

400G Base-FR4 QSFP-DD PAM4 1310nm 2km

SMF Optical Transceiver Module

P/N: HSD1-400-FR-C4S



Product Features

- Compliant to QSFP-DD MSA rev.5.0
- Compliant with 100G Lambda MSA
- 802.3cu compliant
- Compliant with 400GE FR4 specification
- Compliant with QSFP-DD CMIS4.0 management interface
- Non-hermetic package design
- Design incorporates 4 CWDM lanes MUX/DEMUX
- 8x53.125Gbits/s PAM4 electrical interface (400GAUI-8)
- Maximum power consumption 12W
- Duplex LC connector included
- Aggregate bit rate of 425 Gbit/sec
- Transmission up to 2km on single-mode fiber with FEC
- Single 3.3 V power supply required
- Compliant with RoHS 2

Applications

- 400G Ethernet
- Data center network

Product Description

The HSD1-400-FR-C4S is a transceiver module designed for 2km optical communication applications, and it complies with the 100G Lambda MSA standard. This module converts 8-channel 53.125 Gbit/s electrical data into 4-channel 106.25 Gbit/s optical signals, and multiplexes them into a single channel for 425 Gbit/s optical transmission. Similarly, on the receiver side, it optically de-multiplexes a 425 Gbit/s input into 4-channel signals and converts them into 8-channel output electrical data. The module has been designed to withstand harsh operating conditions, including temperature, humidity, and EMI interference. This module offers high functionality and feature integration, accessible via the I2C interface.



P/N	HSD1-400-FR-C4S
Form Factor	QSFP-DD
Wavelength	1271, 1291, 1311, 1331 nm
Connector	Duplex LC
Max Cable Distance	2km
Commercial Temperature Range	0°C~70°C

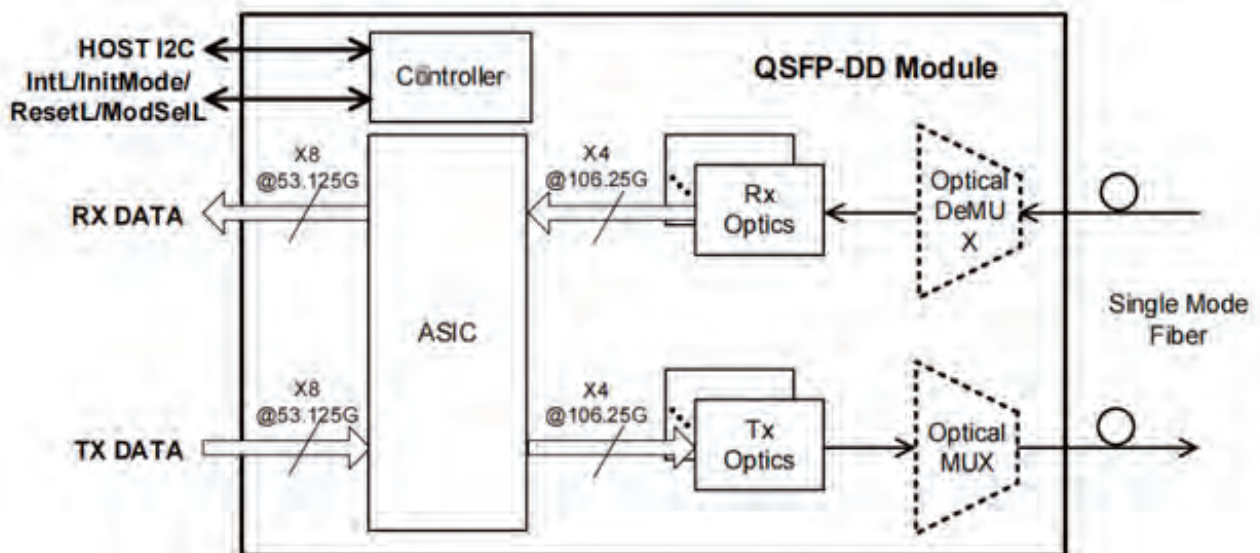


Figure 1 Transceiver block diagram

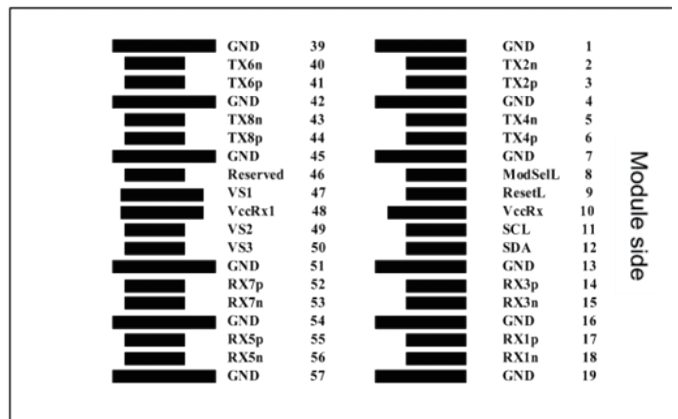
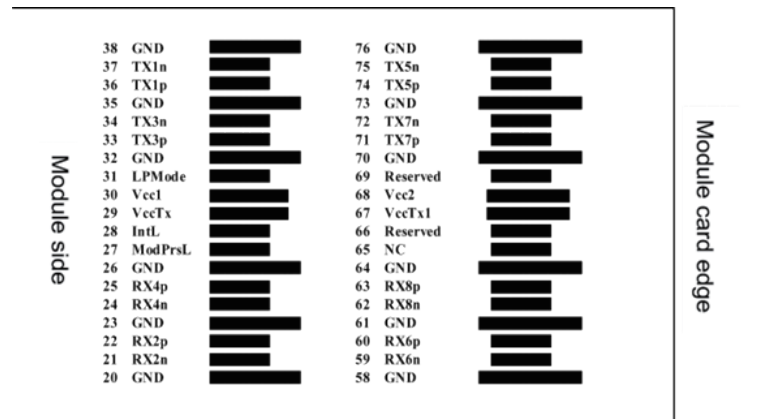
Pin Descriptions

Pin	Logic	Symbol	Description	Plug sequence	Notes
1		GND	Ground	1B	1
2	CML-I	Tx2n	Transmitter Inverted Data Input	3B	
3	CML-I	Tx2p	Transmitter Non-Inverted Data Input	3B	
4		GND	Ground	1B	1
5	CML-I	Tx4n	Transmitter Inverted Data Input	3B	
6	CML-I	Tx4p	Transmitter Non-Inverted Data Input	3B	
7		GND	Ground	1B	1
8	LVTTTL-I	ModSelL	Module Select	3B	
9	LVTTTL-I	ResetL	Module Reset	3B	
10		VccRx	+3.3 V Power Supply Receiver	2B	2
11	LVCNOS-I/O	SCL	2-wire Serial Interface Clock	3B	
12	LVCNOS-I/O	SDA	2-wire Serial Interface Data	3B	
13		GND	Ground	1B	1
14	CML-O	Rx3p	Receiver Non-Inverted Data Output	3B	
15	CML-O	Rx3n	Receiver Inverted Data Output	3B	
16		GND	Ground	1B	1
17	CML-O	Rx1p	Receiver Non-Inverted Data Output	3B	
18	CML-O	Rx1n	Receiver Inverted Data Output	3B	
19		GND	Ground	1B	1
20		GND	Ground	1B	1
21	CML-O	Rx2n	Receiver Inverted Data Output	3B	
22	CML-O	Rx2p	Receiver Non-Inverted Data Output	3B	
23		GND	Ground	1B	1
24	CML-O	Rx4n	Receiver Inverted Data Output	3B	
25	CML-O	Rx4p	Receiver Non-Inverted Data Output	3B	
26		GND	Ground	1B	1
27	LVTTTL-I	ModPrsL	Module Present	3B	
28	LVTTTL-I	IntL	Interrupt	3B	
29		VccTx	+3.3 V Power Supply Transmitter	2B	2
30		Vcc1	+3.3 V Power Supply	2B	2
31	LVTTTL-I	InitMode	Initialization Mode; In legacy QSFP applications, the InitMode pad is called LPMODE	3B	
32		GND	Ground	1B	1
33	CML-I	Tx3p	Transmitter Non-Inverted Data Input	3B	
34	CML-I	Tx3n	Transmitter Inverted Data Input	3B	
35		GND	Ground	1B	1
36	CML-I	Tx1p	Transmitter Non-Inverted Data Input	3B	
37	CML-I	Tx1n	Transmitter Inverted Data Input	3B	
38		GND	Ground	1B	1
39		GND	Ground	1A	1
40	CML-I	Tx6n	Transmitter Inverted Data Input	3A	
41	CML-I	Tx6p	Transmitter Non-Inverted Data Input	3A	
42		GND	Ground	1A	1
43	CML-I	Tx8n	Transmitter Inverted Data Input	3A	
44	CML-I	Tx8p	Transmitter Non-Inverted Data Input	3A	
45		GND	Ground	1A	1
46		Reserved	For future use	3A	3
47		VS1	Module Vendor Specific 1	3A	3

Pin Descriptions

48		VccRx1	+3.3 V Power supply	2A	2
49		VS2	Module Vendor Specific 2	3A	3
50		VS3	Module Vendor Specific 3	3A	3
51		GND	Ground	1A	1
52	CML-O	Rx7p	Receiver Non-Inverted Data Output	3A	
53	CML-O	Rx7n	Receiver Inverted Data Output	3A	
54		GND	Ground	1A	1
55	CML-O	Rx5p	Receiver Non-Inverted Data Output	3A	
56	CML-O	Rx5n	Receiver Inverted Data Output	3A	
57		GND	Ground	1A	1
58		GND	Ground	1A	1
59	CML-O	Rx6n	Receiver Inverted Data Output	3A	
60	CML-O	Rx6p	Receiver Non-Inverted Data Output	3A	
61		GND	Ground	1A	1
62	CML-O	Rx8n	Receiver Inverted Data Output	3A	
63	CML-O	Rx8p	Receiver Non-Inverted Data Output	3A	
64		GND	Ground	1A	1
65		NC	No Connect	3A	3
66		Reserved	For Future Use	3A	3
67		VccTx1	+3.3 V Power Supply	2A	2
68		Vcc2	+3.3 V Power Supply	2A	2
69		Re-served/(epps)	Precision Time Protocol (PTP) Reference Clock Input	3A	3
70		GND	Ground	1A	1

71	CML-I	Tx7p	Transmitter Non-Inverted Data Input	3A	
72	CML-I	Tx7n	Transmitter Inverted Data Input	3A	
73		GND	Ground	1A	1
74	CML-I	Tx5p	Transmitter Non-Inverted Data Input	3A	
75	CML-I	Tx5n	Transmitter Inverted Data Input	3A	
76		GND	Ground	1A	1



1. The QSFP-DD utilizes a common ground (GND) for all signals and power supply. This common ground is shared within the QSFP-DD module, and all module voltages are referenced to this potential unless stated otherwise. Please connect these directly to the host board's signal-common ground plane.

2. The VccRx, VccRx1, Vcc1, Vcc2, VccTx, and VccTx1 should be applied simultaneously. The requirements for the host side of the Host Card Edge Connector are listed in the table. VccRx, VccRx1, Vcc1, Vcc2, VccTx, and VccTx1 can be internally connected within the module in any combination. Each connector Vcc pin is rated for a maximum current of 1000 mA.

3. All Vendor Specific, Reserved, and No Connect pins can be terminated with 50 Ω to the ground on the host. Pad 65 (No Connect) should remain unconnected within the module. Vendor Specific and Reserved pads should have an impedance to GND that is greater than 10 kΩ and less than 100 pF.

4. The Plug Sequence specifies the mating sequence of the host connector and the module.

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit
Maximum supply voltage	Vcc	-0.3	3.3	3.6	V
Storage temperature	Ts	-40		85	°C
Relative humidity	RH	0		85	%

Operating Environments

The electrical and optical characteristics listed below are defined under the specified operating environment, unless otherwise noted. Please connect these directly to the host board's signal-common ground plane.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
Supply voltage	Vcc	3.135	3.3	3.465	V	
Case temperature	T	0		70	°C	
Data rate accuracy		-100		100	ppm	
Link distance		0.5		2000	m	1

1. G.652 Single-mode optical fiber.

Electrical Characteristics

Parameter	Min.	Typ.	Max.	Unit	Notes
Power dissipation			12	W	
Supply current			3.63	A	
Receiver (module input)					
Data rate, each lane	26.5625 ±100 ppm			GBd	
Overload differential voltage pk-pk	900			mV	
Common mode voltage	-350		2850	mV	
Differential termination resistance mismatch			10	%	At 1 MHz
Differential return loss (SDD11)	Equation (16-1)			dB	OIF-CEI-56G-VSR-PAM4
Common mode to differential mode conversion (SCD11)	Equation (16-2)			dB	OIF-CEI-56G-VSR-PAM4
Stressed input test	See OIF-CEI-56G-VSR-PAM4 Section 16.3.10.3				
Transmitter (module output)					
Data rate, each lane	26.5625 ±100 ppm			GBd	
Differential voltage, pk-pk			900	mV	
Common mode voltage (Vcm)	-350		2850	mV	
Common mode noise, RMS			17.5	mV	
Differential termination resistance mismatch			10	%	At 1 MHz
Differential return loss (SDD22)			Equation (16-1)	dB	
Common mode to differential mode conversion (SDC22)			Equation (16-3)	dB	
Common mode return loss (SCC22)			-2	dB	From 250 MHz to fb GHz
Transition time	9.5			ps	
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				

Optical Characteristics

Parameters	Unit	Min.	Typ.	Max.
Transmitter				
Data rate, each Lane	GBd	53.125 ±100 ppm		
Modulation format		PAM4		
Line wavelengths	nm	1264.5	1271	1277.5
		1284.5	1291	1297.5
		1304.5	1311	1317.5
		1324.5	1331	1337.5
Total average launch power	dBm			9.5
Average launch power, each lane	dBm	-3.3		3.5
Optical modulation amplitude (OMA), each lane	dBm	-0.2		3.7
Extinction ratio (ER)	dB	3.5		
Side-mode suppression ratio (SMSR)	dB	30		
Launch power in OMA minus TDECQ, each lane, for ER ≥ 4.5 dB	dB	-1.7		
Launch power in OMA minus TDECQ, each lane, for ER <4.5 dB	dBm	-1.6		
Transmitter and dispersion eye closure for PAM4, each Lane (TDECQ)	dB			3.4
Difference in launch power between any two lanes (OMA outer)	dB			4
RIN _{17.1OMA}	dB/Hz			-136
Optical return loss tolerance	dB			17.1
Transmitter reflectance	dB			-26
Average launch power of OFF transmitter, each Lane	dBm			-20

Receiver				
Data rate, each Lane	GBd	53.125 ±100 ppm		
Modulation format		PAM4		
Damage threshold, each lane	dBm	4.5		
Line wavelengths	nm	1264.5	1271	1277.5
		1284.5	1291	1297.5
		1304.5	1311	1317.5
		1324.5	1331	1337.5
Average receiver power, each lane	dBm	-7.3		3.5
Receiver power, each lane (OMA)	dBm			3.7
Difference in receiver power between any two lanes (OMA)	dB			4.1
Receiver sensitivity (OMA outer), each lane (max)	dBm	See Note		
LOS assert	dBm	-20		
LOS deassert	dBm			-8.6
LOS hysteresis	dB	0.5		
Receiver reflectance	dB			-26
Conditions of stressed receiver sensitivity				
Stressed eye closure for PAM4	dB	0.9		3.4
(SECQ), lane under test				
OMA outer of each aggressor lane	dBm		1.5	
Long term performance test				
BER FLOOR		1E - 6 @ -3.1 ~ 2 dBm		

Note:

The measurement is taken with a conformance test signal for a Bit Error Rate (BER) of 2.4×10^{-4} . A compliant receiver should have stressed receiver sensitivity (Optical Modulation Amplitude (OMA) outer) for each lane, with values below the mask depicted in Figure 3, for Stressed Eye Closure Quaternary

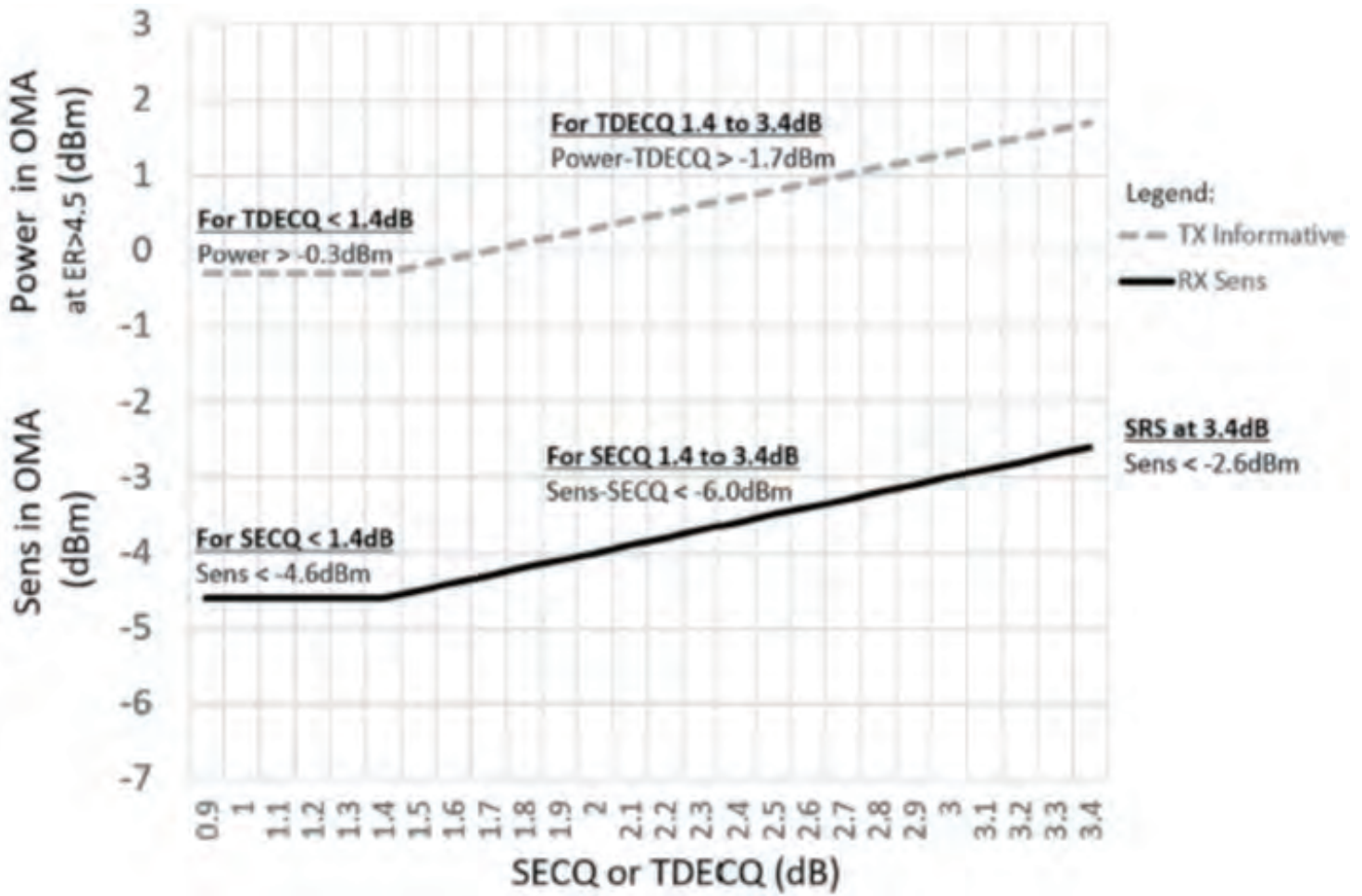


Figure 3 Stressed receiver sensitivity mask for 400GE-FR4(SECQ) values ranging between 0.9 and 3.4 dB.

Digital Diagnostic Monitoring Functions

The digital diagnostic monitoring interface (DDMI) is implemented using an I2C interface, in compliance with CMIS 4.0. The diagnostic management functions are executed and the data addresses are listed in the table below.

Performance item	Data address		
	Alarm & Warning	Alarm & Warning thresholds	Monitor
Module temperature	Lower page 9	Page2h (128-135)	Lower page (14-15)
Module voltage	Lower page 9	Page2h (136-143)	Lower page (16-17)
Bias current	Page11h (143-146)	Page2h (184-191)	Page11h (170-177)
Transmitter optical power	Page11h (139-142)	Page2h (176-183)	Page11h (154-161)
Receiver optical power	Page11h (149-152)	Page2h (192-199)	Page11h (186-193)

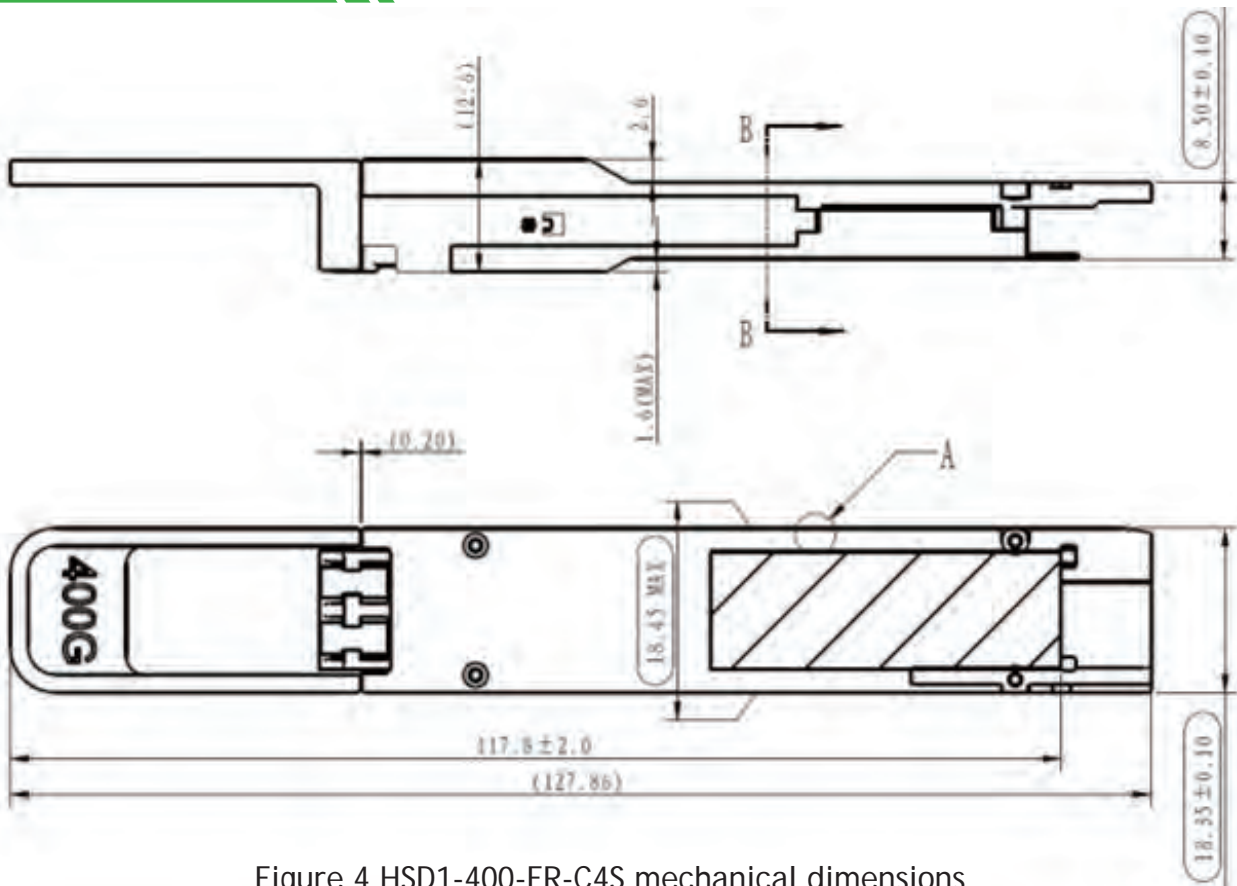
Mechanical Specifications


Figure 4 HSD1-400-FR-C4S mechanical dimensions

Regulatory Compliance

Feature	Agency	Standard	Performance
Safety	NRTL	UL 62368-1	NRTL recognized component for US and Canada
		CAN/CSA C22.2 No. 62368-1	
		IEC 60825-1	
		IEC 60825-2	
	TUV	EN 62368-1	TUV certificate
		EN 60825-1	
		EN 60825-2	
FDA	U.S. 21 CFR 1040.10 & 1040.11	FDA/CDRH certification has been obtained with an accession number according to Laser Notice 56.	
Electromagnetic Compatibility	Radiated emissions	EMC Directive 2014/30/EU EN 55032 CISPR 32 FCC rules 47 CFR Part 15 ICES-003 VCCI-CISPR 32 AS/NZS CISPR 32	This is a Class B digital device, tested with a metal enclosure, showing a minimum -6dB margin to the limit. The final margin may vary depending on the system application. Good system EMI design practice, such as a suitable metal enclosure and adequate bonding, is required to achieve Class B margins at the system level. The tested frequency range is 30 MHz to 40 GHz or 5th harmonic (5 times the highest frequency), whichever is less.
	ESD	EMC Directive 2014/30/EU EN 55035 CISPR 35 IEC/EN 61000-4-2	Withstands discharges of ± 8 kV contact, ± 15 kV air.
	Radiated immunity	EMC Directive 2014/30/EU EN 55035 CISPR 35 IEC/EN 61000-4-3	Field strength of 10 V/m from 80 MHz to 6 GHz.
Restriction of Hazardous Substances	RoHS	EU RoHS (2011/65/EU & (EU) 2015/863) & UK RoHS EN IEC 63000:2018 & BS EN IEC 63000:2018	

China RoHS hazardous substance table

产品满足中国 RoHS 的要求：

部件名称	产品中有害物质的名称及含量					
	镉	铅	汞	六价铬	多溴联苯	多溴二苯醚
机柜/插框	○	×	○	○	○	○
PCBA	○	×	○	○	○	○
辅料	○	×	○	○	○	○
配套设备	○	×	○	○	○	○

本表格依据 SJ/T 11364 的规定编制。

- ：表示该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。
- ×：表示该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。

ESD Warning

Standard ESD precautions must be taken while handling this module. The transceiver is shipped in ESD-protective packaging and should be removed from this packaging within an ESD-protected environment. This environment should include standard grounded benches, floor mats, and wrist straps.

Parameter	Threshold value	Notes
ESD of high-speed pins	1 KV	Human Body Model
ESD of low-speed pins	2 KV	Human Body Model
Air discharge during operation	15 KV	
Direct contact discharges to the case	8 KV	

Safety Specification Design

CAUTION

Do not look directly into the fiber end faces without using eye protection or an optical meter (such as a magnifier or microscope) within 100 mm, unless you have ensured that the laser output is disabled. When operating an optical meter, follow the operation requirements.

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

Attention - L'utilisation des commandes ou réglages ou l'exécution des procédures autres que celles spécifiées dans les présentes exigences peuvent être la cause d'une exposition à un rayonnement dangereux.

Ordering Information

Part number	Description
HSD1-400-FR-C4S	QSFP-DD-400GE-FR4

Product Label



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