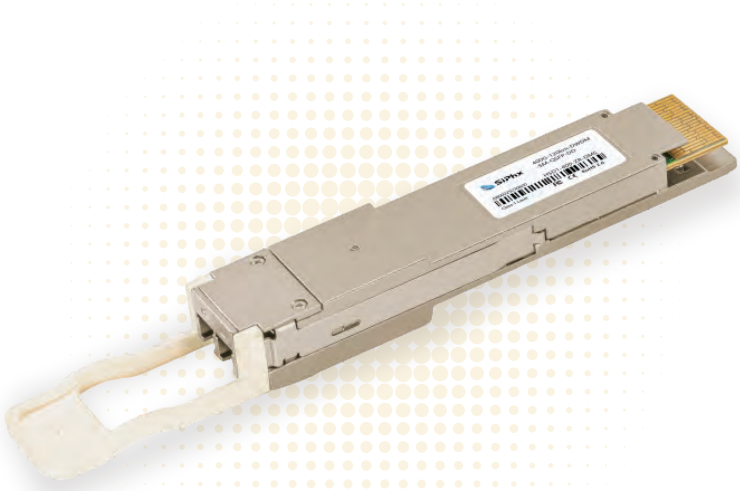
400G BASE-ZR Coherent QSFP-DD 80~120km LC SMF DOM Optical Transceiver Module P/N HSD1-400-ZR-DMS

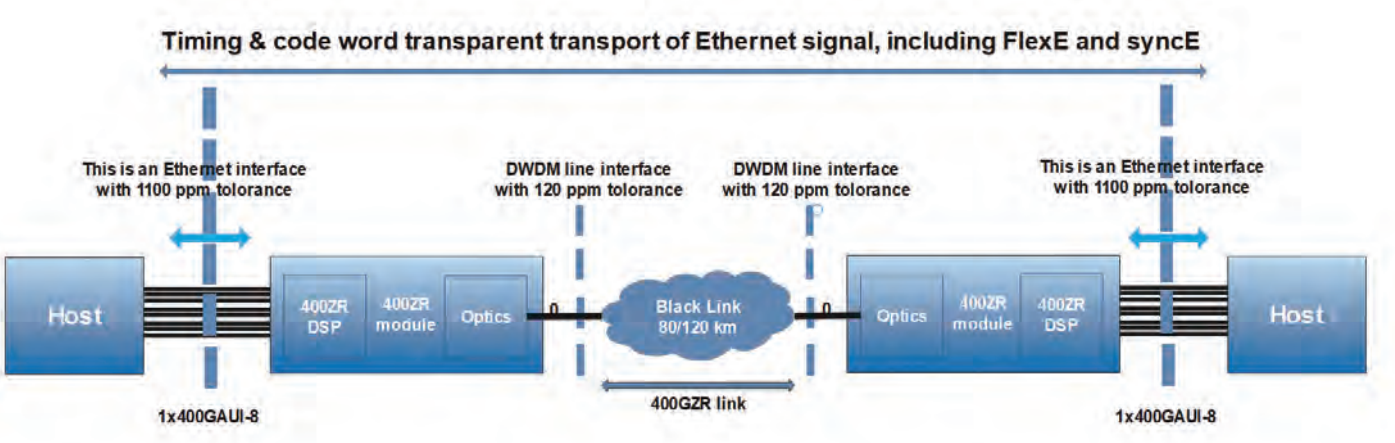


Product Features

QSFP-DD MSA compliant
Compliant with OIF 400ZR, version 01.0, March 10, 2020
Digital diagnostic monitoring support
Hot pluggable by 76-pin electrical interface
Maximum power consumption 16.5 W
400G 16QAM modulation
Compact size (18.4 mm x 93.4 mm x 8.5 mm)
LC duplex connector
400GBASE-R, 425 Gbps bit rate
400G-AUI-8 C2M: 8 x CEI-56G-VSR PAM-4 electrical interface
Operating case temperature: 0°C to 70°C
Single 3.3 V power supply
RoHS 2 compliant

Applications

The SiPhx HSD1-400-ZR-DMS transceiver is intended to be used in conjunction with a host platform to support 400G transmission over optical links in DCI applications, below is the reference diagram. HSD1-400-ZR-DMS is designed for 400ZR type 1 (code 0x01) in amplified applications and type 2 (code 0x02) in unamplified applications.



Three use cases of amplified point-to-point links are identified for 400ZR. For amplified links, the reach is dependent on the OSNR (noise limited) at the receiver. The 400ZR targeted reach for these applications is 80–120 km or longer.

Transceiver line card with 400ZR amplified point to point interface

Router/Switch line card with 400ZR DWDM interfaces

Transceiver line card with 400ZR DWDM interfaces

The following figure shows the example of an unamplified link, where the transmission distance depends on the transmit output power, input receiver sensitivity, and channel loss.

Router/Switch line card using 400ZR for an unamplified link

Product Description

The HSD1-400-ZR-DMS coherent module, compliant with the OIF 400ZR MSA and QSFP-DD MSA standards, is designed for DCI applications. The digital diagnostics function is available via an I2C interface, as specified by the QSFP-DD MSA.

The HSD1-400-ZR-DMS is a C-band 75G/100 GHz grid coherent optical module that combines coherent DSP ASIC functionality with best in class ultra-narrow line-width tunable lasers, high speed modulators and high responsively coherent receivers to deliver high performance at 400G 16QAM modulation formats (at 60G baud rate).

Mechanical dimensions, connectors, and footprint of HSD1-400-ZR-DMS conform to QSFP-DD MSA. The module is QSFP-DD type2 size (18.4 mm x 93.4 mm x 8.5 mm) and hot pluggable by a 76-pin connector. The maximum power consumption is 16.5 W and power supply voltage is +3.3 V.

The functional block diagram is shown as above.

Absolute Maximum Ratings

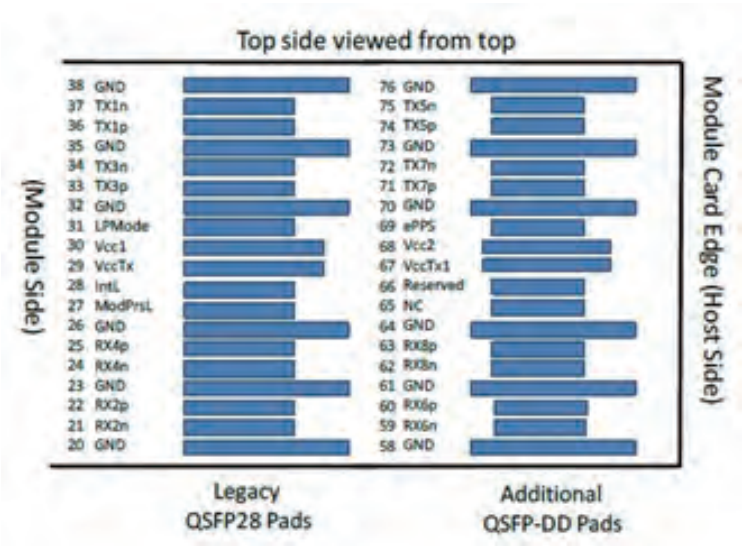
Parameter	Symbol	Min	Typ	Max	Unit	Note
Power supply voltage	Vcc	-0.3	3.3	3.6	V	
Storage temperature	Ts	-40		85	°C	
Relative humidity	RH	15		85	%	Non-condensing
Receiver damage threshold	PRdmg	3			dBm	

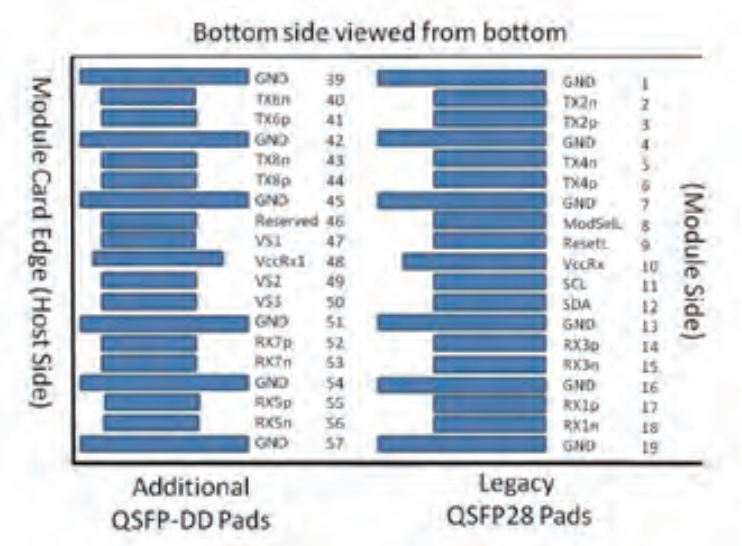
Absolute Maximum Ratings

Parameter		Symbol	Min	Typ	Max	Unit	Note
Supply voltage		Vcc	3.2	3.3	3.4	V	
Case temperature		Top	0		70	°C	
Supply current		Icc			5.2	A	Steady state
Power supply noise	DC-1 MHz	Vrip			2	%	
	1–10 MHz				3		
Module power consumption		Pcc			16.5	W	0-70°C and 3.2-3.4V

Electrical Input/Output

Pad	Logic	Symbol	Description	Notes
1		GND	Ground	1
2	CML-I	Tx2n	Transmitter Inverted Data Input	
3	CML-I	Tx2p	Transmitter Non-Inverted Data Input	
4		GND	Ground	1
5	CML-I	Tx4n	Transmitter Inverted Data Input	
6	CML-I	Tx4p	Transmitter Non-Inverted Data Input	
7		GND	Ground	1
8	LVTTL-I	ModSelL	Module Select	
9	LVTTL-I	ResetL	Module Reset	
10		VccRx	+3.3 V Power Supply Receiver	2
11	LVCMOS-I/O	SCL	2-wire serial interface clock	
12	LVCMOS-I/O	SDA	2-wire serial interface data	
13		GND	Ground	1
14	CML-O	Rx3p	Receiver Non-Inverted Data Output	
15	CML-O	Rx3n	Receiver Inverted Data Output	
16		GND	Ground	1
17	CML-O	Rx1p	Receiver Non-Inverted Data Output	
18	CML-O	Rx1n	Receiver Inverted Data Output	
19		GND	Ground	1
20		GND	Ground	1
21	CML-O	Rx2n	Receiver Inverted Data Output	
22	CML-O	Rx2p	Receiver Non-Inverted Data Output	
23		GND	Ground	1
24	CML-O	Rx4n	Receiver Inverted Data Output	
25	CML-O	Rx4p	Receiver Non-Inverted Data Output	
26		GND	Ground	1
27	LVTTL-O	ModPrsL	Module Present	
28	LVTTL-O	IntL	Interrupt	
29		VccTx	+3.3 V Power supply transmitter	2
30		Vcc1	+3.3 V Power supply	2
31	LVTTL-I	InitMode	Initialization mode; In legacy QSFP applications, the InitMode pad is called LPMODE	
32		GND	Ground	1
33	CML-I	Tx3p	Transmitter Non-Inverted Data Output	
34	CML-I	Tx3n	Transmitter Inverted Data Output	
35		GND	Ground	1
36	CML-I	Tx1p	Transmitter Non-Inverted Data Output	
37	CML-I	Tx1n	Transmitter Inverted Data Output	
38		GND	Ground	1
39		GND	Ground	1
40	CML-I	Tx6n	Transmitter Inverted Data Output	
41	CML-I	Tx6p	Transmitter Non-Inverted Data Output	
42		GND	Ground	1
43	CML-I	Tx8n	Transmitter Inverted Data Output	
44	CML-I	Tx8p	Transmitter Non-Inverted Data Output	
45		GND	Ground	1
46		Reserved	For future use	3
47		VS1	Module Vendor Specific 1	3
48		VccRx1	3.3 V Power Supply	2
49		VS2	Module Vendor Specific 2	3
50		VS3	Module Vendor Specific 3	3
51		GND	Ground	1
52	CML-O	Rx7p	Receiver Non-Inverted Data Output	
53	CML-O	Rx7n	Receiver Inverted Data Output	
54		GND	Ground	1
55	CML-O	Rx5p	Receiver Non-Inverted Data Output	
56	CML-O	Rx5n	Receiver Inverted Data Output	
57		GND	Ground	1
58		GND	Ground	1
59	CML-O	Rx6n	Receiver Inverted Data Output	
60	CML-O	Rx6p	Receiver Non-Inverted Data Output	
61		GND	Ground	1
62	CML-O	Rx8n	Receiver Inverted Data Output	
63	CML-O	Rx8p	Receiver Non-Inverted Data Output	
64		GND	Ground	1
65		NC	No Connect	3
66		Reserved	For future use	3
67		VccTx1	3.3 V Power Supply	2
68		Vcc2	3.3 V Power Supply	2
69		ePPS	Precision Time Protocol (PTP) reference clock input. It is not used	3
70		GND	Ground	1
71	CML-I	Tx7p	Transmitter Non-Inverted Data Input	
72	CML-I	Tx7n	Transmitter Inverted Data Input	
73		GND	Ground	1
74	CML-I	Tx5p	Transmitter Non-Inverted Data Input	
75	CML-I	Tx5n	Transmitter Inverted Data Input	
76		GND	Ground	1





1. QSFP-DD uses common ground (GND) for all signals and power supplies. All are common within the QSFP-DD module and all module voltages are referenced to this potential unless otherwise noted. Connect common ground directly to the host board signal-common ground plane.

2. VccRx, VccRx1, Vcc1, Vcc2, VccTx and VccTx1 shall be applied concurrently. Requirements defined for the host side of the host card edge connector are listed in Error! Reference source not found.. VccRx, VccRx1, Vcc1, Vcc2, VccTx and VccTx1 may be internally connected within the module in any combination. The connector Vcc pins are each rated for a maximum current of 1000 mA.

3. All Vendor Specific, Reserved and No Connect pins may be terminated with 50 ohms to ground on the host. Pad 65 (No Connect) shall be left unconnected within the module. Vendor

Low Speed Control and Sense Signals

Parameter	Symbol	Min	Max	Unit	Condition
SCL and SDA	V_{OL}	0	0.4	V	I_{OL} (max) = 3 mA for fast-mode, 20 mA for fast-mode plus
	V_{OH}	V_{cc}-0.5	V_{cc}+0.3	V	
	V_{IL}	-0.3	Vcc*0.3	V	
	V_{IH}	V_{cc}*0.7	V_{cc}+0.5	V	
Capacitance for SCL and SDA I/O signal	C_i		14	pF	
Total bus capacitive load for SCL and SDA	C_b		100	pF	For 400 kHz clock rate, use 3000 ohms pull-up resistor, max. For 1000 kHz clock rate, refer to **Error! Reference source not found.**.
			200	pF	For 400 kHz clock rate, use 1600 ohms pull-up resistor, max. For 1000 kHz clock rate, refer to **Error! Reference source not found.**.
InitMode, ResetL and ModSelL	V_{IL}	-0.3	0.8	V	
	V_{IH}	2	V_{cc}+0.3	V	
	$\|I_{in}\|$		360	uA	0 V < V_{in} < V_{cc}
IntL	V_{OL}	0	0.4	V	I_{OL} = 2.0 mA
	V_{OH}	V_{cc}-0.5	V_{cc}+0.3	V	10,000 ohms pull up to V_{cc} Host
ModPrsL	V_{OL}	0	0.4	V	IOL = 2.0 mA
	V_{OH}				ModPrsL can be implemented as a short-circuit to GND on the module.

High-Speed Electrical Specifications

The transmitter and receiver comply with the CEI-56G-VSR-PAM4 electrical specifications. The data lines are AC-coupled inside the module.

Parameter	Symbol	Min	Typ	Max	Unit	Note
400GAUI-8 Electrical Characteristics						
Transmitter						
Signaling rate, each lane			26.5625		GBd	PAM4
Differential voltage pk-pk	$V_{in,pp}$			880	mV	
Common mode voltage	V_{cm}	-0.3		2.8	V	
Common mode noise	RMS			17.5	mV	
Differential termination resistance mismatch				10	%	
Transition time	T_r/T_f	12			ps	20%–80%
Eye width at 10-6 probability	EW6	0.2			UI	
Eye height at at 10-6 probability	EH6	32			mV	
Eye linearity		0.85				
Receiver						
Signaling rate, each lane			26.5625		GBd	PAM4
Differential voltage pk-pk	$V_{out,pp}$			900	mV	
Transition time	T_r/T_f	9.5			ps	20%–80%
Near-end eye width at 10-6 probability	EW6	0.265			UI	
Near-end eye height at 10-6 probability	EH6	70			mV	
Far-end eye width at 10-6 probability	EW6	0.2			UI	
Far-end eye height at 10-6 probability	EH6	30			mV	
Near-end eye linearity		0.85				

Note: 400GAUI-8 electrical characteristics refer to CEI-56G-VSR-PAM4 of OIF-CEI-04.0

General Optical Specifications

Parameter	Default	Min	Max	Unit	Conditions/Comments
Channel frequency	193.7	191.3	196.1	THz	ITU-T grid. The frequency is fixed at 193.7 THz for unamplified link applications.
Channel spacing	100	100		GHz	ITU-T G694.1 section 6.
	75	75		GHz	ITU-T G694.1 section 6.
Fiber type	G.652				Single mode fiber. Specified for link budgeting purposes only.
Target reach		80		km	Amplified link – Noise limited

For channel spacing of 100 GHz on a fiber, the allowed channel frequencies (in THz) are defined by 193.1 + n x 0.1 where n is a positive or negative integer including 0. For 400ZR modules, n = 30 to –17 in steps of 1. The specified 48 x 100 GHz DWDM application channels are as defined below.

Index	n (from ITU-T G.694.1)	Frequency (THz)
1	30	196.100
2	29	196.000
3	28	195.900
⋮	⋮	⋮
46	-15	191.600
47	-16	191.500
48	-17	191.400

For channel spacing of 75 GHz or more on a fiber, the allowed channel frequencies (in THz) are defined by 193.1 + 3n x 0.025 where n is a positive or negative integer including 0. For 400ZR modules, 3n = 120 to –69. The reference 64 x 75 GHz DWDM application channels are defined as below.

Index	n (from ITU-T G.694.1)	Frequency (THz)
1	120	196.100
2	117	196.025
3	114	195.950
⋮	⋮	⋮
62	-63	191.525
63	-66	191.450
64	-69	191.375

Transmitter Optical Specifications

Parameter	Min	Typ	Max	Unit	Conditions/Comments
Transmitter frequency range	191.3	193.7	196.1	THz	ITU-T grid. Frequency range over which the specifications hold unless noted otherwise. The frequency is fixed at 193.7 THz for unamplified link applications.
Transmitter laser frequency stability	-1.8		1.8	GHz	Offset from channel frequency set point. The receiver LO has the same frequency accuracy.
Transmitter laser frequency stability	-1.8		1.8	GHz	Offset from channel frequency set point. The receiver LO has the same frequency accuracy.
Transmitter output power	-10		-6	dBm	Measured at optical connector.
Transmitter output power with TX disabled			-20	dBm	Max Output power with TX_DIS asserted
Transmitter output power during wavelength switching			-20	dBm	
Transmitter reflectance			-20	dB	Loss of power in the returned/reflected optical signal
Mean I-Q amplitude imbalance			1	dB	
Transmitter polarization dependent power			1.5	dB	Power difference between X and Y polarization

Receiver Optical Specifications

Parameter	Min	Max	Unit	Conditions/Comments
Frequency offset between RX and LO	-3.6	3.6	GHz	Acquisition Range
Input power range	-12	0	dBm	
Input sensitivity (amplified link application)	-12		dBm	
Input sensitivity (unamplified link application)	-20		dBm	For unamplified link applications, the minimum input power is –20 dBm @receiver OSNR tolerance ≥ 34 dB.
OSNR tolerance (amplified link application)		26	dB/0.1 nm	The OSNR tolerance is referenced to an optical bandwidth of 0.1 nm @193.7 THz or 12.5 GHz.
OSNR tolerance (unamplified link application)	34		dB/0.1 nm	The OSNR tolerance cannot be less than 34 dB for unamplified link applications.
Optical return loss	20		dB	Optical reflectance at connector input
CD Tolerance	2400		ps/nm	Tolerance to chromatic dispersion
Optical path power penalty		0.5	dB	OSNR penalty tolerance due to –35 dB interferometric crosstalk and 2400 ps/nm chromatic dispersion.
PMD tolerance	10		ps	Tolerance to PMD with ≤ 0.5 dB penalty to OSNR sensitivity. 10 ps of PMD corresponds to max 30 ps of DGD and max 500 ps2 of SOPMD
PDL tolerance (amplified link application)	3.5		dB	Tolerance to PDL with < 1.3 dB penalty to OSNR sensitivity When change in PSP is ≤ 1 rad/ms.
PDL tolerance (unamplified link application)	2.5		dB	The PDL tolerance is 2.5 dB in unamplified link application when the receiver OSNR sensitivity penalty is 0.8 dB.
Tolerance to change in SOP	50		krad/s	Tolerance to change in SOP with ≤ 0.5 dB penalty to OSNR sensitivity. Measurement relative to reference with 10 ps PMD and 2.5 dB PDL and SOP of < 1 rad/ms under the same conditions.
Optical input power transient tolerance	+/-2		dB	Tolerance to change in input power with ≤ 0.5 dB penalty to OSNR sensitivity. Received power is within –12 dBm to 0 dBm. Rise/fall times of power change defined by 20%–80% of 50 µs or slower.

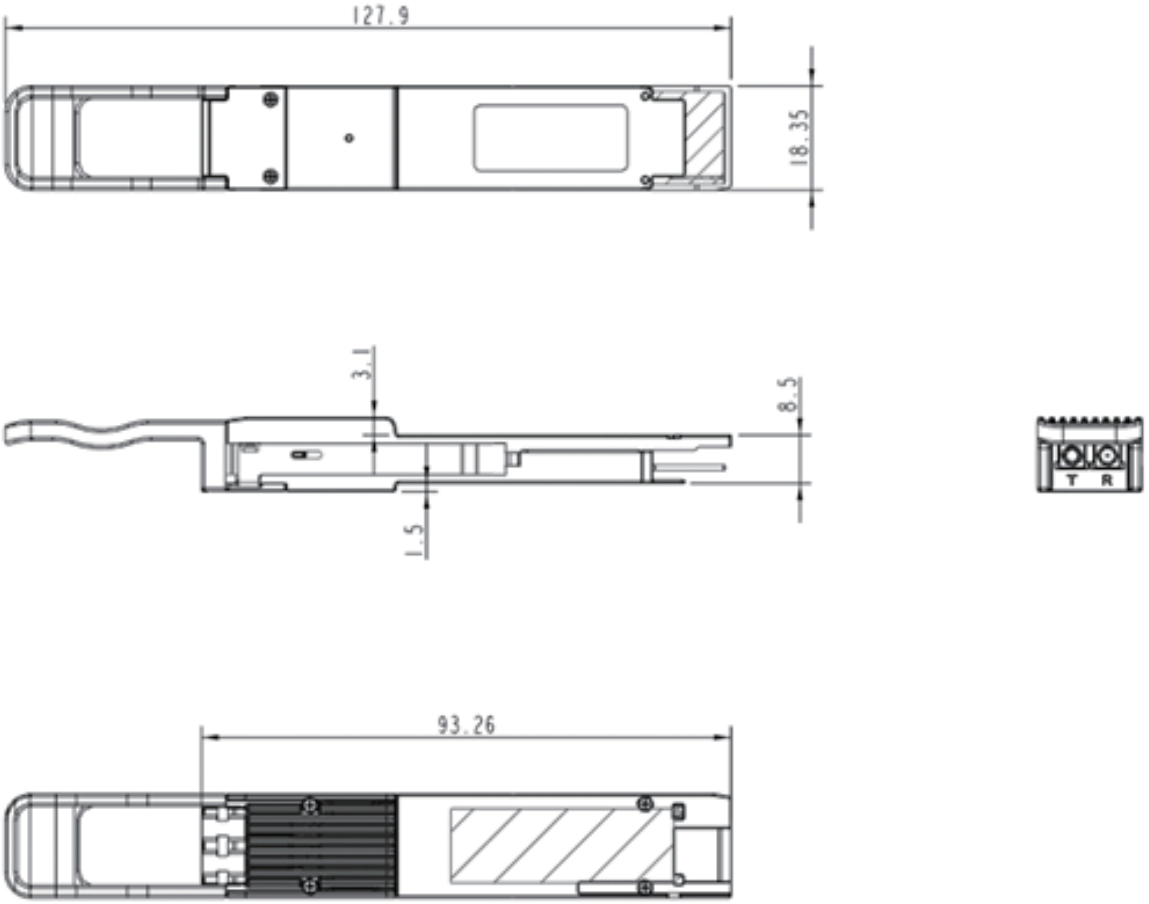
Transmitter Specifications

Parameter	Min	Max	Unit	Conditions/Comments
Transmitter laser disable time		100	ms	The maximum transmitter turn-off time from any condition that results in Tx_Disable == true to reach the Tx output power –20 dBm. Rx shall remain locked and thus LO must remain enabled.
Transmitter turn-up time from warm start		180	Sec	The maximum time from ModuleLowPwr to DataPathActivated state.
Transmitter turn-up time from cold start		200	Sec	The maximum time from deassertion of ResetS == false to DataPathActivated state while LoPwrS == false.
Transmitter wavelength switching time		180	Sec	The maximum time to change wavelengths including turn-up time.
Transmitter wavelength switching time		180	Sec	The maximum time to change wavelengths including turn-up time.
Output power monitor-Accuracy	-2	2	dB	Total output power measurement including all ASE contribution. Measurement accuracy does not contribute to allowable output power signal window

Receiver Specifications

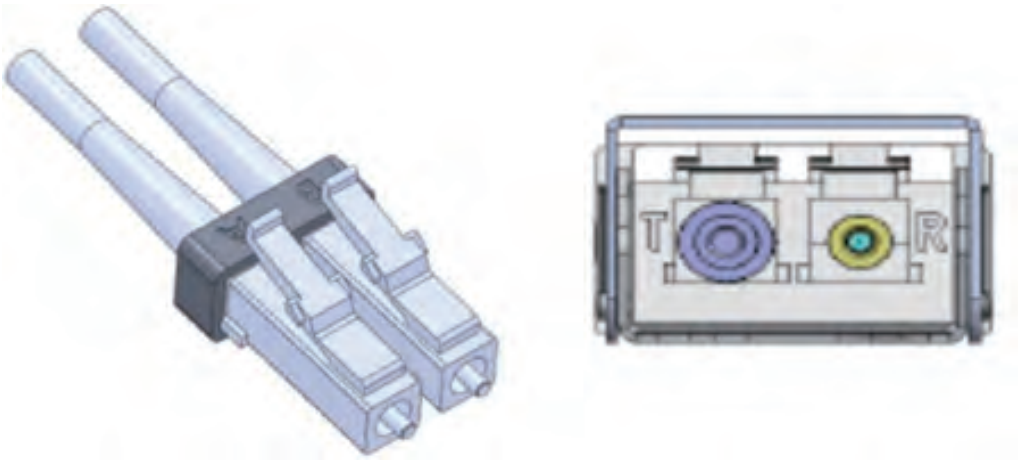
Parameter	Default	Min	Max	Unit	Conditions/Comments
Receiver turn-up time from warm start			10	Sec.	Upon Rx_LOS de-assert, Receiver has been turned up previously.
Receiver turn-up time from cold start			200	Sec.	From module reset, with valid optical input signal present.
Input total power monitor-Accuracy		-4	4	dB	Over the superset of input power, receiver sensitivity and the optical Rx_LOS assert threshold range.
Input channel power monitor - Accuracy		-4	4	dB	The module reports the channel power as received by the module.
Optical LOS assert threshold (amplified link application)	-18	-20	-16	dBm	Total power
Optical LOS assert threshold (unamplified link application)	-26	-28	-24	dBm	Total power
Optical LOS hysteresis		1	2.5	dBm	RX LOS cleared

Mechanical Dimensions



Optical Interface

The dual LC optical patch cord and module receptacle is specified in TIA-604-10 and shown below



Laser Safety

This is a Class 1 Laser Product as defined by IEC 60825-1:2014. When operated within the limits of this specification it is considered non-hazardous. Operating this product in a manner inconsistent with specifications and intended usage may result in hazardous radiation exposure.

Product Label

Ordering Information

Part No.	Data Rate	Wavelength	Max Distance	Case Temperature Range
HSD1-400-ZR-DMS	400Gbps	DWDM	120km	0°C to 70°C

Notice

SiPhx reserves the right to change the specifications of the products identified in this datasheet without prior notice. The applications described herein are for illustrative purposes only, and SiPhx does not guarantee that the identified products will be suitable for the described applications without further testing and/or modification.

Contact Information

株式会社サイフィックス

〒300-3257 茨城県つくば市筑穂1-14-2

029-886-6851

info@siphx.com

https://siphx.com

SiPhx, Inc.
1-14-2 TSUKUHO, TSUKUBA,
IBARAKI 300-3257,
Japan
info@siphx.com