

EOLS-1648-24-X Series

DWDM 4.25Gbps FC/2FC/4FC

Duplex SFP Transceiver

RoHS6 Compliant



Features

- ◆ Operating Data Rate up to 4.25Gbps
- ◆ Available in all 100 GHz C-Band Wavelengths on the DWDM ITU grid
- ◆ DWDM Rated laser and APD High Sensitivity Receiver
- ◆ 24dB Power Budget
- ◆ Single 3.3V Power Supply and LVTTTL Control Logic Interface
- ◆ Hot-Pluggable SFP Footprint Duplex LC Connector Interface
- ◆ Class 1 FDA and IEC60825-1 Laser Safety Compliant
- ◆ Operating Case Temperature Standard: -5°C~+70°C
- ◆ Compliant with SFP MSA Specification
- ◆ Compliant with SFF-8472

Applications

- ◆ Tri-Rate 1.063/2.125/4.25Gbps Fiber Channel
- ◆ 1.25Gbps Ethernet

Ordering Information

| Part No. | Bit Rate | Link Budget | Interface | Temperature | DDMI |
|--|----------------|-------------|-----------|-------------|------|
| EOLS-1648-X ₁ ^{*(note1)} -X ₂ ^{*(note2)} D | 4xFC/2xFC/1xFC | ≥24dB | LC | Standard | YES |

Note1: X₁ refers to link budget; standard version is EOLS-1648-24-X.

Note2: X₂ refers to DWDM wavelength definition in the following table.

X- Channel refers to the following table:

| Channel | Part NO. | Frequency (THz) | Center Wavelength (nm) |
|---------|-----------------|-----------------|------------------------|
| 17* | EOLS-1648-24-17 | 191.7 | 1563.86 |
| 18* | EOLS-1648-24-18 | 191.8 | 1563.05 |

| | | | |
|-----|-----------------|-------|---------|
| 19* | EOLS-1648-24-19 | 191.9 | 1562.23 |
| 20* | EOLS-1648-24-20 | 192.0 | 1561.42 |
| 21 | EOLS-1648-24-21 | 192.1 | 1560.61 |
| 22 | EOLS-1648-24-22 | 192.2 | 1559.79 |
| 23 | EOLS-1648-24-23 | 192.3 | 1558.98 |
| 24 | EOLS-1648-24-24 | 192.4 | 1558.17 |
| 25 | EOLS-1648-24-25 | 192.5 | 1557.36 |
| 26 | EOLS-1648-24-26 | 192.6 | 1556.55 |
| 27 | EOLS-1648-24-27 | 192.7 | 1555.75 |
| 28 | EOLS-1648-24-28 | 192.8 | 1554.94 |
| 29 | EOLS-1648-24-29 | 192.9 | 1554.13 |
| 30 | EOLS-1648-24-30 | 193.0 | 1553.33 |
| 31 | EOLS-1648-24-31 | 193.1 | 1552.52 |
| 32 | EOLS-1648-24-32 | 193.2 | 1551.72 |
| 33 | EOLS-1648-24-33 | 193.3 | 1550.92 |
| 34 | EOLS-1648-24-34 | 193.4 | 1550.12 |
| 35 | EOLS-1648-24-35 | 193.5 | 1549.32 |
| 36 | EOLS-1648-24-36 | 193.6 | 1548.51 |
| 37 | EOLS-1648-24-37 | 193.7 | 1547.72 |
| 38 | EOLS-1648-24-38 | 193.8 | 1546.92 |
| 39 | EOLS-1648-24-39 | 193.9 | 1546.12 |
| 40 | EOLS-1648-24-40 | 194.0 | 1545.32 |
| 41 | EOLS-1648-24-41 | 194.1 | 1544.53 |
| 42 | EOLS-1648-24-42 | 194.2 | 1543.73 |
| 43 | EOLS-1648-24-43 | 194.3 | 1542.94 |
| 44 | EOLS-1648-24-44 | 194.4 | 1542.14 |
| 45 | EOLS-1648-24-45 | 194.5 | 1541.35 |
| 46 | EOLS-1648-24-46 | 194.6 | 1540.56 |
| 47 | EOLS-1648-24-47 | 194.7 | 1539.77 |
| 48 | EOLS-1648-24-48 | 194.8 | 1538.98 |
| 49 | EOLS-1648-24-49 | 194.9 | 1538.19 |
| 50 | EOLS-1648-24-50 | 195.0 | 1537.40 |
| 51 | EOLS-1648-24-51 | 195.1 | 1536.61 |
| 52 | EOLS-1648-24-52 | 195.2 | 1535.82 |
| 53 | EOLS-1648-24-53 | 195.3 | 1535.04 |
| 54 | EOLS-1648-24-54 | 195.4 | 1534.25 |
| 55 | EOLS-1648-24-55 | 195.5 | 1533.47 |
| 56 | EOLS-1648-24-56 | 195.6 | 1532.68 |
| 57 | EOLS-1648-24-57 | 195.7 | 1531.90 |
| 58 | EOLS-1648-24-58 | 195.8 | 1531.12 |
| 59 | EOLS-1648-24-59 | 195.9 | 1530.33 |
| 60* | EOLS-1648-24-60 | 196.0 | 1529.55 |

| | | | |
|-----|-----------------|-------|---------|
| 61* | EOLS-1648-24-61 | 196.1 | 1528.77 |
|-----|-----------------|-------|---------|

*This channel is supported with limited availability; please contact Eoptolink for further details.

Regulatory Compliance

| Feature | Standard | Performance |
|--|--|--|
| Electrostatic Discharge (ESD) to the Electrical Pins | MIL-STD-883G Method 3015.7 | Class 1C (>1000 V) |
| Electrostatic Discharge to the enclosure | EN 55024:1998+A1+A2 IEC-61000-4-2 GR-1089-CORE | Compliant with standards |
| Electromagnetic Interference (EMI) | FCC Part 15 Class B EN55022:2006 CISPR 22B :2006 VCCI Class B | Compliant with standards Noise frequency range: 30MHz to 6GHz. Good system EMI design practice required to achieve Class B margins. System margins are dependent on customer host board and chassis design. |
| Immunity | EN 55024:1998+A1+A2 IEC 61000-4-3 | Compliant with standards. 1KHz sine-wave, 80% AM, from 80MHz to 1GHz. No effect on transmitter/receiver performance is detectable between these limits. |
| Laser Eye Safety | FDA 21CFR 1040.10 and 1040.11 EN (IEC) 60825-1:2007 EN (IEC) 60825-2:2004+A1 | CDRH compliant and Class I laser product. TüV Certificate No. 50135086 |
| Component Recognition | UL and CUL EN60950-1:2006 | UL file E317337 TüV Certificate No. 50135086 (CB scheme) |
| RoHS6 | 2002/95/EC 4.1&4.2 2005/747/EC 5&7&13 | Compliant with standards ^{*note3} |

Note3: For update of the equipments and strict control of raw materials, EOPTOLINK has the ability to supply the customized products since Jan 1st, 2007, which meet the requirements of RoHS6 (Restrictions on use of certain Hazardous Substances) of European Union.

In light of item 5 in RoHS exemption list of RoHS Directive 2002/95/EC, Item 5: Lead in glass of cathode ray tubes, electronic components and fluorescent tubes.

In light of item 13 in RoHS exemption list of RoHS Directive 2005/747/EC, Item 13: Lead and cadmium in optical and filter glass. The three exemptions are being concerned for Eoptolink's transceivers, because Eoptolink's transceivers use glass, which may contain Pb, for components such as lenses, isolators, and other components.

Product Description

The EOLS-1648-X-X series single mode transceiver is small form factor pluggable module for duplex optical data communications such as 4x/2x/1x Fiber Channel and 1000BASE Ethernet. It is with the SFP 20-pin connector to allow hot plug capability. This module is designed for single mode fiber and operates at a 100 GHz C-Band wavelengths on the ITU-T grid. A guaranteed minimum optical power budget of 24dB is offered.

The transmitter section uses a DWDM laser and is a class 1 laser compliant according to International Safety Standard IEC-60825. The receiver section uses an integrated InGaAs detector preamplifier (IDP) mounted in an optical header and a limiting post-amplifier IC.

The EOLS-1648-24-XD series are designed to be compliant with SFF-8472.

Absolute Maximum Ratings

| Parameter | Symbol | Min. | Max. | Unit |
|-----------------------------|--------|------|------|------|
| Storage Temperature | Ts | -40 | +85 | °C |
| Supply Voltage | Vcc | -0.5 | 3.6 | V |
| Operating Relative Humidity | | | 95 | % |

*Exceeding any one of these values may destroy the device immediately.

Recommended Operating Conditions

| Parameter | Symbol | Min. | Typical | Max. | Unit |
|----------------------------|-------------------------------|------|---------|------|------|
| Operating Case Temperature | T _A EOLS-1648-24-X | -5 | | +70 | °C |
| Power Supply Voltage | Vcc | 3.15 | 3.3 | 3.45 | V |
| Power Supply Current | Icc | | | 300 | mA |
| Data Rate | 4xFC | | 4.25 | | Gbps |
| | 2xFC | | 2.125 | | |
| | 1xFC | | 1.063 | | |

Performance Specifications – Electrical

(T_{OP} = -5 to 70°C, V_{CC} = 3.15 to 3.45V)

| Parameter | Symbol | Min. | Typ. | Max | Unit | Notes |
|--------------------------------|---------|------|------|---------|------|---------------------|
| Transmitter | | | | | | |
| LVPECL Inputs(Differential) | Vin | 400 | | 2000 | mVpp | AC coupled input |
| Input Impedance (Differential) | Zin | 85 | 100 | 115 | ohm | Rin > 100 kohm @ DC |
| TX_Dis | Disable | 2 | | Vcc+0.3 | V | |
| | Enable | 0 | | 0.8 | | |
| TX_FAULT | Fault | 2 | | Vcc+0.3 | V | |
| | Normal | 0 | | 0.5 | | |
| Receiver | | | | | | |
| CML Outputs | Vout | 400 | 800 | 1200 | mVpp | AC coupled |

| | | | | | | |
|---------------------------------|--------|-----|-----|----------------------|-----|----------------------------|
| (Differential) | | | | | | output ^{*(note4)} |
| Output Impedance (Differential) | Zout | 85 | 100 | 115 | ohm | |
| RX_LOS | LOS | 2 | | V _{CC} +0.3 | V | |
| | Normal | 0 | | 0.8 | V | |
| MOD_DEF (0:2) | VoH | 2.5 | | | V | With Serial ID |
| | VoL | 0 | | 0.5 | V | |

Optical and Electrical Characteristics

(T_{OP} = -5 to 70 °C, V_{CC} = 3.15 to 3.45V)

| Parameter | Symbol | Min. | Typical | Max. | Unit |
|--|---|------------------|---------|--------|------|
| Power budget @ 9/125µm SMF | | | 26 | | dB |
| Data Rate | | 1.063 | | 4.25 | Gbps |
| Transmitter | | | | | |
| Wavelength | λ | 1528 | | 1564 | nm |
| Spectral Width (-20dB) | $\Delta\lambda$ | | | 0.3 | nm |
| Side Mode Suppression Ratio | SMSR | 30 | | | dB |
| Channel Spacing | Δf | | 100 | | GHz |
| | | | 0.8 | | nm |
| Deviation From Central Frequency, EOL | Δf | | | ±12 | GHz |
| | | | | ±0.096 | nm |
| Average Output Power ^{*(note5)} | P _{out} | 0 | - | 4 | dBm |
| Extinction Ratio ^{*(note6)} | ER | 9 | | | dB |
| Rise/Fall Time(20% ~ 80%) | tr/tf | | | 90 | ps |
| Output Optical Eye ^{*(note6)} | Compliant with ANSI FC-PI specification ^{*(note8)} | | | | |
| TX_Disable Assert Time | t _{off} | | | 10 | us |
| P _{out} @TX Disable Asserted | P _{out} | | | -30 | dBm |
| Receiver | | | | | |
| Center Wavelength | λ_c | 1528 | | 1564 | nm |
| Receiver Sensitivity ^{*(note7)} | 4xFC | P _{min} | | -24 | dBm |
| | 2xFC | | | -25 | |
| | 1xFC | | | -26 | |
| Receiver Overload | P _{max} | -6 | | | dBm |
| Maximum Reflectance Of Receiver | R _f | | | -27 | dB |
| Dispersion Penalty | P _d | | | 2 | dB |
| LOS De-Assert | LOSD | | | -25 | dBm |
| LOS Assert | LOSA | -40 | | | dBm |
| LOS Hysteresis ^{*(note9)} | | 0.5 | | | dB |

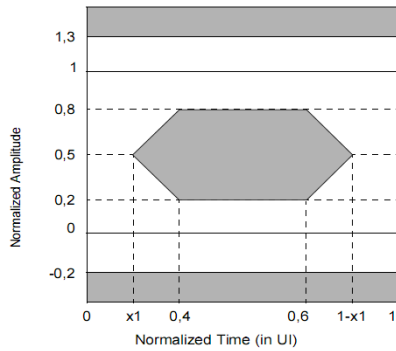
Note4: CML logic, internally AC coupled.

Note5: Output is coupled into a 9/125µm single-mode fiber.

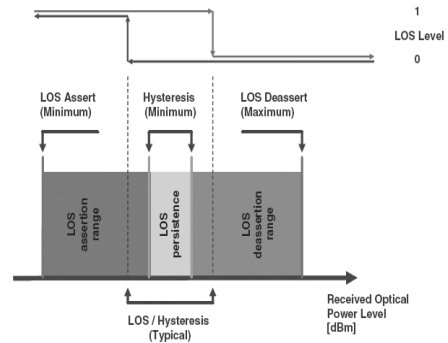
Note6: Filtered, measured with a PRBS 2⁷-1 test pattern @4.25Gbps

Note7: Minimum average optical power measured at BER less than 1E-12, with a 2⁷-1 PRBS and ER=9dB.

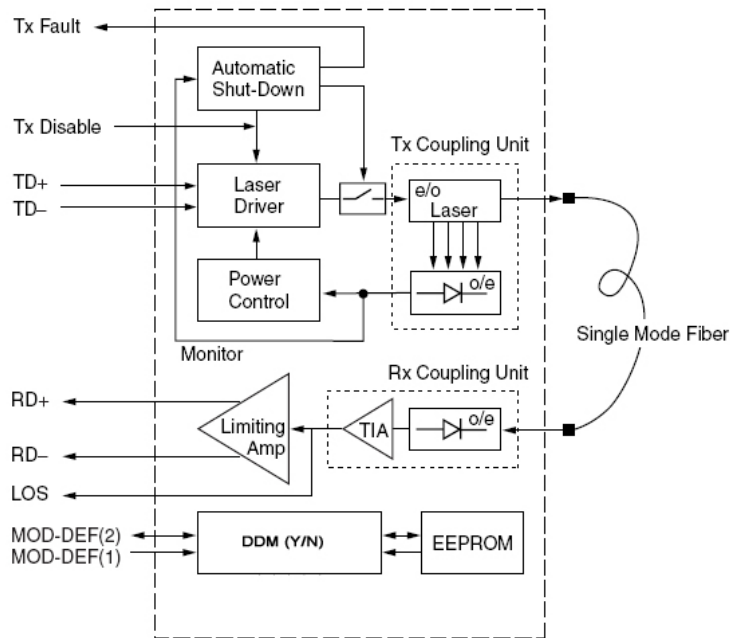
Note8: Eye Pattern Mask



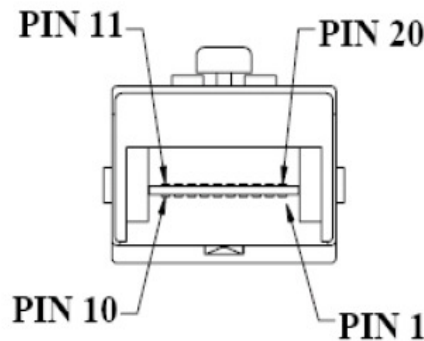
Note9: LOS Hysteresis

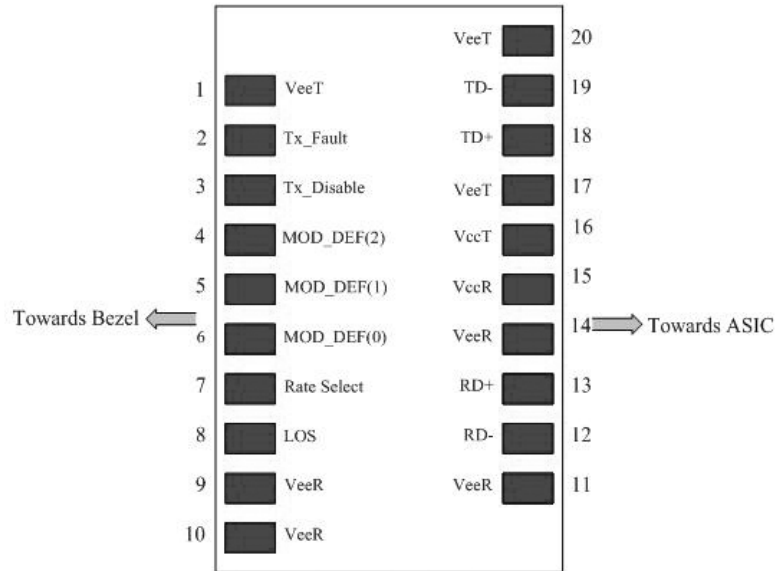


Functional Description of Transceiver



SFP Transceiver Electrical Pad Layout





Pin Function Definition

| Pin Num. | Name | Function | Plug Seq. | Notes |
|----------|-------------|------------------------------|-----------|------------------------------------|
| 1 | VeeT | Transmitter Ground | 1 | 5) |
| 2 | TX Fault | Transmitter Fault Indication | 3 | 1) |
| 3 | TX Disable | Transmitter Disable | 3 | 2) Module disables on high or open |
| 4 | MOD-DEF2 | Module Definition 2 | 3 | 3) Data line for Serial ID. |
| 5 | MOD-DEF1 | Module Definition 1 | 3 | 3) Clock line for Serial ID. |
| 6 | MOD-DEF0 | Module Definition 0 | 3 | 3) Grounded within the module. |
| 7 | Rate Select | Not Connect | 3 | Function not available |
| 8 | LOS | Loss of Signal | 3 | 4) |
| 9 | VeeR | Receiver Ground | 1 | 5) |
| 10 | VeeR | Receiver Ground | 1 | 5) |
| 11 | VeeR | Receiver Ground | 1 | 5) |
| 12 | RD- | Inv. Received Data Out | 3 | 6) |
| 13 | RD+ | Received Data Out | 3 | 6) |
| 14 | VeeR | Receiver Ground | 1 | 5) |
| 15 | VccR | Receiver Power | 2 | 7) 3.3 ± 5% |
| 16 | VccT | Transmitter Power | 2 | 7) 3.3 ± 5% |
| 17 | VeeT | Transmitter Ground | 1 | 5) |
| 18 | TD+ | Transmit Data In | 3 | 8) |
| 19 | TD- | Inv. Transmit Data In | 3 | 8) |
| 20 | VeeT | Transmitter Ground | 1 | 5) |

Notes:

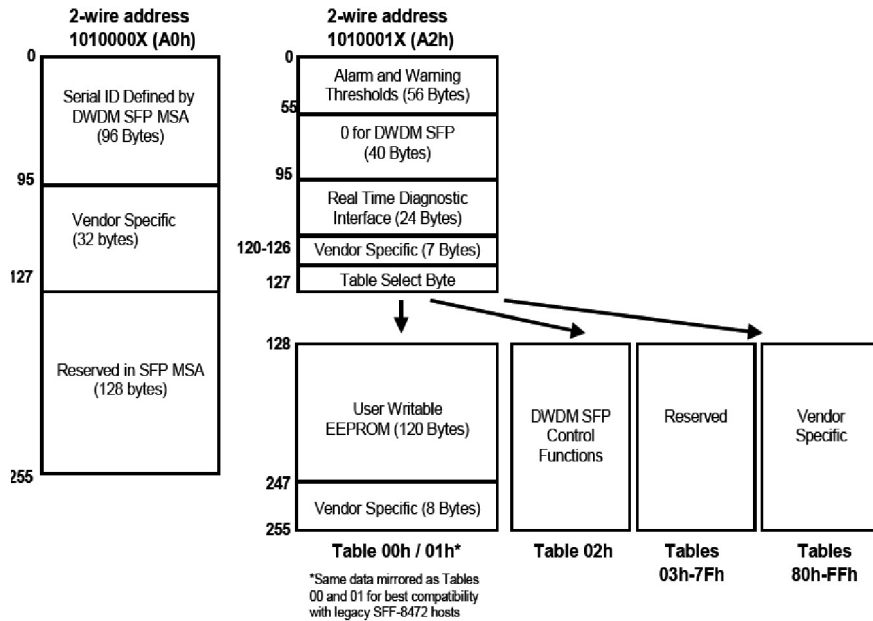
- 1) TX Fault is an open collector/drain output, which should be pulled up with a 4.7K – 10K Ω resistor on the host board. Pull up voltage between 2.0V and VccT, R+0.3V. When high, output indicates a laser fault of some kind. Low indicates normal operation. In the low state, the output will be pulled to < 0.8V.
- 2) TX disable is an input that is used to shut down the transmitter optical output. It is pulled up within the module with a 4.7 – 10 K Ω resistor. Its states are:
Low (0 – 0.8V): Transmitter on
(>0.8, < 2.0V): Undefined
High (2.0 – 3.465V): Transmitter Disabled
Open: Transmitter Disabled
- 3) Modulation Absent, connected to VEET or VEER in the module.
- 4) LOS (Loss of Signal) is an open collector/drain output, which should be pulled up with a 4.7K – 10K Ω resistor. Pull up voltage between 2.0V and VccT, R+0.3V. When high, this output indicates the received optical power is below the worst-case receiver sensitivity (as defined by the standard in use). Low indicates normal operation. In the low state, the output will be pulled to < 0.8V.
- 5) VeeR and VeeT may be internally connected within the SFP module.
- 6) RD-/+ : These are the differential receiver outputs. They are AC coupled 100 Ω differential lines which should be terminated with 100 Ω (differential) at the user SERDES. The AC coupling is done inside the module and is thus not required on the host board. The voltage swing on these lines will be between 400 and 2000mV differential (200 – 1000mV single ended) when properly terminated.
- 7) VccR and VccT are the receiver and transmitter power supplies. They are defined as 3.3V \pm 5% at the SFP connector pin. Maximum supply current is 300mA. Recommended host board power supply filtering is shown below. Inductors with DC resistance of less than 1 ohm should be used in order to maintain the required voltage at the SFP input pin with 3.3V supply voltage. When the recommended supply-filtering network is used, hot plugging of the SFP transceiver module will result in an inrush current of no more than 30mA greater than the steady state value. VccR and VccT may be internally connected within the SFP transceiver module.
- 8) TD-/+ : These are the differential transmitter inputs. They are AC-coupled, differential lines with 100 Ω differential termination inside the module. The AC coupling is done inside the module and is thus not required on the host board. The inputs will accept differential swings of 400 – 2000mV (200 – 1000mV single-ended).

EEPROM

The serial interface uses the 2-wire serial CMOS EEPROM protocol defined for the ATMEL AT24C01A/02/04 family of components. When the serial protocol is activated, the host generates the serial clock signal (SCL, Mod Def 1). The positive edge clocks data into those segments of

the EEPROM that are not writing protected within the SFP transceiver. The negative edge clocks data from the SFP transceiver. The serial data signal (SDA, Mod Def 2) 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 Module provides diagnostic information about the present operating conditions. The transceiver generates this diagnostic data by digitization of internal analog signals. Alarm/warning threshold data is written during device manufacture. TEC current monitoring, laser temperature monitoring, received power monitoring, transmitted power monitoring, bias current monitoring, supply voltage monitoring and transceiver temperature monitoring all are implemented. The diagnostic data are internal calibration and stored in memory locations 96 – 109 at wire serial bus address A2h. The transceiver memory map specific data field defines as following.



EEPROM Serial ID Memory Contents

Accessing Serial ID Memory uses the 2 wire address 1010000X (A0H). Memory Contents of Serial ID are shown in Table 1.

Table 1 Serial ID Memory Contents

| Addr. | Size(bytes) | Name of field | Vaule(Hex) | Description |
|-------|-------------|-----------------|------------|--|
| 0 | 1 | Identifier | 0B | DWDM SFP |
| 1 | 1 | Ext. Identifier | 24 | DWDM,Power:1w~1.5w,Class of temp:[-5□-70□] |
| 2 | 1 | Connector | 07 | LC connector |
| 3-10 | 8 | Transceiver | 00 | Reserved |

| | | | | |
|-------|----|--|----------------|---|
| | | Codes | 00 | - |
| | | | 00 | - |
| | | | 02 | 1000BASE-LX |
| | | | 10 | very long distance (V) |
| | | | 10 | Longwave laser(LL) |
| | | | 01 | Single mode |
| | | | 15 | - |
| 11 | 1 | Encoding | 01 | NRZ |
| 12 | 1 | BR, Nominal | 2B | 4250Mb/s |
| 13 | 1 | Link length | 00 | Supported for 9/125um, units of km. |
| 14 | 1 | | 50 | |
| 15 | 1 | Maximum operating case temperature | 46 | - |
| 16 | 1 | Minimum operating case temperature in °C | FB | - |
| 17 | 1 | Max Supply Current | 6C | - |
| 18 | 1 | Reserved | 00 | - |
| 19 | 1 | Channel spacing and Tuning | 41 | Channel spacing compatibility and number of ITU channels supported |
| 20~35 | 16 | SFP vendor name (ASCII) | XX | Vendor name |
| 36 | 1 | Optional features | 00 | Implemented optional DWDM features |
| 37-39 | 3 | Vendor OUI | 00 00 00 | - |
| 40-55 | 16 | Vendor PN | - | "EOLS-1648-24-X" (ASCII) |
| 56-59 | 4 | Vendor Rev | 31 2E 30 20 | Revision 1.0(ASCII) |
| 60-62 | 3 | Wavelength | XX | Laser Wavelength |
| 63 | 1 | CC-BASE | XX | CC for Base ID fields implemented (addresses 0 to62) |
| 64~65 | 2 | Options | 00 | Reserved |
| | | | 1A | 1.TX_DISABLE is implemented and disables the serial output; 2.TX_FAULT signal implemented; 3.Loss of Signal implemented |
| 66 | 1 | BR, max | 00 | Upper bit rate margin, unit of % |
| 67 | 1 | BR, max | 4B | Lower bit rate margin, unit of % |

| | | | | |
|---------|-----|----------------------------|-----------|--|
| 68~83 | 16 | Vendor SN | XX | Serial number of Transceiver (ASCII) |
| 84~91 | 8 | Date code | XX | The vendor's date code (ASCII) |
| 92 | 1 | Diagnostic Monitoring Type | 68 | 1. Digital diagnostic monitoring implemented 2. Internally Calibrated; 3. Received power measurement type is Average Power |
| 93 | 1 | Enhanced Options | F0 | 1. Optional Alarm/warning flags implemented for all monitored quantities 2. Optional Soft TX_DISABLE control and monitoring implemented 2. Optional Soft TX_FAULT monitoring Implemented 3. Optional Soft RX_LOS monitoring Implemented |
| 94 | 1 | SFF-8472 Compliance | 01 | Includes functionality described in Rev 9.3 of SFF-8472. |
| 95 | 1 | CC_EXT | XX | CC for the extended ID Fields (addresses 64 to 94) implemented. |
| 96~127 | 32 | Vendor Specific | XX | Read only memory |
| 128-255 | 128 | Reserved | Read only | |

Note10: The "XX" byte should be filled in according to practical case. For more information, please refer to the related document of SFP Multi-Source Agreement (MSA).

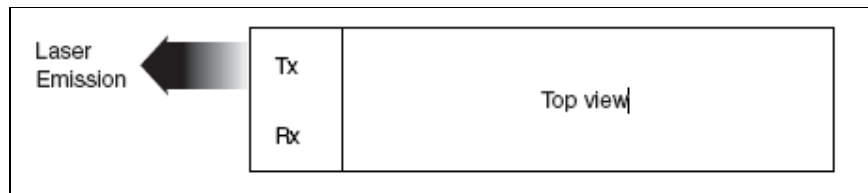
Digital Diagnostic Monitoring Range (2-Wire Address A2H)

| Parameter | Range | Accuracy | Unit | Notes |
|-----------------|--------------|----------|------|-------------------------------------|
| Temperature | -5 ~ 70 | ±3 | °C | |
| Voltage | 0 ~ Vcc | 0.1 | V | |
| Bias Current | 0 ~ 120 | 5 | mA | |
| Tx Power | 1 ~ 4 | ±2 | dBm | |
| Rx Power | -23 ~ -6 | ±2 | dBm | |
| TEC Current | -1200 ~ 1200 | ±60 | mA | |
| TEC Temperature | 20 ~70 | ±0.25 | °C | Relative, absolute accuracy is ±3°C |

Laser Emission Data

| | |
|---|----------|
| Wavelength | > 1528nm |
| Total output power (as defined by FDA: 7mm aperture at 20cm distance) | <0.79mW |
| Total output power (as defined by IEC: 7mm aperture at 10cm distance) | <10mW |
| Beam divergence | 12.5° |

Laser Emission



Obtaining Document

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Or contact Eoptolink Technology Inc., Ltd. listed at the end of the documentation to get the latest documents.

Revision History

| Revision | Initiated | Reviewed | Approved | Revision History | Release Date |
|----------|-----------|----------|----------|---|---------------|
| V1.a | Cathy | Kelly | | Preliminary released. | June 29, 2009 |
| V1.b | Cathy | Kelly | | Correct the EEPROM info. | Sep 29, 2009 |
| V1.c | Cathy | Kelly | | Revise the optical parameters. | Oct 12, 2009 |
| V1.d | Kelly | | | Correct the output power and change logo. | Jan 7, 2010 |

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