

Professional high-speed optical transceiver

## OPN-S1HD445-40LC2 / OPN-S1HD445-40LC2I

10.3 Gbps / 40 km / 50GHz DWDM Digital Diagnostic LC SFP+ SINGLE-MODE  
TRANSCEIVER

### PRODUCT FEATURES

- Up to 10.5 Gb/s Bi-directional Data Links
  - Complaint to SFP+ MSA
- Compliant to IEEE 802.3ae 10GBASE-ER/EW
  - Maximum Link Length of 40 km
- Temperature-stabilized DWDM EML Transmitter
  - 14 dB Power Budget at Least
  - 50 GHz ITU Grid, C Band
- SFF-8472 Digital Diagnostic Function
- AC/AC Coupling according to MSA
  - Single +3.3 V Power Supply
  - RoHS Compliant
- 0 to 70°C Operating: OPN-S1HD445-40LC2
- -50 to 85°C Operating: OPN-S1HD445-40LC2I
- Class 1 Laser International Safety Standard IEC-60825Compliant

### APPLICATIONS

- 10GBASE-ER/EW
- OC-192 / STM-64 IR-2
- 40 km 10G Fibre Channel

### PRODUCT DESCRIPTION

The OPN-S1HD445-40LC2 series single mode transceiver isa small form factor pluggable module for bi-directional serial optical data communications such as IEEE 802.3ae 10GBASE-ER/EW. It is with the SFP 20-pin connector toallow hot plug capability. Digital diagnostic functions areavailable via an I<sup>2</sup>C. This module is designed for single mode fiber and operates at a nominal wavelength of 50GHz ITU Grid, C Band DWDM wavelength. A guaranteed minimum optical link budget of 14 dB is offered. The transmitter section uses temperature-stabilized DWDMelectrical-modulated laser (EML) 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.

### ORDER INFORMATION

| P/No.              | Bit Rate (Gb/s) | 10G     | Distance (km) | Spacing (GHz) | Wavelength (nm) | Package       | Case Temp (°C) | RoHS Compliant |
|--------------------|-----------------|---------|---------------|---------------|-----------------|---------------|----------------|----------------|
| OPN-S1HD445-40LC2  | 9.95 – 10.52    | ER / EW | 40            | 50            | DWDM*           | SFP+ with DMI | 0 to 70        | Yes            |
| OPN-S1HD445-40LC2I | 9.95 – 10.52    | ER / EW | 40            | 50            | DWDM*           | SFP+ with DMI | -50 to 85      | Yes            |

\*XXX: 50GHz ITU Grid wavelength (Please see below)

| Channel # | Product code      | Frequency (THz) | Center Wavelength (nm) | Label |
|-----------|-------------------|-----------------|------------------------|-------|
| 190       | OPN-S1HD190-40LC2 | 191.90          | 1562.23                | 190   |
| 195       | OPN-S1HD195-40LC2 | 191.95          | 1561.83                | 195   |
| 200       | OPN-S1HD200-40LC2 | 192.00          | 1561.42                | 200   |
| 205       | OPN-S1HD205-40LC2 | 192.05          | 1561.01                | 205   |
| 210       | OPN-S1HD210-40LC2 | 192.10          | 1560.61                | 210   |
| 215       | OPN-S1HD215-40LC2 | 192.15          | 1560.20                | 215   |
| 220       | OPN-S1HD220-40LC2 | 192.20          | 1559.79                | 220   |
| 225       | OPN-S1HD225-40LC2 | 192.25          | 1559.39                | 225   |
| 230       | OPN-S1HD230-40LC2 | 192.30          | 1558.98                | 230   |
| 235       | OPN-S1HD235-40LC2 | 192.35          | 1558.58                | 235   |
| 240       | OPN-S1HD240-40LC2 | 192.40          | 1558.17                | 240   |
| 245       | OPN-S1HD245-40LC2 | 192.45          | 1557.77                | 245   |
| 250       | OPN-S1HD250-40LC2 | 192.50          | 1557.36                | 250   |

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| Channel # | Product code      | Frequency (THz) | Center Wavelength (nm) | Label |
|-----------|-------------------|-----------------|------------------------|-------|
| 255       | OPN-S1HD255-40LC2 | 192.55          | 1556.96                | 255   |
| 260       | OPN-S1HD260-40LC2 | 192.60          | 1556.55                | 260   |
| 265       | OPN-S1HD265-40LC2 | 192.65          | 1556.15                | 265   |
| 270       | OPN-S1HD270-40LC2 | 192.70          | 1555.75                | 270   |
| 275       | OPN-S1HD275-40LC2 | 192.75          | 1555.34                | 275   |
| 280       | OPN-S1HD280-40LC2 | 192.80          | 1554.94                | 280   |
| 285       | OPN-S1HD285-40LC2 | 192.85          | 1554.54                | 285   |
| 290       | OPN-S1HD290-40LC2 | 192.90          | 1554.13                | 290   |
| 295       | OPN-S1HD295-40LC2 | 192.95          | 1553.73                | 295   |
| 300       | OPN-S1HD300-40LC2 | 193.00          | 1553.33                | 300   |
| 305       | OPN-S1HD305-40LC2 | 193.05          | 1552.93                | 305   |
| 310       | OPN-S1HD310-40LC2 | 193.10          | 1552.52                | 310   |
| 315       | OPN-S1HD315-40LC2 | 193.15          | 1552.12                | 315   |
| 320       | OPN-S1HD320-40LC2 | 193.20          | 1551.72                | 320   |
| 325       | OPN-S1HD325-40LC2 | 193.25          | 1551.32                | 325   |
| 330       | OPN-S1HD330-40LC2 | 193.30          | 1550.92                | 330   |
| 335       | OPN-S1HD335-40LC2 | 193.35          | 1550.52                | 335   |
| 340       | OPN-S1HD340-40LC2 | 193.40          | 1550.12                | 340   |
| 345       | OPN-S1HD345-40LC2 | 193.45          | 1549.72                | 345   |
| 350       | OPN-S1HD350-40LC2 | 193.50          | 1549.32                | 350   |
| 355       | OPN-S1HD355-40LC2 | 193.55          | 1548.91                | 355   |
| 360       | OPN-S1HD360-40LC2 | 193.60          | 1548.51                | 360   |
| 365       | OPN-S1HD365-40LC2 | 193.65          | 1548.11                | 365   |
| 370       | OPN-S1HD370-40LC2 | 193.70          | 1547.72                | 370   |
| 375       | OPN-S1HD375-40LC2 | 193.75          | 1547.32                | 375   |
| 380       | OPN-S1HD380-40LC2 | 193.80          | 1546.92                | 380   |
| 385       | OPN-S1HD385-40LC2 | 193.85          | 1546.52                | 385   |
| 390       | OPN-S1HD390-40LC2 | 193.90          | 1546.12                | 390   |
| 395       | OPN-S1HD395-40LC2 | 193.95          | 1545.72                | 395   |
| 400       | OPN-S1HD400-40LC2 | 194.00          | 1545.32                | 400   |
| 405       | OPN-S1HD405-40LC2 | 194.05          | 1544.92                | 405   |
| 410       | OPN-S1HD410-40LC2 | 194.10          | 1544.53                | 410   |
| 415       | OPN-S1HD415-40LC2 | 194.15          | 1544.13                | 415   |
| 420       | OPN-S1HD420-40LC2 | 194.20          | 1543.73                | 420   |
| 425       | OPN-S1HD425-40LC2 | 194.25          | 1543.33                | 425   |
| 430       | OPN-S1HD430-40LC2 | 194.30          | 1542.94                | 430   |
| 435       | OPN-S1HD435-40LC2 | 194.35          | 1542.54                | 435   |
| 440       | OPN-S1HD440-40LC2 | 194.40          | 1542.14                | 440   |
| 445       | OPN-S1HD445-40LC2 | 194.45          | 1541.75                | 445   |
| 450       | OPN-S1HD450-40LC2 | 194.50          | 1541.35                | 450   |
| 455       | OPN-S1HD455-40LC2 | 194.55          | 1540.95                | 455   |
| 460       | OPN-S1HD460-40LC2 | 194.60          | 1540.56                | 460   |
| 465       | OPN-S1HD465-40LC2 | 194.65          | 1540.16                | 465   |
| 470       | OPN-S1HD470-40LC2 | 194.70          | 1539.77                | 470   |
| 475       | OPN-S1HD475-40LC2 | 194.75          | 1539.37                | 475   |
| 480       | OPN-S1HD480-40LC2 | 194.80          | 1538.98                | 480   |
| 485       | OPN-S1HD485-40LC2 | 194.85          | 1538.58                | 485   |
| 490       | OPN-S1HD490-40LC2 | 194.90          | 1538.19                | 490   |
| 495       | OPN-S1HD495-40LC2 | 194.95          | 1537.79                | 495   |
| 500       | OPN-S1HD500-40LC2 | 195.00          | 1537.40                | 500   |
| 505       | OPN-S1HD505-40LC2 | 195.05          | 1537.00                | 505   |
| 510       | OPN-S1HD510-40LC2 | 195.10          | 1536.61                | 510   |
| 515       | OPN-S1HD515-40LC2 | 195.15          | 1536.22                | 515   |
| 520       | OPN-S1HD520-40LC2 | 195.20          | 1535.82                | 520   |
| 525       | OPN-S1HD525-40LC2 | 195.25          | 1535.43                | 525   |
| 530       | OPN-S1HD530-40LC2 | 195.30          | 1535.04                | 530   |
| 535       | OPN-S1HD535-40LC2 | 195.35          | 1534.64                | 535   |
| 540       | OPN-S1HD540-40LC2 | 195.40          | 1534.25                | 540   |
| 545       | OPN-S1HD545-40LC2 | 195.45          | 1533.86                | 545   |
| 550       | OPN-S1HD550-40LC2 | 195.50          | 1533.47                | 550   |
| 555       | OPN-S1HD555-40LC2 | 195.55          | 1533.07                | 555   |

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| Channel # | Product code      | Frequency (THz) | Center Wavelength (nm) | Label |
|-----------|-------------------|-----------------|------------------------|-------|
| 560       | OPN-S1HD560-40LC2 | 195.60          | 1532.68                | 560   |
| 565       | OPN-S1HD565-40LC2 | 195.65          | 1532.29                | 565   |
| 570       | OPN-S1HD570-40LC2 | 195.70          | 1531.90                | 570   |
| 575       | OPN-S1HD575-40LC2 | 195.75          | 1531.51                | 575   |
| 580       | OPN-S1HD580-40LC2 | 195.80          | 1531.12                | 580   |
| 585       | OPN-S1HD585-40LC2 | 195.85          | 1530.72                | 585   |
| 590       | OPN-S1HD590-40LC2 | 195.90          | 1530.33                | 590   |
| 595       | OPN-S1HD595-40LC2 | 195.95          | 1529.94                | 595   |
| 600       | OPN-S1HD600-40LC2 | 196.00          | 1529.55                | 600   |
| 605       | OPN-S1HD605-40LC2 | 196.05          | 1529.16                | 605   |
| 610       | OPN-S1HD610-40LC2 | 196.10          | 1528.77                | 610   |

### Absolute Maximum Ratings

| Parameter                    | Symbol | Min  | Max | Units | Notes                                   |
|------------------------------|--------|------|-----|-------|-----------------------------------------|
| Storage Temperature          | Tstg   | -50  | 85  | °C    |                                         |
| Relative Humidity            | RH     | 5    | 85  | %     | Non-condensing                          |
| Operating Case Temperature   | Topr   | 0    | 70  | °C    | OPN-S1HD445-40LC2<br>OPN-S1HD445-40LC2I |
|                              |        | -50  | 85  |       |                                         |
| Power Supply Voltage         | Vcc    | -0.5 | 3.6 | V     |                                         |
| Receiver Input Optical Power | Mip    |      | 3   | dBm   | Average power                           |

### Recommended Operating Conditions

| Parameter                  | Symbol                 | Min   | Typ         | Max   | Units / Notes         |
|----------------------------|------------------------|-------|-------------|-------|-----------------------|
| Power Supply Voltage       | Vcc                    | 3.135 | 3.3         | 3.465 | V                     |
| Operating Case Temperature | Topr                   | 0     |             | 70    | °C/OPN-S1HD445-40LC2  |
|                            |                        | -50   |             | 85    | °C/OPN-S1HD445-40LC2I |
| Relative Humidity          | RH                     | 5     |             | 85    | % / Non-condensing    |
| Power Supply Current       | I <sub>CC(TX+RX)</sub> |       | 320         | 500   | mA/OPN-S1HD445-40LC2  |
|                            |                        |       | 320         | 650   | mA/OPN-S1HD445-40LC2I |
| Data Rate                  |                        |       | 9.95 / 10.3 | 10.5  | Gb/s                  |

### Transmitter Optical Specifications (0°C < Topr < 70°C, 3.13V < Vcc < 3.47V)

| Parameter                                                  | Symbol              | Min  | Typ | Max  | Units | Notes        |
|------------------------------------------------------------|---------------------|------|-----|------|-------|--------------|
| Average Launch Power                                       | P <sub>o, AVG</sub> | -2   |     | 2    | dBm   | 1            |
| Optical Modulation Amplitude                               | P <sub>o, OMA</sub> | -1.7 |     |      |       | 1            |
| Extinction Ratio                                           | ER                  | 8.2  |     |      | dB    |              |
| Center Wavelength Spacing                                  |                     |      | 50  |      | GHz   |              |
| Transmitter Center Wavelength<br>-- over life time         | λ <sub>c</sub>      | X-60 | X   | X+60 | pm    | 2            |
| Output Spectrum Width                                      | Δλ                  | ---  |     | 1    | nm    | -20 dB width |
| Side Mode Suppression Ratio                                | SMSR                | 30   |     |      | dB    |              |
| Transmitter and Dispersion<br>Penalty @ -500 to 1600 ps/nm | TDP                 |      |     | 2    | dB    |              |
| Relative Intensity Noise                                   | RIN                 |      |     | -128 | dB/Hz |              |
| Average Launch Power of OFF<br>Transmitter                 |                     |      |     | -30  | dBm   |              |

1. Output power is power coupled into a 9/125 μm single-mode fiber.
2. X = specified ITU Grid wavelength.

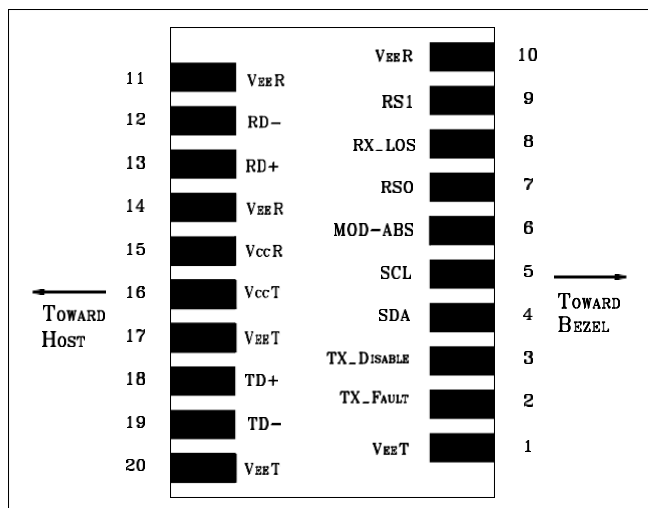
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| Receiver Optical Specifications (0°C < Topr < 70°C, 3.13V < Vcc < 3.47V) |                  |      |     |       |       |                         |
|--------------------------------------------------------------------------|------------------|------|-----|-------|-------|-------------------------|
| Parameter                                                                | Symbol           | Min  | Typ | Max   | Units | Notes                   |
| Sensitivity                                                              |                  |      |     | -16   | dBm   | 3                       |
| Stressed Receiver Sensitivity, OMA                                       |                  |      |     | -11.3 | dBm   |                         |
| Receiver Overload                                                        | P <sub>MAX</sub> | -1   | --- |       | dBm   |                         |
| LOS -- Deasserted                                                        | LOS <sub>D</sub> | ---  | --- | -16   | dBm   | Transition: low to high |
| LOS -- Asserted                                                          | LOS <sub>A</sub> | -28  | --- | ---   | dBm   | Transition: high to low |
| Wavelength of Operation                                                  | λ <sub>c</sub>   | 1480 |     | 1580  | nm    |                         |
| Optical Return Loss                                                      | ORL              |      |     | -27   | dB    |                         |

3. Measured with worst ER; BER < 10<sup>-12</sup> and PRBS 2<sup>31</sup>-1. Equivalent to -14.3 dBm OMA at ER=8.2 dB.

| Electrical Characteristics                               |                  |     |             |                      |                  |                       |
|----------------------------------------------------------|------------------|-----|-------------|----------------------|------------------|-----------------------|
| Parameter                                                | Symbol           | Min | Typ         | Max                  | Units            | Notes                 |
| <b>High-Speed Signal (CML) Interface Specification</b>   |                  |     |             |                      |                  |                       |
| Input Data Rate                                          |                  |     | 9.95 / 10.3 | 10.5                 | Gb/s             |                       |
| Differential Input Impedance                             | R <sub>in</sub>  |     | 100         |                      | Ω                |                       |
| Differential Data Input Amplitude                        |                  | 120 |             | 820                  | mV <sub>pp</sub> | Internally AC coupled |
| Output Data Rate                                         |                  |     | 9.95 / 10.3 | 10.5                 | Gb/s             |                       |
| Differential Output Impedance                            | R <sub>out</sub> |     | 100         |                      | Ω                |                       |
| Differential Data Output Amplitude                       |                  | 350 | 600         | 850                  | mV <sub>pp</sub> | Internally AC coupled |
| <b>Low-Speed Signal (LVTTTL) Interface Specification</b> |                  |     |             |                      |                  |                       |
| Input High Voltage                                       |                  | 2.0 |             | V <sub>cc</sub> +0.3 | V                |                       |
| Input Low Voltage                                        |                  | GND |             | 0.8                  | V                |                       |
| Output High Voltage                                      |                  | 2.4 |             | V <sub>cc</sub>      | V                |                       |
| Output Low Voltage                                       |                  | GND |             | 0.5                  | V                |                       |

## CONNECTION DIAGRAM



| PIN | Signal Name | Description                                                                                       | PIN | Signal Name | Description               |
|-----|-------------|---------------------------------------------------------------------------------------------------|-----|-------------|---------------------------|
| 1   | VEET        | Transmitter Signal Ground                                                                         | 11  | VEER        | Receiver Signal Ground    |
| 2   | TX_Fault    | Transmitter Fault Indication. Logic "1" Output = Laser Fault. Logic "0" Output = Normal Operation | 12  | RD-         | Inverse Receiver Data Out |
| 3   | TX_Disable  | Logic "1" Input (or no connection) = Laser off, Logic "0" = Laser on.                             | 13  | RD+         | Receiver Data Out         |

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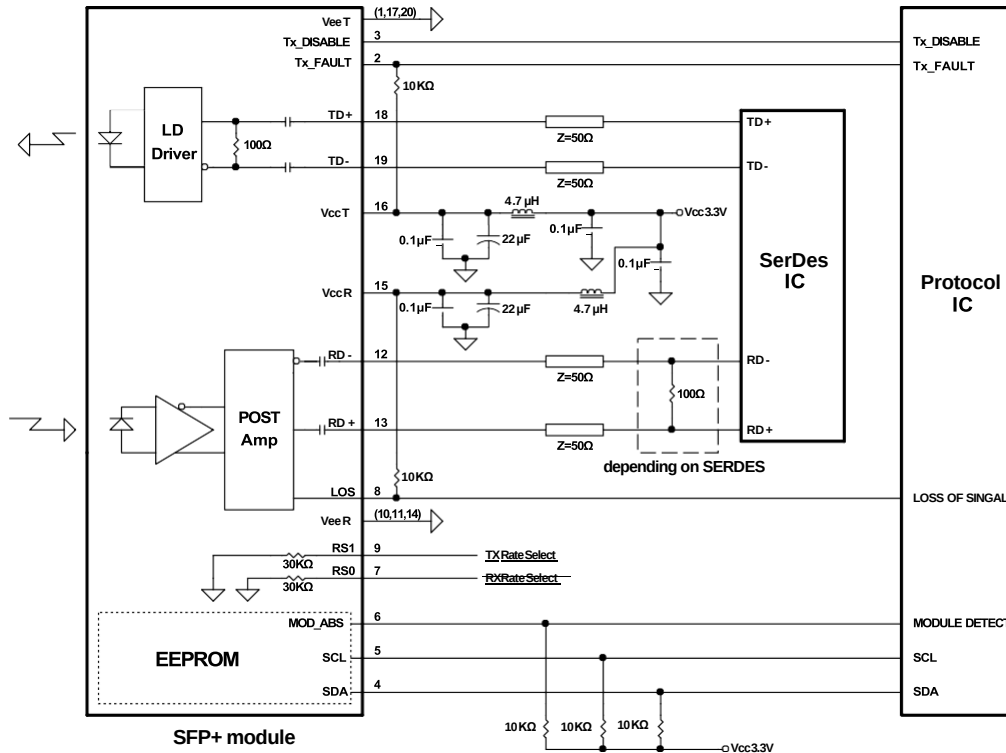
|    |                   |                                                                                                                                   |    |                   |                             |
|----|-------------------|-----------------------------------------------------------------------------------------------------------------------------------|----|-------------------|-----------------------------|
| 4  | SDA               | Modulation Definition 2 – Two wires serial ID Interface                                                                           | 14 | V <sub>EE</sub> R | Receiver Signal Ground      |
| 5  | SCL               | Modulation Definition 1 – Two wires serial ID Interface                                                                           | 15 | V <sub>CC</sub> R | Receiver Power – 3.3V±5%    |
| 6  | MOD-ABS           | Modulation Definition 0 – Ground in Module                                                                                        | 16 | V <sub>CC</sub> T | Transmitter Power – 3.3V±5% |
| 7  | RS0               | RX Rate Select (LVTTL). This pin has an internal 30k pulldown to ground. A signal on this pin will not affect module performance. | 17 | V <sub>EE</sub> T | Transmitter Signal Ground   |
| 8  | RX_LOS            | Loss of Signal Out (OC).                                                                                                          | 18 | TD+               | Transmitter Data In         |
| 9  | RS1               | TX Rate Select (LVTTL). This pin has an internal 30k pulldown to ground. A signal on this pin will not affect module performance. | 19 | TD-               | Inverse Transmitter Data In |
| 10 | V <sub>EE</sub> R | Receiver Signal Ground                                                                                                            | 20 | V <sub>EE</sub> T | Transmitter Signal Ground   |

## MODULE DEFINITION

| Module Definition | PIN 4 | PIN 5 | PIN 6   | Interpretation by Host            |
|-------------------|-------|-------|---------|-----------------------------------|
| 4                 | SDA   | SCL   | MOD-ABS | Serial module definition protocol |

Module Definition 4 specifies a serial definition protocol. For this definition, upon power up, SDA and SCL appear as no connector (NC) and MOD-ABS is TTL LOW. When the host system detects this condition, it activates the serial protocol. The protocol uses the 2-wire serial CMOS E<sup>2</sup>PROM protocol of the ATMEL AT24C01A/02/04 family of components.

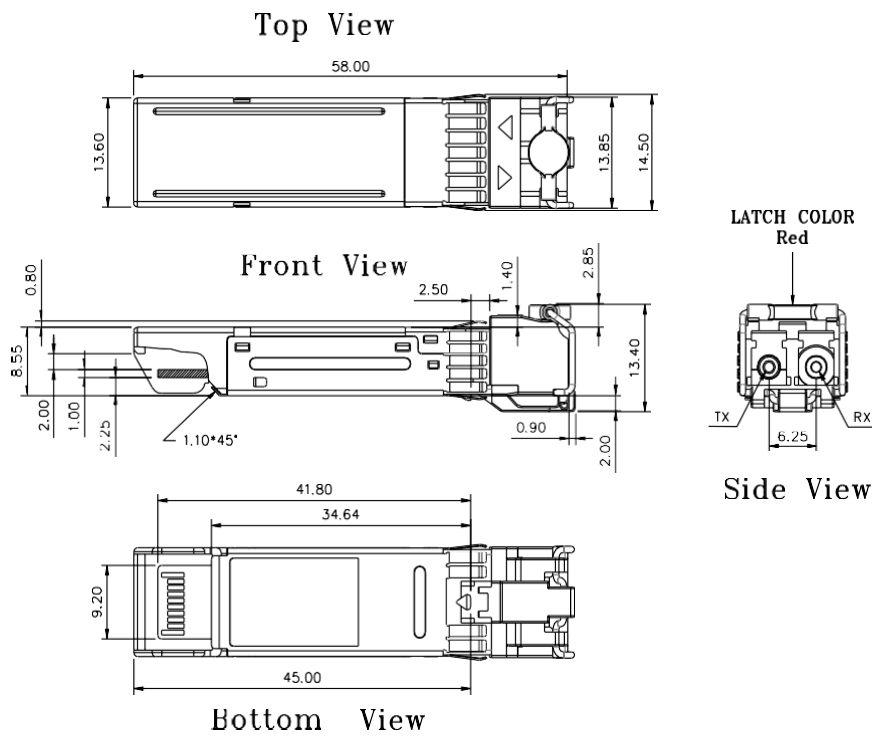
## RECOMMENDED CIRCUIT SCHEMATIC



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### PACKAGE DIAGRAM

Units in mm



**Note:** Specifications subject to change without notice.