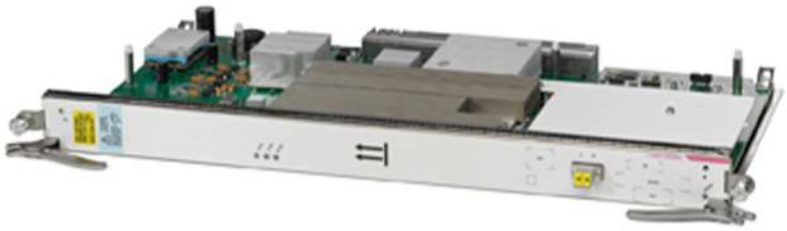
Cisco CRS 1-Port 100 Gigabit Ethernet Coherent DWDM Interface Module

This data sheet provides detailed product specifications for the Cisco® IP over Dense Wavelength-Division Multiplexing (IPoDWDM) solution, the Cisco CRS 1-Port 100 Gigabit Ethernet Coherent DWDM Interface Module (Figure 1). The module connects directly into any DWDM network and provides up to 100 Gbps of data throughput, transporting 100 Gigabit Ethernet LAN Physical Layer (LAN-PHY) and Optical Transport Network (OTN) Transport Unit Level 4 (OTU-4) over a 50-GHz spaced, 50-GHz stabilized, ITU-compliant wavelength. The module is completely tunable across the C band in the ITU 50-GHz grid. The unit uses a Coherent Polarization-Multiplexed Differential Quadrature Phase Shift Key (CP-DQPSK) modulation scheme that is based on the Optical Internetworking Forum (OIF) standard.

Figure 1. Cisco CRS 1-Port 100 Gigabit Ethernet Coherent DWDM Interface Module



Challenge and Solution

The bandwidth carried on core and metropolitan (metro) DWDM networks is growing exponentially, while operators' revenues are not growing as quickly. The Cisco CRS 1-Port 100 Gigabit IPoDWDM solution can dramatically lower the cost to carry bandwidth, helping to maintain and improve customers' profitability in the face of exponential Internet growth due to demand for next-generation services such as Quad play (data, voice, video, and mobility), video distribution, Internet Protocol Television (IPTV), and other high-bandwidth services.

The possibility of transmitting 100-Gbps wavelengths on existing or new Greenfield DWDM systems improves return on investment by increasing the overall capacity per fiber pair without impacting the unregenerated transmission distance, which can be covered through the advance modulation schemes. The scale of 10 Gbps to 40 Gbps and now to 100 Gbps multiplies by a factor of 10 the bandwidth that can be transported over existing fiber networks.

The new Coherent Polarization-Multiplexed Differential Quadrature Phase Shift Key (CP-DQPSK) modulation enables 100-Gbps capacity transmission over existing 10/40-Gbps networks, up to 3000 km, thus enabling Ultra Long Haul (ULH) networks of unregenerated optical links.

The new interface module is designed to provide the following benefits:

- Transport of 100-Gbps wavelengths over fully uncompensated networks, up to 3000 km of unregenerated optical links
- Transport at 100 Gbps over very low-quality fiber with very high Polarization Mode Dispersion (PMD)
- Transport of 100-Gbps wavelengths over existing 50-GHz channel spacing with very high tolerance to filtering penalties

This module helps service providers increase efficiency, improve reliability, and reduce operational and capital costs by eliminating expensive and bulky optical transponder equipment.

Enhanced Forward Error Correction Capability

This module can support a Forward Error Correction (FEC) mechanism. The trunk port supports three software-configurable FEC coding options.

- Generic FEC (GFEC): Standard G.975 Reed-Salomon algorithm with 7 percent overhead.
- Ultra FEC (UFEC): Standard G.975.1 (Sub-clause I.7) with 20 percent overhead. This FEC scheme uses two orthogonally concatenated BCH Enhanced FEC (EFEC) codes. The constructed code is decoded iteratively to rebuild the original frame.
- High-Gain FEC (HG-FEC): High-Gain EFEC with 7 percent overhead, providing better performances than standard G.975.1 7 percent OH FEC. Because of the reduced overhead and lower bit rate, HG-FEC is suitable for all the applications where 100 Gbps wavelengths are passing through a high number of reconfigurable optical add-drop multiplexer (ROADM) nodes with limited pass-band performances.

The different FEC modes extend the reach of the DWDM signal up to 3000 km without requiring signal regeneration. For more information about the Cisco CRS or about other interfaces available for the Cisco CRS, visit: http://www.cisco.com/go/crs.

Protocol Transparency

The module can transparently deliver any 100-Gbps services for cost-effective, point-to-point networking for the Cisco CRS platform (see Table 1).

Table 1. Transponder Client Configurations and Mapping

Client		Mapping	Trunk		
Format	Rate (Gbps)		Format	Rate with 7% GFEC or EFEC OH (Gbps)	Rate with 20% UFEC OH (Gbps)
100GE LAN-PHY	101.125	Bit transparent through standard G.709v3 mapping	OTU-4	111.809	124.964
OTU-4	111.809	Transparent G.709 standard			

Advanced Modulation Scheme

The Cisco CRS 1-Port 100 Gigabit Ethernet Coherent DWDM Interface Module features an advanced modulation scheme to provide optical performances significantly better than industry-standard 10-Gbps equivalent interfaces.

Cisco selected a CP-DQPSK modulation format to optimize 100-Gbps transmission in terms of Optical Signal-to-Noise Ratio (OSNR), Chromatic Dispersion (CD), and Polarization Mode Disperson (PMD) robustness.

The CP-DQPSK modulation scheme consists of multiplexing two DQPSK signals using two different orthogonal light polarizations, as shown in Figures 2 and 3.

Figure 2. CP-DQPSK Logical Modulation Scheme

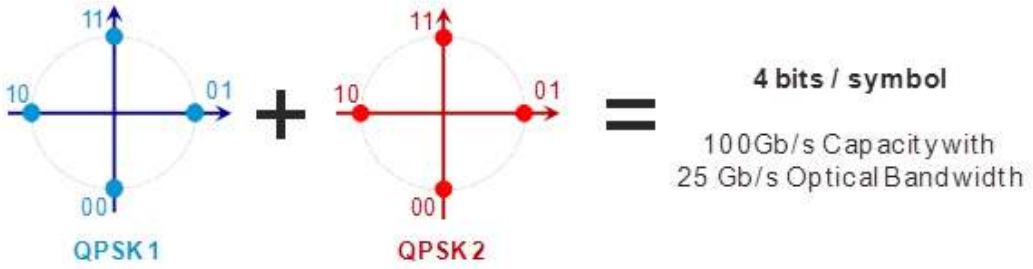
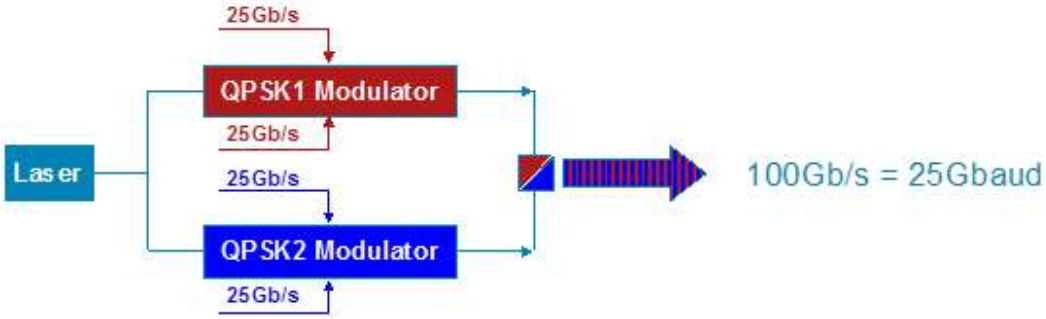
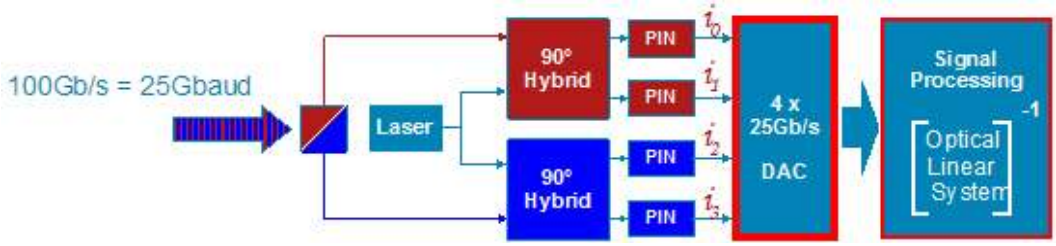


Figure 3. CP-DQPSK Logical Transmitter Scheme



The core of the 100-Gbps CP-DQPSK modulation scheme is the optical receiver, based on coherent optical detection, where a Digital Signal Processor (DSP) calculates the inverse of the optical system matrix, allowing the receiver to recover the original transmitted signals (Figure 4).

Figure 4. CP-DQPSK Logical Receiver Scheme



The main benefits of CP-DQPSK are:

- Strong OSNR performance
- Outstanding CD robustness, eliminating the need for any optical chromatic dispersion compensation solution
- Extended PMD robustness (three times better than 10-Gbps units)
- Very high spectral efficiency, allowing 100-Gbps wavelengths to be transmitted across a high number of ROADMs with negligible penalty

Performance Monitoring

The 100-Gbps DWDM module provides support for both transparent and non-transparent signal transport performance monitoring. The digital wrapper channel is monitored according to G.709 (OTN) and G.8021 standards. Performance monitoring of optical parameters on the client and DWDM line interface include Loss Of Signal (LOS), laser bias current, transmit optical power, and receive optical power. Calculation and accumulation of the performance monitoring data are supported in 15-minute and 24-hour intervals as per G.7710.

Physical system parameters measured at the wavelength level, such as mean PMD, accumulated CD or received OSNR, are also included in the set of performance monitoring parameters. These can greatly simplify troubleshooting operations and enhance the set of data that can be collected directly from the equipment. A detailed list of performance monitors is given in Table 6.

The module incorporates faceplate-mounted LEDs to provide a quick visual check of the operational status of the card.

Product Specifications

Table 2 gives specifications of the Cisco CRS 1-Port 100Gigabit Ethernet CP-DQPSK Full C-Band Tunable DWDM Interface Module.

Table 2. Product Specifications

Feature	Description
Chassis compatibility	Compatible with all current Cisco CRS-1 and CRS-3 line-card chassis
Software compatibility	Cisco IOS® XR Software Release 4.2.3 or later for CRS-3
Protocols	• 100 Gigabit Ethernet • OTU-4 • Encapsulations: ARPA, IEEE 802.2/SAP, IEEE 802.3/SNAP • IEEE 802.x flow control • 802.1q VLAN support, jumbo frames • IEEE 802.1p tagging • Source and destination MAC accounting and VLAN accounting
Port density	One interface module per physical layer interface module (PLIM)
POS feature summary	Not applicable

Feature	Description
OTN (G.709) feature summary	• ITU G.709 • Alarm reporting: Loss of Signal (LOF), Loss of OTN Frame (LOF), Loss of OTN Multiframe (LOM), • OTU alarm indication signal (OTU-AIS), OTU backward defect indication (OTU-BDI), ODU alarm indication signal (ODU-AIS), ODU open connection indication (ODU-OCI), ODU locked (ODU-LCK), ODU backwards defect indication (ODU-BDI), ODU payload type identifier mismatch (ODU-PTIM), OTU signal fail (OTU_SF_BER) and OTU signal degrade (OTU_SD_BER) • OTU_SF_BER and OTU_SD_BER alarms are based on monitoring OTU BIP errors with a user-configurable threshold crossing • Error counts: OTU BIP, OTU BEI, ODU BIP, and ODU BEI • Threshold crossing alerts (TCAs) for OTU BIP errors (SM-TCA) and ODU BIP errors (PM-TCA) with user-configurable threshold • Local (internal) and line (network) loopback
FEC feature summary	• GFEC - G.975.1 – Reed Salomon with 7% Over Head (OH) • HG – FEC – High Gain FEC with 7% OH • UFEC – Ultra FEC with 20% OH – two orthogonally concatenated BCH super FEC codes • FEC statistics for pre-FEC BER, Q, Q Margin, corrected errors (EC) and uncorrected words (UC)
Optical feature summary	• Line rate 111.809Gbps or 27.952 Gbaud +/-20ppm (7% FEC OH) and 124.964Gbps or 31.241Gbaud +/-20ppm (20% OH) • Duplex LC faceplate optical connector • Electronically compensated CD (70,000ps/nm) and DGD (180ps) • Full C-band tunable laser – 1528.77 to 1566.72nm in 50GHz grid • Tx optical power (-1dBm to +1.5dBm) • Tx and Rx optical power monitoring • Optical power monitoring accuracy +/–1 dB
Reliability and availability	• Online insertion and removal (OIR) without affecting system traffic
Network management	• Cisco IOS XR Software command-line interface (CLI) • Simple Network Management Protocol (SNMP) • Extensible Markup Language (XML) interface • CraftWorks Interface (CWI)
Physical dimensions	• Occupies one PLIM slot • Weight: 8.6 lb (3.9 kg) • Height: 20.6 in. (52.32 cm) • Depth: 11.2 in. (28.4 cm) • Width: 1.8 in. (4.57 cm)
Power	180W
Latency (End to End)	• G.709 – Standard FEC: 4 microseconds • G.709 – HG-FEC 7%: 20 microseconds • G.709 – UFEC 20%: 39 microseconds
Environmental conditions	• Storage temperature: –40 to 70℃ (–40 to 158℉) • Operating temperature: ◦ Normal: 0 to 40℃ (32°to 104℉) ◦ Short-term: –5 to 55℃ (23 to 131℉) • Relative humidity: ◦ Normal: 5 to 85% ◦ Short-term: 5 to 90% but not to exceed 0.024 kg water/kg of dry air Short-term refers to a period of not more than 96 consecutive hours and a total of 360 hours, but not more than 15 instances in 1 year.

Approvals and Compliance

Table 3 gives standards compliance information and Table 4 provides additional specifications.

Table 3. Compliance and Agency Approvals

Feature	Description
Safety standards	• UL/CSA/IEC/EN 60950-1 • IEC/EN 60825 Laser Safety • ACA TS001 • AS/NZS 60950 • FDA–Code of Federal Regulations Laser Safety
EMI	• FCC Class A • ICES 003 Class A • AS/NZS 3548 Class A • CISPR 22 (EN55022) Class A • VCCI Class A • BSMI Class A • IEC/EN 61000-3-2: Power Line Harmonics • IEC/EN 61000-3-3: Voltage Fluctuations and Flicker
Immunity (basic standards)	• IEC/EN-61000-4-2: Electrostatic Discharge Immunity (8-kV contact, 15-kV air) • IEC/EN-61000-4-3: Radiated Immunity (10V/m) • IEC/EN-61000-4-4: Electrical Fast Transient Immunity (2-kV power, 1-kV signal) • IEC/EN-61000-4-5: Surge AC Port (4-kV CM, 2-kV DM) • IEC/EN-61000-4-5: Signal Ports (1 kV) • IEC/EN-61000-4-5: Surge DC Port (1 kV) • IEC/EN-61000-4-6: Immunity to Conducted Disturbances (10 Vrms) • IEC/EN-61000-4-8: Power Frequency Magnetic Field Immunity (30A/m) • IEC/EN-61000-4-11: Voltage Dips, Short Interruptions, and Voltage Variations
ETSI and EN	• EN300 386: Telecommunications Network Equipment (EMC) • EN55022: Information Technology Equipment (Emissions) • EN55024: Information Technology Equipment (Immunity) • EN50082-1/EN-61000-6-1: Generic Immunity Standard
Network Equipment Building Standards (NEBS)	This product is designed to meet the following requirements (qualification in progress): • SR-3580: NEBS Criteria Levels (Level 3) • GR-1089-CORE: NEBS EMC and Safety • GR-63-CORE: NEBS Physical Protection

All specifications in Table 4 are worst-case for the operational life of the product.

Table 4. Additional Specifications: DWDM Line Interface

Parameter	DWDM line interface
Connector type	LC
Target distance	3000 km (dependant on network configuration)
Bit rate	27.952 Gbaud ±20 ppm (OTU4 with GFEC or HG-FEC 7% OH) 31.241Gbaud ±20 ppm (OTU4 with UFEC 20% OH)
Automatic laser shutdown and restart	ITU-T G.664 (06/99)
Nominal wavelengths (λ_{Tnom})	Full tunable between 1528.77 and 1566.72nm (C-Band – 50 GHz)
Connector type (TX/RX)	LC, duplex (shuttered)
Transmitter	
Power range	–1 dBm to +1.5 dBm
Wavelength range	Full tunable from 1528.77 nm to 1563.86 nm across 50GHz ITU grid

Parameter	DWDM line interface
Modulation	CP-DQPSK
Minimum Optical Return Loss (ORL)	27 dB
Laser safety class	1
Receiver	
P (RMax) (minimum overload)	0 dBm
Chromatic dispersion tolerance (0.5 dB penalty)	–70,000 to +70,000 ps/nm
PMD tolerance (0.5 dB penalty)	30 ps, 1 X 10^{-5} outage probability
OSNR (back to back) (0.1 nm Res. BW)	7.5 dB (1 X 10^-15 Post FEC BER) (see Table 5)
Receiver reflectance (maximum)	30 dB
Input wavelength bandwidth (λ_{c_rx})	Between 1528.77 and 1566.72 nm (C-Band – 50 GHz)
Single-channel optical link (without DWDM)[2]	
Fiber type	G.652 (SMF), G.653 (DSF) and G.655 (NZ-DSF)
Sensitivity (over dark fiber)	–22 dBm (1 X 10^-15 Post FEC BER)[3]
Link budget (no amplification)	28 dB
Optical path penalty	1 dB
Path length	80 km (G.652/G.655); 100 km (G.653)[4]
Miscellaneous	
Optical power monitoring	Tx and Rx, ±1 dB accuracy

1 Must change RxLOS threshold default from –19.5 dBm to –23.5 dBm.

2 Please contact your Cisco representative for the Application Note on 40 Gbps single-channel CRS-1 interconnection extending to 80 km and beyond.

3 Must change default RxLOS to -30 dBm or less, wavelength set to a channel between 7 and 14 (1531.116 nm and 1533.858 nm)

4 Proper system design required; network may require Dispersion Compensating Units

Table 5. DWDM Receive-Side Optical Performances

CD Tolerance	FEC Type	Pre-FEC BER	Post-FEC BER	Input Power Sensitivity	DGD	OSNR (0.1 nm RBW)
Extended performance						
0 ps/nm	EFEC (20% OH)	<1x10E(–2)	<10E(–15)	0 to –14 dBm	–	7.5 dB
0 ps/nm				(-20dBm with 0.5dB of OSNR penalty)	180 ps	8.0 dB
+/- 70,000 ps/nm					180 ps	9.0 dB
0 ps/nm	HG-FEC (7% OH)	<4.6x10E(–3)	<10E(–15)	0 to –14 dBm	–	8.0 dB
0 ps/nm				(-20dBm with 0.5dB of OSNR penalty)	180 ps	8.5 dB
+/- 70,000 ps/nm					180 ps	9.5 dB

Table 6. Performance Monitoring Parameters

Area	Parameter Name		Description
OTN	**OTUk SM**	**ODUk PM**	
	BBE-SM	BBE-PM	Number of background block errors
	BBER-SM	BBER-PM	Background block error ratio
	ES-SM	ES-PM	Number of errored seconds
	ESR-SM	ESR-PM	Errored seconds ratio
	SES-SM	SES-PM	Number of severely errored seconds
	SESR-SM	SESR-PM	Severely errored seconds ratio
	UAS-SM	UAS-PM	Number of unavailable seconds
	FC-SM	FC-PM	Number of failure counts

Area	Parameter Name	Description
FEC	Bit errors	Number of corrected bit errors
	Uncorrectable words	Number of uncorrectable words
Trunk optical PM	OPT	Transmit optical power
	LBC	Transmitter laser bias current
	OPR	Receiver optical power
	RCD	Residual chromatic dispersion
	PMD	Mean polarization mode dispersion
	OSNR	Optical signal-to-noise ratio, calculated with 0.5 nm RBW

Ordering Information

To place an order, contact your local Cisco representative or visit the Cisco Ordering Home Page, http://www.cisco.com. Use the ordering information in Table 7.

Table 7. Ordering Information

Product Part Number	Product Name
1-100GE-DWDM/C (=)	Cisco CRS 1-Port 100Gigabit Ethernet CP-DQSPK Full C-Band Tunable DWDM Interface Module

Service and Support

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For More Information

For more information about the Cisco CRS 1-Port 100Gigabit Ethernet CP-DQPSK Full C-Band Tunable DWDM Interface Module, contact your local Cisco representative or visit: http://www.cisco.com/go/crs.

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