



OTN XFP MSA Compliant DWDM 11.1Gb/s Transceiver with Integrated G.709 and FEC

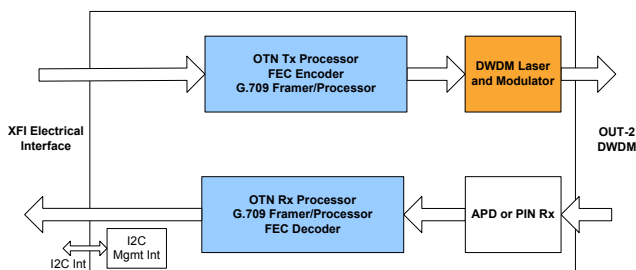


Description

Menara Networks OTN XFP DWDM transceiver combines carrier grade OTN G.709 and FEC performance into a XFP MSA compliant package. OTN XFP is the only industry XFP MSA that can transparently carry a native 10G LAN PHY and SONET/SDH payload with a carrier grade DWDM Optical Transport Network (OTN) interface without the need for bandwidth limitation. OTN XFP offers G.709 compliant Digital Wrapper and Forward Error Correction (FEC) for superior optical performance and management functions equal to those found in DWDM Transponder systems. OTN XFP is designed to interoperate with any Open DWDM line system that support 100GHz spaced wavelengths per the ITU-T C-band grid thus offering complete and cost effective DWDM transport for IP, MPLS, and Ethernet applications.

OTN XFP G.709 digital wrapper overhead and FEC functions are handled by the OTN Processor, which is integrated into the XFP module. The OTN Processor provides Operations Administration and Management (OAM) functions with G.709 alarms and Performance Management statistics.

In those applications where backward compatibility is required, the OTN Digital Wrapper feature can be bypassed via I²C software commands.



Management

Management of OTN XFP is provided via the XFP MSA I²C interface, which supports digital diagnostic monitoring, alarms and loop backs to include G.709 and FEC management registers. Routers and Switches can reap the performance gains of FEC without changes to the existing I²C interface in a management Transparent Mode of operation, in which OTN XFP activates the G.709 Digital Wrapper and FEC coding without the need for I²C provisioning.

Applications

- IP/MPLS and Ethernet Switches
- Access, Metro and Regional Carrier Ethernet DWDM Networks
- MSPP
- Customer Premise Ethernet Demarcation

Features

- Compliant with XFP MSA
- Integrated OTN G.709 Digital Wrapper
- >6dB Net Coding Gain FEC for superior optical performance
- Multi-protocol and bit rate support for 10GE, OC-192/STM-64 and OTN
- Fully transparent 10G LAN PHY OTU2e at 11.09 Gbps
- Adaptive Receiver Decision Threshold Control for improved OSNR range
- ITU-T C-band 100GHz WDM interface
- Up to 80C Extended Case Temperature
- True link BER reporting and Integrated PRBS 10 Gbps BERT for test set free link turn-up
- OTN Digital diagnostics and alarm reporting
- Optional SBS Suppression

OTN XFP MSA Compliant DWDM 10Gb/s Transceiver with Integrated G.709 and FEC

Transceiver Optical Specifications (G.709 and FEC Enabled)

Parameter	Symbol	Min	Typical	Max	Units
Host Native Nominal Bit Rate		9.9533 (SONET/SDH) 10.3125 (LAN PHY)			Gbps
DWDM Line Interface Bit Rate		10.7092 (OTU2) 11.0957 (OTU2e LAN PHY)			Gbps
OTN Interface Bit Rate Deviation		+/- 20 (SONET) +/- 100 (LAN PHY)			ppm
DWDM Wavelength Range	λ_{WDM}	1528.77	-	1564.68	nm
Channel Spacing	$f_{SPACING}$	100			GHz
Wavelength Accuracy (Beginning and End of Life)	$\Delta\lambda_{EOL}$	-100	-	+100	pm
Extinction Ratio	ER	9	-	-	dB
Side Mode Suppression Ratio	SMSR	30	-	-	dB
Average Output Power	P_{OUT}	-1	-	+3	dBm
Average Output Power (Laser off)	P_{DIS}	-40	-	-	dBm
Eye Mask Compliance		GR-253i3/G.959.1			
Receiver Operating Range		1270	-	1610	nm
Receiver Operating Range @ 11.1Gbps 0ps/nm Dispersion	P_{IN}	-28	-	-6	dBm
-850 to +1250ps/nm Dispersion	(70km APD)	-25	-	-7	dBm
Receiver Operating Range @ 11.1Gbps 0ps/nm Dispersion	P_{IN}	-18	-	0	dBm
-800 to +800ps/nm Dispersion	(40km PIN)	-16	-	-2	dBm
OSNR Requirement 0 ps/nm	$OSNR_{MIN}$	16	-	-	dB/
-850 to +1150ps/nm Dispersion	(70km APD)	20	-	-	0.1nm
-18dBm to -8dBm Input					
OSNR Requirement 0 ps/nm	$OSNR_{MIN}$	15.5	-	-	dB/
-800 to +800ps/nm	(40km PIN)	19	-	-	0.1nm
-12dBm to -1dBm Input					
Jitter Compliance	-	802.3ae/GR-253i3			
Operating Case Temperature Normal	T_{CFIXED}	0	-	70	°C
Extended Temperature		0	-	80	
Storage Temperature	T_{stg}	-40	-	85	°C

PRBS-31 “True Link” Pattern Generator and Checker

The OTN XFP “True Link” feature consists of a PRBS-31 Generator and Checker to allow the customer to determine the 11Gbps channel performance without the need for costly 10GE or OC-192 payload test equipment. In the transmit direction a PRBS-31 pattern is generated and inserted into the OTU-2 payload portion of the frame. The OTU-2, ODU-2 and FEC data is generated and monitored normally to allow for link alarming and FEC correction performance monitoring. A status bit is provided to the user to denote PRBS-31 pattern synchronization. In the receive direction, the PRBS-31 payload is decoded and checked for individual bit level errors. A PRBS-31 payload error counter is provided via the OTN XFP standard I2C interface.

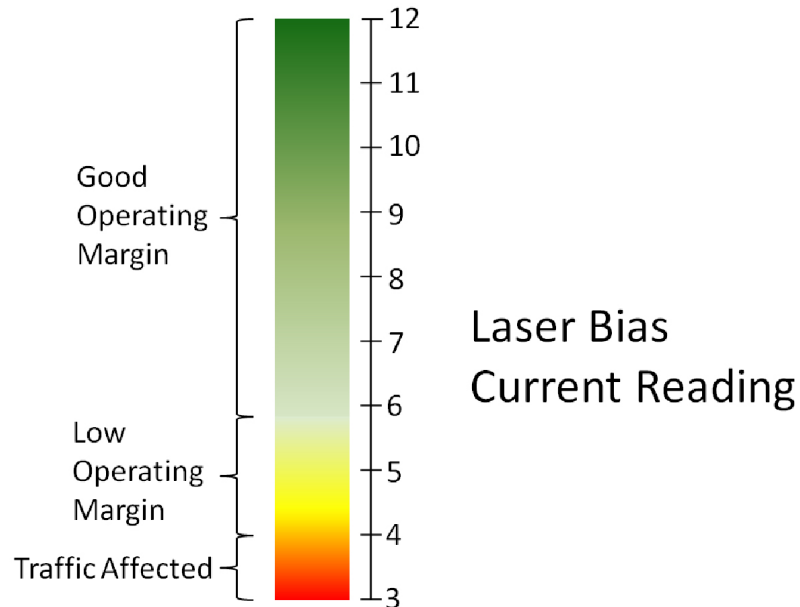
The following I2C registers are used for the True Link feature:

Page	Reg	Bit	Type	Title	Description	Settings
03h	183	7	R/W, SC	PRBS31 Control (Line Side)	PRBS-31 error counter reset (Self Clearing Bit)	1 = Reset PRBS-31 error counter (This bit is self clearing back to zero) 0 = Normal operation.
03h	183	5:6	R/W		Reserved	
03h	183	4	RO		PRBS31 sync status	0 = PRBS-31 Rx pattern sync present 1 = PRBS-31 Rx pattern sync error
03h	183	2:3	R/W		Reserved	
03h	183	1	R/W		Enable PRBS31 pattern on Rx Path	1 = Enable PRBS31 payload read in the Rx direction. If FEC enabled, PRBS31 is error corrected. If FEC is off, PRBS1 raw data is sent. 0 = Disable PRBS31 payload read in the Rx direction.
03h	183	0	R/W		Enable PRBS31 pattern on Tx Path	1 = Enable PRBS31 payload insertion in the Tx direction. The Tx direction PRBS data is inserted as the payload data in the OTU2 frame. 0 = Disable PRBS31 payload insertion in the Rx direction.

Page	Reg	Bit	Type	Title	Description	Settings
03h	184	7:0	RO	PRBS31 Checker (Line Side)	PRBS31 Error Counter (MSB-32 bit counter)	PRBS31 Error Count (MSB- 32 bit)
03h	185	7:0	RO		PRBS31 Error Counter (17 to 24 of 32 bit counter)	PRBS31 Error Count (17 to 24 of 32 bit counter).
03h	186	7:0	RO		PRBS31 Error Counter (8 to 16 of 32 bit counter)	PRBS31 Error Count (8 to 16 of 32 bit counter)
03h	187	7:0	RO		PRBS31 Error Counter (LSB-32 bit counter)	PRBS31 Error Count (LSB- 32 bit).

Link Checker Feature

The OTN XFP has the optional “Link Checker” feature, allowing the customer to proactively monitor the link performance margin in real time locally or remotely. Link Checker provides proactive alarms to alert the customer of a link falling below a pre-defined margin threshold, triggering an investigation of the optical layer to rectify the degradation before the customer takes errors. The user monitors Laser Bias Current to verify the health or margin on the OTN wavelength. The Link Checker margin can vary between 3 and 12, in which the higher the number the higher the margin. This is illustrated in the graph below.



As seen an OTN XFP DWDM channel with a Link Checker reading of 6 or higher is operating with a good operating margin. Between 4 and 6 the link margin is low and may be the indicator of a link problem on the DWDM system. At 4 or below traffic is affected or down on that link.

The link margin is supported through the reading of the FEC Correction Error Rate (FCER) in the XFP and displaying that margin as the Laser Bias Current value on the router. The FEC correction error rate is averaged over a 25 second rolling window by the module software. In the case of failure or no errors being corrected, the correction error rate is shown as 12.

The transposition of the correction error rate to laser bias current is shown below:

The FEC Correction BER can be represented as:

xx = Mantissa yy = Exponent

For example, an error correction error rate of 3×10^{-6}

where the Mantissa xx = 3 and the Exponent yy = 6

The Laser Bias Current on the router is then shown as = yy.xx mA

Therefore a FEC Correction Error Rate (FCER) of 3×10^{-6} is shown as a Laser Bias current of 6.3 mA

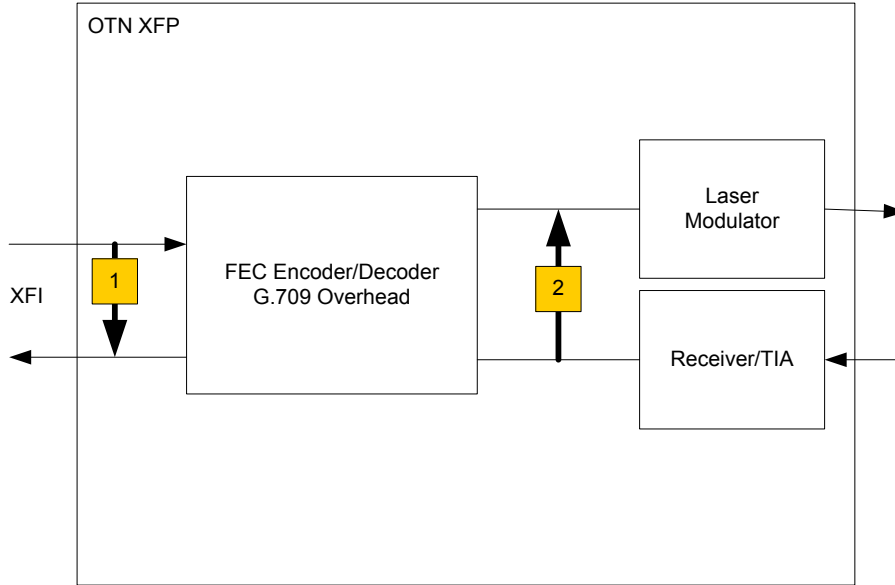
Any error rate $< 10^{-5}$ will raise a Laser Bias Low Alarm in the system, which is an early warning indicator to the NOC to proactively monitor and correct for a degraded link before errors are seen by the customer.

OTN XFP Loopbacks

OTN XFP supports both host and line loopbacks. The host loopback is designed to loopback traffic towards the host before processing by the FEC and G.709 overhead processor in the OTN XFP module. A line loopback loops the traffic towards the OTN fiber network before processing the FEC and G.709 overhead. Both loopbacks are completed in the FEC/G.709 ASIC.

The following loopbacks are supported:

1. Host Loopback (towards host). This is referred to as the XFI loopback in the XFF MSA Rev 4.5.
2. Line Loopback (towards OTN fiber network)



The XFP loopback settings are controlled according to the MSA XFP I2C interface using the following registers:

Table	Reg	Bits	Type	Category	Register Item	Feature Notes
Any	1	2	R/W	Signal Conditioner	Line Side Loopback	0 = Normal Operation 1 = Loopback Module Optical Input to Output
Any	1	1			XFI Loopback	0 = Normal Operation 1 = Loopback Module XFI Input to Output

Startup Autonomous Payload Searching

OTN XFP supports a payload search feature when the module is initially powered up or reset. The Payload Search feature is only valid in OTN mode and is run to select the correct payload data rate for the module if the host does not select the value in the XFP Signal Conditioner register. Since the OTN XFP contains PLLs and reference clocks centered on the exact OTN output bit rate, the module must be configured in the correct payload bit rate mode for proper operation. A module not configured correctly cannot pass traffic.

The Payload Search mode works in the following steps:

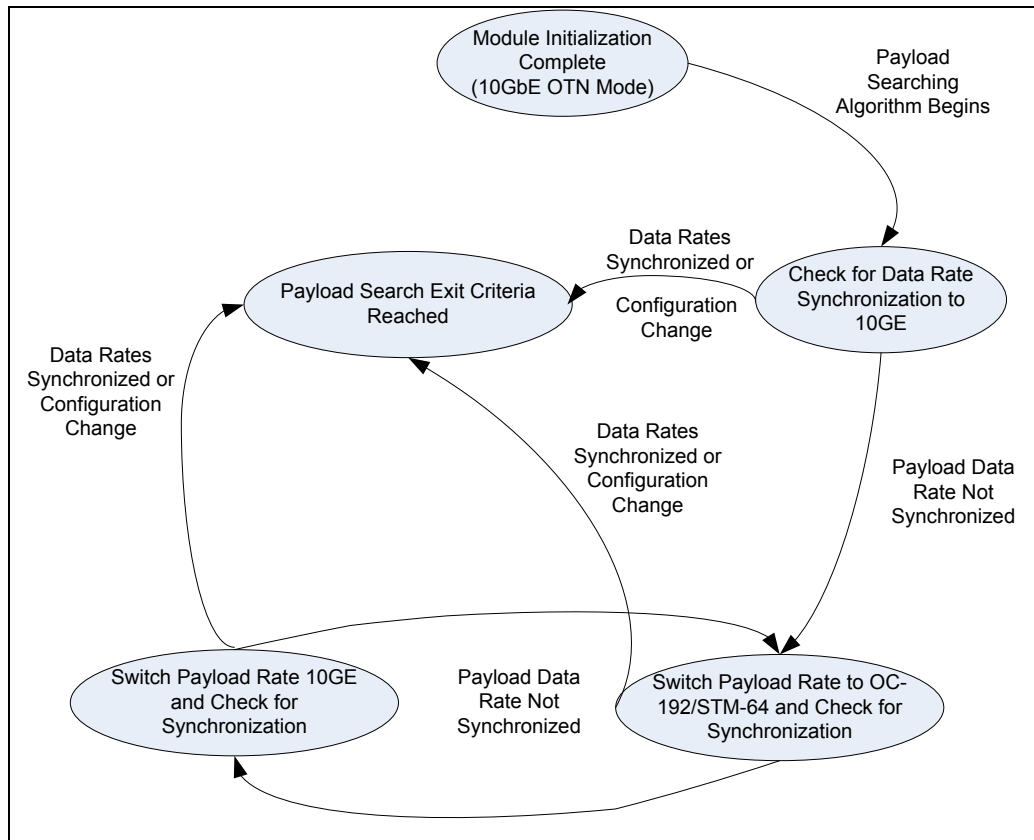
1. Upon module initialization or reset completion, the module default configuration is 10GE LAN PHY (10.3125Gbps) with OTN enabled (11.1Gbps). When the module exits the initialization stage, an internal check is performed on the incoming host side data to see if the payload data rate matches the configured 10GE (10.3125Gbps) data rate.
2. If the module is not able to synchronize to the default configuration data rate of 10GE (10.3125Gbps) with the incoming host data, the module is automatically configured by the firmware to a data rate of OC-192/STM-64 (9.953Gbps) and timing synchronization is checked again.
3. If after step 2 the data rate of the incoming host data is not synchronized to the payload data rate, the module will continue switching between 10GE and OC-192/STM-64 data rates until a synchronization of payload data rate occurs. The time between switches is about 5 seconds. If no input electrical XFI signal is present on the host input side, the Payload Searching algorithm is frozen and resumed when data is detected.
4. If at any time during Step 1. through Step 3. the payload data is correctly synchronized to the module settings, the Autonomous Payload Searching loop is exited. During the Payload Searching algorithm the laser output is disabled and the module is held in a MOD_NR state. The data rate setting of the Signal Conditioner register [1.7:4] will display the OTN XFP current payload data rate setting.

The following conditions force the module to exit the Autonomous Payload Searching algorithm:

Autonomous Payload Search Exit Criteria

Condition	Description	Notes
Host Payload Sync to Module Settings	The host input electrical XFI data rate matches the module payload data rate configuration	Host data must be present
Signal Conditioner Register is written	Lower Memory Register 1 is written	Signifies host is writing data rate value in I2C Register
OTN Setup Register 1 is written	Register [03,128] is written	Signifies host is writing OTN configuration change, which can affect data rate
Payload Search is Disabled	Register [03,192.2] is written to '0'	Host disabled the Payload Search via I2C

The following state diagram explains the Autonomous Payload Search operation:

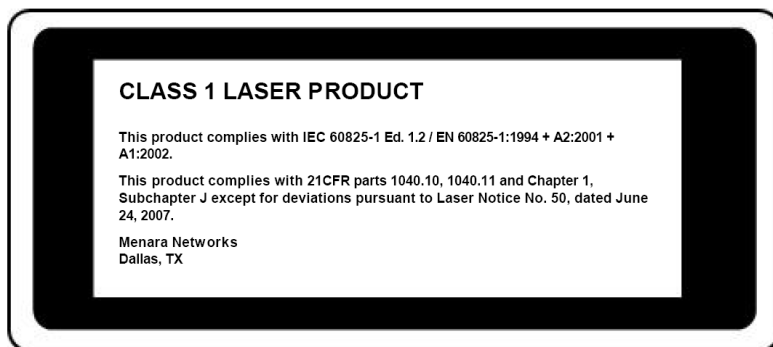


Autonomous Payload Searching Algorithm State Machine

Note: During the Autonomous Payload Searching algorithm, the PM error counters and the PM time counter is delayed due to extra processor power required to support the Payload Search algorithm. Once the payload search algorithm is completed, the host should normalize the PM error and time counters as part of the OTN XFP initialization process.

Laser Safety

OTN XFP is compliant to IEC 60825-1 laser safety. The DWDM laser output is specified as a Class 1 output power as defined in IEC 60825-1.



CAUTION – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

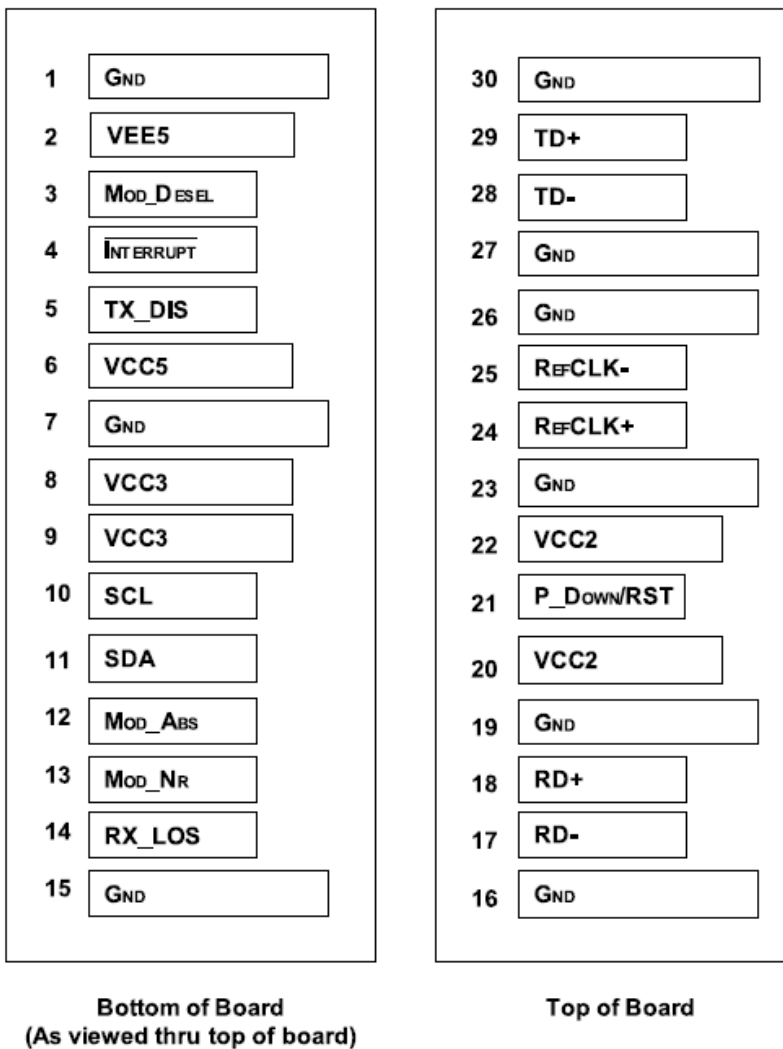
DOM Alarm Thresholds and I2C Locations

All Alarm Thresholds for OTN XFP are configured at the manufacturer and cannot be configured through the I2C interface (i.e. thresholds are not provisionable). Alarm thresholds for each DOM parameter are located in the following registers.

Threshold Value Register	Latched Alarm	Threshold Size (Bytes)	Name
02-03	80.7	2	Transceiver Temp High Alarm
04-05	80.6	2	Transceiver Temp Low Alarm
06-07	82.7	2	Transceiver Temp High Warning
08-09	82.6	2	Transceiver Temp Low Warning
10-17	N/A	8	Reserved
18-19	80.3	2	Laser Bias Current High Alarm
20-21	80.2	2	Laser Bias Current Low Alarm
22-23	82.3	2	Laser Bias Current High Warning
24-25	82.2	2	Laser Bias Current Low Warning
26-27	80.1	2	Laser Output Power High Alarm
28-29	80.0	2	Laser Output Power Low Alarm
30-31	82.1	2	Laser Output Power High Warning
32-33	82.0	2	Laser Output Power Low Warning
34-35	81.7	2	Receive Optical Power High Alarm
36-37	81.6	2	Receive Optical Power Low Alarm
38-39	83.7	2	Receive Optical Power High Warning
40-41	83.6	2	Receive Optical Power Low Warning
N/A	86.7	N/A	5V High Alarm
	86.6		5V Low Alarm
	86.5		3.3V High Alarm
	86.4		3.3V Low Alarm
	86.3		1.8V High Alarm
	86.2		1.8V Low Alarm
	86.1		-5V High Alarm (Not Used)
	86.0		-5V Low Alarm (Not Used)
	87.7		5V High Warning
	87.6		5V Low Warning
	87.5		3.3V High Warning
	87.4		3.3V Low Warning
	87.3		1.8V High Warning
	87.2		1.8V Low Warning
	87.1		-5V High Warning (Not Used)
	87.0		-5V Low Warning (Not Used)

Host Connector Specifications

The XFP PCB host electrical connections are shown in the figure below.



XFP PCB Electrical Connections

Pin No	Name	Logic	Function	Notes
1	GND		Electrical Ground	1
2	VEE5		Optional -5.2V power Supply (Not used)	
3	Mod_DeSel	LVTTL-I	Module De-select; When held low allows module to respond to 2-wire serial interface	
4	Interrupt	LVTTL-O	Interrupt; Indicates presence of an important condition which can be read over the 2-wire serial interface	2
5	Tx_DIS	LVTTL-I	Transmitter Disable; Turns off transmitter laser output	
6	VCC5		+5V Power Supply	
7	GND		Module Ground	1
8	VCC3		+3.3V Power Supply	
9	VCC3		+3.3V Power Supply	
10	SCL	LVTTL-I/O	2-Wire Serial Interface Clock	2
11	SDA	LVTTL-I/O	2-Wire Serial Interface Data Line	2
12	Mod_Abs	LVTTL-O	Indicates Module is not present. Grounded in the Module	2
13	Mod_NR	LVTTL-O	Module Not Ready; Indicating Module Operational Fault	2
14	RX_LOS	LVTTL-O	Receiver Loss Of Signal Indicator	2
15	GND		Module Ground	1
16	GND		Module Ground	1
17	RD-	CML-O	Receiver Inverted Data Output	
18	RD+	CML-O	Receiver Non-Inverted Data Output	
19	GND		Module Ground	1
20	VCC2		+1.8V Power Supply	3
21	P_Down/RST	LVTTL-I	Power down; When high, requires the module to limit power consumption. 2-Wire serial interface must be functional in the low power mode. Reset; The falling edge initiates a complete reset of the module including the 2-wire serial interface, equivalent to a power cycle.	
22	VCC2		+1.8V Power Supply	3
23	GND		Module Ground	1
24	RefCLK+	PECL-I	Reference Clock Non-Inverted Input, AC coupled on the host board	
25	RefCLK-	PECL-I	Reference Clock Inverted Input, AC coupled on the host board	
26	GND		Module Ground	1
27	GND		Module Ground	1
28	TD-	CML-I	Transmitter Inverted Data Input	
29	TD+	CML-I	Transmitter Non-Inverted Data Input	
30	GND		Module Ground	1

Notes:

1. Module ground pins (GND) are isolated from the module case and chassis ground within the module.
2. Shall be pulled up with 4.7K-10K ohms to a voltage between 3.15V and 3.45V on the host board.

Wavelengths Supported

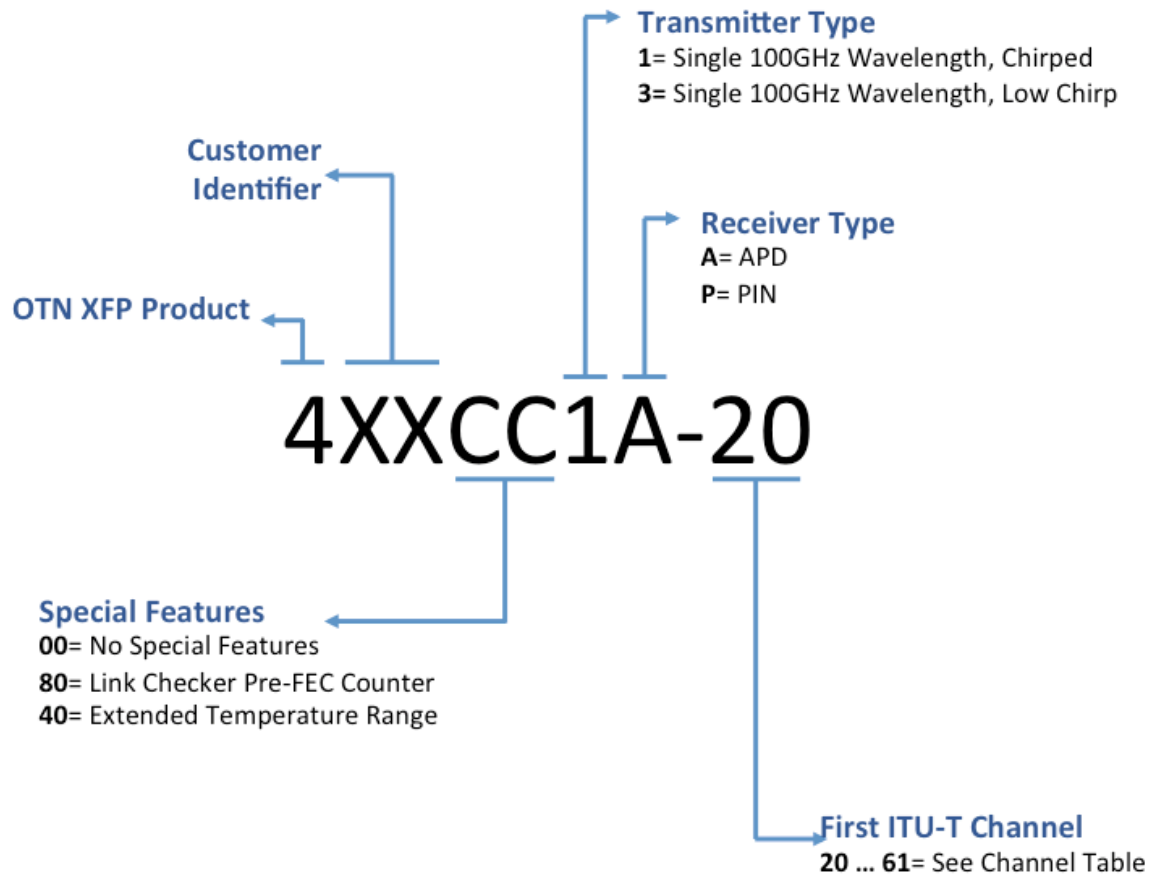
The following table provides correlation of the ITU-T DWDM wavelength and frequency as it relates to Menara Networks ID. Menara DWDM products support a subset of these wavelengths corresponding to frequently used C-band DWDM transmission systems.

Frequency (THz)	Wavelength (nm)	Menara ID
196.10	1528.77	61
196.00	1529.55	60
195.90	1530.33	59
195.80	1531.12	58
195.70	1531.90	57
195.60	1532.68	56
195.50	1533.47	55
195.40	1534.25	54
195.30	1535.04	53
195.20	1535.82	52
195.10	1536.61	51
195.00	1537.40	50
194.90	1538.19	49
194.80	1538.98	48
194.70	1539.77	47
194.60	1540.56	46
194.50	1541.35	45
194.40	1542.14	44
194.30	1542.94	43
194.20	1543.73	42
194.10	1544.53	41
194.00	1545.32	40

Frequency (THz)	Wavelength (nm)	Menara ID
193.90	1546.12	39
193.80	1546.92	38
193.70	1547.72	37
193.60	1548.51	36
193.50	1549.32	35
193.40	1550.12	34
193.30	1550.92	33
193.20	1551.72	32
193.10	1552.52	31
193.00	1553.33	30
192.90	1554.13	29
192.80	1554.94	28
192.70	1555.75	27
192.60	1556.55	26
192.50	1557.36	25
192.40	1558.17	24
192.30	1558.98	23
192.20	1559.79	22
192.10	1560.61	21
192.00	1561.42	20

Ordering Guide

The OTN XFP part number is shown below.



Part Number Examples are shown below:

Part Number	Feature Description	Notes
4XX801A-25	OTN XFP, Single Wavelength DWDM, Link Checker Feature Enabled, ITU-T Channel 25 with APD	
4XX001A-30	OTN XFP, Single Wavelength DWDM, ITU-T Channels 30 with APD	
4XX803P-44	OTN XFP, Single Wavelength DWDM, Link Checker Feature Enabled, ITU-T Channels 44, Low Chirp with PIN	
4XX401A-44	OTN XFP, Single Wavelength DWDM, Extended Temperature, ITU-T Channel 25 with APD	

The OTN XFP host board and GUI part number is shown below.

Part Number	Description
400002A-HOST	OTN XFP Host board, OTN GUI software, wall mount power supply

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