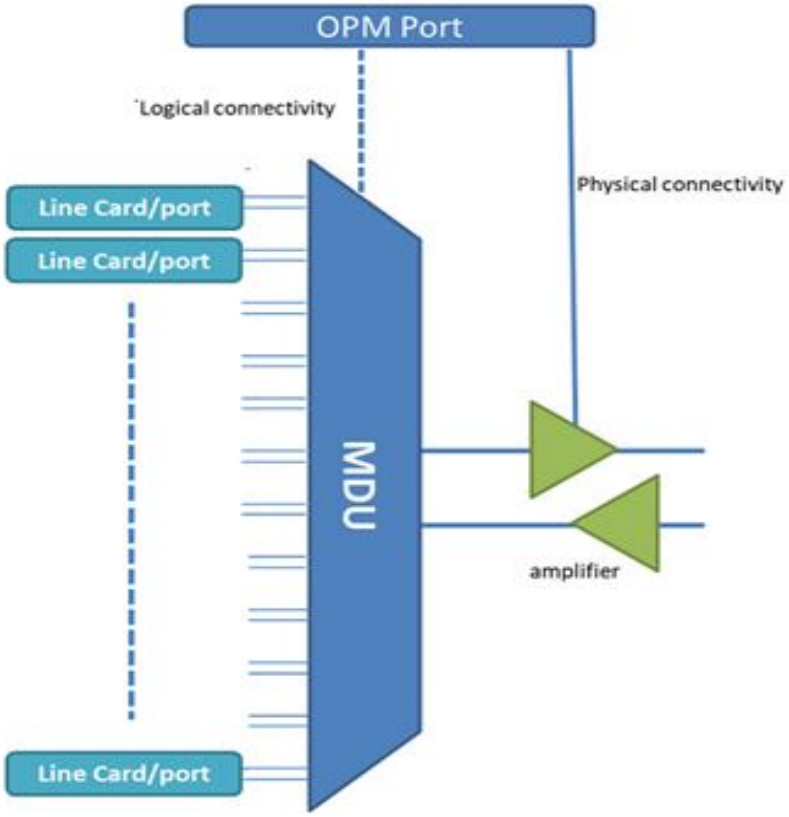
Figure 14: APC with WSS



6.2.3 APC with CFP

Attenuation control for APC regulation is with CFP Tx power on line card. When channel power balancing required and do not have WSS or VOA card, then we can adjust CFP Tx power automatically to balance channel power. This feature is only applicable when both line card and DWDM cards are in same node.

Figure 15: APC with CFP



NOTE: Port connect is mandatory between line port and add/drop port of the Mux/ Demux for APC with CFP.

6.3 Amplifiers

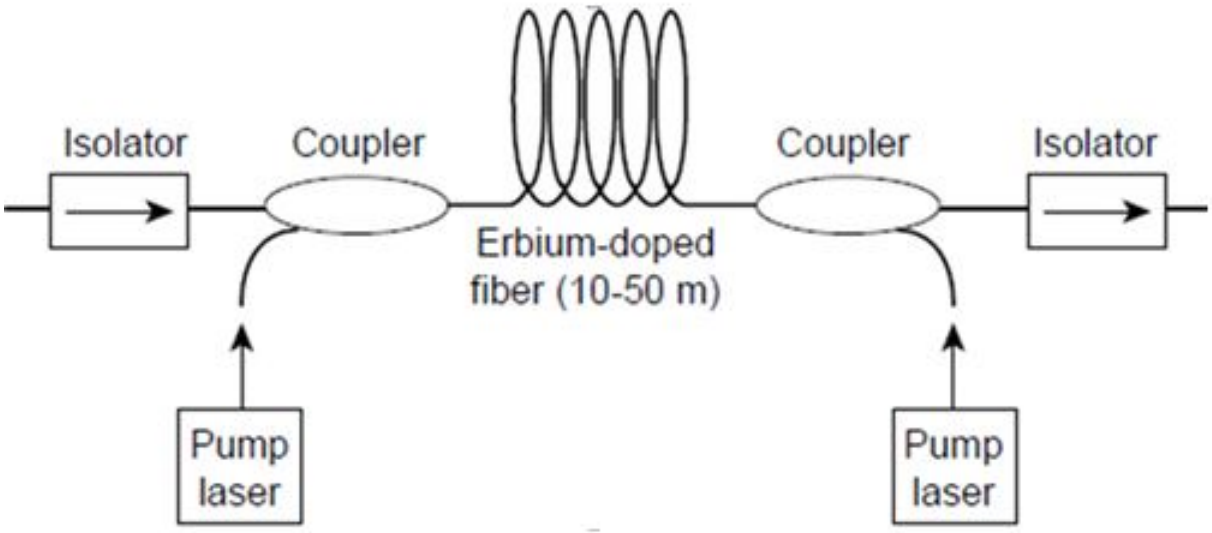
Amplifiers are the last active component in the DWDM system on the transmit side. On the receive side, the preamplifier is the first active component. The TJ1600 product family uses following amplifiers:

- EDFA
- Raman amplifier
- AGC
- APC
- APC
- APS
- APR

6.3.1 EDFA

An Erbium-Doped Fiber Amplifier (EDFA) are the type of amplifiers used. It consists of a length of silica fiber doped with erbium. This fiber is pumped using a pump signal from a laser, typically at a wavelength of 980 nm or 1480 nm. In order to combine the output of the pump laser with the input signal, the doped fiber is preceded by a wavelength-selective coupler. At the output, another wavelength-selective coupler is used to separate the amplified signal from any remaining pump signal power. An isolator is used at the input and/or output of any amplifier to prevent reflections into the amplifier.

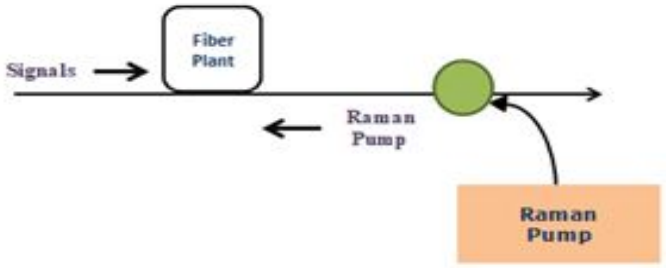
Figure 16: EDFA amplifier



6.3.2 Raman amplifier

The Raman amplifier is an optical amplifier based on Raman amplification. This consists of dual pump around 1450nm with ~450 mW optical power such that when used in single mode fiber, a typical gain of ~ 10dB in counter propagating mode can be achieved with very low effective noise figure. This enables longer reach spans for high loss networks.

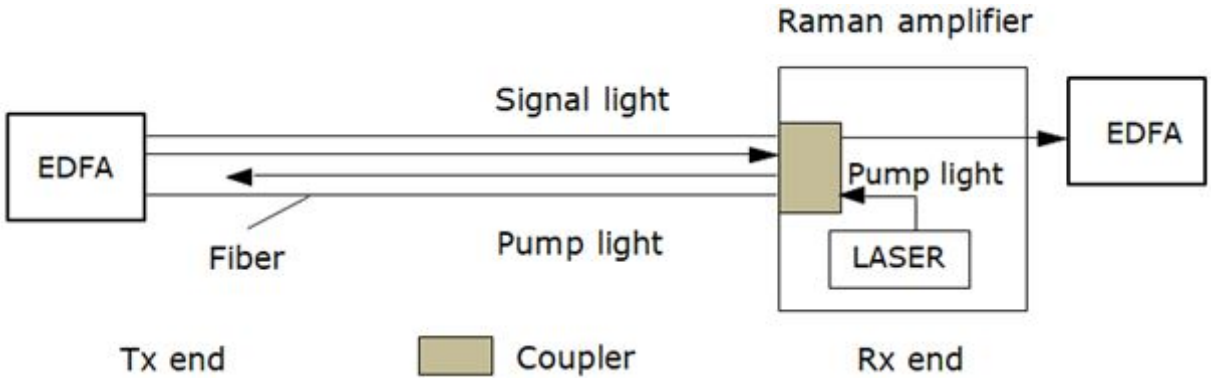
Figure 17: Raman amplifier



Raman amplifier can be used in following two ways:

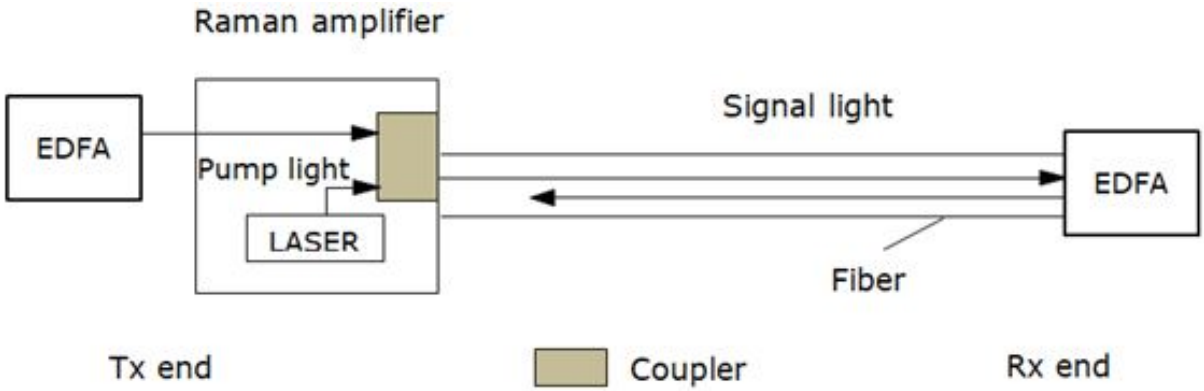
6.3.2.1 Backward pump Raman amplifier

Figure 18: Backward pump Raman amplifier



6.3.2.2 Forward pump Raman amplifier

Figure 19: Forward pump Raman amplifier



6.3.3 AGC

In this mode, gain of the amplifier can be controlled. Automatically adjusts the gain of the amplifier to compensate the span loss.

6.3.4 APC

In this mode, power of the amplifier can be controlled. Automatically adjusts the power of the amplifier to maintain constant output power.

6.3.5 APS

Due to the potential safety hazard that is posed by the high power optical outputs, the system supports APS mechanism to protect against the risk of direct human exposure to high-powered lasers. The APS mechanism acts to detect a fiber disconnection or fiber cuts along the span, and upon doing so, causes the shutdown on the same amplifier output port.

6.3.6 APR

APR reduces the output power level on open line out ports to a safe eye level. If either line output port on the system is open or becomes disconnected, the output power of the port is attenuated to bring it to safe level, if it is not already at safe level. On APR enabled port, when there is a loss of input power on coupled amplifier port, laser shuts down and stop transmitting power at APR enabled port.

6.4 C-D-C-G

This section introduces Colorless-Directionless-Contentionless-Gridless (CDCG) functions.

6.4.1 Colorless functions

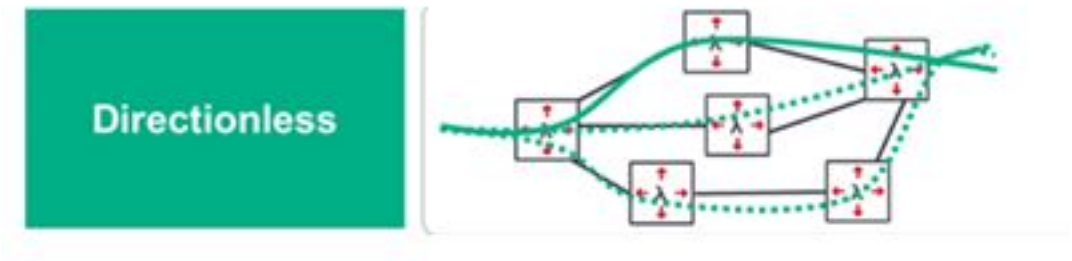
Colorless functionality enables any wavelength to be added/dropped on any port. Operators can remotely reconfigure wavelengths without site visits.

Figure 20: Colorless

6.4.2 Directionless functions

Directionless functionality allows any wavelength to be routed to any direction by software without any physical changes.

Figure 21: Directionless



6.4.3 Contentionless functions

Contentionless ROADMs eliminate wavelength blocking so that operators can add or drop the same wavelength at the same add/drop structure. Together the capabilities of Colorless, Directionless, and Contentionless (CDC) are what provide ultimate flexibility at the optical layer required for a fully agile photonic architecture.

Figure 22: Contentionless

6.4.4 Gridless

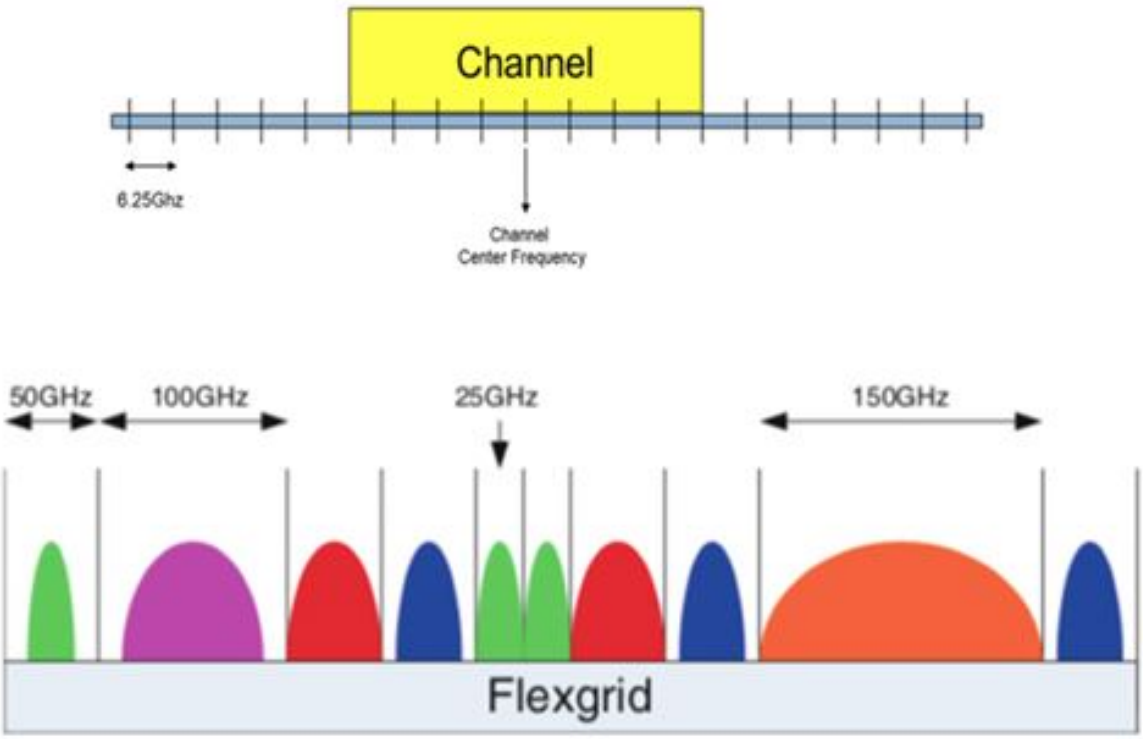
Flex-grid offers service providers the ability to define individual spectral widths for each wavelength.The channels spectral width must be a multiple of 6.25GHz.

This is commonly referred to as "n x 6.25 GHz".

For example, a wavelength can be assigned a spectral width of:

- 37.5 GHz = 6 x 6.25 GHz
- 50 GHz = 8 x 6.25 GHz
- 75.0 GHz = 12 x 6.25 GHz

Figure 23: Gridless



7 Ethernet

This chapter describes the prominent Ethernet features supported in the TJ1600 product family.

7.1 VLAN

VLAN switching is supported as per IEEE 802.1q and VLAN stacking (Q-in-Q) is supported as per IEEE 802.1ad. CSMA/CD Ethernet - Carrier Sense Multiple Access/ Collision Detection is supported as per IEEE 802.3 standards.

7.2 Ethernet services

- 1024 Ethernet Virtual Connection (EVC) are supported on the node.
- 2048 Flow points are supported on the node
- ELINE EVC
- ELAN EVC

Note: Only two flow points can be present in an ELINE EVC.

VLAN + DSCP and VLAN + PRIO classification are not supported.

7.2.1 ELINE EVC

EPL service

EPL service is a dedicated port based service, analogous to a TDM private line. An EPL service is configured as an ELINE service, which requires two interfaces to participate in the service. The interfaces participating in an EPL service should be configured as transparent ports. Link integrity is supported in the EPL service. No other services can be associated with the ports participating in the EPL service.

EVPL service

Flows contributing to an EVPL service are identified using the {port and CVID/SVID} fields in the incoming frame as the key. EVPL is configured as an ELINE service but the participating port need not be transparent. Ports participating in EVPL can be part of any service. Exception is if the port is transparent, that port cannot be part of any other service.

The differentiation stated above is only from an application perspective. From configuration perspective, EPL is just a degenerate case of more sophisticated EVPL.

7.2.2 ELAN EVC

EPLAN service

EPLAN service is configured similar to the EPL service, except that service type is ELAN. Any number of ports, which are part of service are configured in transparent mode.

ETREE service

ETREE service is emulated using the hub and spoke service construct of MPLS-TP. This service is created from NMS as it involves multiple nodes. ETREE service is considered as a special case of ELAN service. It is primarily intended to support multicast services like IPTV. In this service, all participating L2 end points are modeled either as a root or a leaf. Leaf to leaf communication can be configured or disabled by the user.

7.3 LAG

Link Aggregation Group (LAG) is used for protecting Ethernet links across link failures. Only static LAG is supported where two interfaces are part of the LAG and traffic is carried on one interface and the other is on standby to provide protection for the work interface.

7.4 MPLS-TP

Multi Protocol Label Switching - Transport Profile (MPLS-TP) is a new formulation of MPLS, being standardized by ITU-T and designed specifically for connection-oriented packet transport network based on well-known and widely deployed IP/MPLS technology and standards. The MPLS-TP meets all the requirements of transport networks but is packet switched in nature. The MPLS-TP supports following features:

- **Management plane**:
  - Statically configure label switch path and pseudowire and manage through NMS
  - OAM handling
- **Data plane**:
  - Forwarding based on LSP/PW label
  - Bi-directional path (LSP) for traffic and OAM
  - OAM support through Associated channel (PW ACH and GE ACH). OAM supports bidirectional forwarding detection (BFD), pseudowire status messaging (PWSM), LSP-Ping, and LSP traceroute.
- **Protection**:
  - MPLS-TP dual-homed pseudowire protection
  - Tunnel protection
  - Pseudowire protection
- **Loop prevention**: MPLS Core may use a full mesh of PWs so there may be possibility of loop. To prevent the loop **split-horizon** forwarding is used.
- **Multisegment pseudowire**: Multi segment pseudowire allows reduction in tunnel count and efficient setup of the tunnel.

MPLS-TP is supported with the following limitations:

- Tagged MPLS is not supported.
- Same per-hop behavior (Cos-EXP to EXP-Cos profile) must be used across the network.

7.5 OAM

OAM operation is supported by Connectivity Fault Management (CFM) and supported in accordance with IEEE 802.1ag.

CFM monitors Ethernet links and services to locate and debug any faults in the network or service. CFM comprises of the Continuity Check Message (CCM) protocol ensuring MEP based fault detection. MEPs can be configured on tunnel or pseudowire level.

7.6 QoS

Providing Quality of Service (QoS) is also one of the 5 tenets of Carrier Ethernet technologies. Standard based services, Scalability, Reliability, QOS, and Service Management.

Supports QoS for the PTN technologies like MPLS-TP. Supports Ingress QoS and Egress QoS that are implemented in every Network Element (NE).

The following points apply to all the PTN technologies and differ only based on the encodings of color and CoS in the Packet headers.

The size of queues for CEF-5 card is 400MB.

7.6.1 Ingress QoS

UNI and Ethernet NNI functionalities supported are:

- Associating a class of service that is a QoS service level
- Traffic conditioning

MPLS-NNI functionalities supported are:

- Associating a class of service that is a QoS service level based on the packet headers.
- Inferring the color of a packet based on the packet headers.

7.6.2 Egress QoS

The egress QoS functionalities supported are:

- Queue admission based on the color and CoS of the packet arrived at based on the Ingress QoS step.
- Scheduling among the different CoS queues.
- Every egress port is assigned 8 CoS queues. Packets can be mapped to specific CoS queues dynamically using .1p (or DSCP) to CoSQ profile. By default, all packets are mapped to CoSQ-0. The queues can be configured as a Strict Priority or WFQ from scheduling perspective, using scheduler profiles. Every queue is

assigned 6MB of memory/buffer depth. Port level shaper (single rate) with configurable burst size is supported.

7.6.3 Storm control

Storm control is supported through a flow-policer to block or discard the packets which would otherwise limit the traffic in the network. This is available only for ELAN service.

Following are the limitations in QOS:

- CoS-DSCP mapping profile attached on a flow point affects all the flow points on the same port.
- Priority tag is not supported for Q-in-Q.

7.7 LLDP

The Link Layer Discover Protocol (LLDP) is supported on Ethernet ports for discovery of neighboring devices. For enabling LLDP on individual ports, user needs to create **LLDPInterfaceConfig** object and configure BPDU tunneling for peering LLDP messages. Supported in accordance with 802.1ab. Supports Packet Trunk object creation for auto-discovery of the topology in the NMS.

7.8 BPDU Tunneling

The Bridge Protocol Data Unit (BPDU) configuration is service level peering, tunneling and discarding of BPDU packets. Based on the service type, BPDU configuration is profiled into following four types:

- **Peer**- LACP & LLDP; Discard- remaining BPDUs
- **Tunnel**- all type of BPDUs
- **Peer**- LACP & LLDP; Tunnel- STP & GARP (01:80:C2:00:00:2x range); Discards- remaining BPDUs
- **Peer**- LACP, LLDP and STP; Tunnel- GARP; Discards- remaining BPDUs

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NOTE: BPDU is supported in the range of 01:80:C2:00:00:00 to 01:80:C2:00:00:2F.

7.9 Port mirroring

The port mirroring is commonly used for network appliances that require monitoring of the network traffic, such as an intrusion-detection system. The Egress and Ingress port mirroring are supported.

The port mirroring enables data plane monitoring functionality which allows the user to send an entire traffic stream for testing. Port mirroring sends a copy of packets of a port's traffic stream, called **mirrored port**, into an analyzer port. The port mirroring is used for network monitoring. It can be used for intrusion detection, security breaches, and protocol analysis.

There is no limitation on the number of mirroring sources and more than a single source can be mapped to a single analyzer destination.

8 DCN

This chapter describes prominent Data Communication Network (DCN) features supported in TJ1600 Product family.

8.1 DCN Features

8.1.1 GCC

A DCN is General communication channel (GCC) on the node. The NEs can be provisioned to act as an OSPF router for GCC in remote management. It can exchange and maintain the routing information on GCC to which it is connected using the NMS port. The network element processes the router information on the NMS port, if the OSPF Ethernet parameter is enabled.

Similarly, the routing information on the data communication channel is processed.

8.1.2 ECC

The Error correction code (ECC) memory is a type of computer data storage that uses an error correction code to detect and correct n-bit data corruption which occurs in memory.

8.1.3 OSC

The Open Sound Control (OSC) is a protocol for networking sound synthesizers, computers, and other multimedia devices for purposes such as musical performance or show control.

8.2 External management

This is an interface provided to manage external devices co-located with the node using the same IP network. The number of external management interfaces is 3 in TJ1600-11 and 1 in TJ1600-6. This feature is not supported in TJ1600-2.

8.3 OSPF area

8.3.1 Single area

The Open Shortest Path First (OSPF) is an interior gateway routing protocol based on the shortest path first or link-state algorithm.

It uses a Link State Routing (LSR) algorithm and falls into the group of interior routing protocols, operating within a single Autonomous System (AS). Routers use link-state algorithms to send routing information to all nodes in an internetwork by calculating the shortest path to each node based on a topography of the Internet constructed by each node.

Each router sends that portion of the routing table (keeps track of routes to particular network destinations) that describes the state of its own links, and the complete routing structure (topography). The advantage of shortest path first algorithms is that it results in smaller and more frequent updates everywhere. The converge is quick, thus

preventing problems such as routing loops and count-to-infinity (when routers continuously increment the hop count to a particular network) thus resulting in a stable network.

OSPF networks can be divided into sub-sections called areas. An area is a group of OSPF networks, routers, and links that have the same area identification. It helps in reducing the size of the router database because the router has network topology information only possess information about network topology of only with in that area. The default area parameter is 0.0.0.1. Any valid IP address is an acceptable area parameter. TJ1600 supports single OSPF area.

8.3.2 Multi OSPF

TJ1600 supports multi OSPF area also. The multi area OSPF refers to the division of a large OSPF area into smaller areas. In bigger network deployments, the multi area OSPF helps decrease processing and memory overhead. A hierarchical network design is required for multi area OSPF.

8.4 VLAN management

The node uses OSPF protocol for the network discovery. Every node acts as a router for the DCN. After the VLAN management is enabled, each and every node establishes a one to many connections with its neighboring nodes. On each link, the node forms OSPF P2P (point to point) network on that link. This type of setup ensures that the OSPF packet generated from one node with the management VLAN will terminate at its neighboring node and does not travel over to other nodes thus preventing the formation of L2 loop.

The VLAN management has to be configured on the network side interfaces, and the VLAN should be associated with the interface.

NOTE: This feature is supported only in CEF-5 card.

8.5 Proxy ARP

The proxy ARP allows the gateway node to respond to Address Resolution Protocol (ARP) requests for subtending nodes that are within the same subnet as the customer DCN address range. The proxy ARP feature removes the need for customers to provision static routes on their routers and routing protocols (OSPF) between the gateway network elements and the customer DCN.

The proxy ARP is only supported on the LAN interface of the node. At the gateway node, the IP address of neighboring nodes is provisioned for proxy ARP.

TJ1600-I supports both automatic and manual proxy ARP modes.

9 System

This chapter describes the main system features supported in the TJ1600 product family.

9.1 ALS

The Automatic Laser Shutdown (ALS) is a technique used to shut down automatically the lasers used in long distance optic fiber communication links in the event of fiber damage or for maintenance. This safety feature prevents dangerous levels of laser light from leaking out of a broken fiber, provided ALS is provisioned on both ends of the fiber pair.

The following series of events take place:

- If a fiber is cut, the receiver detects a Loss of Signal (LOS).
- The ALS agent turns off the transmitter.
- The receiver at the far end then detects LOS and its ALS agent turns off the transmitter.

9.2 10G/100G-600G Transmission system

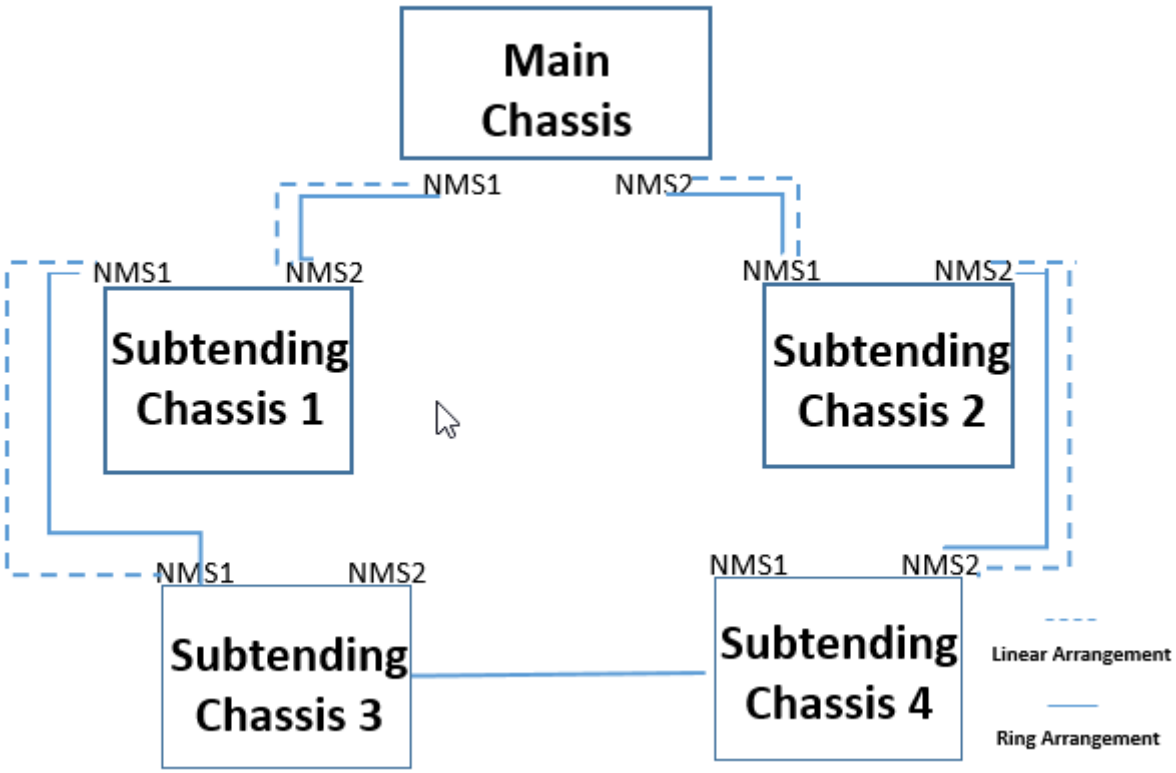
10G/100G - 600G transmission system is a high-capacity OTN transport system mainly used in backbone network, metropolitan area network and data center interconnected transmissions. It supports large bandwidth granularity multiplexing, electrical layer cross connection, multi service mapping and 10G/100G - 600G transmission. It is applied to build an end-to-end OTN backbone transmission solution.

9.3 Multi-shelf (main-subtending)

Additional LAN interfaces are provided in the OAM card for connecting main and subtending chassis. In case of TJ1600-6SR chassis, the NMS1 and NMS2 ports in main chassis can be connected to two other subtending chassis using two RJ-45 cables. The subtending chassis in turn can connect to other subtending chassis thus supporting a linear or ring form of multi shelf arrangement.

The figure shows the multi shelf connection between main and subtending chassis.

Figure 24: Multi shelf connection between main and subtending



9.4 Dynamic license

Following features are license dependent and are enabled based on the features/cards opted:

- EFEC
- HCPSLine28 card (second transponder)
- OPM card (view channel OSNR)
- DWDM GMPLS (WSON)
- SDH/OTN GMPLS
- CEF-5 cards
- CHANNEL_OSNR
- QSFP28_TRANS2CLIENT
- FLEX_GRID_DWDM
- OTN_FEC_I_4
- AGG200G
- AGG2400

9.5 Loopbacks

Loopbacks are performed to check the continuity on OTN Client ports. The ports can be configured for facility loopback and terminal loopback. The exact location of failure can be detected using loopbacks. Facility and terminal loopbacks can be performed to test the electrical and optical connectivity of the node.

NOTE: All line cards support both client side and line side loopback.

Facility loopback and terminal loopback are traffic affecting. Application of facility or terminal loopback on the near end port (with respect to NMS server) of a remotely managed node will result in loss of connectivity with the node and the downstream network. Hence, while applying loopbacks, the node should be provided with IBC protection or should have a personnel placed at the site of the node to avoid loss of connectivity.

9.6 SNMP

SNMP is used for managing complex networks. It allows network devices to exchange management information. SNMP trap is an SNMP application that uses the SNMP trap operation to send information to a network manager. The traps are sent when a fault happens in a network and a alarm/event is raised in the node or when configuration change happens on network element through any interface. The SNMP allows network administrator to find and interpret network problems and plan network growth. SNMPv1, SNMPv2 and SNMPv3 are supported.

9.7 Synchronization

The Synchronization feature provides the timing and synchronization management functionality for the node. All the SDH nodes in a network are synchronized to the same highly accurate clock called the Primary Reference Clock (PRC). Synchronization option allows to view Synchronization status, Nominate timing reference and view Nominated timing references.

9.7.1 STM port

TJ1600 product supports assigning STM port for clock recovery. All other interfaces on the node are timed using the clock that was recovered from the designated port.

NOTE: This is supported only in TJ1600-11 with HCPXCC04 controller card and the STM port should be in non-TTM mode.

9.7.2 BITS

The BITS clock input/output is at 2.048 MHz and can be nominated as a reference for node synchronization. Loss-of-Signal (LOS) is detected on the clock input and this alarm is used as a trigger to change over to the next synchronization reference.

The BITS data input/output is at 2.048 Mbps. Both PCM30 and PCM31 (with/without CRC) framing can be used on the input. This input can be nominated as a reference for node synchronization. The LOS, LOF, and AIS are detected on this input and this alarm is used as a trigger to change over to the next synchronization reference. The alarms are reported on the user interface.

NOTE: This is supported only in TJ1600-11 with HCPXCC04 controller card.

9.7.3 SyncE

Sync-E involves feeding of one node in an Ethernet network with a PRC and employing Ethernet PHY circuitry with well-engineered timing recovery circuitry to set up a fully frequency Synchronized network. It provides access to a highly accurate and stable frequency reference to the applications requiring it. Enables or disables the port's ability to broadcast SyncE frames.

Advantages:

- Sync-E is not influenced by congestion or other dynamic conditions in the network. Buffering and delay will not vary with varying network conditions.
- Sync-E is used for applications where the network is relatively noisy and required carrier class synchronization in the network.

10 GMPLS

Generalized Multiprotocol Label Switching (GMPLS) is an extension of the MPLS signaling protocols to enable easy setup/restoration for use in SDH, OTN, and WSON. It is a technology independent protocol, applicable to SDH, OTN, and WSON thus promising the possibility of a unified control plane for end-to-end provisioning across different layers of the network. Every node in a GMPLS cloud has a network view of the topology and failures, and hence capable of autonomously re-configuring/routing the circuits in response to network faults in a deterministic way. The GMPLS implements an additional level of protection to the networks by establishing one or more pre-signaled backup paths (reroute) for each connection and enabling very fast switching in case of failure.

You can select the desired service type from the following list:

- **Bronze service:** select Service_1
- **Silver service:** select Service_1_R
- **Gold service:** select Service_1_1_R
- **Platinum service:** select Service_1_1_F

The two services can be paired together if service pairing is set as **Enabled**.

Similarly, you can follow reroute option if reroute option is set as **Enable**. This is applicable only to the provisioned circuit. The **Reroute FreqTuning** parameter checks for availability of other frequencies to reach the egress path in case of fiber cut.

Route selection metric

You can select the route selection metric type from the drop down list to be followed by GMPLS circuits across network.

- **Available_Bandwidth:** Indicates rerouting is based on the available path with maximum bandwidth.
- **Number of Hops:** Indicates rerouting path selection is based on shortest path with least number of hops/nodes.
- **User_Defined:** Indicates rerouting path selection is based on cost defined by the user for each path in a GMPLS network.
- **Latency:** Indicates rerouting path selection is based on the latency/delay.

10.1 Bronze service (Service_1)

It is an unprotected service. Bronze service have dedicated work path only. In case of failure in traffic flow path, the traffic goes down. The cross-connects is retained and once the fault is rectified, the traffic is restored.

10.2 Silver service (Service_1_R)

It provides 1+R protection and a GMPLS based restoration. Silver service has two types of reversion mode:

- Revertive
- Non-revertive

10.2.1 Revertive

A dedicated work path exists for silver service (revertive). When a work path fails, a protect path is found, and traffic is redirected there. The cross-connects will always be present in the job path. After the failure in the work path, a new way is discovered. When it is restored, traffic returns to the work path. When traffic returns to the work path, the reroute path is removed.

10.2.2 Non-revertive

Silver service (non-revertive) does not have dedicated work and protection path. In case of failure in work path, finds the restoration path and traffic comes up on restoration path. The cross-connects is deleted from the original work path permanently. The restored path is the new work path. The traffic does not switch back to the original work path when it is restored.

10.3 Gold service (Service_1_1_R)

Gold service offers GMPLS-based restoration and 1+1 protection. The focused work and protective path of the gold service. The traffic shifts to protect the path in the event of a failure in the work path. The cross-connects is kept constantly in the work path. If the original work path is not restored after any failure in the protect path, the traffic either switches to the original work path or reroutes to a new re-route path (if the work path is restored).

10.4 Platinum service (Service_1_1_F)

Platinum service offers continuous 1+1 protection. The focused work and protective path of platinum service. Traffic switches to the protect path in the event of a work path failure, and a new work path called the redirected work path is generated. A new protect path with the name redirected protect path is generated in the event that the protect path fails. One extra work/protect path is produced for each time the work/protect path fails.

NOTE 1: Single or more than one direction less (local drop) ROADMs are supported.

The Bronze/Silver (Non-revertive) service creation supported from MDU which is directly connected at directional ROADM.

NOTE 2: For WSON, the protection switching and rerouting times are in the order of few seconds.

11 Security

NOTE: Security feature is supported only in TJ1600-11 with HCPXCC04 controller card.

The node is secured by:

- **SSH:** For secure login to the secure shell.
- **HTTPS:** For secure login to the node UI.
- **SFTP:** For secure file transfer including software build during node upgrade.

Acronym

Acronym	Definitions
ADM	Add-drop Multiplexer
AGC	Automatic Gain Control
AIS	Alarm Indication Signal
ALS	Automatic Laser Shutdown
AN	Auto Negotiation
APB	Automatic Power Balancing
APC	Automatic Power Control
APR	Automatic Power Reduction
APS	Automatic Power Shutdown
ARP	Address Resolution Protocol
AS	Autonomous System
BFD	Bidirectional Forwarding Detection
BPDU	Bridge Protocol Data Unit
CCM	Continuity Check Message
CDG	Colorless Directionless Gridless
CE	Carrier Ethernet
CFM	Connectivity Fault Management
CFP	Contention Free Periods
CoS	Class of Service
CSF	Common Service Framework
CVID	Customer VLAN ID
DSCP	Differentiated Services Code Point
DWDM	Dense Wavelength Division Multiplexing
DXC	Distributed cross-connect
ECC	Error Correction Code
ELAN	Ethernet Local Area Network
EoS	Ethernet over SDH
EPL	Ethernet Private Line
EVC	Ethernet Virtual Connection

Acronym	Definitions
FEP	Forward Error Correction
FPU	Fiber Protection Unit
FRU	Field Replacable Unit
FTP	File Transfer Protocol
GCC	General Communication Channel
GE	Gigabit Ethernet
GFP-F	Generic Frame Procedure - Framed
GMPLS	Generalized Multiprotocol Label Switching
ILA	Inline Amplifier
LCAS	Link Capacity Adjustment Scheme
LI	Link Integrity
LOF	Loss of Frame
LOS	Loss of Signal
LLDP	Link Layer Discover Protocol
MIB	Management Information Base
MPLS-TP	Multi Protocol Label Switching - Transport Profile
NE	Network Element
NG-OTN	Next Generation OTN
NG-SDH	Next Generation SDH
NMS	Network Management System
NPP	Network Port Protection
NTP	Network Time Protocol
OAM	Operations Administration and Maintenance
ODU	Optical Data Unit
OSC	Optical Supervisory Channel
OTN	Optical Transport Network
OTU	Optical Transport Unit
OSC	Open Sound Control
OSPF	Open Shortest Path First
PRC	Primary Reference Clock

Acronym	Definitions
PTN	Private Telecommunications Network
PWSM	Pseudo Wire Status Messaging
QoS	Quality of Service
ROADM	Reconfigurable Optical Add-Drop Multiplexer
RPP	Regenerator Port Pairing
RPR	Resilient Packet Ring
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Networking
SNMP	Simple Network Management Protocol
Sync-E	Synchronous Ethernet
TDM	Time Division Multiplexing
VCAT	Virtual Concatenation
VLAN	Virtual Local Area Network
WDM	Wavelength Division Multiplexing
WSON	Wavelength Switched Optical Network