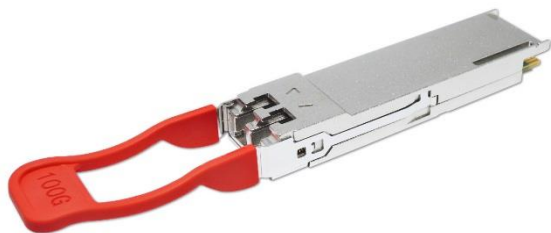




## **100G QSFP28 ER4 Dual-Rate Transceiver** **Hot Pluggable, Duplex LC, LAN-WDM EML, SMF 40KM, DDM**

**Part Number: FQ28-K7-L13-40DR**



### **Overview**

FQ28-K7-L13-40DR is a 4-Channel LWDM 1300nm QSFP28 transceiver for 100GbE and OTU4 applications especially in Telecom, Datacom, Data Center & Storage networks. The transmitter converts 4-Channel 25/28G electrical input data to four LWDM optical signals and multiplex that into one 103/112G signal. The receiver demultiplex the 103/112G signal reversely and converts that to 4-Channel 25/28G electrical output data. The techniques bring a compact transceiver module for an aggregate bandwidth of 103/112Gbps up to SMF 40km optical links.

### **Applications**

- 100GBASE-ER4 Ethernet
- OTN OTU4 @112.1G
- Data Centers Switch Interconnect
- Server and Storage Area Network Interconnect

### **Features**

- Compliant with IEEE802.3ba 100GBASE-ER4
- Compliant with ITU G.959.1 OTU4 4L1-9D1F
- Compliant with SFF-8665 QSFP28 MSA
- Compliant with IEEE 802.3bm CAUI-4 Interface
- 4CH LWDM MUX / DEMUX design
- Data Rate up to 27.9525Gbps per Lane
- Built in quad Tx CDR and Rx CDR
- Hot Pluggable QSFP28 footprint
- O-Band LWDM EML transmitter
- APD receiver
- Duplex LC connector
- 2-wire interface for management and diagnostic monitor compliant with SFF-8636
- Single 3.3V power supply
- Link distance 40km over SM fiber
- Maximum Power consumption 4.5W
- RoHS compliant



## Laser Safety

- This is a Class 1 Laser Product complies with 21 CFR 1040.10 and 1040.11 except for conformance with IEC 60825-1 Ed. 3., as described in Laser Notice No. 56, dated May 8, 2019.
- Caution: Use of control or adjustments or performance of procedure other than those specified herein may result in hazardous radiation exposure.

## Absolute Maximum Ratings

| Parameters                | Symbol           | Min. | Max. | Unit |
|---------------------------|------------------|------|------|------|
| Storage Temperature       | T <sub>ST</sub>  | -40  | +85  | °C   |
| Storage Relative Humidity | RH               | 0    | 85   | %    |
| Supply Voltage            | V <sub>CC3</sub> | -0.5 | +3.6 | V    |

## Recommended Operating Conditions

| Parameters                               | Symbol          | Min.  | Typ.     | Max.               | Unit |
|------------------------------------------|-----------------|-------|----------|--------------------|------|
| Case Operating Temperature               | T <sub>OP</sub> | 0     | -        | +70                | °C   |
| Supply Voltage                           | V <sub>CC</sub> | +3.13 | +3.3     | +3.47              | V    |
| Data Rate, per Lane                      | DR              |       | 25.78125 | 27.9525            | Gb/s |
| Data Rate Accuracy ( 100GBASE-ER4 )      | ΔDR             | -100  |          | +100               | ppm  |
| Data Rate Accuracy ( OTU4 4L1-9D1F )     | ΔDR             | -20   |          | +20                | ppm  |
| Bit Error Rate                           | BER             |       |          | 5x10 <sup>-5</sup> |      |
| Supply Current                           | I <sub>CC</sub> |       |          | 1360               | mA   |
| Power Consumption                        | P               |       |          | 4.5                | W    |
| Transceiver Power-on Initialization Time |                 |       |          | 2000               | ms   |
| Control Input Voltage High               | V <sub>IH</sub> | 2.0   |          | V <sub>CC</sub>    | V    |
| Control Input Voltage Low                | V <sub>IL</sub> | GND   |          | 0.8                | V    |
| Control Output Voltage High              | V <sub>OH</sub> | 2.0   |          | V <sub>CC</sub>    | V    |
| Control Output Voltage Low               | V <sub>OL</sub> | GND   |          | 0.8                | V    |



## Transmitter Electro-optical Characteristics

V<sub>CC</sub> = 3.13V to 3.47V, T<sub>OP</sub> = 0 °C to 70 °C

| Parameters                                                                   | Symbol               | Min.                                 | Typ.     | Max.    | Unit  | Note |
|------------------------------------------------------------------------------|----------------------|--------------------------------------|----------|---------|-------|------|
| IEEE 802.3ba 100GBASE-ER4                                                    |                      |                                      |          |         |       |      |
| Operating Data Rate, per Lane                                                | DR                   |                                      | 25.78125 |         | Gb/s  |      |
| Total Average Launch Power                                                   | TP <sub>AVG</sub>    |                                      |          | +10.5   | dBm   |      |
| Average Launch Power, per Lane                                               | P <sub>AVG</sub>     | -2.9                                 |          | +4.5    | dBm   |      |
| Optical Modulation Amplitude (OMA), per Lane                                 | P <sub>OMA</sub>     | +0.1                                 |          | +4.5    | dBm   | 1    |
| Difference in Launch Power between any two Lanes (OMA)                       | P <sub>TX-DIFF</sub> |                                      |          | 3.6     | dB    |      |
| Transmitter Dispersion Penalty, per Lane                                     | TDP                  |                                      |          | 2.5     | dB    |      |
| Launch Power in OMA minus Transmitter and Dispersion Penalty (TDP), per Lane | OMA-TDP              | -0.65                                |          |         | dB    | 1    |
| ITU G.959.1 OTU4 4L1-9D1F                                                    |                      |                                      |          |         |       |      |
| Operating Data Rate, per Lane                                                | DR                   |                                      | 27.9525  |         | Gb/s  |      |
| Total Average Launch Power                                                   | TP <sub>AVG</sub>    |                                      |          | +10.5   | dBm   |      |
| Average Launch Power, per Lane                                               | P <sub>AVG</sub>     | -1.1                                 |          | +4.5    | dBm   |      |
| IEEE 802.3ba 100GBASE-ER4 & ITU G.959.1 OTU4 4L1-9D1F                        |                      |                                      |          |         |       |      |
| Optical Wavelength, each Lane                                                | λ <sub>L0</sub>      | 1294.53                              | 1295.56  | 1296.59 | nm    |      |
|                                                                              | λ <sub>L1</sub>      | 1299.02                              | 1300.05  | 1301.09 | nm    |      |
|                                                                              | λ <sub>L2</sub>      | 1303.54                              | 1304.58  | 1305.63 | nm    |      |
|                                                                              | λ <sub>L3</sub>      | 1308.09                              | 1309.14  | 1310.19 | nm    |      |
| Spectral Width (-20dB)                                                       | Δλ                   |                                      |          | 1       | nm    |      |
| Side Mode Suppression Ratio                                                  | SMSR                 | 30                                   |          |         | dB    |      |
| Optical Extinction Ratio                                                     | ER                   | 7                                    |          |         | dB    |      |
| Optical Eye Mask { X1, X2, X3, Y1, Y2, Y3 }                                  |                      | { 0.25, 0.4, 0.45, 0.25, 0.28, 0.4 } |          |         |       | 2    |
| Average Launch Power OFF, per Lane                                           | P <sub>OFF</sub>     |                                      |          | -30     | dBm   |      |
| Relative Intensity Noise (OMA)                                               | RIN                  |                                      |          | -130    | dB/Hz |      |
| Optical Return Loss Tolerance                                                | ORLT                 |                                      |          | 20      | dB    |      |
| Transmitter Reflectance                                                      | R <sub>TX</sub>      |                                      |          | -12     | dB    |      |
| Input Differential Impedance                                                 | Z <sub>IN</sub>      | 90                                   | 100      | 110     | Ω     |      |
| Differential Data Input Voltage                                              | V <sub>IN-PP</sub>   | 180                                  |          | 1000    | mVpp  |      |

**Note1:** Transmitter wavelength and launch power need to meet the OMA minus TDP specs to guarantee link performance.

**Note2:** Hit ratio 5x10<sup>-5</sup> hits per sample.



## Receiver Electro-optical Characteristics

V<sub>CC</sub> = 3.13V to 3.47V, T<sub>OP</sub> = 0 °C to 70 °C

| Parameters                                                       | Symbol              | Min.  | Typ.     | Max.  | Unit | Note |
|------------------------------------------------------------------|---------------------|-------|----------|-------|------|------|
| <b>IEEE 802.3ba 100GBASE-ER4</b>                                 |                     |       |          |       |      |      |
| Operating Data Rate, per Lane                                    | DR                  |       | 25.78125 |       | Gb/s |      |
| Average Receive Power, per Lane                                  | PRX-AVG             | -20   |          | -4.9  | dBm  |      |
| Receiver Power (OMA), per Lane                                   | PRX-OMA             |       |          | -1.9  | dBm  |      |
| Receiver Sensitivity (OMA), per Lane                             | SEN <sub>OMA</sub>  |       |          | -18.5 | dBm  | 1    |
| Stressed Receiver Sensitivity (OMA), per Lane                    | SRS <sub>OMA</sub>  |       |          | -16.5 | dBm  | 1    |
| <b>ITU G.959.1 OTU4 4L1-9D1F</b>                                 |                     |       |          |       |      |      |
| Operating Data Rate, per Lane                                    | DR                  |       | 27.9525  |       | Gb/s |      |
| Average Receive Power, per Lane                                  | PRX-AVG             | -19.1 |          | -4.9  | dBm  | 2    |
| Equivalent Sensitivity, per Lane                                 | SEN <sub>EQV</sub>  |       |          | -20.6 | dBm  | 2    |
| Optical Path Penalty                                             |                     |       |          | 1.5   | dB   |      |
| <b>IEEE 802.3ba 100GBASE-ER4 &amp; ITU G.959.1 OTU4 4L1-9D1F</b> |                     |       |          |       |      |      |
| Damage Threshold, per Lane                                       | D <sub>TH</sub>     | -3    |          |       | dBm  | 3    |
| Receiver Reflectance                                             | R <sub>RX</sub>     |       |          | -26   | dB   |      |
| LOS De-Assert                                                    | LOS <sub>D</sub>    |       |          | -20   | dBm  |      |
| LOS Assert                                                       | LOS <sub>A</sub>    | -35   |          |       | dBm  |      |
| LOS Hysteresis                                                   | LOS <sub>HY</sub>   | 0.5   |          |       | dB   |      |
| Receiver Electrical 3dB upper Cutoff Frequency, each Lane        | F <sub>CUT</sub>    |       |          | 31    | GHz  |      |
| Output Differential Impedance                                    | Z <sub>OUT</sub>    | 90    | 100      | 110   | Ω    |      |
| Differential Data Output Voltage                                 | V <sub>OUT-PP</sub> |       |          | 900   | mVpp |      |
| <b>Conditions of Stress Receiver Sensitivity Test (Note.4)</b>   |                     |       |          |       |      |      |
| Vertical Eye Closure Penalty, per Lane                           | VECP                |       | 1.5      |       | dB   |      |
| Stressed Eye J2 Jitter, per Lane                                 | J2                  |       | 0.3      |       | UI   |      |
| Stressed Eye J9 Jitter, per Lane                                 | J9                  |       | 0.47     |       | UI   |      |

**Note1:** Measured with conformance test signal at receiver input for BER= 5x10<sup>-5</sup>.

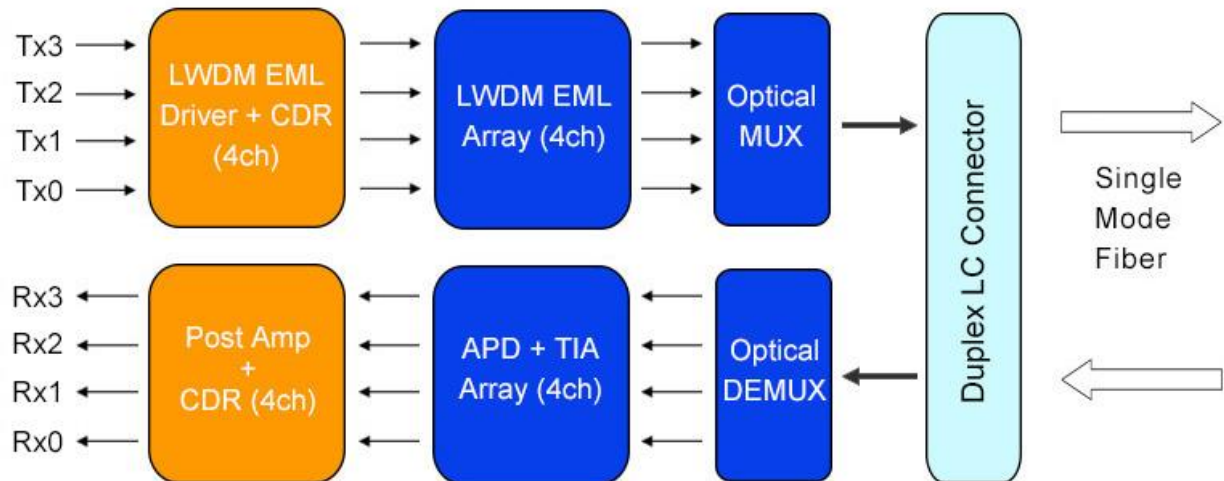
**Note2:** Measured with conformance test signal at receiver input for BER = 1x10<sup>-6</sup> per ITU-OTU4 with Tx ER > 7dB

**Note3:** The receiver shall be able to tolerate, without damage, continuous exposure to a modulated optical input signal having this power level on one lane. The receiver does not have to operate correctly at this input power.

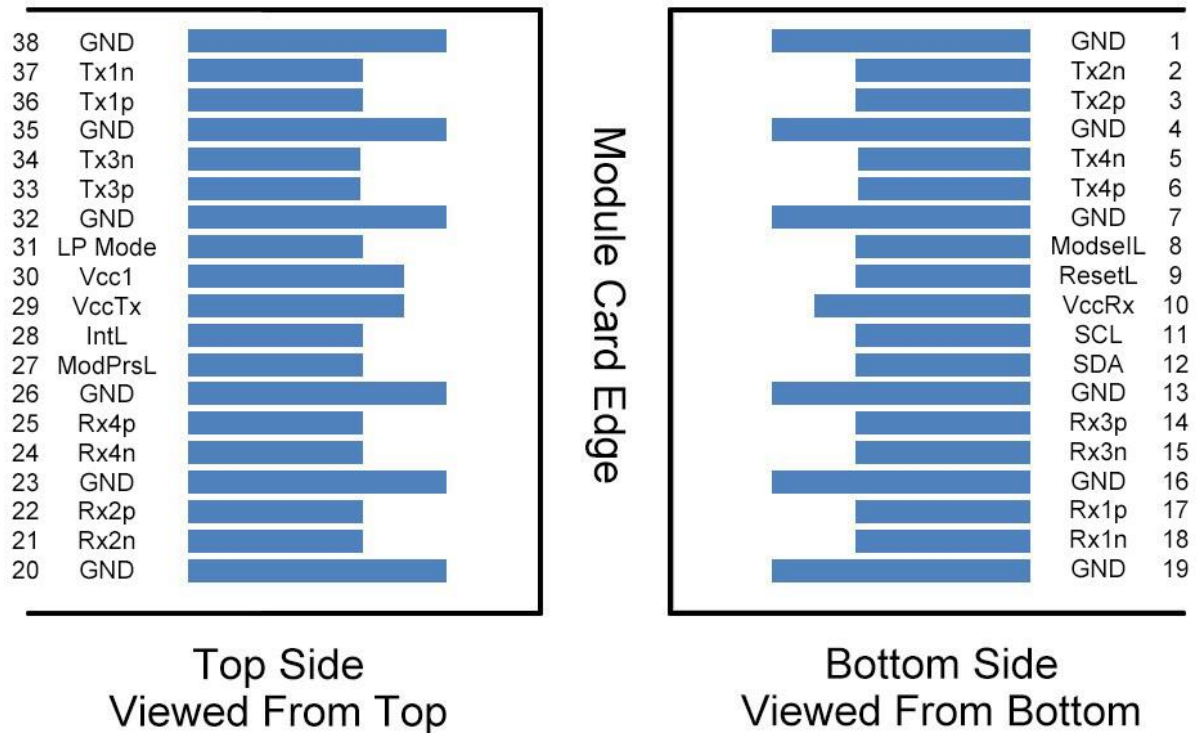


**Note4:** Vertical eye closure penalty and stressed eye jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

## Transceiver Block Diagram



## Pin Assignment





## Pin Description

| Pin | Logic       | Name    | Function / Description              |
|-----|-------------|---------|-------------------------------------|
| 1   |             | GND     | Module Ground                       |
| 2   | CML-I       | Tx2n    | Transmitter Inverted Data Input     |
| 3   | CML-I       | Tx2p    | Transmitter Non-Inverted Data Input |
| 4   |             | GND     | Module Ground                       |
| 5   | CML-I       | Tx4n    | Transmitter Inverted Data Input     |
| 6   | CML-I       | Tx4p    | Transmitter Non-Inverted Data Input |
| 7   |             | GND     | Module Ground                       |
| 8   | LVTLL-I     | ModSelL | Module Select                       |
| 9   | LVTLL-I     | ResetL  | Module Reset                        |
| 10  |             | VccRx   | +3.3V Power Supply Receiver         |
| 11  | LVC MOS-I/O | SCL     | 2-Wire Serial Interface Clock       |
| 12  | LVC MOS-I/O | SDA     | 2-Wire Serial Interface Data        |
| 13  |             | GND     | Module Ground                       |
| 14  | CML-O       | Rx3p    | Receiver Non-Inverted Data Output   |
| 15  | CML-O       | Rx3n    | Receiver Inverted Data Output       |
| 16  |             | GND     | Module Ground                       |
| 17  | CML-O       | Rx1p    | Receiver Non-Inverted Data Output   |
| 18  | CML-O       | Rx1n    | Receiver Inverted Data Output       |
| 19  |             | GND     | Module Ground                       |
| 20  |             | GND     | Module Ground                       |
| 21  | CML-O       | Rx2n    | Receiver Inverted Data Output       |
| 22  | CML-O       | Rx2p    | Receiver Non-Inverted Data Output   |
| 23  |             | GND     | Module Ground                       |
| 24  | CML-O       | Rx4n    | Receiver Inverted Data Output       |
| 25  | CML-O       | Rx4p    | Receiver Non-Inverted Data Output   |
| 26  |             | GND     | Module Ground                       |
| 27  | LVTLL-O     | ModPrsL | Module Present                      |
| 28  | LVTLL-O     | IntL    | Interrupt                           |
| 29  |             | VccTx   | +3.3V Power Supply Transmitter      |
| 30  |             | Vcc1    | +3.3V Power Supply                  |
| 31  | LVTLL-I     | LPMODE  | Low Power Mode                      |
| 32  |             | GND     | Module Ground                       |

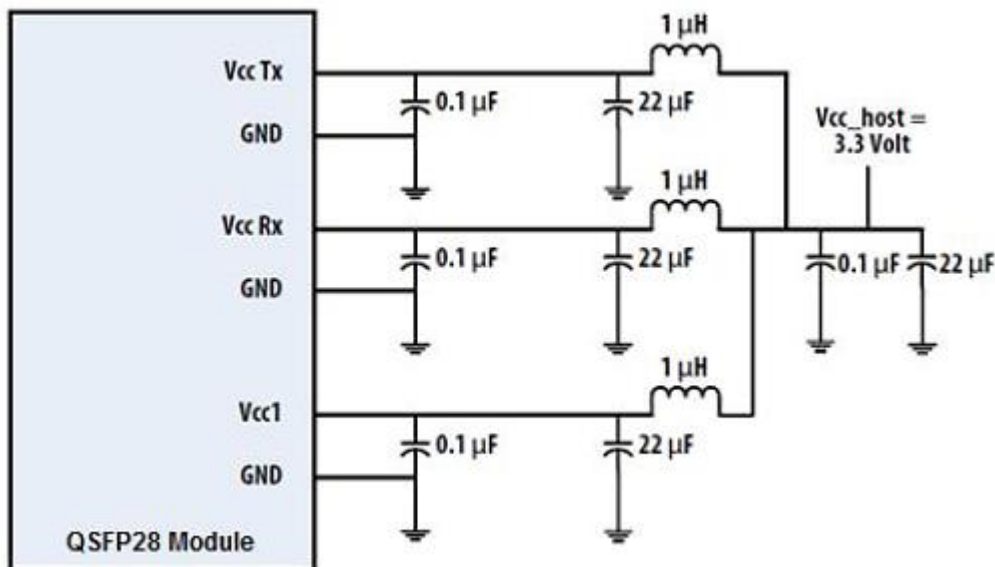


|    |       |      |                                     |
|----|-------|------|-------------------------------------|
| 33 | CML-I | Tx3p | Transmitter Non-Inverted Data Input |
| 34 | CML-I | Tx3n | Transmitter Inverted Data Input     |
| 35 |       | GND  | Module Ground                       |
| 36 | CML-I | Tx1p | Transmitter Non-Inverted Data Input |
| 37 | CML-I | Tx1n | Transmitter Inverted Data Input     |
| 38 |       | GND  | Module Ground                       |

**Note1:** GND is the symbol for signal and supply (power) common for QSFP28 modules. All are common within the QSFP28 module and all module voltages are referenced to this potential unless otherwise noted. Connect these directly to the host board signal common ground lane.

**Note2:** VccRx, Vcc1 and VccTx are the receiver and transmitter power suppliers and shall be applied concurrently. Recommended host board power supply filtering is shown below. Vcc Rx, Vcc1 and Vcc Tx may be internally connected within the QSFP28 transceiver module in any combination. The connector pins are each rated for a maximum current of 1000mA.

## Recommended Power Supply Filter





## Digital Diagnostic Functions

As defined by the QSFP28 MSA, Ficer's QSFP28 transceivers provide digital diagnostic functions via a 2-wire serial interface, which allows real-time access to the following operating parameters:

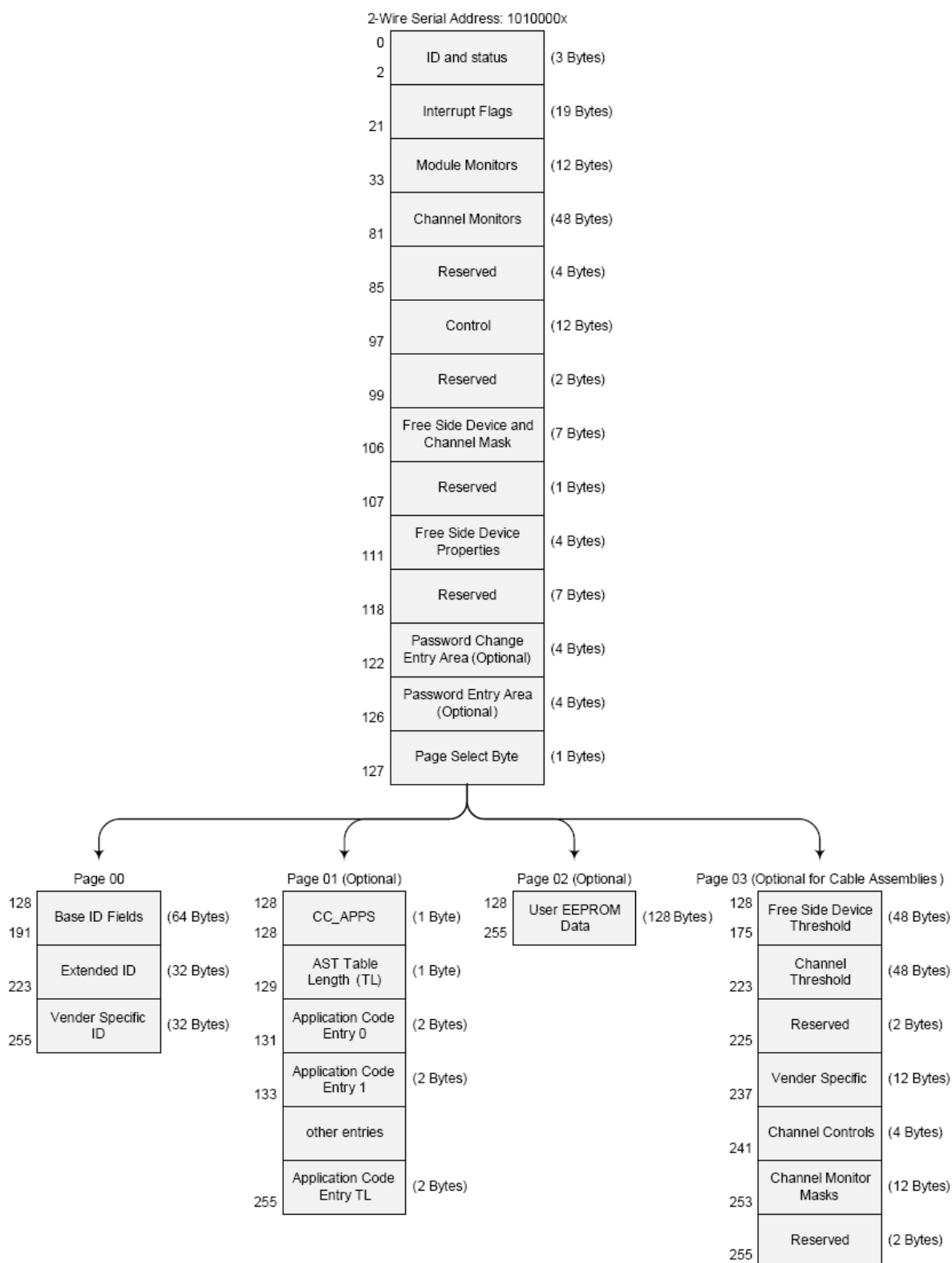
- Transceiver temperature
- Laser bias current (4-Channel)
- Transmitted optical power (4-Channel)
- Received optical power (4-Channel)
- Transceiver supply voltage

It also provides a sophisticated system of alarm and warning flags, which may be used to alert end-users when particular operating parameters are outside of a factory-set normal range.

The operating and diagnostics information is monitored and reported by a Digital Diagnostics Controller (DDC) inside the transceiver, which is accessed through the 2-wire serial interface. When the serial protocol is activated, the serial clock signal (SCL pin) is generated by the host. The positive edge clocks data into the QSFP28 transceiver into those segments of its memory map that are not write-protected. The negative edge clocks data from the QSFP28 transceiver. The serial data signal (SDA pin) is bi-directional for serial data transfer. The host uses SDA in conjunction with SCL to mark the start and end of serial protocol activation. The memories are organized as a series of 8-bit data words that can be addressed individually or sequentially. The 2-wire serial interface provides sequential or random access to the 8 bit parameters, addressed from 000h to the maximum address of the memory.

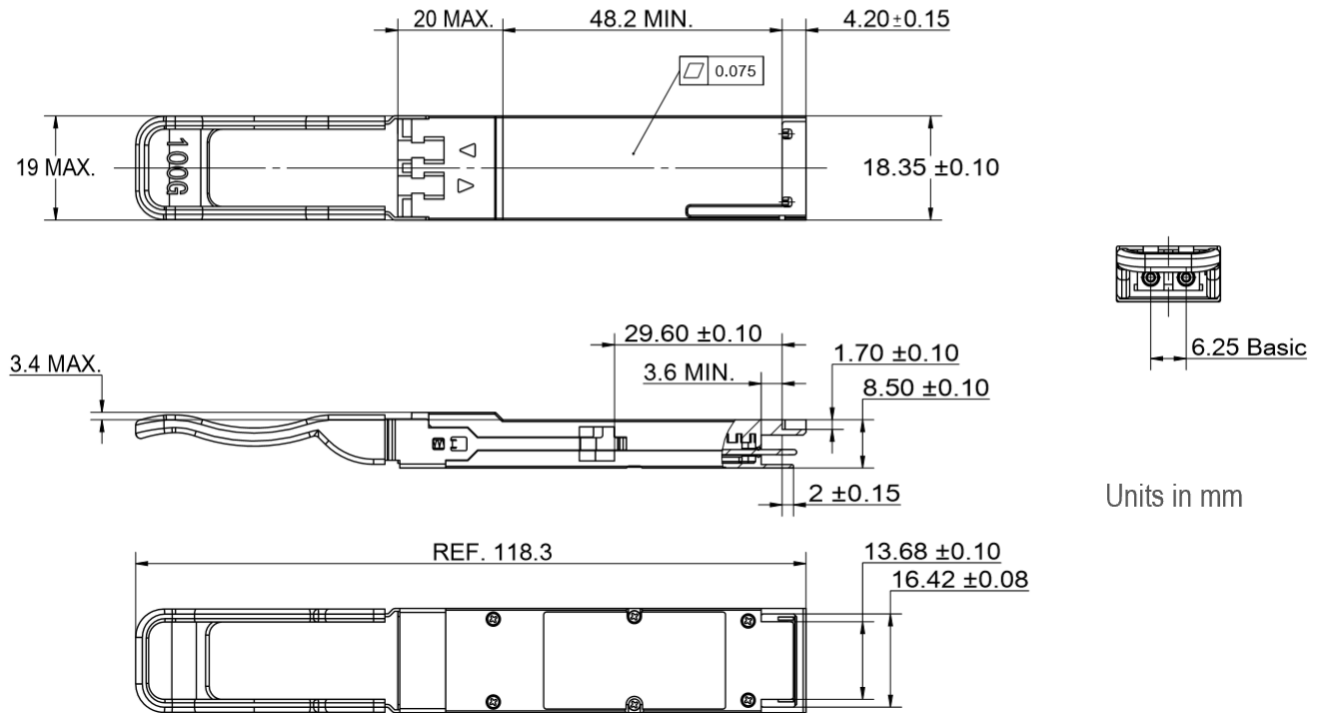
For more detailed information including memory map definitions, please see the QSFP28 MSA Specification.

## Digital Diagnostic Memory Map





## Mechanical Dimensions



(All Dimensions are  $\pm 0.20\text{mm}$  Unless Otherwise Specified, Unit: mm)

## Ordering Information

| Part No.         | Tx                                                   | Rx                                                   | Link                  | DDM | Temp.  |
|------------------|------------------------------------------------------|------------------------------------------------------|-----------------------|-----|--------|
| FQ28-K7-L13-40DR | 1295.56 nm<br>1300.05 nm<br>1304.58 nm<br>1309.14 nm | 1295.56 nm<br>1300.05 nm<br>1304.58 nm<br>1309.14 nm | SMF 40km<br>(FEC Off) | Yes | 0~70°C |

**Note:** Distances are indicative only. To calculate a more precise link budget based on specific conditions in your application, please refer to the optical characteristics