400G CFP2-DCO Coherent Transceiver
P/N: HSC2-400-LH-DMS

Product Features

- Compliant with CFP2 MSA
- Compliant with Open ZR+ MSA, OIF 400ZR MSA, support OFEC and CFEC FEC
- Line rate 100G/200G/300G/400G
- Client rate 1/2/3/4x100GbE or 1x400GbE
- C-band tunable, supports 100/75/50GHz grid spacing, support 0.1GHz fine turning
- EDFA inside, High output Power, max TX power +4dBm at 193.7THz, +1dBm at C-band
- TX VOA inside, output power -10~1dBm tunable
- Duplex LC connector
- Operating case temperature: 0C to 70°C
- Single 3.3 V power supply
- Typ power consumption: 22W (400G ZR)/24W(400G ZR+)/26W(400G MR)
- RoHS 2 compliant

Applications

- Edge DCI with extended Reach or with OLP protection
- WDM Over Metro or Long Haul DWDM
- Up to 80Km ~ 800km at 400G mode

Compliance

- **Open ZR+ MSA 2.0 and OIF-400ZR-02.0**
- **IEEE Std 802.3-2018**

Product Description

The SiPhx 400G CFP2-DCO ProTransceiver is a high performance, high output power, cost effective module for optical data communication applications from 100G to 400G. The 400G CFP2-DCO Pro is deigned to 100G/200G long haul and 400G Metro IP over DWDM applications without inline chromatic dispersion compensation.

The 400G CFP2 Pro 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 100G DP-QPSK/ 200G DP-QPSK 400G DP-16QAM modulation format. With EDFA and VOA inside the TX optical path the output optical power is -10~5 dBm tunable, at the 400G Gray Light mode (193.7THz) the output power is 4dBm.

The 400G CFP2-DCO Pro coherent transceiver Compliant with the OIF CFP2 MSA. Digital diagnostics functions are available via an I2C interface as specified by the CFP2 MSA. Mechanical dimensions, connectors and footprint conform to CFP2 MSA.

Optical Transmission Modes

The 400G CFP2-DCO Pro coherent transceiver can be operated in following basic transmission modes listed in Table 1. For the detail of all the operation modes, please refer to Table 7 CFP2-DCO modes of working.

Mode	Order information	Modulation	FEC	Power Consumption (W)	Max. B2B ROSNR (dB)
400G ZR	HSC2-400-ZR-C6C	DP-16QAM	CFEC	22	26
400G ZR+	HSC2-400-ZRP-C6C	DP-QPSK 100G ZR+	OFEC*	14	12.5
		DP-QPSK 200G ZR+	OFEC*	18	16
		DP-16QAM 400G ZR+	OFEC*	24	24
400G MR	HSC2-400-MR-C6C	PS-DP-16QAM (400G)	OFEC	26	22

***following Open ZR+ MSA defined frame and OFEC**

Table 1: CFP2- DCO optical transmission modes

Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Storage temperature	Ts	-40		85	C	
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

Parameter		Symbol	Min.	Typ.	Max.	Unit	Note
Operating Case Temperature		TC	0		70	C	
Power supply voltage		VCC	3.135	3.3	3.465	V	
		ICC			7.2	A	
Maximum sustained peak Current(<500ms)					7.4	A	
Maximum Instantaneous peak current(<50us)					9	A	
Electro-Static discharge		ESD			1000	V	
Power Consumption		PD		22	22.5	W	1
Relative humidity		RH	15		85	%	
Client Mode	400G (400 ZR/400G ZR+ /400G MR)		1 x 400GAUI-8				
			4 x 100GAUI-2				
	200G (200ZR+)		2 x 100GAUI-2				
			2 x CAUI-4				
	100G (100ZR+)		1 x 100GAUI-2				
			1 x CAUI-4				
Transmission Distance	400G (400ZR)				120		
	400G (400ZR+)				450		
	400G(400GMR)				600	Km	
	200G (200ZR+)				1000		
	100G (100ZR+)				2000		
Power Supply Noise		Vrip			1%	DC-1MHz	
					2%	1-10MHz	

Notes

[1] In 400GbE mode, the typical power consumption is 22W and the maximum power consumption is 22.5W .When switching to 4×100GbE mode , the typical power consumption will be 23W and the maximum power consumption will be 23.5W, the current will also change accordingly.

Transmitter Operating Characteristic

Parameters		Unit	Min.	Type	Max.	Note
Baud Rate	400G ZR	GBd	59.843750000±20ppm			400ZR
	400G ZR+		60.138546798±20ppm			400ZR+
	400G MR		63.144600000±20ppm			400GMR
	200G		60.138546798±20ppm			200ZR+
	100G		30.069273399±20ppm			100ZR+
Transmitter frequency range		THz	191.3		196.1	
Flexible DWDM Grid		GHz	6.25			
Frequency Fine Tuning range		GHz	-5		5	bright tuning
Frequency Fine Tuning step		GHz	0.1			
Laser frequency accuracy		GHz	-1.8		1.8	
Transmitter laser disable time		ms			100	
Transmitter wavelength switching time		s			60	
Transmitter laser enable time		S			10	
Transmit Output Power Adjustable Range		dBm	-10		1	The absolute accuracy is ±1dB
Transmit Output Power at 400G Gray Light mode		dBm	3	4	5	At 193.7THz
Transmit Output Power Adjust step		dB	0.1			
Optical power setting accuracy		dB	-1		1	Diff between setting and reporting
Output power monitor accuracy		dB	-1		1	
			-0.5		0.5	At fixed wavelength, room temp
Power stability		dB	-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	38			
Lorentzian linewidth		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

Parameters		Unit	Min.	Type	Max.	Note	
Modulation format	400G ZR		ZR400-CFEC-16QAM			CFEC FEC, NCG 10.8dB	
	400G ZR+		ZR400-OFEC-16QAM			OFEC FEC, Net Coding Gain(NCG) 11.6dB, Thretical Max PreFEC BER 2.0E-2	
	400G MR		MR400-OFEC-PS-16QAM				
	200G		ZR200-OFEC-QPSK				
	100G		ZR100-OFEC-QPSK				
Frequency offset between received carrier and LO		GHz	-3.6		3.6		
Input power range	400G	dBm	-12		0	Signal power, OSNR>26dB,400ZR	
			-12		0	Signal power,OSNR>24dB,400ZR+	
			-21		0	400G Gray Light ,OSNR>34dB	
	200G		-18		0	Signal power, OSNR>16dB,200ZR+	
	100G		-18		0	Signal power, OSNR>12.5dB,100ZR+	
OSNR Tolerance	400G	dB/0.1nm			26	400ZR	Measured back-to-back with short optical channel
					24	400ZR+	
					22	400G MR	
	200G				16	200ZR+	
	100G				12.5	100ZR+	
RX sensitivity	400G Gray Light	dBm	-20			400ZR	Inband (IB)OSNR≥34dB
			-22			400ZR+	
			-24			400GMR	
non-damaging input power		dBm			10	Total power	
Optical input power monitor accuracy		dB	-2		2	Total power	
MAX FEC Pre Ber			0.017		0.02		
Chromatic dispersion tolerance	400G	ps/nm			2,400	400G ZR	Tolerance to CD with≤0.5 dB penalty to OSNR sensitivity when change in SOP is ≤ 1 rad/ms
					20,000	400ZR+	
					24,000	400GMR	
	200G				50,000	200ZR+	
	100G				100,000	100ZR+	
	400G Gray Light				2400	400G ZR	
					20,000	400ZR+	
CD monitor accuracy		ps/nm	-200		200		
DGD tolerance	400G	ps	33			400G ZR	OSNR penalty<0.5dB
			66			400ZR+	
			72			400GMR	
	200G		83			200ZR+	
	100G		100			100ZR+	
DGD monitor accuracy		ps	-15		15	0~40ps for 400ZR 0~100ps for 400/200/100ZR+/	
Peak PDL tolerance		dB			3	Tolerance to peak PDL with ≤1.3dB additional OSNR penalty when change in SOP is ≤1 rad/ms	
					3.5	Tolerance to peak PDL with ≤1.8dB additional OSNR penalty when change in SOP is ≤1 rad/ms	
Tolerance to change in SOP		krad/s	50			With ≤ 0.5 dB additional OSNR penalty over all PMD and PDL values	
Optical return loss		dB	20			Optical reflectance at Rx connector input.	
Optical Rx_LOS Assert Threshold	400G	dBm	-20	-18	-16		
	400G Gray Light		-28	-26	-24		
	200G		-26	-24	-22		
	100G		-26	-24	-22		
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 see IEEE Std 802.3-2018 Annex 120E. The data lines are AC-coupled and terminated in the module per the following figure from the CFP2 MSA.

Operating Characteristic-Elec. High Speed

Parameter	Symbol	Min	Max	Unit	note
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)					
Parameter	**Symbol**	**Min**	**Max**	**Unit**	**note**
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 returnloss (min)		Equation (83E–6)			IEEE Std 802.3-2018 Annex 120E
Differential termination mismatch			10	%	
Module stressed input test		See 120E.3.4.1			IEEE Std 802.3-2018 Annex 120E
Single-ended voltage tolerance range (min)		-0.4	3.3	V	
DC common mode voltage(min)		-350	2850	mV	

Operating Characteristic-Elec. High Speed

CAUI-4 C2M Electrical Characteristics					
Transmitter(module output)					
Parameter	**Symbol**	**Min**	**Max**	**Unit**	**note**
Signaling Rate, each lane		25.78125 ± 100 ppm		GBd	NRZ
AC common-mode output voltage (RMS)	RMS		17.5	mV	
Differential Voltage pk-pk	Vin, pp	750	900	mV	
Eye width	UI	0.57			
Eye height, differentia	mV	228			
Vertical eye closure	dB	5.5			
Differential output return loss		Equation (83E-2)			IEEE Std 802.3-2018 Annex 83E
Common to differential mode conversion return loss		Equation (83E-3)			IEEE Std 802.3-2018 Annex 83E
Differential termination mismatch		-	10	%	At 1 MHz
Transition time(20% to 80%)	Trise/Tfall	12		Ps	20% to 80%
DC common mode voltage	Vcm	-350	2850	mV	

Receiver (module input)					
Parameter	**Symbol**	**Min**	**Max**	**Unit**	**note**
Signaling rate per lane		25.78125 ± 100 ppm		GBd	NRZ
Differential pk-pk input voltage tolerance	Vout, pp	900		mV	
Differential input return loss (min)		Equation (83E–5)			IEEE Std 802.3-2018 Annex 83E
Differential to common-mode input returnloss (min)		Equation (83E–6)			IEEE Std 802.3-2018 Annex 83E
Differential termination mismatch			10	%	IEEE Std 802.3-2018 Annex 83E
Module stressed input test		See 83E.3.4.1			
Single-ended voltage tolerance range (min)		-0.4	3.3	V	
DC common mode voltage(min)		-350	2850	mV	

Operating Characteristic-Elec. Low Speed

Parameters	Symbol	Unit	Min.	Max.	Note
SCL and SDA	VOL	0	0.4	V	IOL(max)=3mA for fast mode, 20ma for
SCL and SDA	VOH	Vcc-0.5	Vcc+0.3	V	Fast-mode plus
	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 Pullup resistor, max. For 1000kHz clock rate refer to Figure 45 (CFP2-Hardware-rev5p0)
			200	pF	For 400kHz clock rate use 1.6 k Ohms pullup resistor, max. For 1000kHz clock rate refer to Figure 45 (CFP2-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

Parameter	Symbol	Min.	Max.	Unit	Note
Temperature monitor absolute error	DMI_Temp	-3	3	C	Over operating temp
TX power monitor absolute error	DMI_TX	0.666666667	1/1.5	dB	-15 ~ -9 dBm ±1dB@(25~60)°C ±1dB@(0~70)°C
RX power monitor absolute error	DMI_RX	0.75	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 & Status I/O Timing Characteristics

PARAMETER	Symbol	Min	Max	Unit	Note
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 mode)	ton_losf		10	ms	Note6
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 Rx LOS,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

PARAMETER	Symbol	Fast Mode (400 KHz)		Fast Mode Plus (1		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 Hig	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 CFP2 module releasing SCL and SDA
ModSelL Setup Time1	tSU.ModS elL	2		2		ms	setup time on the select lines before the start of a host initiated serial bus sequence
ModSelL Hold Time1	tHD.ModS elL	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_h old		500		500	µs	Maximum time the CFP2 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 = 70°C

Note 1: When the host has determined that module is CFP2, the management registers can be read to determine alternate supported ModSelL set up and hold times.

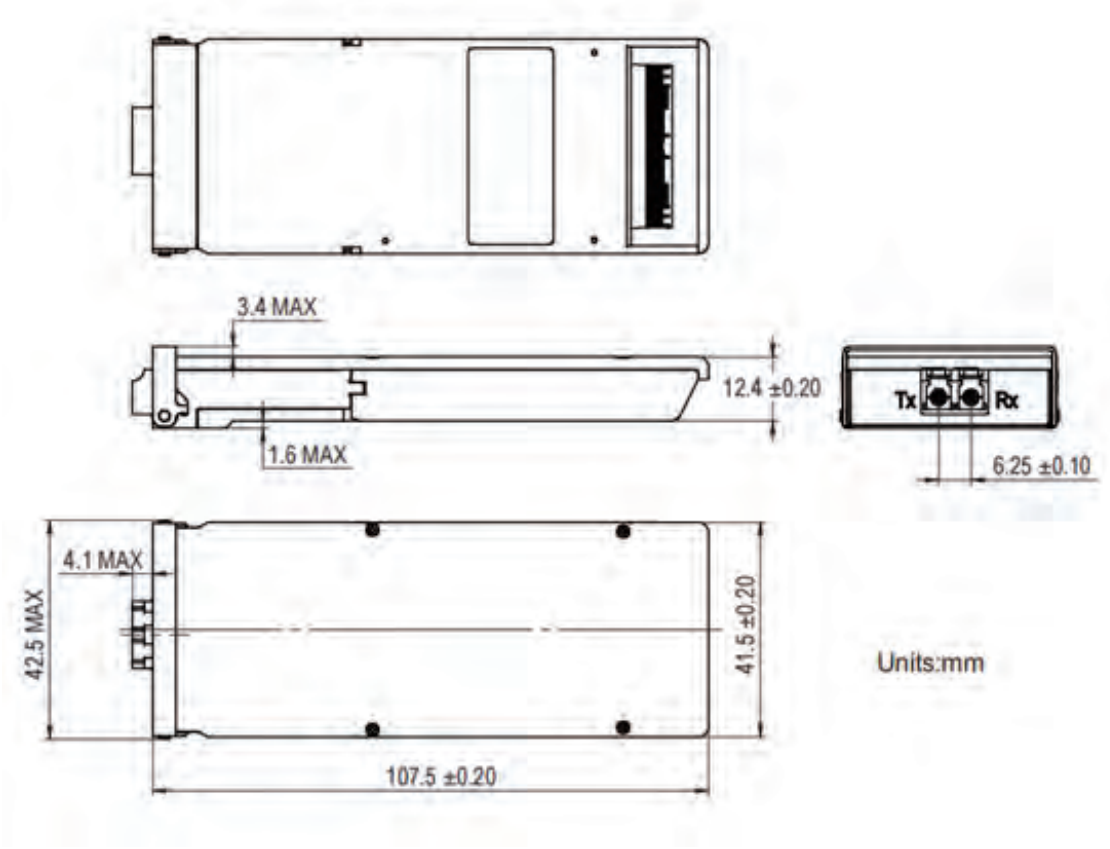
PIN Definition (Bottom)

PIN	Name of Pin	Structure (Input / Output)	Logic
1	GND	GND	Ground
2	OHIO RDn (TX_MCLKn)	O	CML
3	OHIO_RDp (TX_MCLKp)	O	CML
4	GND	GND	Ground
5	OHIO_TDn (N.C.)	I	CML
6	OHIO_TDp (N.C.)	I	CML
7	3.3V GND	PWR GND	Ground
8	3.3V GND	PWR GND	Ground
9	3.3V	PWR	Power
10	3 3V	PWR	Power
11	3.3V	PWR	Power
12	3.3V	PWR	Power
13	3.3V GND	PWR GND	Ground
14	3.3V GND	PWR GND	Ground
15	VND IO A	I/O	N.C
16	VND IO B	I/O	N.C
17	PRG CNTL1	I	LVCMOS w/PUR
18	PRG CNTL2	I	LVCMOS w/PUR
19	PRG CNTL3	I	LVCMOS w/PUR
20	PRG ALRM1	O	LVCMOS
21	PRG ALRM2	O	LVCMOS
22	PRG ALRM3	O	LVCMOS
23	GND	GND	Ground
24	TX DIS	I	LVCMOS w/PUR
25	RX LOS	O	LVCMOS
26	MOD LOPWR	I	LVCMOS w/PUR
27	MOD ABS	O	GND
28	MOD RSTn	I	LVCMOS w/PUR
29	GLB ALRMn	O	LVCMOS
30	GND	GND	Ground
31	MDC	I	1.2V LVCMOS
32	MDIO	I/O	1.2V LVCMOS
33	PRTADR0	I	1.2V LVCMOS
34	PRTADR1	I	1.2V LVCMOS
35	PRTADR2	I	1.2V LVCMOS
36	VND IO C	I/O	N.C
37	MSA BER Threshold	O	3.3V LVCMOS
38	VND IO E _ _	I/O	N.C
39	3.3V GND	PWR GND	Ground
40	3.3V GND	PWR GND	Ground
41	3.3V	PWR	Power
42	3.3V	PWR	Power
43	3.3V	PWR	Power
44	3.3V	PWR	Power
45	3.3V GND	PWR GND	Ground
46	3.3V GND	PWR GND	Ground
47	OHIO REFCLKn (N C)	I	CML
48	OHIO_REFCLKp (N C)	I	CML
49	GND	GND	Ground
50	(RX_MCLKn) Vendor Out 1n	O	CML
51	(RX_MCLKp) Vendor_Out 1p	O	CML
52	GND	GND	Ground

PIN Definition (Top)

PIN	Name						Description
	4x25G NRZ	8x25G NRZ	2x50G PAM4	4x50G PAM4	6x50G PAM4	8x50G PAM4	
104	GND	GND	GND	GND	GND	GND	Ground
103	N.C.	TX4n	N.C.	N.C.	TX4n	TX4n	Transmitter lane 4 / N.C
102	N.C.	TX4p	N.C.	N.C.	TX4p	TX4p	
101	GND	GND	GND	GND	GND	GND	Ground
100	TX3n	TX3n	N.C.	TX3n	TX3n	TX3n	Transmitter lane 3 / N.C
99	TX3p	TX3p	N.C.	TX3p	TX3p	TX3p	
98	GND	GND	GND	GND	GND	GND	Ground
97	TX2n	TX2n	N.C.	TX2n	TX2n	TX2n	Transmitter lane 2 / N.C
96	TX2p	TX2p	N.C.	TX2p	TX2p	TX2p	
95	GND	GND	GND	GND	GND	GND	Ground
94	N.C.	TX5n	N.C.	N.C.	TX5n	TX5n	Transmitter lane 5 / N.C
93	N.C.	TX5p	N.C.	N.C.	TX5p	TX5p	
92	GND	GND	GND	GND	GND	GND	Ground
91	N.C.	TX6n	N.C.	N.C.	N.C.	TX6n	Transmitter lane 6 / N.C
90	N.C.	TX6p	N.C.	N.C.	N.C.	TX6p	
89	GND	GND	GND	GND	GND	GND	Ground
88	TX1n	TX1n	TX1n	TX1n	TX1n	TX1n	Transmitter lane 1
87	TX1p	TX1p	TX1p	TX1p	TX1p	TX1p	
86	GND	GND	GND	GND	GND	GND	Ground

Dimensions



Notice

SiPhx reserves the right to change specifications of products identified in this datasheet without notice. Applications described herein are for illustrative purposes only, and SiPhx makes no warranty that 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