

## 10-Gigabit Ethernet DWDM OTN PIC Optical Interface Support (T640 Router)

Table 1 describes the optical interfaces supported on the 10-Gigabit Ethernet DWDM OTN PIC.

**Table 1: Optical Interface Support for the 10-Gigabit Ethernet DWDM OTN PIC**

<b>Model number</b>	<ul style="list-style-type: none"> <li>■ PC-1XGE-DWDM-OTN</li> </ul>
<b>Features</b>	<ul style="list-style-type: none"> <li>■ 10-Gigabit digital wrapper with over-clocked G.709 framing</li> <li>■ Generic Reed-Solomon forward error correction (GFEC) and enhanced forward error correction (EFEC) to transport 10GBASE-R (10-Gigabit Ethernet LAN PHY)</li> <li>■ Reduced cost of deploying and maintaining the network due to: <ul style="list-style-type: none"> <li>■ Fewer optical-electrical-optical (OEO) conversions</li> <li>■ Fewer optical amplifiers and regenerators</li> </ul> </li> <li>■ 89 tunable wavelengths (channels) supported per DWDM-OTN module</li> <li>■ Link fault switchover</li> </ul>
<b>Transceiver type</b>	<ul style="list-style-type: none"> <li>■ Dense wavelength division multiplexing (DWDM) module</li> </ul>
<b>Standards</b>	<ul style="list-style-type: none"> <li>■ ITU-T G.709—Interfaces for the Optical Transport Network (OTN). The PC-1XGE-DWDM-OTN PIC supports two OTN extended mappings: <ul style="list-style-type: none"> <li>■ Supplement 43, section 7.1, optical channel payload unit 2e (OPU2e). This mapping inserts the original 10GE LAN PHY signal into a “digital wrapper” with overclocked G.709 framing that results in a line rate of 11.1 Gbps instead of the standard 10.7 Gbps.</li> <li>■ Supplement 43, section 7.2, optical channel payload unit 1e (OPU1e). This mapping inserts the original 10GE LAN PHY signal into a “digital wrapper” with overclocked G.709 framing, but without the use of fixed stuff bytes, that results in a line rate of 11.05 Gbps instead of the standard 10.7 Gbps.</li> </ul> <p><i>See ITU-T Series G Supplement 43, ver 02/2008 for more information about OPU2e and OPU1e extended mappings.</i></p> </li> <li>■ ITU-T G.975—GFEC</li> <li>■ ITU-T G.975.1—Enhanced FEC</li> <li>■ ITU-T G.694.1—Spectral grids for WDM applications: DWDM frequency grid Series G: Transmission Systems and Media, Digital Systems and Networks Transmission media characteristics-Characteristics of optical components and subsystems</li> <li>■ IEEE 802.3ae—2005</li> <li>■ RFC 3591—Definitions of Managed Objects for the Optical Interface Type</li> </ul>
<b>Optical interface</b>	<ul style="list-style-type: none"> <li>■ Single-mode optical fiber</li> </ul>
<b>Line interface</b>	<ul style="list-style-type: none"> <li>■ Line rate: <ul style="list-style-type: none"> <li>■ 10GE LAN PHY: 10.3125 Gbps (pass-through)</li> <li>■ G.709 LAN PHY without fixed stuff bytes: 11.049 Gbps</li> <li>■ G.709 LAN PHY with fixed stuff bytes: 11.0957 Gbps</li> </ul> </li> <li>■ Transmit line rate deviation: G.709 LAN PHY modes: <math>\pm 20</math> ppm</li> <li>■ Dispersion window: <math>\pm 1200</math> ps/nm or <math>\pm 1600</math> ps/nm (maximum)</li> <li>■ FEC type (software selectable): Generic Reed-Solomon RS (255, 239) code computed as specified in Annex A/G. 709 (GFEC) or enhanced (EFEC)</li> </ul>

**Table 1: Optical Interface Support for the 10-Gigabit Ethernet DWDM OTN PIC** *(continued)*

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<b>Optical transmitter</b>	<ul style="list-style-type: none"><li>■ Transmitter type: LiNbO<sub>3</sub> MZI (Lithium Niobate Mach-Zehnder Interferometer)</li><li>■ Modulation format: Nonreturn-to-zero (NRZ)</li><li>■ Channel-plan wavelength range: 1528.77 through 1563.86 nm</li><li>■ Channel-plan frequency range: 191.7 through 196.1 THz</li><li>■ Channel spacing: 50 GHz</li><li>■ Channel tunability: 89 channels—see Table 2</li><li>■ Output power (on): +3 to +7 dBm</li><li>■ Output power (off): ≤ -40 dBm</li><li>■ Output power stability: -1.5 to +1.0 dB</li><li>■ Wavelength accuracy: ±25 pm, ±3.125 GHz</li><li>■ Tuning time: Warm tune - 10 seconds; cold start - 40 seconds</li><li>■ Extinction ratio: ≥ 11 dB</li><li>■ Crossing ratio: 45 to 55 percent</li><li>■ Side-mode suppression ratio: ≥ 30 dB</li><li>■ Optical spectral width: ≤ 25 GHz (informational, not a specification)</li><li>■ Average relative intensity noise (RIN):<ul style="list-style-type: none"><li>■ 10 MHz to 1 GHz: -110 dB/Hz</li><li>■ 1 GHz to 10 GHz: -145 dB/Hz</li></ul></li><li>■ Output OSNR:<ul style="list-style-type: none"><li>■ Minimum: 50 dB (0.1 nm resolution bandwidth)</li><li>■ Typical: 55 dB (0.1 nm resolution bandwidth)</li></ul></li><li>■ Polarization extinction ratio: 20 dB</li><li>■ Eye mask compliance: 802.3—2005</li><li>■ Jitter generation compliance: GR-253/G.8251</li></ul>
<b>Optical receiver</b>	<ul style="list-style-type: none"><li>■ Receiver type: Avalanche photodiode (APD)</li><li>■ Average receive power (input power range): see Input Power Range in Table 3</li><li>■ Jitter tolerance compliance: GR-253/G.8251/802.3ae (LAN PHY)</li><li>■ Rx DTV setting:<ul style="list-style-type: none"><li>■ No FEC (pass-through): Static (factory optimized value)</li><li>■ GFEC: Managed by electronic dispersion compensation (EDC)</li><li>■ EFEC: Managed by EDC</li></ul></li><li>■ Rx wavelength range: 1527 to 1567 nm</li><li>■ Overload (receiver saturation): -5 dBm (high OSNR), -8 dBm (low OSNR)</li><li>■ Damage input power: +5 dBm</li><li>■ Optical return loss: ≥ 27 dB</li></ul>

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**Table 1: Optical Interface Support for the 10-Gigabit Ethernet DWDM OTN PIC (continued)**

<b>Optical performance</b>	<p>Optical Applications—Power-Limited Receiver (High OSNR):</p> <ul style="list-style-type: none"> <li>■ Sensitivity: <ul style="list-style-type: none"> <li>■ No FEC: –5 to –24 dBm (&gt; 33 dB/0.1 nm OSNR, 0 ps/nm CD) at <math>10^{-12}</math> BER (10.3 Gbps)</li> <li>■ GFEC: –5 to –28 dBm at <math>8 \times 10^{-5}</math> pre-FEC BER (&gt; 33 dB/0.1 nm OSNR, 0 ps/nm CD) (<math>10^{-15}</math> post-FEC BER) (11.05 and 11.1 Gbps)</li> <li>■ EFEC: –5 to –28 dBm at <math>1 \times 10^{-3}</math> pre-FEC BER (&gt; 33 dB/0.1 nm OSNR, 0 ps/nm CD) (<math>10^{-15}</math> post-FEC BER) (11.05 and 11.1 Gbps)</li> </ul> </li> <li>■ Chromatic dispersion (CD) power penalty: <ul style="list-style-type: none"> <li>■ No FEC: 3 dB (typical penalty at <math>\pm 1200</math> ps/nm without EDC)</li> <li>■ GFEC or EFEC: 3 dB (typical penalty at <math>\pm 1600</math> ps/nm with EDC)</li> </ul> </li> </ul> <p>Optical Applications—Noise-Limited Receiver (Low OSNR):</p> <ul style="list-style-type: none"> <li>■ Required OSNR: <ul style="list-style-type: none"> <li>■ No FEC (10.3 Gbps): <ul style="list-style-type: none"> <li>■ 26 dB/0.1 nm (–8 to –22 dBm Rx input power range, 0 ps/nm CD, at <math>10^{-12}</math> BER)</li> <li>■ 26 dB/0.1 nm (–8 to –20 dBm Rx input power range, <math>\pm 1000</math> ps/nm without EDC, at <math>10^{-12}</math> BER)</li> <li>■ 30 dB/0.1 nm (–8 to –20 dBm Rx input power range, <math>\pm 1200</math> ps/nm without EDC, at <math>10^{-12}</math> BER)</li> </ul> </li> <li>■ GFEC (11.05 and 11.1 Gbps): <ul style="list-style-type: none"> <li>■ 15.5 dB/0.1 nm (–8 to –20 dBm Rx input power range, 0 ps/nm, at <math>\leq 10^{-5}</math> pre-FEC BER, <math>\leq 10^{-15}</math> post-FEC BER)</li> <li>■ 17 dB/0.1 nm (–8 to –20 dBm Rx input power range, <math>\pm 1200</math> ps/nm with EDC, at <math>\leq 10^{-5}</math> pre-FEC BER, <math>\leq 10^{-15}</math> post-FEC BER)</li> </ul> </li> <li>■ EFEC (11.05 and 11.1 Gbps): <ul style="list-style-type: none"> <li>■ 12 dB/0.1 nm (–8 to –20 dBm Rx input power range, 0 ps/nm, at <math>\leq 10^{-4}</math> pre-FEC BER, <math>\leq 10^{-15}</math> post-FEC BER)</li> <li>■ 14 dB/0.1 nm (–8 to –20 dBm Rx input power range, <math>\pm 1200</math> ps/nm with EDC, at <math>\leq 10^{-4}</math> pre-FEC BER, <math>\leq 10^{-15}</math> post-FEC BER)</li> <li>■ 16 dB/0.1 nm (–8 to –20 dBm Rx input power range, 0 ps/nm CD, <math>10^{-15}</math> post-FEC BER)</li> </ul> </li> </ul> </li> <li>■ CD OSNR penalty: <ul style="list-style-type: none"> <li>■ GFEC: 1.5 dB (typical penalty at <math>\pm 1200</math> ps/nm with Rx input power range from –8 to –20 dBm).</li> <li>■ EFEC: 2 dB (typical penalty at <math>\pm 1200</math> ps/nm with Rx input power range from –8 to –20 dBm).</li> </ul> </li> </ul> <p>For more detailed information, see Table 3.</p>
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Table 2 provides the supported wavelengths for the 100-GHz grid and the 50-GHz offset in both THz and nm.

**Table 2: Supported Wavelengths for the 10-Gigabit Ethernet DWDM OTN PIC**

100-GHz Grid		50-GHz Offset		100-GHz Grid		50-GHz Offset	
THz	nm	THz	nm	THz	nm	THz	nm
191.70	1563.86	191.75	1563.45	194.00	1545.32	194.05	1544.92
191.80	1563.04	191.85	1562.63	194.10	1544.52	194.15	1544.12
191.90	1562.23	191.95	1561.82	194.20	1543.73	194.25	1543.33
192.00	1561.41	192.05	1561.01	194.30	1542.93	194.35	1542.53
192.10	1560.60	192.15	1560.20	194.40	1542.14	194.45	1541.74
192.20	1559.79	192.25	1559.38	194.50	1541.34	194.55	1540.95
192.30	1558.98	192.35	1558.57	194.60	1540.55	194.65	1540.16
192.40	1558.17	192.45	1557.76	194.70	1539.76	194.75	1539.37
192.50	1557.36	192.55	1556.95	194.80	1538.97	194.85	1538.58
192.60	1556.55	192.65	1556.15	194.90	1538.18	194.95	1537.79
192.70	1555.74	192.75	1555.34	195.00	1537.39	195.05	1537.00
192.80	1554.94	192.85	1554.53	195.10	1536.60	195.15	1536.21
192.90	1554.13	192.95	1553.73	195.20	1535.82	195.25	1535.42
193.00	1553.32	193.05	1552.92	195.30	1535.03	195.35	1534.64
193.10	1552.52	193.15	1552.12	195.40	1534.25	195.45	1533.85
193.20	1551.72	193.25	1551.31	195.50	1533.46	195.55	1533.07
193.30	1550.91	193.35	1550.51	195.60	1532.68	195.65	1532.28
193.40	1550.11	193.45	1549.71	195.70	1531.89	195.75	1531.50
193.50	1549.31	193.55	1548.91	195.80	1531.11	195.85	1530.72
193.60	1548.51	193.65	1548.11	195.90	1530.33	195.95	1529.94
193.70	1547.71	193.75	1547.31	196.00	1529.55	196.05	1529.16
193.80	1546.91	193.85	1546.51	196.10	1528.77		
193.90	1546.11	193.95	1545.72				

The OSNR performance listed in Table 3 is for an appropriate level of optical filtering of the amplified spontaneous emission (ASE) reaching the receiver and is derived using a 0.22-nm 3-dB full-width Gaussian filter. When no FEC is used, there is no OTN framing.

**Table 3: Optical Signal-to-Noise Ratio (OSNR) Performance for the 10-Gigabit Ethernet DWDM OTN PIC**

OSNR (dB/0.1 nm)	OSNR (dB/0.5 nm)	FEC Type	Pre-FEC BER	Post-FEC BER	Input-Power Range (ROP) (dBm)	CD Tolerance (ps/nm)
33	26	None	$10^{-12}$	NA	-5 to -24	0
33	26	None	$10^{-12}$	NA	-5 to -21	$\pm 1200$ (no EDC)
26	19	None	$10^{-12}$	NA	-8 to -22	0
26	19	None	$10^{-12}$	NA	-8 to -20	$\pm 1000$ (no EDC)
30	23	None	$10^{-12}$	NA	-8 to -20	$\pm 1200$ (no EDC)
33	26	GFEC	$8 \times 10^{-5}$	$10^{-15}$	-5 to -28	0
33	26	GFEC	$8 \times 10^{-5}$	$10^{-15}$	-5 to -25	$\pm 1600$ (with EDC)
15.5	8.5	GFEC	$10^{-5}$	$10^{-15}$	-8 to -20	0
17	10	GFEC	$10^{-5}$	$10^{-15}$	-8 to -20	$\pm 1200$ (with EDC)
33	26	EFEC	$10^{-3}$	$10^{-15}$	-5 to -28	0
33	26	EFEC	$10^{-3}$	$10^{-15}$	-5 to -25	$\pm 1600$ (with EDC)
12	5	EFEC	$7 \times 10^{-4}$	$10^{-15}$	-8 to -20	0
14	7	EFEC	$7 \times 10^{-4}$	$10^{-15}$	-8 to -20	$\pm 1200$ (with EDC)

- Related Topics**
- 10-Gigabit Ethernet DWDM OTN PIC (T640 Router)
  - T640 Router Overview
  - High Availability Features (T640 Router)
  - PIC Combinations (T640 Router)
  - T640 PICs Supported
  - FPCs Supported (T640 Router)
  - PIC/FPC Compatibility (T640 Router)

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