400Gb/s QSFP-DD ZR Coherent Optical Transceiver

Features

- Compliant with QSFP-DD MSA, Type 2B package
- Up to120km transmission distance
- Client signal 400GbE or 4x100GbE
- Line Modulation format 400G DP-16QAM
- C-band tunable, supports 100/75GHz grid spacing, support 0.1GHz fine turning
- TX power -13dBm~-9dBm tunable
- Support ingress LF hold-off time configure
- Support hitless firmware upgrade
- Compact size (18.35 mm x 93.26 mm x 8.5 mm)
- Duplex LC connector
- Operating case temperature: 0°C to 75°C
- Maximum power consumption 18W (400GbE)
- Single 3.3 V power supply
- RoHS 2 compliant

Applications

- Edge DCI 400GBASE-ZR application
- 30~40Km unamplified 400GbE P2P link
- Up to 120Km P2P link with amplification

Compliance

- OIF-400ZR-02.0
- OIF-CMIS-05.2
- IA OIF-C-CMIS-01.2
- QSFP-DD-Hardware-Rev6.3
- IEEE Std 802.3-2018

Description

The 400G QSFP-DD ZR Transceiver is a high performance, cost effective module for optical data communication applications to 400G. The 400G QSFP-DD ZR is deigned to 400G 120Km DCI DWDM applications without inline chromatic dispersion compensation.

The 400G QSFP-DD ZR is a C-Band optical frequency tunable coherent optical module, combines 7nm 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 DP-16QAM modulation formats. With VOA inside the TX optical path, the out output optical is -13dBm~-9dBm Configurable.

The 400G QSFP-DD ZR coherent transceiver Compliant with the OIF QSFP-DD MSA. Digital diagnostics functions are available via an I2C interface as specified by the QSFP-DD MSA. Mechanical dimensions, connectors and footprint conform to QSFP-DD MSA. The module is 18.35 mm x 93.26 mm x 8.5 mm in size and hot pluggable by 76 PIN PAD and host connector.

Absolute Maximum Ratings

Table1-Absolute Maximum Ratings

Parameter	Symbols	Min.	Typical	Max	Unit	Note
Storage Temperature	Ts	-40		85	℃	
Power Supply	Vcc	-0.3	3.3	3.6	V	not damaged
Relative Humidity	RH	5		85	%	Non-condensing
Receiver damage threshold	PRdmg	10			dBm	Total optical power
ESD Sensitivity				1000	V	

Recommended Operating Conditions

Table2-Recommended Operating Conditions

Parameter	Symbols	Min.	Typical	Max.	Unit	Note
Operating Case Temperature	Top	0		+75	℃	
Power Supply Voltage	Vcc	3.135	3.3	3.465	V	
	Icc			6.1	A	Note1
Maximum sustained peak Current(＜500ms)				6.3	A	
Maximum Instantaneous peak current(＜50us)				7.6	A	
Electro-Static discharge	ESD			1000	V	
Power Consumption(400ZR+)	P_D			18	W	Note1
Relative humidity	RH	15		85	%	
Client Mode	1 x 400GAUI-8 (OIF-400ZR-02.0) 4 x 100GAUI-2					

Transmission Distance			80	120	km	30~40Km unamplified P2P link
Power Supply Noise	Vrip			1%	DC-1M Hz	
				2%	1-10M Hz	

Notes:

[1] Maximum power consumption is 18W in 400GbE mode. In 4×100GbE mode , the maximum power consumption will be 19W， and the current will also change accordingly.

Optical, Electrical Characteristic

Table3-Transmitter Operating Characteristic-Optical， Electrical

Parameter	Unit	Min.	Type	Max.	Notes
Modulation format		ZR400-CFEC-16QAM			CFEC FEC, NCG 10.8dB SFF-8024 Media ID 3Eh/3Fh
Baud Rate		59.843750000±20ppm			
Transmitter frequency range	THz	191.3		196.1	OIF 400ZR app code 0x01/03
	THz		193.7		OIF 400ZR app code 0x02, fixed wavelength
Flexible DWDM Grid	GHz	3.125			OIF 400ZR app code 0x01/03
Frequency Fine Tuning range	GHz	-5		5	bright tuning, OIF 400ZRapp code 0x01/03
Frequency Fine Tuning step	GHz	0.1			OIF 400ZR app code 0x01/03
Laser frequency accuracy	GHz	-1.8		1.8	
TX spectral Upper Mask	(GHz,dB)			(30.0, 0.0) (37.0,-10.0) (39.2,-15.0) (40.4,-20.0)	Refer to OIF-400ZR-02.0 13.3.201a
TX spectral Lower Mask	(GHz,dB)	(30.0,-9.0) (31.3,-20.0) (31.3,-35.0)			Refer to OIF-400ZR-02.0 13.3.201b
Transmitter laser disable time	ms			100	
Transmitter wavelength switching time	s			60	
Transmitter laser enable time	s			10	
Tx output power(at Program Output Power Max)	dBm	-10		-6	At Programmed Output Power Max, transmit output power over wavelength, temperature, and aging.

					0x01/03 – 400ZR,DWDM amplified
	dBm	-9		-6	193.7THz, 0x02 – 400ZR,Single wavelength,Unamplified
Transmit Output Power Adjustable Range	dBm	-13		-9	The absolute accuracy is ±1dB OIF 400ZR app code 0x01/03
Transmit Output Power Adjust step	dB	0.1			OIF 400ZR app code 0x01/03
Optical power setting accuracy	dB	-1		1	Diff between setting and reporting
Output power monitor accuracy	dB	-1		1	
Power stability	dB	-0.5		0.5	At fixed wavelength, room temp
		-1		1	At fixed wavelength, environment temp
Total output power with Tx disabled	dBm			-20	
Total output power during wavelength switching	dBm			-20	
Transmitter reflectance	dB			-20	Looking into the Tx
Inband (IB) OSNR	dB	40			
Out-of-band (OOB) OSNR	dB	35			
Lorentzian line width	kHz			300	Tx and LO
Relative intensity noise	dB/Hz			-140	
Mean I-Q amplitude imbalance	dB			1	
Transmitter polarization dependent power	dB			1.5	
DC I-Q offset (mean perpolarization)	dB			-26	
I-Q instantaneous offset	dB			-20	

Receiver Operating Characteristic-Optical

Table4-Receiver Operating Characteristic-Optical

Parameter	Unit	Min.	Type	Max.	Notes
Modulation format		ZR400-CFEC-16QAM			CFEC FEC, Net Coding Gain(NCG) 10.8dB
Baud Rate		59.843750000±20ppm			
Frequency offset between received carrier and LO	GHz	-3.6		3.6	
Input power range	dBm	-12		0	Signal power of the channel for the 26dB OSNR tolerance 0x01 – 400ZR,DWDM amplified
	dBm	-20		0	

OSNR Tolerance	dB/0.1nm			26	Measured back-to-back with short optical channel
RX sensitivity	dBm	-20			Inband (IB) OSNR ≥34dB
non-damaging input power	dBm			10	Total power
Optical input power monitor accuracy	dB	-2		2	
MAX Pre-FEC BER		0.01		0.0125	
Chromatic dispersion tolerance	ps/nm			2400	OSNR penalty < 0.5dB, when change in SOP is < 1 rad/ms
CD monitor accuracy	ps/nm	-200		200	
Average PMD(DGD) tolerance	ps	10(33)			OSNR penalty<0.5dB
DGD monitor accuracy	ps	-15		15	0~40ps
Peak PDL tolerance	dB			3.5	Tolerance to peak PDL with < 1.8 dB penalty to OSNR tolerance (13.3.330) when change in SOP is < =1 rad/ms.Test configuration: PDL emulator applied before noise loading.
Tolerance to change in SOP	krad/s	50			With ≤ 0.5 dB OSNR penalty
Optical return loss	dB	20			Optical reflectance at Rx connector input.
Optical Rx_LOS Assert Threshold	dBm	-28	-26	-24	OIF 400ZR app code 0x01, 0x02, 0x03
Optical Rx_LOS Hysteresis	dB	1	1.5	2.5	
Optical input power transient tolerance	dB	-2		2	Tolerance to change in input power with < 0.5 dB penalty to OSNR tolerance. The 20% to 80% rise/fall times for the input power change shall be no faster than 50 μs.
Service recovery time	ms			40	

The transmitter and receiver comply with the 400GAUI-8 C2M and CEI-56G-VSR-PAM4 electrical specification, electrical interface definitions refer to IEEE Std 802.3-2018 Annex 120E. The data lines are AC-coupled and terminated in the module per the following figure from the QSFP-DD MSA.

Operating Characteristic-Electrical highspeed

Table5-Operating Characteristic-Electrical highspeed

Parameter	Symbols	Min.	Max.	Unit	Notes
400GAUI-8 C2M and 100GAUI-2 C2M Electrical Characteristics					
Transmitter(module output)					
Signaling Rate, each lane		26.5625 ± 100 ppm		GBd	PAM-4
AC common-mode output voltage (RMS)	RMS		17.5	mV	
Differential Voltage pk-pk	Vin, pp	750	900	mV	
Near-end ESMW (Eye symmetry mask width)		0.265		UI	
Near-end Eye height, differential		70		mV	
Far-end ESMW		0.2		UI	
Far-end Eye height， differential		30		mV	
Far-end pre-cursor ISI ratio		-4.5	2.5	%	
Differential output return loss		Equation (83E-2)			IEEE Std 802.3-2018 Annex 120E
Common to differential mode conversion return loss		Equation (83E-3)			IEEE Std 802.3-2018 Annex 120E
Differential termination mismatch			10	%	At 1 MHz
Transition time(20% to 80%)	Trise/Tfall	9.5		Ps	20% to 80%
DC common mode voltage	Vcm	-350	2850	mV	
Receiver (module input)					
Signaling rate per lane		26.5625 ± 100 ppm		GBd	PAM-4
Differential pk-pk input voltage tolerance	Vout, pp	900		mV	
Differential input return loss (min)		Equation (83E–5)			IEEE Std 802.3-2018 Annex 120E
Differential to common-mode input return loss (min)		Equation (83E–6)			IEEE Std 802.3-2018Annex 120E
Differential termination mismatch			10	%	
Module stressed input test		See 120E.3.4.1			IEEE Std 802.3-2018Annex 120E
Single-ended voltage tolerance range (min)		-0.4	3.3	V	
DC common mode voltage(min)		-350	2850	mV	

Operating Characteristic-Electrical Lowspeed

Table6-Operating Characteristic-Electrical lowspeed

Parameter	Symbols	Min.	Max.	Unit	Notes
SCL and SDA	VOL	0	0.4	V	IOL(max)=3mA for fast mode, 20ma for Fast-mode plus
	VOH	Vcc-0.5	Vcc+0.3	V	
SCL and SDA	VIL	-0.3	Vcc*0.3	V	

	VIH	VCC*0.7	Vcc+0.5	V	
Capacitance for SCL and SDA I/O signal	Ci		14	pF	
Total bus capacitive load for SCL and SDA	Cb		100	pF	For 400kHz clock rate, use 3.0 k Ohms pull up resistor max. For 1000kHz clock rate, refer to Figure 45 (QSFP-DD-Hardware-rev5p0)
			200	pF	For 400kHz clock rate, use 1.6 k Ohms pull up resistor max. For 1000kHz clock rate, refer to Figure 45 (QSFP-DD-Hardware-rev5p0)
InitMode, ResetL and ModSelL IntL	VIL	-0.3	0.8	V	
	VIH	2	VCC+0.3	V	
	|Iin|		360	uA	0V＜Vin＜Vcc
	VOL	0	0.4	V	IOL=2.0mA
	VOH	VCC-0.5	VCC+0.3	V	10k ohms pull up to Host Vcc
ModPrsL	VOL	0	0.4	V	IOL=2.0mA
	VOH				ModPrsL can be implemented as a short-circuit to GND on the module

Digital Diagnostic Functions

Table7-Digital Diagnostic Functions

Parameter	Symbols	Min	Max	Unit	Notes
Temperature monitor absolute error	DMI_Temp	-3	3	℃	Over operating temp
TX power monitor absolute error	DMI_TX	-1/-1.5	1/1.5	dB	-15 ~ -9 dBm
RX power monitor absolute error	DMI_RX	-1.5/-2	1.5/2	dB	±1.5dB @ (-12 ~ 0) dBm ±2dB @ (-18 ~ 0) dBm
Supply voltage monitor absolute error	DMI_VCC	-3	3	%	
Bias current monitor absolute error	DMI_Ibias	-10	10	%	
No-power monitor RX		-40		dBm	
Tx_disable power monitor		-40		dBm	

Control and Status I/O Timing Characteristics

Table8-Control and Status I/O Timing Characteristics

Parameter	Symbols	Min	Max	Unit	Notes
MgmtInitDuration	Max MgmtInit		2000	ms	Note1
ResetL Assert Time	t_reset_init	10		us	Note2
IntL Assert Time	ton_IntL		200	ms	Note3
IntL Deassert Time	toff_IntL		500	us	Note4
Rx LOS Assert Time	ton_los		100	ms	Note5
Rx LOS Assert Time (optional fast	ton_losf		10	ms	Note6

mode)					
Rx LOS Deassert Time	toff_los		100	ms	
Tx Fault Assert Time	ton_Txfault		200	ms	Note7
Flag Assert Time	ton_flag		200	ms	Note8
Mask Assert Time	ton_mask		100	ms	Note9
Mask Deassert Time	toff_mask		100	ms	Note10
High power up state			180	s	
Software TX disable assert time			100	ms	
Software TX disable de-assert time			10	s	

Notes:

[1] Time from power on, hot plug or rising edge of reset until completion of the MgmtInit State

[2] Minimum pulse time on the ResetL signal to initiate a module reset

[3] Time from occurrence of condition triggering IntL until Vout:IntL=Vol

[4] Time from clear on read operation of associated flag until Vout:IntL=Voh. This includes deassert times for RxLOS,Tx Fault and other flag bits

[5] Time from Rx LOS condition present to Rx LOS bit set (value = 1b) and IntL asserted

[6] Time from Rx LOS state to Rx LOS bit set (value = 1b) and IntL asserted

[7] Time from Tx Fault state to Tx Fault bit set (value=1b) and IntL asserted

[8] Time from occurrence of condition triggering flag to associated flag bit set (value=1b) and IntL asserted

[9] Time from mask bit set (value=1b) until associated IntL assertion is inhibited

[10] Time from mask bit cleared (value=0b) until associated IntL operation resumes

IIC 2-wire specification

Table9-IIC 2-wire specification

Parameter	Symbols	Fast Mode(400 KHz)		Fast Mode Plus (1 MHz)		Unit	Conditions
		Min	Max	Min	Max		
Clock Frequency	fSCL	0	400	0	1000	KHz	
Clock Pulse Width Low	tLOW	1.3		0.5		μs	
Clock Pulse Width High	tHIGH	0.6		0.26		μs	
Time bus free before new transmission can start	tBUF	20		1		μs	Between STOP and START and between ACK and ReStart
START Hold Time	tHD.STA	0.6		0.26		μs	The delay required between SDA becoming low and SCL starting to go low in a START
START Setup Time	tSU.STA	0.6		0.26		μs	The delay required between SCL becoming high and SDA starting to go low in a START
Data In Hold Time	tHD.DAT	0		0		μs	
Data In Setup Time	tSU.DAT	0.1		0.1		μs	
Input Rise Time	tR		300		120	ns	From (VIL,MAX=0.3*Vcc)

							to (VIH, MIN=0.7*Vcc)
Input Fall Time	tF		300		120	ns	From (VIH,MIN=0.7*Vcc) to (VIL,MAX=0.3*Vcc)
STOP Setup Time	tSU.STO	0.6		0.6		μs	
STOP Hold Time	tHD.STO	0.6		0.26		μs	
Aborted sequence -bus release	Deselect_Abort	2		2		ms	Delay from a host de-asserting ModSelL (at any point in a bus sequence) to the QSFP-DD module releasing SCL and SDA
ModSelL Setup Time1	tSU.ModSelL	2		2		ms	ModSelL Setup Time is the setup time on the select lines before the start of a host initiated serial bus sequence.
ModSelL Hold Time1	tHD.ModSelL	2		2		ms	ModSelL Hold Time is the delay from completion of a serial bus sequence to changes of module Select status.
Serial Interface Clock Holdoff "Clock Stretching"	T_clock_hold		500		500	μs	Maximum time the QSFP-DD module may hold the SCL line low before continuing with a read or write operation
Complete Single Sequential Write	tWR		40		40	ms	Complete (up to) 4 Byte Write
Endurance (Write Cycles)		50k			50k	cycles	Module Case Temperature =75℃
Note 1: When the host has determined that module is QSFP-DD, the management registers can be read to determine alternate supported ModSelL set up and hold times.							

Pin-out Definitions

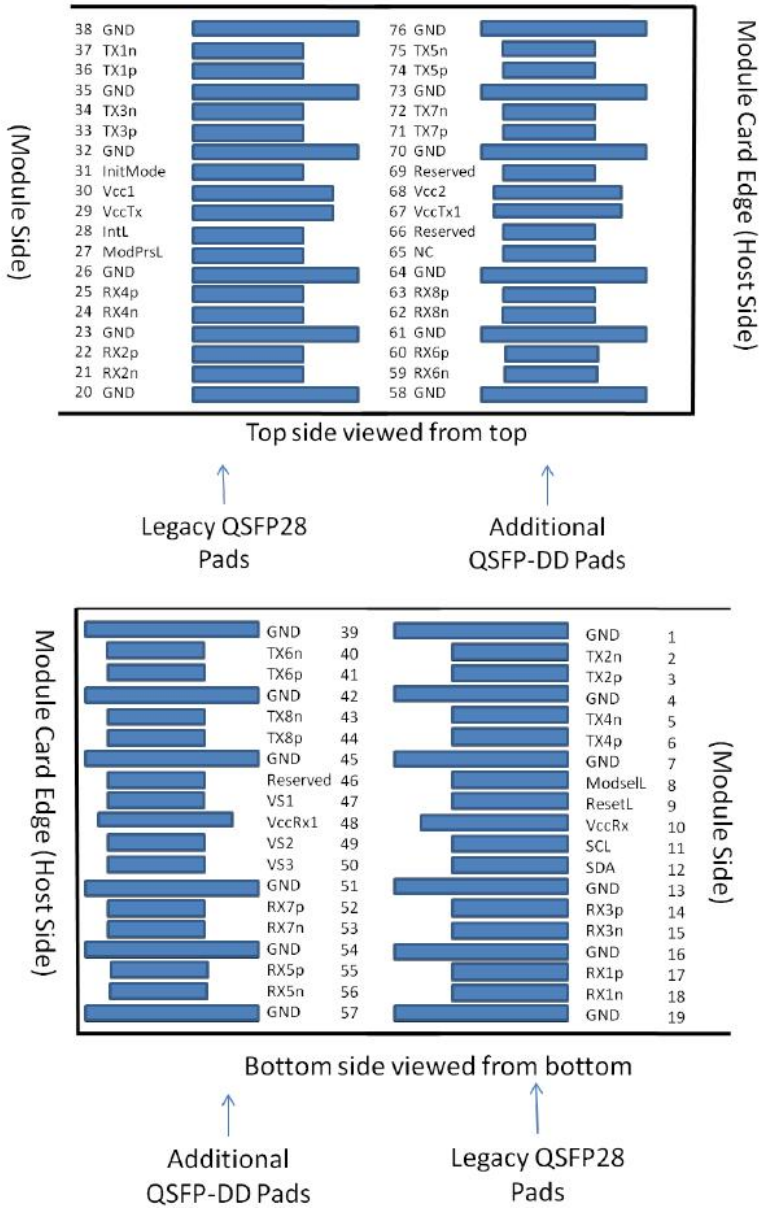

Figure 1 Pin view

Pin Function Definitions

Table10-Pin Function Definitions

Pin	Logic	Symbol	Description	Plug Sequence4	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	LVTTL-I	ModSelL	Module Select	3B	
9	LVTTL-I	ResetL	Module Reset	3B	
10		Vcc Rx	+3.3V Power Supply Receiver	2B	2
11	LVCMOS-I/O	SCL	2-wire serial interface clock	3B	
12	LVCMOS-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	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	LVTTL-O	ModPrsL	Module Present	3B	
28	LVTTL-O	IntL/RxLOSL	Interrupt. Optionally configurable as RxLOSL via the management interface (SFF-8636)	3B	
29		VccTx	+3.3V Power supply transmitter	2B	2
30		Vcc1	+3.3V Power supply	2B	2
31	LVTTL-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
48		VccRx1	3.3V 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	3.3V Power Supply	2A	2
68		Vcc2	3.3V Power Supply	2A	2
69		Reserved	For future Use	3A	3
70		GND	Ground	1A	
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

Notes:

[1] QSFP-DD uses common ground (GND)for all signals and supply (power). All are common within the QSFP-DD module and all module voltages are referenced to this potential unless otherwise noted. Connect these 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. 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 1500 mA.

[3] All Vendor Specific, Reserved and No Connect pins may be terminated with 50ohms to ground on the host. Pad 65 (No Connect) shall be left unconnected within the module. Vendor specific and Reserved pads shall have an impedance to GND that is greater than 10K ohms and less than 100pF.

Transceiver Block Diagram

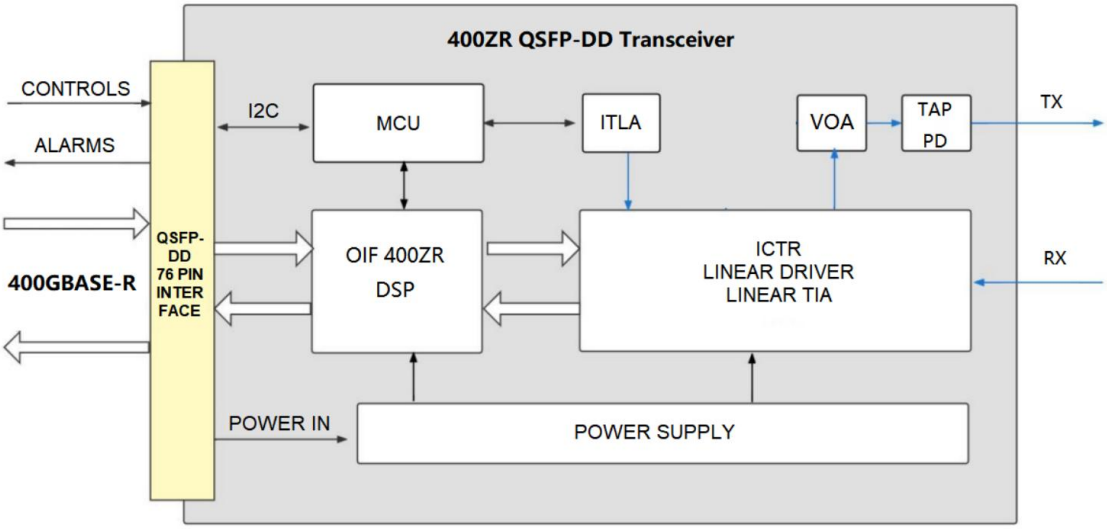

Figure 2 Transceiver Block Diagram

Recommended Interface Circuit

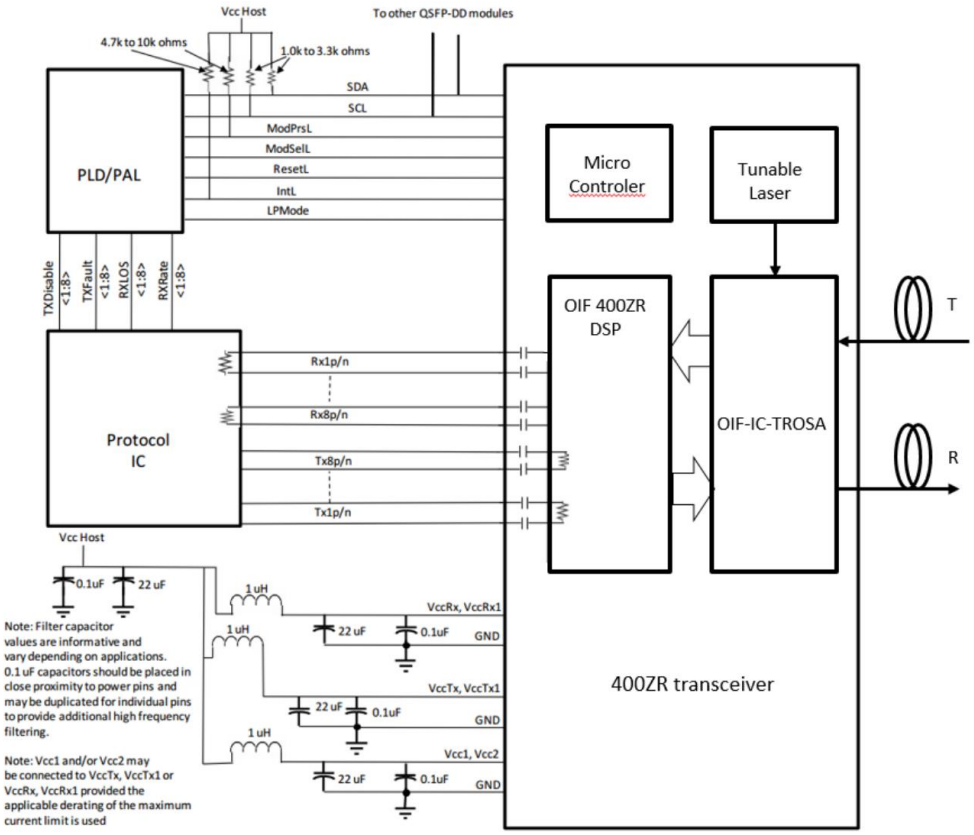

Figure 3 Recommended Interface Circuit

Dimensions

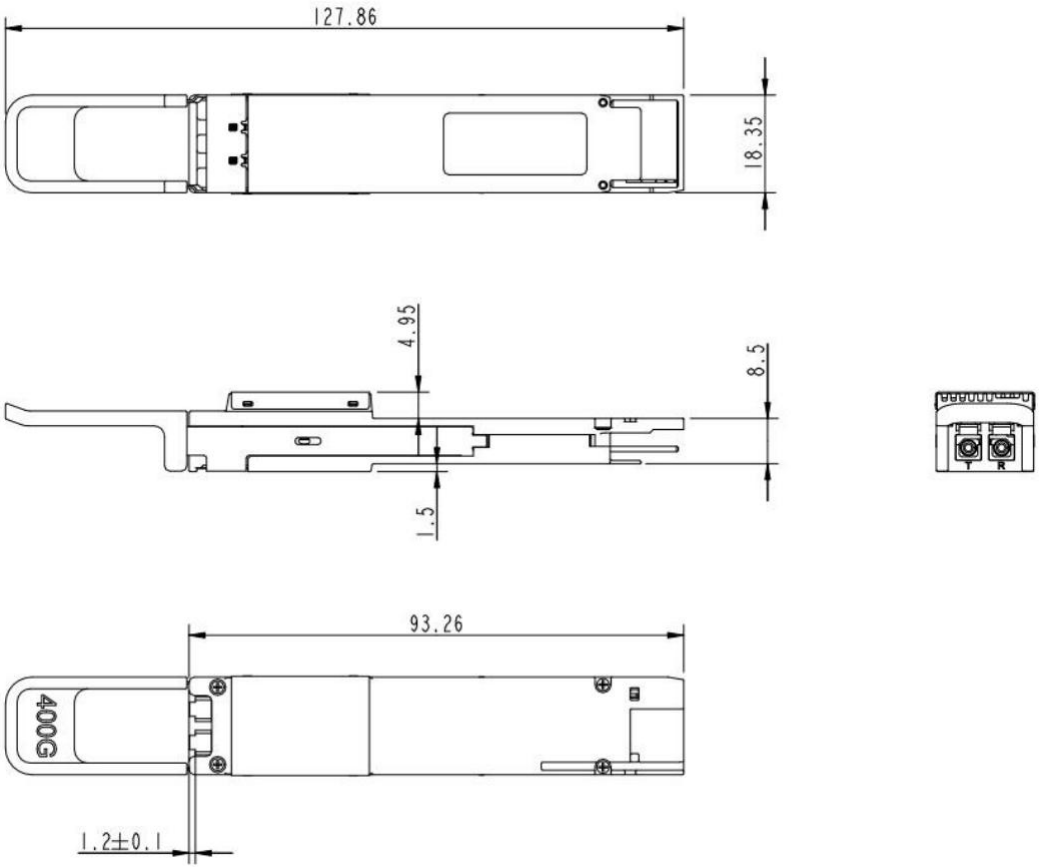

Figure4 Dimensions

EEPROM Information

Table11-Absolute Maximum Ratings

Parameter	Unit	threshold	Description
Temp low warning	℃	0	Min. case temperature
Temp high warning	℃	75	Max. case temperature
Voltage low warning	V	3.135	-5% Vcc target
Voltage high warning	V	3.465	+5% Vcc target
Tx power low warning	dBm	-15	OIF 400ZR app code 0x01/03
		-9	OIF 400ZR app code 0x02
Tx power high warning	dBm	-6	
Rx power low warning	dBm	-22	
Rx power high warning	dBm	2	
laser temp low warning	℃	0	

laser temp high warning	℃	70	
Temp low alarm	℃	-10	
Temp high alarm	℃	85	
Voltage low alarm	V	2.97	
Voltage high alarm	V	3.63	
Tx power low alarm	dBm	-18	OIF 400ZR app code 0x01/03
		-12	OIF 400ZR app code 0x02
Tx power high alarm	dBm	-4	
Rx power low alarm	dBm	-24	
Rx power high alarm	dBm	6	
Optional laser temp low alarm	℃	-10	
Optional laser temp high alarm	℃	80	

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