



ASR 9000 1/10/40/100G LAN/WAN/OTN White Paper

Audience

This white paper is intended to help the readers obtain a quick understanding on 1/10/40/100GE Ethernet port on a Line Card in general and how it has been implemented in ASR9k including the configuration detail. It also includes a 'frequently asked questions' (FAQ) section, which cover some of the potential field questions that might pop up while deploying this feature using ASR9k. Overall, this white paper can be a quick reference guide for anyone working on these Line Cards.

Disclaimer

- This white paper is based on ASR9k Release 4.3.1.
- ❖ If anyone thinks that this white paper needs to be updated with some more specific detail, which might benefit the overall audience, feel free to let the authors know so that we can keep the document live and effective.

Revision

Version	Date	User id	Comments
1.0	05/20/2013	rramacha@cisco.com	Initial draft
1.1	05/29/2013	rramacha@cisco.com	Updated FEC mode table (Table 6 and Table 7)

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1. General

The Cisco ASR 9000 Series Aggregation Services Routers is the baseline for next-generation [Carrier Ethernet](#) networks, providing up to 96 terabits (Tbps) per system. Its architecture design enables capabilities for next generation Internet that includes mobile aggregation & virtualization and also reduces operational cost & complexity.

1.1 Ethernet Line Cards

Ethernet Line Cards in ASR9000 can be called as First and Second generation based on the Network processor (NP) used. The Second generation Line Card is also referred to as Enhanced Ethernet Line Card.

Table 1 Supported Transport Modes and Optics Types for Line Cards

Line Card/Modular Port Adapter (MPA)	Generation	Supported Transport modes	Supported Optics Type
A9K-40G	First Generation	1GE LAN	SFP
A9K-4T	First Generation	10GE LAN	XFP
A9K-8T/4	First Generation	10GE LAN	XFP
A9K-2T20G	First Generation	1GE LAN; 10GE LAN/WAN PHY/OTN	SFP for 1GE Ports; XFP for 10GE Ports
A9K-8T	First Generation	10GE LAN/WAN PHY/OTN	XFP
A9K-16T/8	First Generation	10GE LAN/WAN PHY/OTN	SFP+
A9K-24-10GE	Second Generation	10GE LAN/WAN PHY/OTN	SFP+
A9K-36-10GE	Second Generation	10GE LAN/WAN PHY/OTN	SFP+
A9K-MPA-20x1GE	Second Generation	10GE LAN/WAN PHY/OTN	SFP
A9K-MPA-2x10GE	Second Generation	10GE LAN/WAN PHY/OTN	XFP
A9K-MPA-4x10GE	Second Generation	10GE LAN/WAN PHY/OTN	XFP
A9K-MPA-8x10GE	Second Generation	10GE LAN/WAN PHY/OTN	SFP+
A9K-MPA-1x40GE	Second Generation	10GE LAN/OTN	QSFP+
A9K-MPA-2x40GE	Second Generation	10GE LAN/OTN	QSFP+
A9K-2x100GE	Second Generation	100GE LAN, LAN PP*	CFP
A9K-1x100GE	Second Generation	100GE LAN, LAN PP*	CFP

* LAN PP – LAN Proactive Protection – “Cisco Proprietary”

1.2 Optics OIR

After removing Optics, it is recommended to wait for 10 seconds for Software cleanup to complete before inserting another Optics. Also, after Optics insertion, it is recommended to wait for 10 seconds before removing it. After Optics insertion, software waits for power to stabilize before applying configuration. If the above recommendation is not followed, then it may affect the functionality of Optics.

1.3 Third Party Optics

ASR 9000 supports only Cisco Optics listed in the following data-sheet (Ref. 3).
http://www.cisco.com/en/US/prod/collateral/routers/ps9853/data_sheet_c78-624747.html

Third Party Optics support policy is discussed here.

<https://supportforums.cisco.com/blogs/asr9k/2013/03/18/asr9000-policy-3rd-party-optics>
http://www.cisco.com/en/US/prod/prod_warranty09186a00800b5594.html

1.4 Transceiver permit pid all

ASR 9000 supported Optics has undergone extensive thermal, electrical and optical testing during qualification. Cisco policy is to support only optics mentioned in the data-sheet (Ref. 3). When a new Optics is inserted, Software reads Optics EEPROM and performs Security, Type and Product ID (PID) verification. If the inserted Optics is not a supported one, then Optics Transmit Laser will be turned off. This will cause Loss-of-signal (LOS) and Local Fault (LF) at far-end port. As an over-ride for PID check for a given port, the following CLI can be used. But, it is to be noted that there is no guarantee that an un-supported Optics will work even after configuring 'transceiver permit pid all' CLI. An un-supported optics may also damage the Hardware since it may violate thermal and electrical specification of the Line Card. Cisco recommends only to use ASR 9000 supported Optics.

PID Over-ride command:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#transceiver permit pid all
RP/0/RSP0/CPU0:ios(config-if)#commit
```

1.5 Statistics

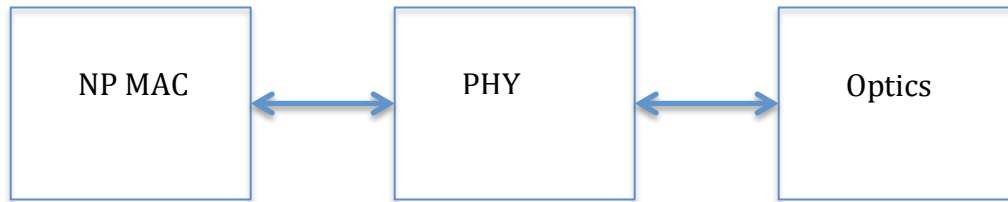


Figure 1 Data-path between MAC and Optics

MAC Ingress (packets received from Optics) and Egress Packet counts (Packets transmitted to Optics) can be displayed as given below.

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/0 stats
Statistics for interface GigabitEthernet0/5/0/0 (cached values):
```

Ingress:

```

Input total bytes      = 0
Input good bytes      = 0

Input total packets   = 0
Input 802.1Q frames   = 0
Input pause frames    = 0
Input pkts 64 bytes   = 0
Input pkts 65-127 bytes = 0
Input pkts 128-255 bytes = 0
Input pkts 256-511 bytes = 0
Input pkts 512-1023 bytes = 0
Input pkts 1024-1518 bytes = 0
Input pkts 1519-Max bytes = 0

Input good pkts       = 0
Input unicast pkts    = 0
Input multicast pkts  = 0
Input broadcast pkts  = 0

Input drop overrun    = 0
Input drop abort      = 0
Input drop invalid VLAN = 0
Input drop invalid DMAC = 0
Input drop invalid encap = 0
Input drop other      = 0
  
```

Input error giant = 0
 Input error runt = 0
 Input error jabbers = 0
 Input error fragments = 0
 Input error CRC = 0
 Input error collisions = 0
 Input error symbol = 0
 Input error other = 0

Input MIB giant = 0
 Input MIB jabber = 0
 Input MIB CRC = 0

Egress:

Output total bytes = 0
 Output good bytes = 0

Output total packets = 0
 Output 802.1Q frames = 0
 Output pause frames = 0
 Output pkts 64 bytes = 0
 Output pkts 65-127 bytes = 0
 Output pkts 128-255 bytes = 0
 Output pkts 256-511 bytes = 0
 Output pkts 512-1023 bytes = 0
 Output pkts 1024-1518 bytes = 0
 Output pkts 1519-Max bytes = 0

Output good pkts = 0
 Output unicast pkts = 0
 Output multicast pkts = 0
 Output broadcast pkts = 0

Output drop underrun = 0
 Output drop abort = 0
 Output drop other = 0

Output error other = 0

RP/0/RSP0/CPU0:ios#sh int gigabitEthernet 0/5/0/0

GigabitEthernet0/5/0/0 is up, line protocol is up

Interface state transitions: 11

Hardware is GigabitEthernet, address is 0022.bde2.b179 (bia 0022.bde2.b179)

Internet address is Unknown

MTU 1514 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)

reliability 255/255, txload 0/255, rxload 0/255

Encapsulation ARPA,
 Full-duplex, 1000Mb/s, link type is force-up
 output flow control is off, input flow control is off
 loopback not set,
 ARP type ARPA, ARP timeout 04:00:00
 Last input 2d04h, output 2d04h
 Last clearing of "show interface" counters 2d01h
 5 minute input rate 0 bits/sec, 0 packets/sec
 5 minute output rate 0 bits/sec, 0 packets/sec
 0 packets input, 0 bytes, 0 total input drops
 0 drops for unrecognized upper-level protocol
 Received 0 broadcast packets, 0 multicast packets
 0 runts, 0 giants, 0 throttles, 0 parity
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
 0 packets output, 0 bytes, 0 total output drops
 Output 0 broadcast packets, 0 multicast packets
 0 output errors, 0 underruns, 0 applique, 0 resets
 0 output buffer failures, 0 output buffers swapped out
 0 carrier transitions

Notes:

- 1) Packet input and output count doesn't include counts for Preamble (7 bytes), SFD (1 byte), FCS (4 bytes).
- 2) Input error giant: The total number of well-formed and valid packets that are dropped because they are larger than the configured MRU. This counter is similar to the RFC2819 definition of etherStatsOversizedPkts, but is based on MRU rather than a fixed size of 1518 octets.
- 3) Runt: Any frame received lesser than 64 bytes is counted as 'runt' and dropped.
- 4) Input MIB giant: The total number of well-formed and valid packets that are larger than 1518 bytes. (Regardless of whether the packets are dropped due to MRU consideration). This counter strictly matches the RFC2819 definition of etherStatsOversizePkts.
- 5) Input error symbol: A Symbol error means the interface detects an undefined (invalid) Symbol received. Small amounts of symbol errors can be ignored. Large amounts of symbol errors can indicate a bad fiber or Optics.
- 6) Input error jabbers: A jabber is a frame longer than 1518 octets (which exclude framing bits, but include FCS octets), which does not end with an even number of octets (alignment error) or has a bad FCS error.

1.6 MTU

In ASR 9000, the maximum allowed receive Ethernet frame size can't exceed 9220 bytes which includes 4 bytes of CRC. If 'mtu' CLI is not configured, then default MTU of 1514 bytes is selected by software and internally 12 extra bytes are added to take care of QinQ header and CRC bytes. So, with default MTU configuration, any frame above 1526

(including CRC), will be dropped as 'giants'. Maximum allowed user configurable MTU is 9216 bytes but in MAC hardware the maximum allowed is 9220 bytes. So, with 'mtu 9216' configuration, the maximum allowed receive frame size can't exceed 9220 bytes (including 4 bytes of CRC).

MTU configuration command:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#mtu 9216
RP/0/RSP0/CPU0:ios(config-if)#commit
```

1.7 Link Defects

A Port link can go down for several reasons. The following CLI may be used to find out the reason for it.

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/0 internal
```

```
Port Number      : 0
Board Type       : 0x00000235
Port Type        : 1GE
Transport mode   : LAN
BIA MAC addr     : 0022.bde2.b178
Oper. MAC addr   : 0022.bde2.b178
Egress MAC addr  : 0022.bde2.b178
Port Available   : true
Status polling is : enabled
Status events are : enabled
I/F Handle       : 0x0e000240
Cfg Link Enabled : tx/rx enabled
H/W Tx Enable    : no
MTU              : 1526
H/W Speed        : 1 Gbps
H/W Duplex       : Full
H/W Loopback Type : None
H/W FlowCtrl Type : None
H/W AutoNeg Enable : Off
H/W Link Defects : (0x0000026a) RX_LOS HW_LINK LASI NO_OPTICS TX_FAULT
```

Table 2 Various Link Defects

Defect	Cause/Meaning	Defect Source	Effect	Recovery
NO_OPTICS	Optics is not present	Optics	Port is receiving LOS. Link Down.	Insert an Optics
TX_FAULT	Optics is reporting TX Fault. Optics TX Laser is not healthy.	Optics	Port Link is down. Far-end may be down due to LOS.	Try port 'shut' followed by 'no shut'. Try Optics OIR. If it doesn't solve the issue, replace the Optics.
MOD_NOT_RDY	Optics is reporting Module Not Ready. Optics TX laser or PHY clocking issue.	Optics	Port Link is down. Far-end may go down due to RFI.	Try port 'shut' followed by 'no shut'. Try Optics OIR. If it doesn't solve the issue, replace the Optics.
RX_LOS	Optics is receiving Loss-of-Signal. This will cause MAC Local Fault (LF) and PHY LASI.	Optics	Port Link is down. Far-end may go down due to RFI.	Check the fiber; check whether far-end port is 'no shut'.
XCVR_SECURITY	Not a Cisco supported Optics. Security check failed.	Optics	Port Link is down. Optics Transmit Laser is disabled. Far-end will see LOS.	Try Optics OIR. Use ASR9k supported Optics. If it is 3 rd party Optics, you may try 'service unsupported'.
SFP_HW_LINK	Copper/100FX Transceiver PHY is reporting Link Down	Optics	Port Link is down. Far-end may be down too.	Try Optics OIR. Check cable/fiber. Ensure both ends has matching

				autoneg, speed, flow-control commands. For 100FX, configure 'no autoneg' and 'speed 100' on both sides.
XCVR_PID_UNSUP	Optics Product ID is not supported for ASR9k.	Optics	Port Link is down. Optics TX laser is disabled. Far-end will see LOS.	Try Optics OIR. If it is a 3 rd party Optics, try port 'transceiver permit pid all' command.
XCVR_TYPE_UNSUP	Not a correct Optics type for this port. Instead of SFP+, a SFP is inserted in a 10GE port.	Optics	Port Link is down. Optics TX laser may be disabled. Far-end may see LOS.	Check and replace the Optics. If it is a 3 rd party Optics, try 'service unsupported'
UNSUP_CFG	User has configured an unsupported command. For example, 'autoneg' is configured for 100FX or 'speed' is configured for 1GE Optical SFP	Optics	Port Link is down. Optics TX laser is disabled.	Remove the unsupported port command.
LASI	PHY TX/RX link is DOWN (because of RX_LOS/PCS/PMA layers DOWN). If it is a 10GE/40GE port, then 'sh controllers tenGigE <> xgxs' provides additional information.	PHY	Port Link is disabled. If MAC is seeing HW_LINK defect, then far-end may get RFI.	Try Optics OIR, shut/no shut. Check health of fiber and Optics. If the Optics is DOM supported, 'sh controller <> phy' will provide TX/RX Power information. Also, check port configuration at both ends.

HW_LINK	MAC is seeing local fault. MAC RX link is DOWN (because of RX_LOS/PCS/PMA layers DOWN)	MAC	Port Link is down. Far-end may be get Remote Fault.	Try Optics OIR and shut/no shut. Check health of fiber and Optics. If the Optics is DOM supported, 'sh controller <> phy' will provide TX/RX Power information. Also, check port configuration at both ends.
RFI	MAC is seeing Remote fault. Far-end is seeing Local Fault.	MAC	Port Link is down. Far-end may be getting Local Fault.	Try shut/no shut and Optics OIR. Problem may be with Optics Transmit or TX fiber. Check whether near-end has enabled TX laser. Use 'sh controller <> {internal phy}'.
AUTO_NEG	Specific to 1GE port. Auto-negotiation is not complete	MAC/PHY	Port Link is down.	Try shut/no shut and Optics OIR. Check the health of Optics, Fiber. Check port configuration both sides.
FIA_INIT	Fabric is not ready to receive (some initialization issue).	Fabric	All ports are down.	Line Card reload may recover.
FIA_SHUTDOWN	Fabric is shutdown	Fabric	All ports are down.	Line Card reload may

				recover.
G709_LICENSE	No G.709 license is available	G.709 Software License	Warning message	License has expired or not available. Buy, new license.
ADV_OPT_PIE	Advanced Optics Pie is not installed.	G.709 Software License	Port transmit is disabled. Port Link is down.	Install Advanced Optic Pie
DWDM_LASER_SHUT	Port is in OTN mode but TX laser is disabled by Software	OTN	Port transmit is disabled. Port Link is down.	Configure 'admin-state in-service' under 'controller dwdm <>'.
WANPHY_SD_SF_BER	Link is down because of Signal Fail (SF) alarm from WAN PHY. If the rate of B2 BIP error is above the SF configured threshold, the above defect is raised	WAN PHY	Port transmit is disabled. Port Link is down.	Use 'sh controller wanphy <>' to check B2 BIP error counts. If it is increasing, then check whether far-end is configured for WAN PHY mode. Check the health of Optics and Fiber.
MODE_CHANGE	Port transmit is disabled momentarily during mode change. (lan/wanphy/otn changed using 'transport-mode <>' under 'interface tengig <>')	PHY	Port Link is down. Far-end may flap due to clock configuration change.	Internal software change and reconfig of PHY and clocking logic. Will clear after few minutes.

1.8 packet-gap non-standard

By default, Ethernet port operates at default Inter-frame-gap (IFG) of 12 bytes.

If the Far-end system needs a non-standard IFG, then the following CLI can be used to change IFG to 16 bytes. This CLI is supported only for 10GE port.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
RP/0/RSP0/CPU0:ios(config-if)#packet-gap non-standard
RP/0/RSP0/CPU0:ios(config-if)#commit
```

1.9 small-frame-padding

The following CLI allows ASR 9000 to pad Transmit/Egress Frames smaller than 68-bytes to 68 bytes (including CRC). This CLI is supported only for Second Generation Line Cards starting from 4.3.1 IOS XR Release.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
RP/0/RSP0/CPU0:ios(config-if)#small-frame-padding
RP/0/RSP0/CPU0:ios(config-if)#commit
```

1.10 loopback

ASR 9000 supports the following loopback types for debugging purpose. For 1GE/100GE, the loopback takes place at MAC whereas for 10GE/40GE, it is done at PHY.

```
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#loopback ?
  external  Enable external loopback (requires loopback connector)
  internal  Enable internal loopback
  line      Enable line loopback
```

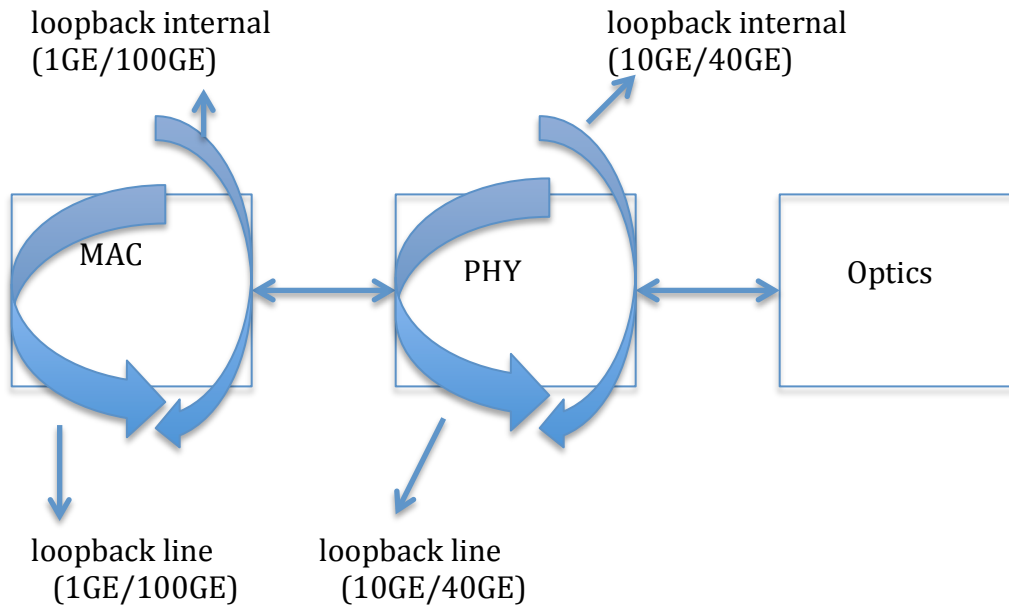


Figure 2 Loopback configuration

Loopback external (Applicable only to RJ45 SFP):

Configure 'loopback external', when a port is operating at 1000 Mbps Speed using an external loopback plug. With speed 10 Mbps or 100 Mbps, external loopback plug will work fine without the below configuration.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#loopback external
RP/0/RSP0/CPU0:ios(config-if)#commit
```

1.11 carrier-delay

The interface configuration command 'carrier-delay' is used to delay the processing of hardware link down/up notifications. By default, without any 'carrier-delay' configuration, the hardware allows faster link-down notification for signal failure condition such as LOS. To allow soaking time against noise causing link flap, 'carrier-delay {up | down} <msec>' may be used. For some Line Cards, the Link UP may take several seconds since clock stabilization occurs when the receive signal state changes from LOS to normal.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
```



```
RP/0/RSP0/CPU0:ios(config-if)#carrier-delay ?
down Set the carrier delay down value
up Set the carrier delay up value
RP/0/RSP0/CPU0:ios(config-if)#carrier-delay down ?
<0-2147483647> Delay in milliseconds
```

1.12 Optic Pie

To use the following features, 'asr9k-optic-px.pie' needs to be installed. Without Optic Pie, the link is brought down and also Transmit Laser is disabled.

- OTN mode in 10G port
- OTN mode in 40G port
- LAN Proactive Protection in 100G port

1.13 Optics DOM

DOM feature is supported only on Optics that provides this functionality (Ref. 5). Software periodically collects the following sensor data from supported Optics.

- *Transceiver Temperature*
- *Transceiver power supply voltage*
- *Transceiver Bias Current*
- *Transceiver Transmit Power*
- *Transceiver Receive Power*

The alarms and warnings available for each of the above sensors are read from Optics EEPROM.

- *High Alarm*
- *Low Alarm*
- *High Warning*
- *Low Warning*

Line Card sends a message to RSP which in turn will raise a CISCO-ENTITY-SENSOR-MIB SNMP trap for the corresponding alarm or warning. Alarms are of major severity while warnings are of minor severity for MIB. The following CLI can be used to show DOM data.

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/1 phy
```

```
< snip>
```

```
Temperature: 40.055
Voltage: 3.265 Volt
Tx Bias: 9.464 mAmps
Tx Power: 0.344 mW (-4.64 dBm)
Rx Power: 0.260 mW (-5.85 dBm)
Oper. Status/Control: Rx Rate Select,
```

2. 1GE Interface

2.1 LAN Mode

This is the default mode for a 1GE port. The following CLIs can be used to check the status of a given port.

```
RP/0/RSP0/CPU0:ios#sh int gigabitEthernet 0/5/0/39
GigabitEthernet0/5/0/39 is up, line protocol is up
.... <snip>
```

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/39 internal
```

```
Port Number      : 39
Port Type        : GE
Transport mode   : LAN
BIA MAC addr     : 001d.e5eb.8d17
Oper. MAC addr   : 001d.e5eb.8d17
Egress MAC addr  : 001d.e5eb.8d17
Port Available   : true
Status polling is : enabled
Status events are : enabled
I/F Handle       : 0x0e000a80
Cfg Link Enabled : tx/rx enabled
H/W Tx Enable    : yes <<<<<< Optics Laser is Enabled
UDLF enabled     : no
SFP PWR DN Reason : 0x00000000
SFP Capability    : 0x000000e7
MTU              : 1526
H/W Speed        : 100 Mbps
H/W Duplex       : Full
H/W Loopback Type : None
H/W FlowCtrl type : None
H/W AutoNeg Enable: Off
H/W Link Defects : (0x00000000) None <<<<<< No Defects
Link Up          : yes <<<< Port Link is Up
Link Led Status  : Link up -- Green/Amber
Input good underflow : 0
Input ucast underflow : 0
Output ucast underflow : 0
Input unknown opcode underflow: 0
Pluggable Present : yes
Pluggable Type   : 1000BASE-T <<< RJ45 SFP is present
```

Pluggable Compl. : Compliant <<<< Passed Security Check
Pluggable Type Supp.: Supported <<<< Passed Optics Type Check
Pluggable PID Supp. : Supported <<<< Passed PID check
 Pluggable Scan Flg: false

2.2 Uni-directional link Fault

Uni-directional Link Fault detection (UDLF) is a feature of 802.3 OAM that allows a host that detects a fault on the RX channel of a link to notify the peer via an 802.3 OAM message, so that the peer can disable the interface. In 10/40/100GE, when a Near-end port receives LOS, MAC sends Remote Fault (RF) to Far-end so that port is brought down. But, in case of 1GE, RF is not defined as a standard. So, this will cause Far-end port to stay UP even when a Near-end port is DOWN. By enabling UDLF feature at both ends, the Near-end notifies Far-end with OAM message whenever the port link is down due to LOS.

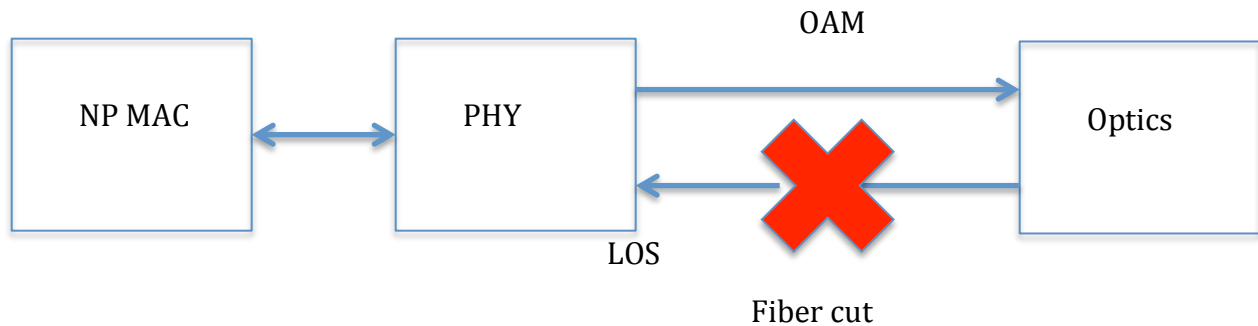


Figure 3 UDLF Notification with LOS

Configuration to Enable UDLR:
 interface GigabitEthernet0/6/0/2
 ethernet oam
 uni-directional link-fault detection
 action
 uni-directional link-fault efd
 !

2.3 Optics

Only 'Full-duplex' operation is supported since 'Half-duplex' capability is not available in MAC. **It is to be noted that the default configuration is 'no negotiation' which means Auto-negotiation is turned off. Please enable 'negotiation auto' in 1GE port if auto-negotiation is enabled at Link Partner (Far-end) port.**

Enable Auto-negotiation:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#negotiation auto
RP/0/RSP0/CPU0:ios(config-if)#commit
```

Disable Auto-negotiation:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#no negotiation auto
RP/0/RSP0/CPU0:ios(config-if)#commit
```

2.3.1. 1GE Optical SFP

With 1GE fixed Speed Optical SFP, ‘negotiation auto’ and ‘no negotiation auto’ are supported, it’s mandatory that both Near and Far-ends have matching configuration. But, it is recommended to use Auto-negotiation (AN) at both ends to ensure Speed, Flow-control (FC) and Master/Slave are negotiated and resolved.

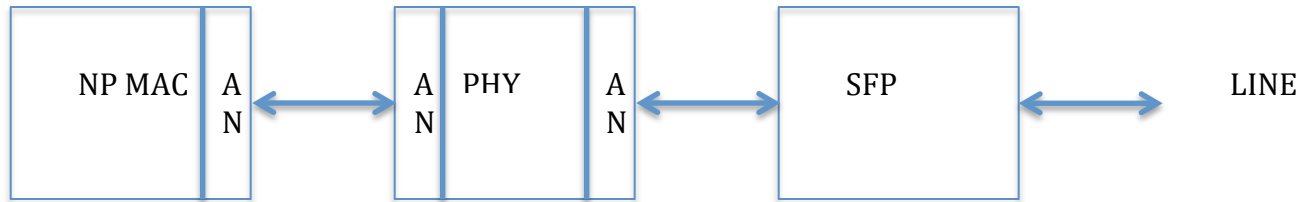


Figure 4 Auto-negotiation with 1GE Optical SFP

Table 3 Near-end Resolved Speed for Optical SFP

Auto-negotiation	Near-end (Config)	Far-end (Config)	Near-end (Result)
ON	None (Advertise Speed 1000, Full-duplex)	None	1000 Mbps (Resolved)
OFF	Speed 1000	Speed 1000	1000 Mbps

Table 4 Near-end Resolved Flow-control for Optical SFP

Auto-negotiation	Near-end (Config)	Far-end (Config)	Near-end (Result)
ON	Ingress	None	None
ON	Bidirectional	None	None
ON	Bidirectional	Ingress	Bidirectional
ON	Ingress	Ingress	None
ON	Ingress	Bidirectional	Ingress

Resolved Speed and Flow-control with Autoneg:

RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/8 internal

Port Number : 8

Port Type : GE

Transport mode : LAN <<<< LAN Mode

BIA MAC addr : 001d.e5eb.8cf8

Oper. MAC addr : 001d.e5eb.8cf8

Egress MAC addr : 001d.e5eb.8cf8

Port Available : true

Status polling is : enabled

Status events are : enabled

I/F Handle : 0x0e0002c0

Cfg Link Enabled : tx/rx enabled

H/W Tx Enable : yes <<<<< Optics TX Laser Enabled

UDLF enabled : no

SFP PWR DN Reason : 0x00000000

SFP Capability : 0x00000024

MTU : 1526

H/W Speed : 1 Gbps

H/W Duplex : Full

H/W Loopback Type : None

H/W FlowCtrl type : None

H/W AutoNeg Enable: On <<<<<<<<<< Autoneg Enabled

H/W AutoNeg Mask : None (0x0000)

H/W AutoNeg Speed : Unknown (0)

H/W AutoNeg Duplex: Invalid (0)

H/W AutoNeg FlowC : None (0)

Resolved AutoNeg Mask : None (0x0000) <<<<< Autoneg Resolved State

Resolved AutoNeg Speed : 1 Gbps (3)

Resolved AutoNeg Duplex: Full (2)

Resolved AutoNeg FlowC : None (0)

Local Autoneg RFI : None <<<<<< Autoneg Local end configuration

Local Autoneg Pause : Asym (Ingress)

Local Autoneg Speed : 1Ge Full

Local Autoneg Speed Mask : 1Gb

Local Autoneg Duplex Mask : full
Link Partner Autoneg RFI : None <<<<< **Autoneg Far-end configuration**
 Link Partner Autoneg Pause : None
 Link Partner Autoneg Speed : 1Ge Full
 Link Partner Autoneg Speed Mask : 1Gb
 Link Partner Autoneg Duplex Mask : full
H/W Link Defects : (0x00000000) None <<<< **No Defects**
Link Up : yes <<<< **Link is UP**
Link Led Status : Link up -- Green/Amber <<< **LED is Green**
 Input good underflow : 0
 Input ucast underflow : 0
 Output ucast underflow : 0
 Input unknown opcode underflow: 0
 Pluggable Present : yes
 Pluggable Type : 1000BX-10-D
 Pluggable Compl. : Compliant
 Pluggable Type Supp.: Supported
 Pluggable PID Supp. : Supported

RP/0/RSP0/CPU0:ios#sh int gigabitEthernet 0/5/0/8

GigabitEthernet0/5/0/8 is up, line protocol is up
 Interface state transitions: 15
 Hardware is GigabitEthernet, address is 001d.e5eb.8cf8 (bia 001d.e5eb.8cf8)
 Internet address is Unknown
 MTU 1514 bytes, BW 1000000 Kbit (Max: 1000000 Kbit)
 reliability 255/255, txload 0/255, rxload 0/255
 Encapsulation ARPA,
Full-duplex, 1000Mb/s, link type is autonegotiation <<<< **Autoneg ON, Speed 1000 Mbps**
output flow control is off, input flow control is off <<< **Flow-control OFF**
 loopback not set,
 Last input 1d07h, output never
 Last clearing of "show interface" counters never
 5 minute input rate 0 bits/sec, 0 packets/sec
 5 minute output rate 0 bits/sec, 0 packets/sec
 6 packets input, 360 bytes, 2 total input drops
 0 drops for unrecognized upper-level protocol
 Received 6 broadcast packets, 0 multicast packets
 0 runts, 0 giants, 0 throttles, 0 parity
 0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
 0 packets output, 0 bytes, 0 total output drops
 Output 0 broadcast packets, 0 multicast packets
 0 output errors, 0 underruns, 0 applique, 0 resets
 0 output buffer failures, 0 output buffers swapped out
 15 carrier transitions

2.3.2. Copper/RJ45 SFP

Copper SFP is a PHY based SFP that allows 10/100/1000 Mbps of Speed and Flow-control configuration whether Auto-negotiation is enabled are not. But, it is recommended to use Auto-negotiation (AN) at both ends to ensure Speed, Flow-control (FC) and Master/Slave are negotiated and resolved.

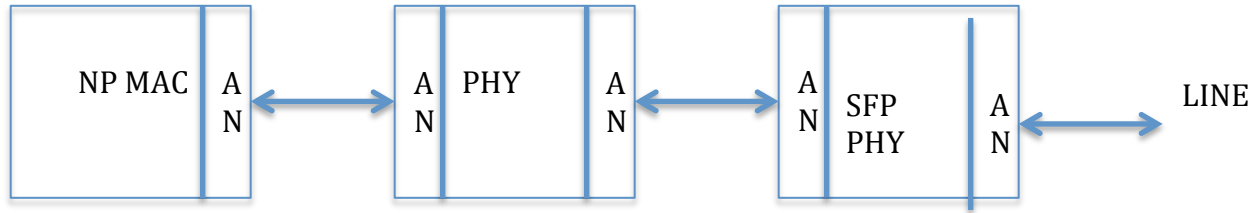


Figure 5 Auto-negotiation with Copper SFP

Table 5 Near-end Resolved Speed for Copper SFP

Auto-negotiation (Both Sides)	Near-end (Config)	Far-end (Config)	Near-end (Result)
ON	None (Advertise Speed 1000/100/10, Full-duplex)	None	1000
ON	None (Advertise Speed 1000/100/10, Full-duplex)	Speed 1000	1000
ON	None (Advertise Speed 1000/100/10, Full-duplex)	Speed 100	100
ON	None (Advertise Speed 1000/100/10, Full-duplex)	Speed 10	10
ON	Speed 1000	None	1000
ON	Speed 100	None	100
ON	Speed 10	None	10
OFF	Speed 1000	Speed 1000	1000
OFF	Speed 100	Speed 100	100
OFF	Speed 10	Speed 10	10

Resolved Speed and Flow-control with Autonegotiation:

```
RP/0/RSP0/CPU0:IOS#sh int gigabitEthernet 0/5/0/34
```

```
GigabitEthernet0/5/0/34 is up, line protocol is up
Interface state transitions: 5
Hardware is GigabitEthernet, address is 001d.e5eb.8d12 (bia 001d.e5eb.8d12)
Internet address is Unknown
MTU 1514 bytes, BW 100000 Kbit (Max: 100000 Kbit)
  reliability 255/255, txload 0/255, rxload 0/255
Encapsulation ARPA,
Full-duplex, 100Mb/s, THD, link type is autonegotiation <<< Resolved Speed
output flow control is off, input flow control is on <<< Resolved Flow-control
loopback not set,
Last input 00:00:00, output 00:00:00
Last clearing of "show interface" counters never
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  1875 packets input, 395625 bytes, 0 total input drops
  0 drops for unrecognized upper-level protocol
Received 0 broadcast packets, 1875 multicast packets
  0 runts, 0 giants, 0 throttles, 0 parity
  0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
  1875 packets output, 395625 bytes, 0 total output drops
Output 0 broadcast packets, 1875 multicast packets
  0 output errors, 0 underruns, 0 applique, 0 resets
  0 output buffer failures, 0 output buffers swapped out
  5 carrier transitions
```

2.3.3. 100FX Optical SFP

GLC-GE-100FX is a PHY based Optical SFP. Auto-negotiation is not supported but 'speed 100' needs to be configured.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int gigabitEthernet 0/5/0/0
RP/0/RSP0/CPU0:ios(config-if)#no negotiation auto
RP/0/RSP0/CPU0:ios(config-if)#commit
RP/0/RSP0/CPU0:ios(config-if)#speed 100
RP/0/RSP0/CPU0:ios(config-if)#commit
```

2.3.4. CWDM/DWDM SFP

1GE port supports several CWDM and DWDM Optics (Ref. 3).

2.3.5. GLC-BX10-U/D SFP

GLC-BX-D and GLC-BX-U Optics (Ref. 10) operate with single strand using Single Mode Fiber (SMF). GLC-BX-D transmits 1490-nm and receives 1310-nm wavelength, whereas GLC-BX-U receives 1490-nm and transmits 1310-nm wavelength signal. Bi-directional communication is achieved with integrated Wavelength-division multiplexing (WDM) splitter inside the optics. This optics also provides Digital optical monitoring (DOM) support. No special configuration is needed to operate this SFP.

```
RP/0/RSP0/CPU0:ios#sh running-config interface gigabitEthernet 0/5/0/8
interface GigabitEthernet0/5/0/8
negotiation auto
```

```
RP/0/RSP0/CPU0:ios#sh running-config interface gigabitEthernet 0/5/0/9
interface GigabitEthernet0/5/0/9
negotiation auto
```

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/8 internal
....
<snip>
Pluggable Type    : 1000BX-10-D
Pluggable Compl.  : Compliant
Pluggable Type Supp.: Supported
Pluggable PID Supp. : Supported
```

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/9 internal
....
<snip>
Pluggable Type    : 1000BX-10-U
Pluggable Compl.  : Compliant
Pluggable Type Supp.: Supported
Pluggable PID Supp. : Supported
```

```
RP/0/RSP0/CPU0:ios#sh controllers gigabitEthernet 0/5/0/8 phy
```

```
SFP EEPROM port:8
  Xcvr Type: SFP
  Xcvr Code: 1000BX-10-D
  Encoding: 8B10B
  Bit Rate: 1300 Mbps
  Link Reach 9u fiber (Km): 10000 meter
  Link Reach 9u fiber (100m): 10000 meter
  Vendor Name: CISCO-FIBERXON
  Vendor OUI: 00.1f.22
  Vendor Part Number: 9912C-SL10G-CIC (rev.: 10 )
```

Laser wavelength: 1490 nm (fraction: 0.00 nm)

....

```
<snip> ** DOM Data **
  Temperature: 37.719
  Voltage: 3.265 Volt
  Tx Bias: 17.104 mAmps
  Tx Power: 0.311 mW (-5.07 dBm)
  Rx Power: 0.352 mW (-4.54 dBm)
  Oper. Status/Control:
```

.....

3. 10GE Interface

3.1 LAN Mode

This is default mode of operation.

3.2 WAN PHY Mode

PHY device maps 10GE LAN streams to STS-192c SPE and this limits the data-rate to 9.584 Gbps. WAN PHY provides rich SONET OAM capabilities for link management. It is to be noted that WAN PHY line-rate is lower than 10GE LAN rate (10.3125 Gbps). When WAN PHY mode is configured, transmit Inter-frame-gap (IFG) is set to 16 bytes instead of default 12 bytes in MAC.

LAN to WAN PHY Configuration:

```
RP/0/RSP0/CPU0:ios#sh running-config interface tenGigE 0/6/0/0
interface TenGigE0/6/0/0
transport-mode wan
```

```
RP/0/RSP0/CPU0:IOS#sh running-config controller wanphy 0/6/0/0
controller wanphy0/6/0/0
wanmode on
```

WAN PHY to LAN Mode:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
RP/0/RSP0/CPU0:ios(config-if)#no transport-mode
RP/0/RSP0/CPU0:ios(config-if)#commit
```

WAN PHY Alarm Status:

```
RP/0/RSP0/CPU0:IOS#sh controllers wanphy 0/6/0/0 alarms
Interface: wanphy0/6/0/0
Configuration Mode: WAN Mode
SECTION
  LOF = 2, LOS = 2, BIP(B1) = 0
```

LINE

AIS = 0, RDI = 0, FEBE = 0, BIP(B2) = 0

PATH

AIS = 0, RDI = 0, FEBE = 0, BIP(B3) = 0

LOP = 0, NEWPTR = 0, PSE = 0, NSE = 0

WIS ALARMS

SER = 263414, FELCDP = 0, FEAISP = 0

WLOS = 2, PLCD = 2

LFEBIP = 0, PBEC = 0, PLMP = 0

Active Alarms[All defects]: los, lof, sef,**Active Alarms[Highest Alarms]: los**

Rx(K1/K2): N/A, Tx(K1/K2): N/A

S1S0 = N/A, C2 = N/A

PATH TRACE BUFFER

Remote IP addr:

BER thresholds: SF = 10e-3 SD = 10e-6

TCA thresholds: N/A

Alarm reporting enabled for: los, lof, lop

Layered Alarm Status (Optics, PHY, MAC):

(Note: This CLI is applicable only for 10GE port in Second Generation Line Card)

RP/0/RSP0/CPU0:ios#sh controllers tenGigE 0/6/0/0 xgxs

OPTICS:

Rx LOS Fault : Yes

Tx Fault : No

PHY:

Tx Align Fault : No

PMA/PMD:

Rx LOS Fault : Yes

Rx PMA link Fault : Yes

WANPHY Mode:

SECTION:

Los: Yes, Lof: Yes

LINE:

Ais: No, Rdi: No

PATH:

Ais: No, Lop: No

Plm: No, Lcd: No

PCS:

Rx PCS link Fault : Yes

Rx PCS lock Fault : Yes

MAC:

Rx Local Fault : Yes

Rx Remote Fault : No

3.2.1. SD/SF BER

Software sets Signal Degrade (SD) and Signal Fail (SF) thresholds to 10e-3 and 10e-6 respectively.

```
RP/0/RSP0/CPU0:ios#sh controllers wanphy 0/6/0/0 alarms | inc SD
BER thresholds: SF = 10e-3 SD = 10e-6
```

SD/SF BER threshold is configurable using 'threshold' command.

Software monitors B2 BIP errors and asserts SD/SF BER alarms whenever the error-rate exceeds the threshold. Port link will go down once BIP error-rate exceeds SF BER threshold.

Threshold configuration:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller wanphy 0/6/0/0
RP/0/RSP0/CPU0:ios(config-wanphy)#threshold ?
sd-ber Set Signal Degrade BER threshold
sf-ber Set Signal Fail BER threshold
```

Alarm reporting configuration:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller wanphy 0/6/0/0
RP/0/RSP0/CPU0:ios(config-wanphy)#report ?
line-ais Set Line Alarm Indication Signal reporting status
lof Set Loss of Frame reporting status
lop Set Loss Of Pointer reporting status
los Set Loss of Signal reporting status
path-ais Set Path Alarm Indication Signal reporting status
path-fe-ais Set Path Far End Alarm Indication Signal reporting status
path-fe-plm Set Path Far End Label Mismatch reporting status
path-lcd Set Loss Of Code-Group Delineation reporting status
path-plm Set Path Payload Label Mismatch reporting status
path-rdi Set Path Remote Defect Indication Signal reporting status
rdi Set Remote Defect Indicator reporting status
sd-ber Set LBIP BER in excess of SD threshold reporting status
sf-ber Set LBIP BER in excess of SF threshold reporting status
```

Also, link will go down if any of the following alarm is asserted.

LOS, LOF, AIS-L, AIS-P, LOP-P, UNEQ-P.

3.3 OTN Mode

10GE LAN traffic is mapped to OPU2e or OPU1e containers. OTN provides Forward Error Correction (FEC) feature in addition to SONET like OAM capabilities.

asr9k-optic-px.pie is needed to operate in OTN mode.

Optics Transmit Laser will be disabled if Pie is not installed and activated.

LAN to OPU2e Configuration:

```
RP/0/RSP0/CPU0:ios#conf t
```

```
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
```

```
RP/0/RSP0/CPU0:ios(config-if)#transport-mode otn bit-transparent ?
```

```
  opu1e  10GBASE-R over OPU1e without fixed stuffing (11.0491Gb/s)
```

```
  opu2e  10GBASE-R over OPU2e with fixed stuffing (11.0957Gb/s)
```

```
RP/0/RSP0/CPU0:ios#sh running-config interface tenGigE 0/6/0/0
```

```
interface TenGigE0/6/0/0
```

```
transport-mode otn bit-transparent opu2e
```

```
RP/0/RSP0/CPU0:ios#sh running-config controller dwdm 0/6/0/0
```

```
controller dwdm0/6/0/0
```

```
admin-state in-service
```

OPU2e to LAN mode:

```
RP/0/RSP0/CPU0:ios#conf t
```

```
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
```

```
RP/0/RSP0/CPU0:ios(config-if)#no transport-mode
```

```
RP/0/RSP0/CPU0:ios(config-if)#commit
```

OTN Alarm Status:

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/6/0/0 g709
```

OTU

```
LOS = 1      LOF = 0      LOM = 0
```

```
BDI = 0      IAE = 0      BIP = 0
```

```
BEI = 0      TIM = 0
```

ODU

```
AIS = 0      BDI = 0      OCI = 0
```

```
LCK = 0      BIP = 0      BEI = 0
```

```
PTIM = 0     TIM = 0
```

FEC Mode: Standard (Default)

```
EC(current second) = 0      EC = 0      UC = 0
```

```
pre-FEC BER < 9.34E-11     Q > 6.45     Q Margin > 6.09
```

Remote FEC Mode: Unknown

FECMISMATCH = 0

Detected Alarms: LOS

Asserted Alarms: LOS

Alarm Reporting Enabled for: LOS LOF LOM IAE OTU-BDI OTU-TIM OTU_SF_BER
 OTU_SD_BER ODU-AIS ODU-BDI OCI LCK PTIM ODU-TIM ODU_SF_BER ODU_SD_BER
 FECMISMATCH

BER Thresholds: OTU-SF = E-3 OTU-SD = E-6
 ODU-SF = E-3 ODU-SD = E-6

Layered Alarm Status (Optics, PHY, MAC):

(Note: This CLI is applicable only to 10 port in Second Generation Line Card)

RP/0/RSP0/CPU0:ios#sh controllers tenGigE 0/6/0/0 xgxs

OPTICS:

Rx LOS Fault : Yes
 Tx Fault : No

PHY:

Tx Align Fault : No

PMA/PMD:

Rx LOS Fault : Yes
 Rx PMA link Fault : Yes

OTU2 Mode:

OTU:

Los: Yes, Oof: Yes, Lof: Yes
 Lom: Yes, Oom: Yes
 Ais: No, Iae: Yes
 Bdi: Yes, Tim: No

ODU:

Bdi: Yes, Ais: No, Lck: No
 Oci: No, Tim: No, Ptim: Yes

PCS:

Rx PCS link Fault : Yes
 Rx PCS lock Fault : Yes

MAC:

Rx Local Fault : Yes
 Rx Remote Fault : No

Supported FEC Modes:

RP/0/RSP0/CPU0:ios#conf t

RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0

RP/0/RSP0/CPU0:ios(config-dwdm)#g709 fec ?

disable Disable FEC
 enhanced Enhanced FEC mode
 high-gain High Gain FEC mode
 long-haul Long Haul FEC mode
 standard Standard FEC mode

RP/0/RSP0/CPU0:ios(config-dwdm)#g709 fec enhanced ?
 i.4 efec i.4
 i.7 efec i.7

Table 6 Supported FEC modes on 10G

Configuration	FEC Modes (Second Generation Line Card)	FEC Mode (First Generation Line Card)
g709 fec standard	ITU G.975 (GFEC) default	ITU G.975 (GFEC) default
g709 fec enhanced i.4	ITU G.975, I.4 (EFEC)	ITU G.975, I.4 (EFEC)
g709 fec enhanced i.7	ITU G.975, I.7 (UFEC)	Not Supported
g709 disable	No FEC	No FEC
g709 fec high-gain	Not Supported	Not Supported
g709 fec long-haul	Not Supported	Not Supported

Loopback:

When a port is in OTN mode, loopback is configured under 'controller dwdm'.

```

RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#loopback ?
  internal Select internal loopback mode
  line Select line loopback mode
  
```

Performance Monitoring (PM) configuration:

```

RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#pm ?
  15-min Configure pm parameters of 15 minute interval
  24-hour Configure pm parameters of 24 hour interval
RP/0/RSP0/CPU0:ios(config-dwdm)#pm 15-min ?
  fec Configure fec g709 performance monitoring
  optics Configure optics performance monitoring
  otn configure otn g709 performance monitoring
RP/0/RSP0/CPU0:ios (config-dwdm)#pm 15-min fec ?
  report set fec TCA reporting status
  threshold Configure fec threshold
  
```

Show Performance Monitoring Information:

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/6/0/0 pm interval ?
  15-min  Show pm data in 15 minute interval
  24-hour show pm data in 24 hour interval
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/6/0/0 pm history ?
  15-min  show all pm data in 15 minute interval
  24-hour show all pm data in 24 hour interval
  fec     show all fec data in 15 minute and 24 hour interval
  optics  show all optics data in 15 minute and 24 hour interval
  otn     show all otn data in 15 minute and 24 hour interval
|   Output Modifiers
<cr>
```

3.3.1. Proactive Protection

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state out-of-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#proactive
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state in-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
```

BER threshold

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#proactive ?
  revert  Configure Revert thresholds
  trigger Configure trigger thresholds
<cr>
```

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/6/0/0 proactive
Proactive Protection Status: ON
```

Proactive Protection State: Normal -Interface is Up

Inputs affecting proactive protection state:

```
Transport admin state      : In Service
Trigger threshold         : 6E-5 (Default 6E-5)
Revert threshold          : 1E-5 (Default 1E-5)
Trigger integration window : 30 ms
Revert integration window  : 20000 ms
Received APS               : 0x0f (No Request)
Transmitted APS            : 0x0f (No Request)
```


3.3.2. SD/SF BER

Signal Degrade (SD) and Signal Failure (SF) threshold can be configured in OTU and ODU layers. Software monitors BIP errors from OTU and ODU layers for raising Alarms. Port link will go down for if BIP error rate exceeds SF threshold.

The default BER thresholds are given below.

BER Thresholds: OTU-SF = E-3 OTU-SD = E-6
 ODU-SF = E-3 ODU-SD = E-6

SD/SF BER threshold configuration:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/6/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state out-of-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 otu ?
  overhead  Configure OTU overhead
  report    Configure OTU alarm reporting
  threshold Configure OTU threshold value
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 otu threshold ?
  sd-ber   Set Signal Degrade BER threshold
  sf-ber   Set Signal Failure BER threshold
```

```
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 odu ?
  overhead Configure ODU overhead
  report   Configure ODU alarm reporting
  threshold Configure ODU threshold value
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 odu threshold ?
  sd-ber  Set Signal Degrade BER threshold
  sf-ber  Set Signal Failure BER threshold
```

3.4 Unidirectional Link Routing

The Unidirectional Link Routing (UDLR) feature is currently supported only in 10GE LAN mode only. It allows a physical port to receive or transmit data with a single fiber.

'transport-mode {rx-only | tx-only}' CLI is used for this purpose.

```
RP/0/RSP0/CPU0:ios(config)#int tenGigE 0/6/0/0
RP/0/RSP0/CPU0:ios(config-if)#transport-mode ?
  rx-only 10GE UDLR Mode, Receive Only
  tx-only 10GE UDLR Mode, Transmit Only
```

3.5 Optics

3.5.1. SR/LR/ER/ZR/DWDM Optics

Ref. 3 for all ASR 9000 supported XFP and SFP+ Optics.

3.5.2. Tunable Optics

Ref. 9 provides the specification for Tunable DWDM XFP. This Optics allows 80 DWDM ITU-50GHz channels for tuning.

ASR 9000 follows CRS-1 for 'wavelength' to Channel mapping. Please use 'sh controller dwdm <> wavelength-map' CLI to see the correct channel to wavelength mapping.

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/6/0/7 wavelength-map
Wavelength band: C-Band
MSA ITU channel range supported: 3-84
```

Wavelength map table

ITU Ch Num	G.694.1 Ch Num	Frequency (THz)	Wavelength (nm)
3	58	196.00	1529.553
4	57	195.95	1529.944
5	56	195.90	1530.334
6	55	195.85	1530.725
7	54	195.80	1531.116
.....			
<snip>			
.....			
80	-19	192.15	1560.200
81	-20	192.10	1560.606
82	-21	192.05	1561.013
83	-22	192.00	1561.419
84	-23	191.95	1561.826

To get 1531.116 nm, 'Wavelength 7' will be configured.

```
RP/0/RSP0/CPU0:IOS#conf t
RP/0/RSP0/CPU0:IOS(config)#controller dwdm 0/6/0/7
RP/0/RSP0/CPU0:IOS(config-dwdm)#wavelength 7
RP/0/RSP0/CPU0:IOS(config-dwdm)#commit
```

Instead of Channel Number, desired frequency can be configured using ‘wavelength frequency <>’ command.

```
RP/0/RSP0/CPU0:IOS(config-dwdm)#wavelength frequency ?
<19115-19610> Enter 5-digit Frequency data; e.g. 19580 for 195.8 THz
```

Supported Tunable Optics Frequency is described in Ref. 9.

4. 40GE Interface

40GE Modular Port Adapter (MPA) implements 40GE LAN and 40GE mapped onto OTU3 (43.0184 Gbps) modes. It also supports G.709 OTN OTU3 framing with triple FEC (GFEC (Reed-Solomon), EFEC (G.975.1, I.4) and UFEC (G.975.1, 1.7)).

4.1 LAN Mode

This is the default mode for the MPA.

```
RP/0/RSP0/CPU0:IOS#sh int fortyGigE 0/0/0/0
FortyGigE0/0/0/0 is up, line protocol is up
Interface state transitions: 1
Hardware is FortyGigE, address is 0022.bde5.aaec (bia 0022.bde5.aaec)
Layer 1 Transport Mode is LAN
```

4.2 OTN Mode

To change Transport mode from LAN to OTU3 (43.0184 Gbps), use ‘g709 enable’ CLI.

To revert back to LAN mode, ‘no g709 enable’ needs to be configured.

asr9k-optic-px.pie is needed to operate in OTN mode.

Optics Transmit Laser will be disabled if Pie is not installed and activated.

If a port is in OTU3 mode, then ‘admin-state out-of-service’ configuration is needed before moving to any other command. G.709 Optics pie and License are needed to support OTU3 mode.

Change from LAN to OTU3:

```
RP/0/RSP0/CPU0:IOS#conf t
RP/0/RSP0/CPU0:IOS(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:IOS(config-dwdm)#g709 enable
RP/0/RSP0/CPU0:IOS(config-dwdm)#commit
RP/0/RSP0/CPU0:IOS(config-dwdm)#admin-state in-service
RP/0/RSP0/CPU0:IOS(config-dwdm)#commit
```

Change from OTU3 to LAN:

```
RP/0/RSP0/CPU0:IOS#conf t
RP/0/RSP0/CPU0:IOS(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:IOS(config-dwdm)#admin-state out-of-service
RP/0/RSP0/CPU0:IOS(config-dwdm)#commit
RP/0/RSP0/CPU0:IOS(config-dwdm)#no g709 enable
RP/0/RSP0/CPU0:IOS(config-dwdm)#commit
```

```
RP/0/RSP0/CPU0:IOS#sh controllers fortyGigE 0/0/0/0 internal
Tue Apr 30 00:09:44.419 UTC
```

```
Port Number      : 0
Board Type       : 0x0000023a
Port Type        : 40GE
Transport mode   : OTN(opu3)
BIA MAC addr     : 0022.bde5.aaec
Oper. MAC addr   : 0022.bde5.aaec
Egress MAC addr  : 0022.bde5.aaec
Port Available   : true
Status polling is : enabled
Status events are : enabled
I/F Handle       : 0x000001c0
Cfg Link Enabled : tx/rx enabled
H/W Tx Enable   : no
MTU              : 1526
H/W Speed        : 40 Gbps
H/W Duplex       : Full
H/W Loopback Type : None
H/W FlowCtrl Type : None
H/W AutoNeg Enable : Off
H/W Link Defects : (0x0000202a) RX_LOS HW_LINK LASI G709_LICENSE
H/W Raw Link Defects : (0x0000202a) RX_LOS HW_LINK LASI G709_LICENSE
.....
<snip>
```

Alarm Status:

```
RP/0/RSP0/CPU0:IOS#sh controllers dwdm 0/0/0/0
Tue Apr 30 09:29:16.745 UTC
```

```
Port dwdm0/0/0/0
```

```
Controller State: Up
```

Transport Admin State: In Service

Loopback: None

G709 Status

OTU

LOS = 1 LOF = 0 LOM = 0
 BDI = 0 IAE = 0 **BIP** = 0
 BEI = 0 TIM = 0

ODU

AIS = 0 BDI = 0 OCI = 0
 LCK = 0 **BIP** = 0 BEI = 0
 PTIM = 0 TIM = 0

FEC Mode: Standard (Default)

EC(current second) = 0 EC = 0 UC = 0
 pre-FEC BER < 2.32E-11 Q > 6.66 Q Margin > 6.37

Remote FEC Mode: Standard

FECMISMATCH = 0

Detected Alarms: None

Asserted Alarms: None

Alarm Reporting Enabled for: LOS LOF LOM IAE OTU-BDI OTU-TIM OTU_SF_BER

OTU_SD_BER ODU-AIS ODU-BDI OCI LCK PTIM OD

U-TIM ODU_SF_BER ODU_SD_BER FECMISMATCH

BER Thresholds: OTU-SF = E-3 OTU-SD = E-6

ODU-SF = E-3 ODU-SD = E-6

Connectivity Info

Network Port ID: Not Configured

Network Connection ID: Not Configured

OTU TTI Sent String ASCII : Tx TTI Not Configured

OTU TTI Received String ASCII : Rx TTI Not Received

OTU TTI Expected String ASCII : Exp TTI Not Configured

ODU TTI Sent String ASCII : Tx TTI Not Configured

Layered Alarm Status (Optics, PHY, MAC):

RP/0/RSP0/CPU0:ios#sh controllers fortyGigE 0/0/0/0 xgxs

OPTICS:

Rx LOS Fault : No

Tx Fault : No

PHY:

Tx Align Fault : No

PMA/PMD:

Rx LOS Fault : No

Rx PMA link Fault : No

OTU3 Mode:

OTL:

Otl_lol: No, Otl_ola: No, Otl_ola_d: No

Otl_skew_oor: No, Otl_skew_oor_d: No

OTU:

Los: No, Oof: No, Lof: No

Lom: No, Oom: No

Ais: No, Iae: No

Bdi: No, Tim: No

ODU:

Bdi: No, Ais: No, Lck: No

Oci: No, Tim: No, Ptim: No

GMP:

Oof_1027b: No, Oof_1027_d: No

Dec_513b_e: No, Sync_fail: No

PCS:

Rx PCS link Fault : No

Rx PCS lock Fault : No

MAC:

Rx Local Fault : No

Rx Remote Fault : No

Supported FEC Modes:

RP/0/RSP0/CPU0:ios#conf t

RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0

RP/0/RSP0/CPU0:ios(config-dwdm)#g709 fec ?

disable Disable FEC

enhanced Enhanced FEC mode

high-gain High Gain FEC mode

long-haul Long Haul FEC mode

standard Standard FEC mode

RP/0/RSP0/CPU0:ios(config-dwdm)#g709 fec enhanced ?

i.4 efec i.4

i.7 efec i.7

Table 7 Supported FEC modes on 40G

Configuration	FEC Mode
g709 fec standard	G.975.1 (GFEC) default
g709 fec enhanced i.4	G.975.1, I.4 (EFEC)
g709 fec enhanced i.7	G.975.1, I.7 (UFEC)
g709 fec disable	No FEC
g709 fec high-gain	Not Supported
g709 fec long-haul	Not Supported

Loopback:

When a port is in OTN mode, loopback is configured under 'controller dwdm'.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#loopback ?
  internal Select internal loopback mode
  line     Select line loopback mode
```

Performance Monitoring (PM) configuration:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#pm ?
  15-min  Configure pm parameters of 15 minute interval
  24-hour Configure pm parameters of 24 hour interval
RP/0/RSP0/CPU0:ios(config-dwdm)#pm 15-min ?
  fec     Configure fec g709 performance monitoring
  optics  Configure optics performance monitoring
  otn     configure otn g709 performance monitoring
RP/0/RSP0/CPU0:ios (config-dwdm)#pm 15-min fec ?
  report  set fec TCA reporting status
  threshold Configure fec threshold
```

Show Performance Monitoring Information:

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/0/0/0 pm interval ?
  15-min  Show pm data in 15 minute interval
  24-hour show pm data in 24 hour interval
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/0/0/0 pm history ?
  15-min  show all pm data in 15 minute interval
  24-hour show all pm data in 24 hour interval
  fec     show all fec data in 15 minute and 24 hour interval
  optics  show all optics data in 15 minute and 24 hour interval
  otn     show all otn data in 15 minute and 24 hour interval
|       Output Modifiers
<cr>
```

4.2.1. Proactive Protection

With 'Proactive Protection' feature enabled, software monitors FEC errors for the configured threshold and notifies upper-layer protocols once the error-rate crosses the threshold.

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state out-of-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#proactive
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state in-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
```

BER threshold

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#proactive ?
  revert  Configure Revert thresholds
  trigger Configure trigger thresholds
<cr>
```

```
RP/0/RSP0/CPU0:ios#sh controllers dwdm 0/0/0/0 proactive
Proactive Protection Status: ON
```

Proactive Protection State: Normal -Interface is Up

Inputs affecting proactive protection state:

```
Transport admin state      : In Service
Trigger threshold         : 6E-5 (Default 6E-5)
Revert threshold          : 1E-5 (Default 1E-5)
Trigger integration window : 30 ms
Revert integration window  : 20000 ms
Received APS              : 0x0f (No Request)
Transmitted APS           : 0x0f (No Request)
```

4.2.2. SD/SF BER

Signal Degrade (SD) and Signal Failure (SF) threshold can be configured in OTU and ODU layers. Software monitors BIP errors from OTU and ODU layers for raising Alarms. Port link will go down for if BIP error rate exceeds SF threshold.

The default BER thresholds are given below.
 BER Thresholds: OTU-SF = E-3 OTU-SD = E-6
 ODU-SF = E-3 ODU-SD = E-6

SD/SF BER threshold configuration:

```
RP/0/RSP0/CPU0:ios#conf t
RP/0/RSP0/CPU0:ios(config)#controller dwdm 0/0/0/0
RP/0/RSP0/CPU0:ios(config-dwdm)#admin-state out-of-service
RP/0/RSP0/CPU0:ios(config-dwdm)#commit
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 otu ?
  overhead  Configure OTU overhead
  report    Configure OTU alarm reporting
  threshold Configure OTU threshold value
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 otu threshold ?
  sd-ber   Set Signal Degrade BER threshold
  sf-ber   Set Signal Failure BER threshold
```

```
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 odu ?
  overhead Configure ODU overhead
  report    Configure ODU alarm reporting
  threshold Configure ODU threshold value
RP/0/RSP0/CPU0:ios(config-dwdm)#g709 odu threshold ?
  sd-ber   Set Signal Degrade BER threshold
  sf-ber   Set Signal Failure BER threshold
```

4.3 Optics

40GE MPA supports the following Cisco QSFPs.

QSFP-40G-SR4 - LAN mode only

QSFP-40GE-LR4 - LAN mode only

QSFP-40G-LR4 - LAN/OTU3 modes

5. 100GE Interface

5.1 LAN Mode

LAN is the default mode for a 100GE port.

5.2 LAN PP Mode



Figure 6 LAN Proactive Protection

In LAN Proactive Protection (PP) mode, ONS M6 terminates OTU4 signal and monitors Forward-error-correction (FEC) errors. Whenever the error-rate exceeds the user-configured threshold, M6 notifies ASR 9000 through a Cisco proprietary signal. This allows fast reroute (FRR) in case of signal deterioration in OTU4 link. `asr9k-optic-px.pie` is needed to support this feature. Optics Transmit Laser will be disabled if Pie is not installed and activated.

Proactive configuration in ASR 9000:

```
RP/0/RSP0/CPU0:ios#show run controller dwdm 0/3/0/0
controller dwdm0/3/0/0
proactive
admin-state in-service
```

Proactive Status:

```
RP/0/RSP0/CPU0:ios#show controllers dwdm 0/3/0/0 proactive
Proactive Protection Status: ON
```

Proactive Protection State: Normal -Interface is Up <<< proactive intf is up.

Inputs affecting proactive protection state:

```
Transport admin state    : In Service
Trigger threshold       : 6E-5
Revert threshold        : 1E-5
Trigger integration window : 30 ms
Revert integration window  : 20000 ms
Received APS           : 0x0f (No Request)
Transmitted APS        : 0x0f (No Request)
```

G.709 Optics Pie is needed for PP:

```
RP/0/RSP0/CPU0:RR02#show controllers hundredGigE 0/3/0/0 internal
```

```

Port Number      : 0
Board Type       : 0x003b0262
Port Type        : 100GE
Transport mode   : LAN_PP
BIA MAC addr     : 0022.bde5.aaa0
Oper. MAC addr   : 0022.bde5.aaa0
Egress MAC addr  : 0022.bde5.aaa0
Port Available   : true
Status polling is : enabled
Status events are : enabled
I/F Handle       : 0x060000c0
Cfg Link Enabled : tx/rx enabled
H/W Tx Enable    : no
MTU              : 1526
H/W Speed        : 100 Gbps
H/W Duplex       : Full
H/W Loopback Type : None
H/W FlowCtrl Type : None
H/W AutoNeg Enable : Off
Link Faults      : (0x00008000) G709_LICENSE <<< Active alarm when optic pie is absent
Raw Link Faults  : (0x00008000) G709_LICENSE
Link Up          : no
Link Led Status  : Link down -- Red
Pluggable Present : yes
Pluggable Type   :
Pluggable PID    : CFP-100G-SR10
Pluggable Compl. : Compliant
Pluggable Type Supp.: Supported
Pluggable PID Supp. : Supported
NP->Mac Lane Sync : 0x001fffff
PHY->Mac Lane Sync : 0x000fffff
Mac Version      : 0x00000022

```

5.3 Optics

100GE ports support the following Cisco Supported Optics (Ref. 3).

```

CFP-100G-LR4
CFP-100G-SR10

```

6. FAQ

Q: 1GE port: Link is not coming up. How do I debug?

- a) Check configuration on both sides (autoneg, speed, flow control) using 'sh running interface giga <>'
- b) If the Optics are DOM supported, check Optics Power levels using 'sh controller giga <> phy'
- c) Check the reason for the link failure using 'sh controller giga <> internal'. Meaning of Link defect is discussed in Table 2.
- d) Also, ensure FPGA images are up-to-date using 'sh hw-mod location all <>'

Q: 10/100 Mbps with Copper SFP: ARP and ping packets are not received by ASR9k port

SFP-GE-T PHY doesn't handle odd number of preamble and this will cause silent drop of Ethernet Frames. The issue is not seen with 1000 Mbps. This may happen if the far-end switch is not following IEEE standard for transmission of Preamble.

Q: 10/40/100GE port: Link is not coming up. What do I check?

- a) Check configuration on both sides using 'sh running interface ... <>'
- b) If the Optics are DOM supported, check Optics Power levels using 'sh controller ... <> phy'
- c) Check the reason for the link failure using 'sh controller ... <> internal'

Q: 10/40G OTN mode: Link is not coming up. How do I debug?

- a) Check 'admin-state in-service' is configured under 'controller dwdm'
- b) Check both ends use correct OTN modes
- c) Check both ends use same FEC modes
- d) Check the reason for the link failure using 'sh controller <> internal'
- e) Check the reason for the defect in Table 2
- f) Ensure Optics pie is installed
- g) Check Optics type used

Q: After LOS cleared, the port link takes several seconds to come up.

Is it normal?

Yes, this is normal.

When Receive Loss-of-Signal (LOS) state changes to Normal, PHY and clock Logic is reconfigured. Software waits for Clock lock before bringing link Up.

Q: During Line Card reload, link flap occurs. Is it normal?

Yes, this is normal. During Line Card reload, various hardware logics including MAC, PHY and Clocking undergo device configuration. This will cause link flap at Near and Far-ends.

Q: Link Flap occurred during traffic condition. How do I debug?

- a) Check Optics power status using 'sh controller <> internal'
- b) Check 'sh interface' for input errors
- c) Check 'sh controller <> stat' for various input errors
- d) If the optical receive power is low, clean or replace the optics and fiber at both ends
- e) Monitor 'symbol' and 'crc' error count using 'sh controller <> stat'
- f) If 'OTN' mode is used, check 'sh controller dwdm <>' for various BIP and other error counts
- g) If 'WAN' mode is used, check 'sh controller wanphy all' for various BIP and other error counts
- h) Get 'sh log location <>' output
- i) If it is a first generation Line Card, then get the trace log
 sh ether-ctrl gigabitEthernet trace location <> (for 1GE)
 sh ether-ctrl tenGigE trace location <> (for 10GE)

If it is a second generation Line Card, then get the following trace log

sh controllers vic ltrace all location <>

sh controller <> <> reg (need few snap-shots of this command with 3 minute interval)

Q: Tunable Optics: How do I check what 'wavelength' is configured in Optics?

RP/0/RSP0/CPU0:ios#sh controllers tenGigE 0/6/0/7 phy | inc Wavelength Control

Wavelength Control: **setpoint=1556.50 nm**, error=0.00 nm

Also, Configured Optics 'Channel ID'(Ref. 9) can be obtained from Optics.

RP/0/RSP0/CPU0:SH6#sh controllers tenGigE 0/6/0/7 phy | inc Wavelength Chann

Wavelength Channel: 14

7. Glossary

CLI – Command Line Interface

EFD – Ethernet Fault Detection

FRR – Fast-reroute to back-up link in case the main data-link fails

OTN – Optical Transport Network

MAC – Media Access Control

PHY – Physical Layer device connects MAC to Optics

Optics – SFP, SFP+, XFP, QSFP+, CFP

SPE – Synchronous Payload Envelope

8. References:

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