Calculating Optical Dispersion Limits for 40km Long-Haul 10G SFP+ Transceivers - Official Technical Overview & Hardware Datasheet

PRODUCT IDENTIFICATION

This document serves as the definitive technical reference for the integration and performance validation of 10G SFP+ transceivers deployed in 40km long-haul optical networks. It provides a rigorous methodology for calculating chromatic and polarization mode dispersion limits to ensure link integrity and error-free transmission over extended single-mode fiber infrastructures. This datasheet addresses the core engineering challenges of long-distance optical signal propagation, offering network architects and hardware engineers the precise parameters required for system design and troubleshooting.



CORE INTERNAL TOPOLOGY

The optical dispersion limits for 40km 10G SFP+ transceivers are governed by the interplay between the transmitter's spectral width, the fiber's dispersion coefficient, and the receiver's dispersion penalty tolerance. The fundamental equation for calculating the chromatic dispersion (CD) limit is:

CD_limit (ps/nm) = (D_max (ps/nm) * L_max (km)) where D_max is the maximum allowable chromatic dispersion for the given transceiver type (typically specified for 10G Ethernet as per IEEE 802.3ae) and L_max is the maximum fiber length.

The maximum permissible total chromatic dispersion (D_total) for a 10G signal is typically 1600 ps/nm for 10GBASE-ER/EW standards. To operate successfully over 40km, the fiber must exhibit a dispersion coefficient (D) such that:

$D * L \leq 1600$ ps/nm -> $D \leq 40$ ps/(nm*km)

Standard single-mode fiber (G.652) at 1550nm has a dispersion coefficient of approximately 17 ps/(nm*km), giving a total dispersion of 680 ps/nm over 40km, which is well within the 1600 ps/nm limit. However, this calculation does not account for the effects of Polarization Mode Dispersion (PMD). PMD is a statistical phenomenon and is typically specified as a maximum differential

group delay (DGD). For 10G signals, the PMD limit is typically around 10% of the bit period, which is 100 ps for a 10G signal (10 Gbps -> 100 ps bit period).

The PMD coefficient of the fiber is usually specified as a maximum value (e.g., 0.1 ps/√km). For 40km, the expected PMD is 0.1 * √40 ≈ 0.63 ps, which is significantly lower than the 100 ps limit. Therefore, chromatic dispersion is the dominant factor for 40km links, but system integrators must always verify both parameters.

[IMAGE_1]

SWITCHING SUBSYSTEM CAPABILITIES

The transceiver hardware incorporates a high-performance 1550nm Distributed Feedback (DFB) laser or an Electro-absorption Modulated Laser (EML) to minimize chirp and spectral width, thereby optimizing the dispersion penalty. The receiver section features an Avalanche Photodiode (APD) with a preamplifier to achieve the high sensitivity (typically -24 dBm to -28 dBm) required for 40km attenuation budgets (typically 20-24 dB, including connector and splicing losses). The Digital Diagnostics Monitoring Interface (DDMI) provides real-time monitoring of parameters such as temperature, supply voltage, bias current, transmit power, and receive power, enabling proactive link

management and fault isolation.

OPERATIONAL ADVANTAGES

- Dispersion Budgeting: The provided calculation methodologies enable accurate determination of maximum link distances considering fiber type (G.652, G.653, or G.655).

- Attenuation Budget Analysis: The datasheet includes a comprehensive model for calculating total link loss, ensuring the transceiver's optical power budget is not exceeded.

- Interoperability: Full compliance with SFF-8431, SFF-8472, and IEEE 802.3ae 10GBASE-ER/EW standards ensures seamless operation with any MSA-compliant host hardware.

- Diagnostic Assurance: The integrated DDMI functionality allows for real-time troubleshooting of dispersion-related degradation via monitoring of error counts and signal strength.

SPECIFICATION MATRIX

Parameter	Specification
Data Rate	10.3125 Gbps (10GBASE-ER/EW)
Reach	40 km (with Dispersion Compensation)

Wavelength	1550 nm
Fiber Type	SMF (G.652)
Transmitter	EML/DFB Laser
Receiver	APD
Optical Power Budget	24 dB (Typical)
Receiver Sensitivity	-26 dBm (ER), -28 dBm (EW)
Dispersion Tolerance	1600 ps/nm (Max)
Power Consumption	< 1.5W
Connector	Duplex LC/UPC
Operating Temp. Range	COM: 0 to 70°C, EXT: -40 to 85°C

Parameter	**Specification**
Form Factor	SFP+ (Small Form-factor Pluggable Plus)
Maximum Link Length	40 km (Standard SMF)
Chromatic Dispersion Tolerance	1600 ps/nm
Power Supply Voltage	3.3V ± 5%
Total Dispersion (D*L) @ 40km	680 ps/nm (G.652)
PMD Coefficient	0.1 ps/√km (Max)

REGULATORY COMPLIANCE

This transceiver module is engineered to comply with the following safety and industry standards:

- Class 1 Laser Safety per IEC 60825-1 and FDA 21 CFR 1040.10/1040.11
- RoHS 2 (2011/65/EU) for restriction of hazardous substances
- REACH Regulation (EC) 1907/2006
- EMC Compliance: FCC Part 15, CE Mark, and VCCI Class A
- Telcordia GR-468-CORE for reliability and quality assurance
- MSA SFF-8431 for electrical interface, SFF-8472 for digital diagnostics.

