

## Product Specification

### 100GBASE-DR QSFP28 Optical Transceiver Module

#### Finisar® Transceiver

#### FTLC4351RHPL

#### PRODUCT FEATURES

- Hot-pluggable QSFP28 form factor
- Supports 103.1Gb/s aggregate bit rate
- Power dissipation < 4W (FEC bypass mode), <4.5W (FEC Termination Mode)
- RoHS-6 compliant
- Commercial case temperature range of 0°C to +70°C
- Single 3.3V power supply
- 1x100Gb/s optics
- 4x25G retimed electrical interface (CAUI-4 and 100GAUI-4)
- Duplex LC receptacles
- I2C management interface



#### APPLICATIONS

- 100GBASE-DR (500m) applications
- Bookend CWDM4 LITE MSA applications
- Breakout from extended reach 400G-DR4 (500m)

Finisar's FTLC4351RHPL QSFP28 transceiver modules are designed for use in 100 Gigabit Ethernet links on up to 500 m of single mode fiber. They are compliant with the QSFP28 MSA<sup>1</sup>, 100G Lambda MSA<sup>2</sup>, and portions of IEEE 802.3-2018<sup>3</sup>, IEEE 802.3bm<sup>4</sup>, IEEE 802.3cd<sup>5</sup>, and IEEE 802.3 cu<sup>6</sup>. Digital diagnostic functions are available via the I2C interface, as specified by the QSFP28 MSA and Finisar Application Notes AN-2185<sup>7</sup>. The optical transceiver is RoHS compliant as described in Application Note AN-2038<sup>8,9</sup>.

#### PRODUCT SELECTION

<b>FTLC4351RHPL</b>
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- 1: Gen 1
- R: Ethernet maximum bit rate (103.1 Gb/s)
- H: 1x100G optical architecture (500 m)
- P: Pull-tab release
- L: LC straight receptacle

## I. Pin Descriptions

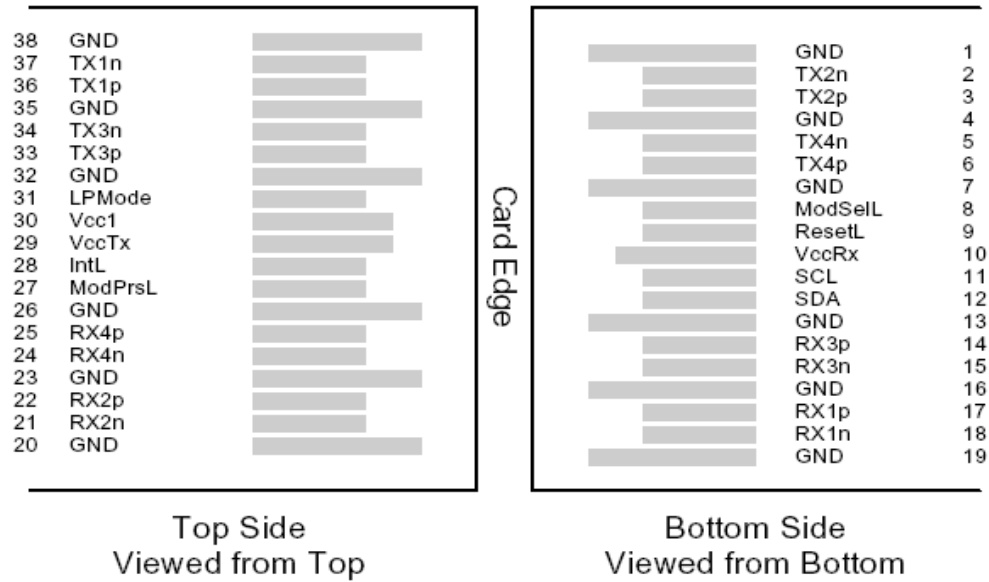


Figure 1 – QSFP28-compliant 38-pin connector (per SFF-8679)

Pin	Symbol	Name/Description	Notes
1	GND	Ground	1
2	Tx2n	Transmitter Inverted Data Input	
3	Tx2p	Transmitter Non-Inverted Data Input	
4	GND	Ground	1
5	Tx4n	Transmitter Inverted Data Input	
6	Tx4p	Transmitter Non-Inverted Data Input	
7	GND	Ground	1
8	ModSelL	Module Select	
9	ResetL	Module Reset	
10	Vcc Rx	+3.3 V Power supply receiver	
11	SCL	2-wire serial interface clock	
12	SDA	2-wire serial interface data	
13	GND	Ground	1
14	Rx3p	Receiver Non-Inverted Data Output	
15	Rx3n	Receiver Inverted Data Output	
16	GND	Ground	1
17	Rx1p	Receiver Non-Inverted Data Output	
18	Rx1n	Receiver Inverted Data Output	
19	GND	Ground	1
20	GND	Ground	1
21	Rx2n	Receiver Inverted Data Output	
22	Rx2p	Receiver Non-Inverted Data Output	
23	GND	Ground	1
24	Rx4n	Receiver Inverted Data Output	
25	Rx4p	Receiver Non-Inverted Data Output	
26	GND	Ground	1
27	ModPrsL	Module Present	
28	IntL	Interrupt	
29	Vcc Tx	+3.3 V Power supply transmitter	

30	Vcc1	+3.3 V Power Supply	
31	LPMODE	Low Power Mode	
32	GND	Ground	1
33	Tx3p	Transmitter Non-Inverted Data Input	
34	Tx3n	Transmitter Inverted Data Input	
35	GND	Ground	1
36	Tx1p	Transmitter Non-Inverted Data Input	
37	Tx1n	Transmitter Inverted Data Input	
38	GND	Ground	1

Notes

1. Circuit ground is internally isolated from chassis ground.

**II. Absolute Maximum Ratings**

Module performance is not guaranteed beyond the operating range (see Section VI). Exceeding the limits below may damage the transceiver module permanently.

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Maximum Supply Voltage	Vcc	-0.5		3.6	V	
Storage Temperature	T <sub>S</sub>	-40		+85	°C	
Case Operating Temperature	T <sub>OP</sub>	0		+70	°C	
Relative Humidity	RH	15		85	%	1
Receiver Damage Threshold	P <sub>Rdmg</sub>	5.5			dBm	

Notes:

1. Non-condensing.

**III. Electrical Characteristics (EOL, T<sub>OP</sub> = 0 to +70 °C, V<sub>CC</sub> = 3.135 to 3.465 Volts)**

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
Supply Voltage	Vcc	3.135		3.465	V	
Supply Current	Icc			1.435	A	1
Module total power, FEC bypass Mode	P <sub>f</sub>			4	W	2
Module total power, FEC Termination Mode	P			4.5	W	2
<b>Transmitter</b>						
Signaling rate per lane		25.78125 ± 100 ppm			GBd	3
		26.5625 ± 100 ppm			GBd	4
Differential data input swing per lane	V <sub>in,pp</sub>			900	mV	
Differential input return loss (min)	RL <sub>d</sub> (f)	9.5 – 0.37f, 0.01 ≤ f < 8 4.75 – 7.4log <sub>10</sub> (f/14), 8 ≤ f < 19			dB	
Differential to common mode input return loss (min)	RL <sub>dc</sub> (f)	22-20(f/25.78), 0.01 ≤ f < 12.89 15-6(f/25.78), 12.89 ≤ f < 19			dB	
Differential termination mismatch				10	%	
<b>Stressed input parameters</b>						
Eye width			0.46		UI	3,4
Applied pk-pk sinusoidal jitter		Per IEEE 802.3bm Table 88-13				3
Applied pk-pk sinusoidal jitter		Per IEEE 802.3bm Table 87-13				4
Eye height			95		mV	3,4
DC common mode voltage		-350		2850	mV	

Receiver						
Signaling rate per lane		25.78125 ± 100 ppm			GBd	3
		26.5625 ± 100 ppm			GBd	4
Differential data output swing	V <sub>out,pp</sub>	100		400	mV <sub>pp</sub>	5
		300		600		
		400		800		
		600		1200		
Eye width		0.57			UI	6,7
Eye height		228			mV	6,7
Vertical eye closure	VEC			5.5	dB	6
Vertical eye closure	VEC8			5	dB	7
Differential output return loss (min)	RL <sub>d</sub> (f)	9.5 – 0.37f, 0.01 ≤ f < 8 4.75 – 7.4log <sub>10</sub> (f/14), 8 ≤ f < 19			dB	
Common to differential mode conversion return loss (min)	RL <sub>dc</sub> (f)	22-20(f/25.78), 0.01 ≤ f < 12.89 15-6(f/25.78), 12.89 ≤ f < 19			dB	
Differential termination mismatch				10	%	
Transition time, 20% to 80%	t <sub>r</sub> t <sub>f</sub>	12			ps	

**Notes:**

1. Steady state
2. Maximum total power value is specified across the full temperature and voltage range.
3. IEEE 802.3-2018 Annex 83E.
4. IEEE 802.3cd Annex 135E.
5. Output voltage is settable in 4 discrete ranges via I2C. Default range is Range 2 (400 – 800 mV).
6. IEEE 802.3-2018 Annex 83E, defined at 10<sup>-15</sup> probability
7. IEEE 802.3cd Annex 135E, defined at 10<sup>-8</sup> probability

**IV. Optical Characteristics (EOL, T<sub>OP</sub> = 0 to +70 °C, V<sub>CC</sub> = 3.135 to 3.465 Volts)**

Parameter	Symbol	Min	Typ	Max	Unit	Ref.
<b>Transmitter</b>						
Signaling Speed per Lane (PAM4)		53.125 ± 100 ppm			Gbd	1
Modulation format		PAM4				
Lane center wavelengths (range)		1304.5 – 1317.5			nm	
Total Average Launch Power	P <sub>OUT</sub>	-2.4		4	dBm	2
Transmit OMA Power	TxOMA	-0.2		4.2	dBm	3
Launch power in OMA <sub>outer</sub> minus TDECQ, (min):						
for TDECQ < 1.4 dB		-0.2		4.2	dBm	
for 1.4dB ≤ TDECQ ≤ 3.4 dB		-1.5+TDECQ		4.2	dBm	
Transmitter and dispersion penalty eye closure for PAM4 (TDECQ)	TDECQ			3.4	dB	
Transmitter eye closure for PAM4 (TECQ)	TECQ			3.4	dB	
TDECQ - TECQ				2.5	dB	
Over/under-shoot				22	%	
Transmitter power excursion				2.8	dBm	
Sidemode Suppression ratio	SSR <sub>min</sub>	30			dB	
Average launch power of OFF transmitter				-15	dBm	
Optical Extinction Ratio	ER	3.5			dB	
Optical Return Loss Tolerance				17.1	dB	
Transmitter Reflectance	ORL			-26	dB	4
Transmitter Transition Time				17	ps	
Relative Intensity Noise, OMA	RIN			-136	dB/Hz	

Receiver						
Signaling Speed per Lane (PAM4)		53.125 ± 100 ppm			GBd	5
Modulation format		PAM4				
Lane center wavelengths (range)		1304.5 – 1317.5			nm	
Damage threshold	P <sub>Rdmg</sub>	5.5			dBm	6
Receive Power (OMA)	R <sub>xOMA</sub>			4.7	dBm	
Average Receive Power	R <sub>xP</sub>	-7.1		4.5	dBm	7
Receiver Sensitivity (OMA <sub>outer</sub> ): For TECQ < 1.4dB For 1.4dB ≤ TECQ ≤ 3.4dB	R <sub>xsens</sub>			-4.5 -5.9+TECQ	dBm	8
Optical Return Loss (Receiver Reflectance)	ORL			-26	dB	
Stressed Receiver Sensitivity (OMA)	SRS			-2.5	dBm	9
Stressed eye closure for PAM4 (SECQ), lane under test				3.4	dB	10
OMA <sub>outer</sub> of each aggressor lane				4.2	dBm	10

**Notes:**

1. Transmitter consists of a single laser operating at 26.5625 Gb/s.
2. Average launch power, (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.
3. Even if the TDECQ < 1.4 dB for an extinction ratio of ≥ 4.5 dB or TDECQ < 1.3 dB for an extinction ratio of < 4.5 dB, the OMA<sub>outer</sub> (min) must exceed this value.
4. Transmitter reflectance is defined looking into the transmitter.
5. Receiver consists of a single photodetector operating at 26.5625 Gb/s.
6. The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level. The receiver does not have to operate correctly at this input power.
7. Average receive power, each lane (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.
8. Receiver sensitivity (OMA<sub>outer</sub>) is informative, per IEEE 802.3cu Table 140-7.
9. Measured with conformance test signal at TP3 (see 3.11) for the BER specified in IEEE Std 802.3cd clause 140.1.1.
10. These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

**V. General Specifications**

Parameter	Symbol	Min	Typ	Max	Units	Ref.
Nominal Bit Rate	BR			103.1	Gb/s	
Bit Error Ratio	BER			2.4x10 <sup>-4</sup>		1
<b>Maximum Supported Reach</b>						
Fiber Type						
SMF per G.652	LossBdgt			6.8	dB	2
Operating Distance		0.002		0.5	km	
Channel Insertion Loss				See IEEE802.3c d 140.10	dB	

**Notes:**

1. Tested with a 2<sup>31</sup> – 1 PRBS.
2. Max discrete reflectance is -35dB.

## VI. Environmental Specifications

Finisar FTLC4351RHPL QSFP28 transceivers have an operating case temperature range of 0°C to +70°C.

Parameter	Symbol	Min	Typ	Max	Units	Ref.
Case Operating Temperature	T <sub>op</sub>	0		+70	°C	
Storage Temperature	T <sub>sto</sub>	-40		+85	°C	

## VII. Regulatory Compliance

Finisar FTLC4351RHPL QSFP28 transceivers are Class 1 laser eye safety compliant per IEC 60825-1. They are certified per the following standards:

Feature	Agency	Standard
Laser Eye Safety	FDA/CDRH	CDRH 21 CFR 1040 and Laser Notice 50
	CSA	IEC60825-2:2004+A1+A2
	TüV	EN60825-1:2014 & EN60825-2:2006+A1+A2
Electrical Safety	CSA	IEC60950-1:2005+A1+A2
	TüV	EN60950-1:2006+A11+A1+A12+A2
	UL/CSA	CLASS 3862.13 & CLASS 3862.93

Copies of the referenced certificates are available at Finisar Corporation upon request.

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

## VIII. Digital Diagnostics Functions

FTLC4351RHPL QSFP28 transceivers support the I2C-based diagnostics interface specified by the SFF Committee<sup>1</sup>. See also Finisar Application Notes AN-2185<sup>7</sup>.

## IX. Memory Contents

Per SFF-8665 Specification<sup>1</sup>. See Finisar Application Note AN-2185<sup>7</sup>.

## XI. Mechanical Specifications

Finisar FTLC4351RHPL transceivers are compatible with the QSFP28 Specification for pluggable form factor modules.

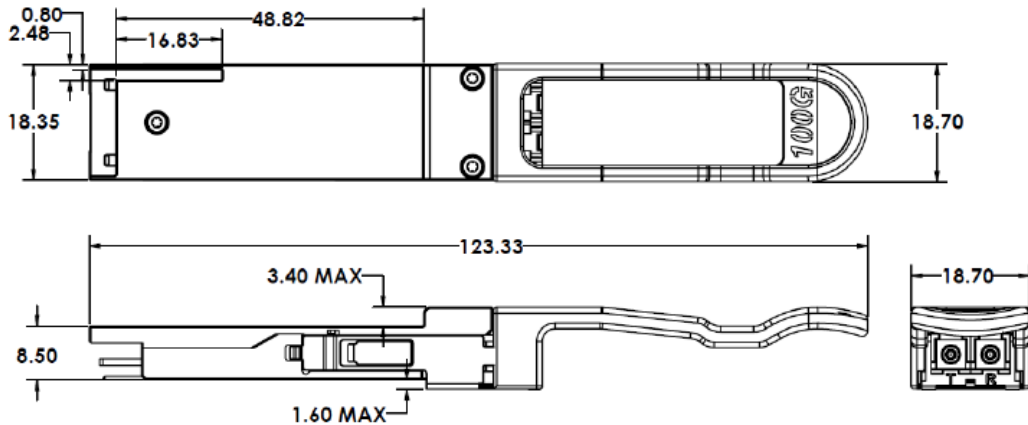


Figure 2. FTLC4351RHPL Mechanical Dimensions.

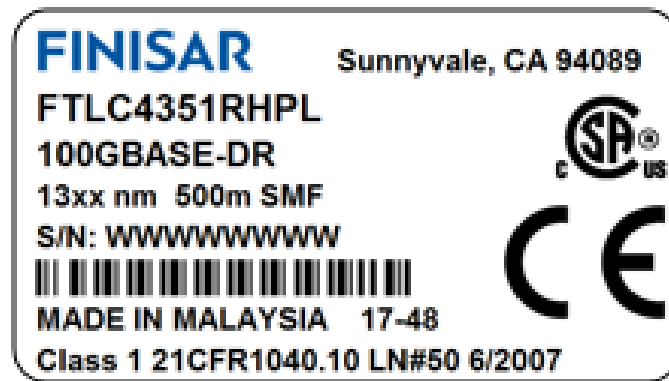


Figure 3. Product Label (Not to Scale)

## XII. References

1. SFF-8665: “QSFP+ 28Gb/s 4X Pluggable Transceiver Solution (QSFP28)”, Rev 1.9, June 29, 2015 and associated SFF documents referenced therein:
  - i. SFF-8661
  - ii. SFF-8679
  - iii. SFF-8636
  - iv. SFF-8662
  - v. SFF-8663
  - vi. SFF-8672
  - vii. SFF-8683
2. 100G Lambda MSA, Rev 2.0 September 18, 2018
3. “IEEE P802.3-2018, Standard for Ethernet”.
4. “IEEE P802.3bm, CAUI-4 Interface”.

5. “IEEE P802.3cd, Standard for Ethernet, Amendment 3: Media Access Control Parameters for 50 Gb/s and Physical Layers and Management Parameters for 50 Gb/s, 100 Gb/s, and 200 Gb/s Operation”.
6. “IEEE P802.3cu, Amendment: Physical Layers and Management Parameters for 100 Gb/s and 400 Gb/s Operation over Single Mode fiber at 100 Gb/s per Wavelength”.
7. Application Note AN-2185, EEPROM Map, Finisar Corporation.
8. Directive 2011/65/EU of the European Council Parliament and of the Council, “on the restriction of the use of certain hazardous substances in electrical and electronic equipment” as well as Commission Delegated Directive (EU) 2015/863 amending Annex II to Directive 2011/65/EU. Certain products may use one or more exemptions as allowed by the Directive.
9. Application Note AN-2038: “II-VI Implementation of RoHS Compliant Transceivers”.

## **XII For More Information**

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