# DM/SP7041-X
# 1000BASE-T Small Form Factor
# Pluggable Module
# Specification and
# Design Verification Test

✓ISO 9001 Certified



METHODE ELECTRONICS, INC.

7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

Table of Contents



**List of Figures**



**List of Tables**



**✓ISO 9001 Certified**



METHODE ELECTRONICS, INC.
7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**1.0 Scope**

This document describes the specification of Small Form-factor Pluggable 1000Base-T transceiver.

**2.0 Product Overview**

The 1000Base-T SFP module is the Small Form-factor Pluggable Transceiver MSA (see **[1]**) compliant transceiver. It provides the Gigabit Ethernet IEEE 802.3 compliant physical layer interface (see **[2]** and **[3]**) to network platforms that have MSA compliant SFP ports.

**2.1 Functional Description**

The module has two interfaces: the host interface and the MDI interface. The MDI interface provides 1000Base-T connectivity over the Category-5 cable. The host interface provides the data transfer over the 1.25 GHz PECL differential interface to the host board and control and configuration functions through the serial management interface.
The module provides for transparent Autonegotiation between the MAC and the link partner on the copper side. The MAC performs 1000Base-X Autonegotiation (**[2],** Clause 37). The MAC sees the 1000Base-T SFP transceiver as if it was an optical transceiver. On the MDI side the transceiver performs 1000Base-T Autonegotiation according to the IEEE 802.3u, Clause 28.
The default mode of operation after power-up is 1000Base-T, full duplex, over SERDES interface.
The management interface is the 2-wire serial interface (see **[4]**), which provides the access to the EEPROM containing transceiver's ID data, security key and other information according to **[1]**. Also, the serial management interface provides access to the transceiver's PHY registers.
Also, the transceiver shall provide for the triple speed (10/100/1000Base-T) operation over SGMII interface.
The SGMII mode, however, is configured through the serial management interface, by writing appropriate PHY registers.

**2.2 Key Features**

- IEEE 802.3z, IEEE 802.3u, IEEE 802.3ab compliant;
- SFP MSA compliant;
- Hot-pluggable SFP footprint;
- RJ-45 connector;
- Support for bail type ejector latch mechanism;
- Unshielded cable support;
- 1000Base-T, full duplex default operating mode;
- 10/100/1000Base-T operation on platforms supporting SGMII;
- Auto MDI/MDIX;
- TDR functionality support;
- FCC Class A compliant;
- Commercial operating temperature range;
- Support for shielded cable.


7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

### 3.0 Block Diagram

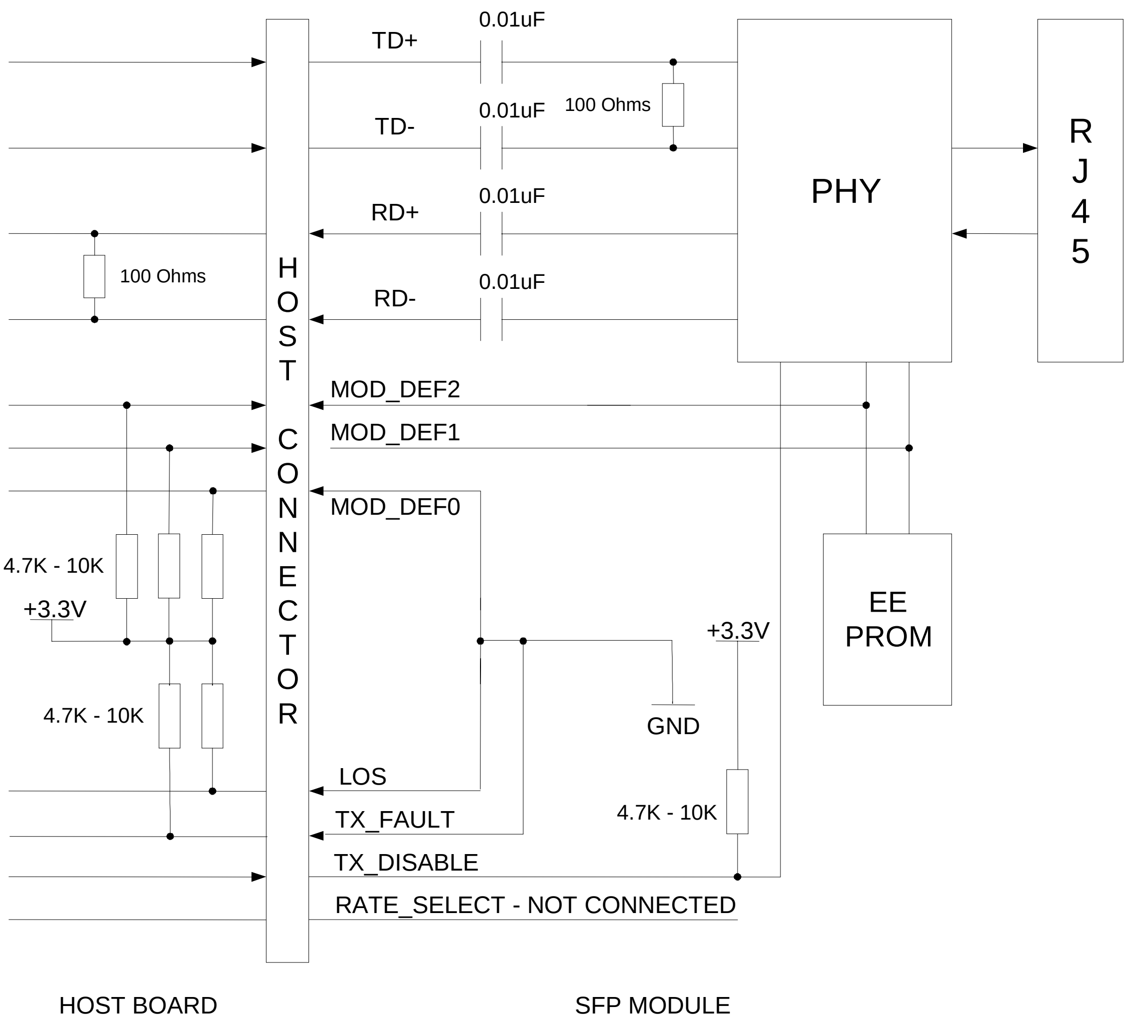



**Figure 3-1 1000Base-T SFP Transceiver Block Diagram**



METHODE ELECTRONICS, INC.

7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**4.0 I/O Interface**
Table 4-1 shows the host interface signals and their functions.

| Signal Name | Function | I/O | Connector Pin # |
|---|---|---|---|
| Vee | Ground | | 1, 9, 10, 11, 14, 17, 20 |
| Vcc | +3.3V | Input | 15, 16 |
| RX- | Receive Data, Differential | Output | 12 |
| RX+ | Receive Data, Differential | Output | 13 |
| LOS | Grounded on the SFP | Output | 8 |
| TX+ | Transmit Data, Differential | Input | 18 |
| TX- | Transmit Data, Differential | Input | 19 |
| TX_DISABLE | Transmitter Disable, Active High (on 1000Base-T SFP module used as reset) | Input | 3 |
| TX_FAULT | Grounded on the SFP Module | Output | 2 |
| MOD_DEF(0) | Grounded on the SFP Module | Output | 6 |
| MOD_DEF(1) | Serial Clock | Input | 5 |
| MOD_DEF(2) | Serial Data | BiDir | 4 |
| RATE SELECT | Unused | NC | 7 |

**Table 4-1 Host Board Connector Pinout**

**4.1 Host Side Electrical I/O Specifications**
Table 4-2 shows the required electrical I/O specifications for the host board interface signals.

| Parameter | | Symbol | Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|---|
| Supply Voltage | | Vcc | 3.315 | 3.3 | 3.465 | V | |
| Supply Current | | Icc | | | 300 | mA | |
| Inrush Current | | Icc' | | | 30 | mA | 1 |
| **Input** | | | | | | | |
| Input differential impedance | | Rin | 90 | 100 | 110 | Ohm | |
| Single ended data input swing | | Vin,pp | 100 | | 1200 | mV | |
| Tx Disable | Disable | Vd | 2 | | Vcc | V | |
| | Enable | Ven | Vee | | Vee+0.8 | V | |
| MOD_DEF1 | High | Vihmin | 2 | | Vcc | V | |
| | Low | Vilmax | Vee | | Vee+0.8 | V | |
| MOD_DEF2 (when host drives) | High | Vihmin | 2 | | Vcc | V | |
| | Low | Vilmax | Vee | | Vee+0.8 | V | |
| **Output** | | | | | | | |
| Single ended data output swing | | Vout,pp | 350 | | 800 | mV | 3 |
| Data output rise time | | Tr | | | 300 | ps | 4 |
| Data output fall time | | Tf | | | 300 | ps | 4 |
| Tx Fault | Fault | Vfault | N/A | | N/A | V | 2 |
| | Normal | Vnormal | Vee | | Vee+0.5 | V | 2 |
| LOS | Fault | Vlosfault | N/A | | N/A | V | 2 |
| | Normal | Vlosnormal | Vee | | Vee+0.5 | V | 2 |
| MOD_DEF0 | High | Vihmin | N/A | | N/A | V | 2 |
| | Low | Vilmax | Vee | | Vee+0.5 | V | 2 |
| MOD_DEF2 (when SFP drives) | High | Vihmin | 2.3 | | Vcc | V | |
| | Low | Vilmax | Vee | | Vee+0.5 | V | |

**Table 4-2 Host Board Interface Electrical I/O Specifications**

Notes:
1. The maximum inrush current during the hot plugging shall not exceed 30 mA.
2. The signal is grounded on the SFP module.
3. Measured with 100 Ohms differential termination.
4. 20%-80%

According to **[1]**, Appendix B2 and Fig 2B, TD+/- and RD+/- differential signals are AC coupled. The AC coupling is done on the SFP module and is not required on the host board.

**4.2 Power Supply Voltage and Power Consumption Requirements**
The SFP transceiver shall operate within its full specification, when the supply voltage is within 3.3V +/- 5%.
The power consumption shall not exceed 1W max under all operating conditions.
The maximum inrush current during hot plugging of the transceiver is 30 mA.


METHODE ELECTRONICS, INC.
7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**5.0 Media Interface**

**5.1 Transmitter Electrical Specifications**
The 1000BASE-T module achieves 1000 Mb/s of data transmission by using four Category 5 twisted-pairs at a data rate of 250Mb/s each as well as a more sophisticated five-level (+2,+1,0,-1,-2) coding scheme called PAM-5. The transmit waveform test is performed by transmitting the following sequence of data symbols continuously on all four channels: (see figure 5-1)

{(+2 followed by 127 0 symbols), (-2 followed by 127 0 symbols), (+1 followed by 127 0 symbols), (-1 followed by 127 0 symbols), (128 +2 symbols, 128 –2 symbols, 128 +2 symbols, 128 –2 symbols), (1024 0 symbols)}

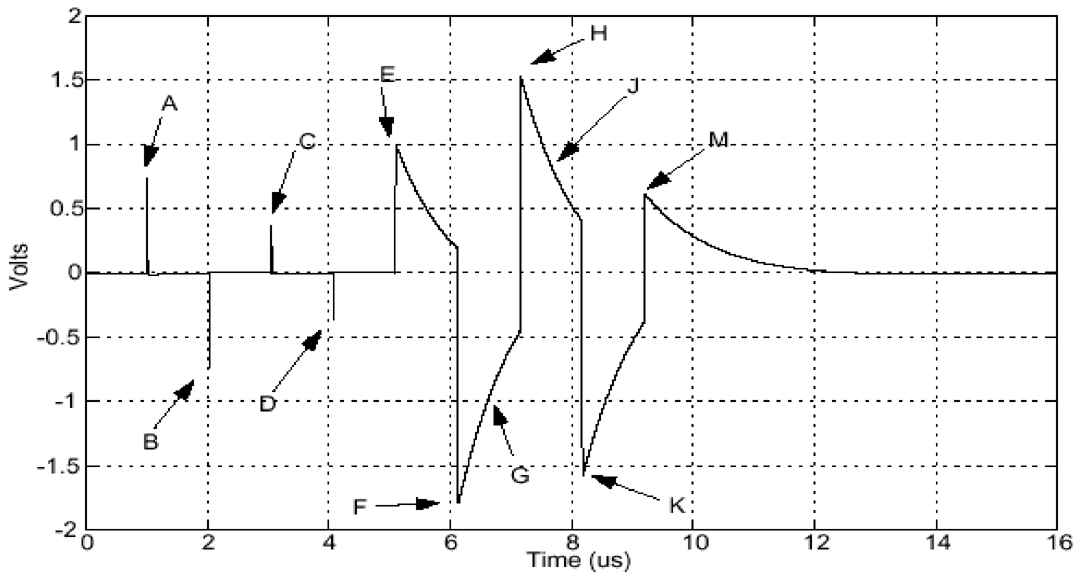



**Figure 5-1 Transmitter Waveform Example**

The voltage waveforms around points A,B,C and D defined in Figure 5–1,after normalization, shall lie within the time domain template 1 defined in Figure 5–2. These measurements are to be made for each pair. The waveforms may be shifted in time as appropriate to fit within the template.

The waveform around point A is normalized by dividing by the peak value of the waveform at A.
The waveform around point B is normalized by dividing by the negative of the peak value of the waveform at A.
The waveform around point C is normalized by dividing by 1/2 the peak value of the waveform at A.
The waveform around point D is normalized by dividing by the negative of 1/2 the peak value of the waveform at A.

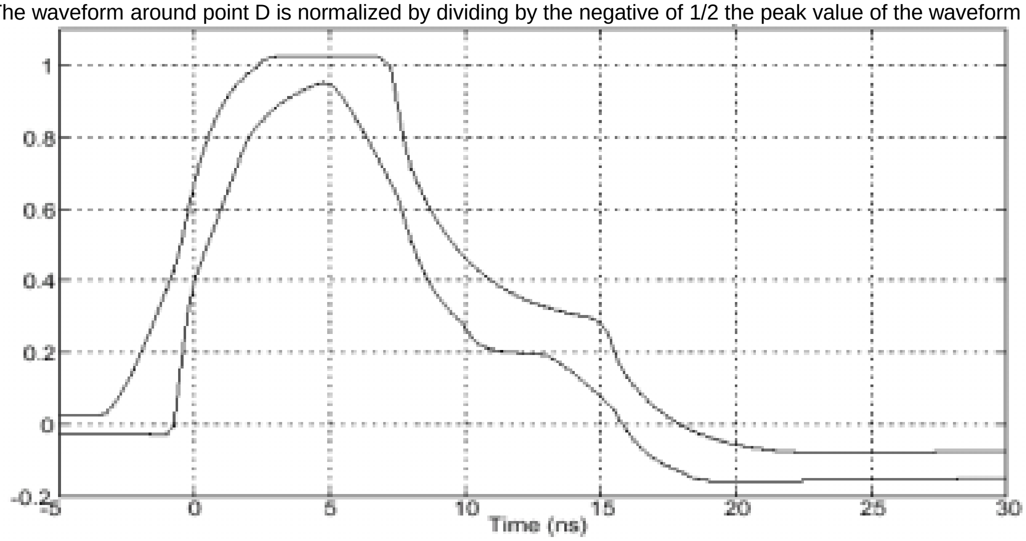



**Figure 5-2 Normalized Time Domain Transmit Template 1**



METHODE ELECTRONICS, INC.
7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

The voltage waveforms around points F and H defined in Figure 5-1,after normalization, shall lie within the time domain template 2 defined in Figure 5-3. These measurements are to be made for each pair. The waveforms may be shifted in time as appropriate to fit within the template.
The waveform around point F is normalized by dividing by the peak value of the waveform at F.
The waveform around point H is normalized by dividing by the peak value of the waveform at H.

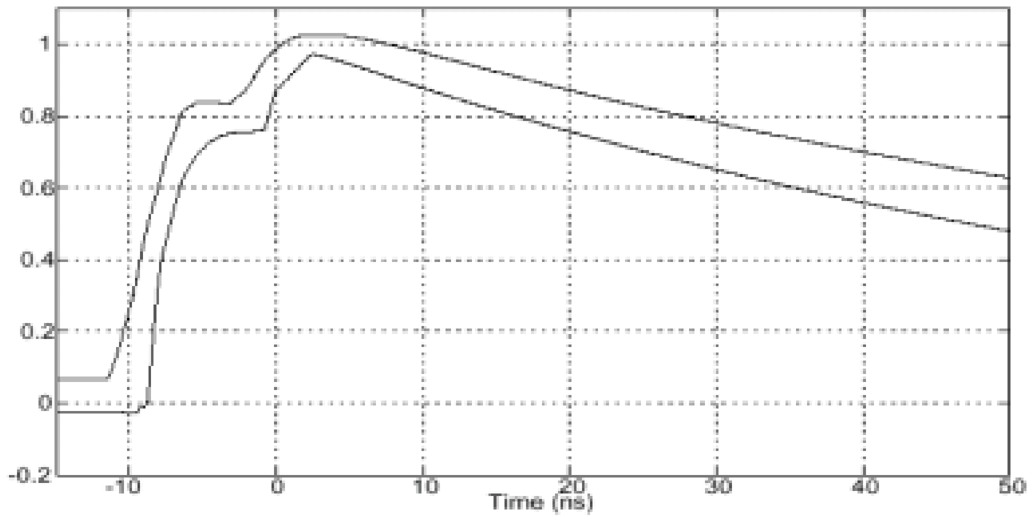



**Figure 5-3 Normalized Time Domain Transmit Template 2**

The measured normalized waveforms are shown within the templates described above in Figure 5-4 and 5-5.

40.6.1.2.1 Peak Differential Output Voltage and Level Accuracy

| Description | Rep. | Min. | Meas | Max. | Units |
|---|---|---|---|---|---|
| Point A | +2mV | 0.67 | 0.6737 | 0.82 | V |
| Point B | +2mV | -0.82 | -0.6777 | -0.67 | V |
| Point C | +2mV | - | 0.3362 | - | V |
| Point D | +2mV | - | -0.3374 | - | V |
| (1 + Point A/Point B) * 100% | +0.25% | -1 | 0.59 | 1 | % |
| (1 - (0.5 * (PointA + PointB) / 2) / PointC) * 100% | +0.5% | -2 | -0.48 | 2 | % |
| (1 - (0.5 * -(PointA + PointB) / 2) / PointD) * 100% | +0.5% | -2 | -0.15 | 2 | % |

40.6.1.2.3 Differential Output Template 1

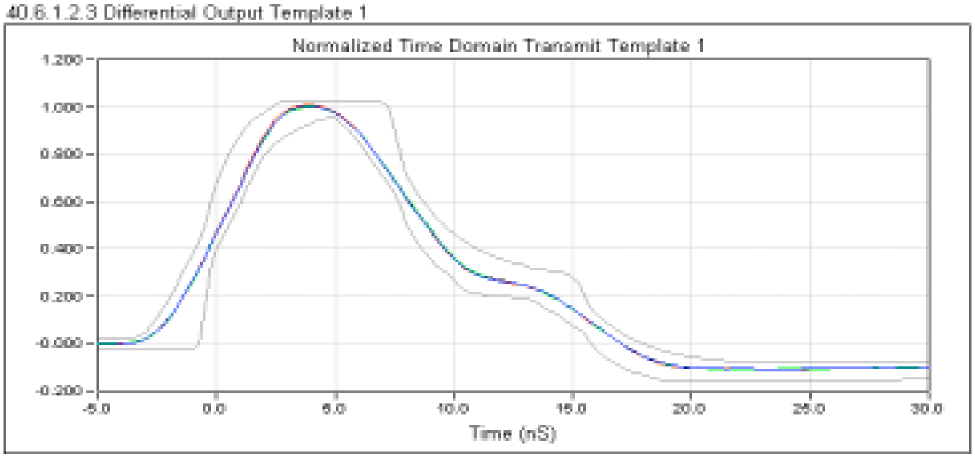



**Figure 4-4 Measured Normalized Waveform at A,B,C and D**


7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

40.6.1.2.2 Maximum Output Droop

| Description | Rep. | Min | Meas | Max | Units |
|---|---|---|---|---|---|
| Point F | +-2mV | - | -1.956 | - | V |
| Point G | +-2mV | - | -1.835 | - | V |
| Point H | +-2mV | - | 1.960 | - | V |
| Point J | +-2mV | - | 1.854 | - | V |
| (PointG / PointF) * 100% | +-0.5% | 73.1 | 93.8 | - | % |
| (PointH / PointJ) * 100% | +-0.5% | 73.1 | 94.6 | - | % |

40.6.1.2.3 Differential Output Template 2

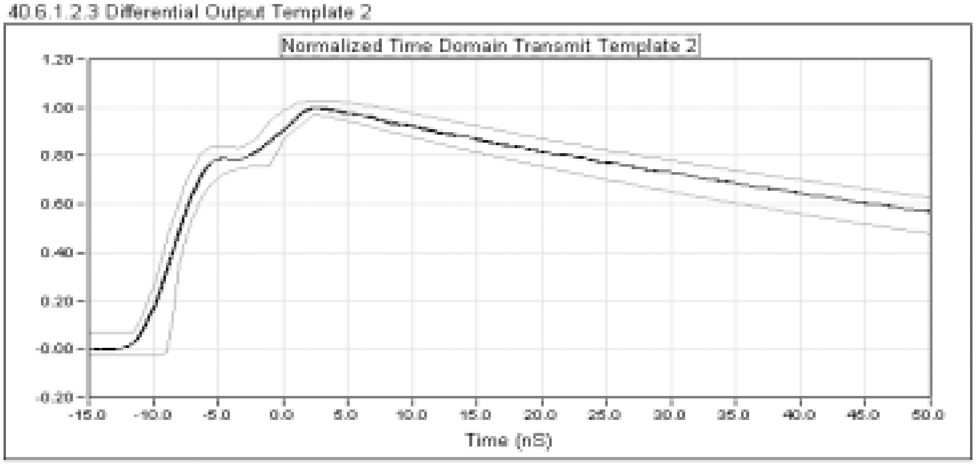



**Figure 5-5 Measured Normalized Waveform at F,G,H and J**

**5.2 Return Loss**

**10 Base-T**: The differential input impedance shall be such that any reflection due to differential signals incident upon the RD circuit from a twisted pair having any impedance within the range of 85 ohms to 111 ohms shall be at least 15 dB below the incident over the frequency range of 5.0 MHz to 10 MHz. The return loss shall be maintained when the receiver circuit is powered.

TX Return Loss 10BaseT

| Frequency | Specification | Port4 | Compliant |
|---|---|---|---|
| 5MHz | 15dB | 39 | Yes |
| 10MHz | 15dB | 42 | Yes |
| | | | |

RX Return Loss 10BaseT

| Frequency | Specification | Port4 | Compliant |
|---|---|---|---|
| 5MHz | 15dB | 31 | Yes |
| 10MHz | 15dB | 31 | Yes |
| | | | |



METHODE ELECTRONICS, INC.
7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**100Base-T:** The differential impedance shall be such that the return loss is greater than 16dB from 2Mhz to 30Mhz, greater than (16-20log(f/30 Mhz)) dB from 30Mhz to 60Mhz, and greater than 10dB from 60Mhz to 80Mhz. The requirement is specified for any reflection due to differential signals incident upon the RD circuit from a twisted pair having any impedance within the range of 85 ohms to 111 ohms. The return loss shall be maintained when the receiver circuit is powered.

RX Return Loss 100BaseT

| Frequency | Specification | Port4 | Compliant |
|---|---|---|---|
| 2MHz | 16dB | 47 | Yes |
| 30MHz | 16dB | 26 | Yes |
| 60MHz | 9.98dB | 19 | Yes |
| 80MHz | 10dB | 17 | Yes |
| | | | |

TX Return Loss 100BaseT

| Frequency | Specification | Port4 | Compliant |
|---|---|---|---|
| 2MHz | 16dB | 31 | Yes |
| 30MHz | 16dB | 33 | Yes |
| 60MHz | 9.98dB | 25 | Yes |
| 80MHz | 10dB | 22 | Yes |
| | | | |

**1000Base-T:** The differential impedance at the MDI for each transmit/receive channel shall be such that any reflection due to differential signals incident upon the MDI from a balanced cabling having an impedance of 100 ohms ± 15% is attenuated, relative to the incident signal, at least 16 dB over the frequency range of 1.0 MHz to 40 MHz and at least 10 –20log 10(*f* /80)dB over the frequency range 40 MHz to 100 MHz (*f* in MHz). This return loss shall be maintained at all times when the PHY is transmitting data or control symbols.

Return Loss 1000BaseT

| Return Loss | Test Mode 4 | | | | | | |
|---|---|---|---|---|---|---|---|
| Frequency MHz | Return Loss | Spec in dB | Pair 1-2 | Pair 3-6 | Pair 4-5 | Pair 7-8 | Compliant |
| 1 | 1 MHZ | 16 | 24 | 25 | 25 | 22 | Yes |
| 10 | 10 MHZ | 16 | 35 | 32 | 31 | 34 | Yes |
| 20 | 20 MHZ | 16 | 33 | 36 | 28 | 32 | Yes |
| 30 | 30 MHZ | 16 | 26 | 34 | 27 | 28 | Yes |
| 40 | 40 MHZ | 16 | 23 | 33 | 23 | 25 | Yes |
| 50 | 50 MHZ | 14.8 | 22 | 31 | 22 | 23 | Yes |
| 60 | 60 MHZ | 12.5 | 19 | 26 | 20 | 20 | Yes |
| 70 | 70 MHZ | 11.16 | 18 | 23 | 18 | 18 | Yes |
| 80 | 80 MHZ | 10 | 18 | 21 | 18 | 16 | Yes |
| 90 | 90 MHZ | 8.98 | 17 | 20 | 16 | 15 | Yes |
| 100 | 100 MHZ | 8.06 | 16 | 18 | 15 | 14 | Yes |



7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

### 6.0 Mechanical Description

The transceiver shall be compliant with common SFP mechanical outline (see **[1]**, Appendix A1, Table 1, Figures 1A, 1B, 2 and 3).

**6.1 1000Base-T SFP Transceiver Dimensions**
Figure 5-1 Illustrates the Mechanical Dimensions of the Transceiver

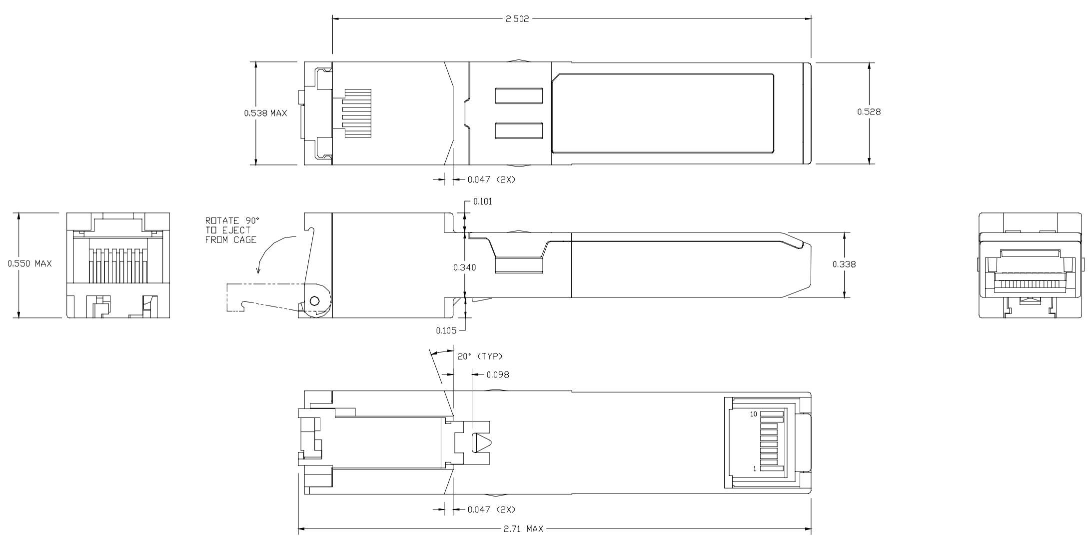



**Figure 6-1 Mechanical Dimensions of Transceiver**

**6.2 Mating of SFP Transceiver to SFP Host Board Connector**
The pads on the PCB of the SFP transceiver shall be designed for a sequenced mating as follows:

| | |
|---|---|
| First mate: | Ground contacts |
| Second mate: | Power contacts |
| Third mate: | Signal contacts |

The SFP MSA specification for a typical contact pad plating for the PCB is 0.38 micrometers minimum hard gold over 1.27 micrometers minimum thick nickel. To ensure the long term reliability performance after a minimum of 50 insertion removal cycles, the contact plating of the transceiver is 0.762 micron (30 microinches) over 3.81 micron (150 microinches) of Ni on Cu contact pads.

**6.3 RJ45 Connector**
RJ45 connector shall support shielded and unshielded cables. Also, the connector is mechanically robust enough and designed to prevent loss of link, when the cable is positioned or moves in different angles. The connector shall pass the "wiggle" RJ45 connector operational stress test. During the test, after the cable is plugged in, the cable is moved in circle to cover all 360 deg in the vertical plane, while the data traffic is on. There shall be no link or data loss.

**6.4 Insertion, Extraction and Retention Forces**
The requirement for various functional forces and durability cycles are specified in Table 5-1.

| Measurement | Minimum | Maximum | Units | Comments |
|---|---|---|---|---|
| SFP transceiver insertion | N/A | 40 | Newtons | Insertion force should ensure that<br>1) Retention force is within the spec listed in row 3 of this table;<br>2) The performance at the operation temperature range after minimum insertion/removal cycles;<br>3) Module pass shock and vibe test in Section 7. |
| SFP transceiver extraction | N/A | 11.5 | Newtons | Insertion force should ensure that<br>1) Retention force is within the spec listed in row 3 of this table;<br>2) The performance at the operation temperature range after minimum insertion/removal cycles;<br>3) Module pass shock and vibe test in Section 7. |
| SFP transceiver retention | 90 | 170 | Newtons | No damage to transceiver and no degradation of performance at operation temperature range. |
| Cage retention (latch strength) | 180 | N/A | Newtons | No damage to latch below 180N. |
| Cage kick out spring force | 11.5 | 22 | Newtons | |
| Insertion/removal cycles, connector/cage | 100 | N/A | Cycles | |
| Insertion/removal cycles, SFP transceiver | 50 | N/A | Cycles | No degradation of performance after minimum 50 insertion/removal cycles at operation temperature ranges and pass shock and vibe tests in Section 7. |

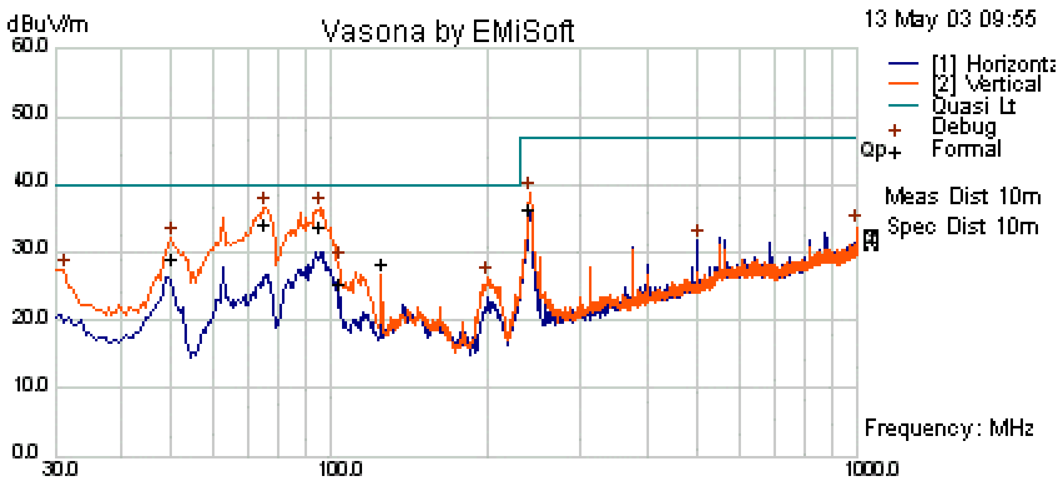
**Table 6-1 Insertion, Extraction and Retention Forces for SFP Transceivers**

**7.0 Regulatory Requirements**

The SFP transceiver modules, when integrated into the host systems, will be required to meet the Regulatory, Customer and Compliance requirements. In order to achieve this, the module must be evaluated in considering its use in the equipment designs. The transceiver module shall meet the current version, at the time of manufacturing, of the applicable EMI/EMC specifications for telecom and datacom equipment for North America, European, Japan and Telcordia standards.
The transceiver shall meet EMI/EMC specifications tested simultaneously (32 and 48 transceivers) and connected to Category5 cables running PRBS pattern or other data patterns at all applicable speeds for the specific network platforms.

**7.1 EMI**

The 1000Base-T SFP transceiver shall meet the applicable Class A requirements for electromagnetic emissions at least 6 dB margin.





7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**7.2 RF Immunity**

The transceiver shall meet the requirements for Radio Frequency Immunity in accordance with IEC 61000-4-3 (80-1000 MHz) and GR-1089 or equivalent elsewhere.
This includes no significant measurable effect from a 10 V/m, 80% AM Modulated field applied between 10 kHz to 10 GHz to the SFP module. If measurable effects are recorded, then data indicating performance with field strength and receiver sensitivity are required.

**7.3 Electrostatic Discharge (ESD)**

The transceiver shall meet the requirements for Direct and Indirect ESD in accordance with IEC 61000-4-2:

- Direct ESD only to the accessible portions of the module (i.e. front panel connector receptacle). 15 kV (Air Discharge and 8 kV (Contact)).
- Indirect ESD 8 kV (contact discharge method used to apply discharge to coupling plane).

**7.4 Conducted Immunity**

The module or the host platform shall not show susceptibility to conducted immunity when applied to the interface cable per the requirement of IEC 61000-4-6. The module shall operate error free under the worst case conditions (10V).

**7.5 Fast Transients**

The module or the host platform shall not show susceptibility to fast transients when applied to the interface cable per the requirements of IEC 61000-4-4. The module shall operate error free under the worst case conditions (1 kV for signal port).

**7.6 Surge on Signal Ports**

The module or the host platform shall not show susceptibility to surge on signal ports when applied to the interface cable per the requirements of IEC 61000-4-5. The module shall operate error free under the worst case conditions (2 kV common mode, 1 kV differential mode).

**7.7 Safety**

**7.7.1 Isolation requirement (HiPot)**

The SFP module shall meet at least one of the following isolation requirements as per IEC 60950:
- 1500 Vrms at 50 to 50 Hz applied for 60 sec.
- 2250 Vdc applied for 60 sec

**7.7.2 Flammability**

The PCB of the SFP module shall be min. V-0 UL flame rated. Applicable standards:
UL/CSA 60950 and IEC 60950.



7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**8.0 Environmental and Quality Requirements**

**8.1 Storage Temperature**

The SFP transceiver module shall be capable of storage in –40 to +85 deg C (non-condensing environment).

**8.2 Operating Temperature**

The SFP transceiver module shall be capable of operating within specifications in 0 to +70 deg C ambient environment with 100 LFM airflow over the SFP module.

**8.3 Relative Humidity (Non-Operational)**

The SFP module shall be subjected to the temperature and humidity profile as per MIL STD 810 Method 507.3, Procedure III.
- Test description: The module shall be subjected to the temperature and humidity profile detailed in the Aggravated Humidity test in MIL-STD-810 Method 507.3, Procedure III, for five 24 hour cycles. The maximum relative humidity is 95%. The product shall be non-operational during this entire period.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Failure of test unit to perform ping or traffic test;
  2. Excessive corrosion of components.

**8.4 Four Corner Test**
This test consists of passing traffic over 100m cable while margining 3.3V voltage +/- 5% at -5 deg C and +55 deg C ambient temperature. There shall be no loss of link or lost frames.

**8.5 Shock**

During the shock test, an SFP module is plugged into an SFP port of a Gigabit Ethernet switch.

**8.5.1 Operational**

After 50 insertion/removal cycles the SFP module shall be plugged into an SFP port of a Gigabit Ethernet switch and subjected to the following test conditions. The Target Minimum Velocity Change Input shall be 2.39 m/s.
- Test description: The product shall be subjected to one each half sine impact for each direction (positive and negative) in each of three axes at the specified velocity change limit above. The pulse width shall be 2 ms or less.
- Failure Criteria: The product is considered to have failed this test if any of the following occurred:
  1. Excessive exterior damage such that the product is considered unsalable;
  2. Structural, power or other system damage that render the unit to be unsalable;
  3. Failure of test unit to perform ping or traffic test.

**8.5.2 Non-Operational**

After 50 insertion/removal cycles the SFP module shall be plugged into an SFP port of a Gigabit Ethernet switch and subjected to the following test conditions. The parameters are specified in the following table:

| Minimum Peak Acceleration Input | Maximum Peak Acceleration Input | Minimum Velocity Change (m/s) | Minimum Velocity Change (in/sec) |
|---|---|---|---|
| 65G | 80G | 4.78 | 188 |

**Table 8-1 Non-Operational Shock Parameters**

- Test description: Product shall be subjected to one each trapezoidal shock pulse impact for each direction (positive and negative) in each of 3 axes at a level not to exceed the maximum peak acceleration value above. Trapezoidal shock pulse generation is per ASTM D3332. As a minimum, the product should be tested and pass at its minimum peak acceleration input level above or until it fails, whichever occurs first.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Excessive exterior damage such that the product is considered unsalable;
  2. Structural, power or other system damage that render the unit to be unsalable;
  3. Failure of test unit to perform ping or traffic test.



7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**8.6 Vibrations**

During the vibrations test, an SFP module is plugged into an SFP port of a Gigabit Ethernet switch.

**8.6.1 Operational**

After minimum of 50 insertion/removal cycles the SFP module shall be plugged into an SFP port of a Gigabit Ethernet switch and subjected to the following test conditions.
- Test description: The test shall be run at standard room conditions. The product shall be fixtured to the table of the vibration test machine in each of 3 mutually perpendicular axes and subjected to a random vibration input for a period of 2 hours per axis. The input acceleration level shall be 0.41 Grms over the frequency band of 3 to 500 Hz with spectral break points of 0.0005 $G^2$/Hz at 10 Hz and 200 Hz and 5dB/octave roll off at each end. MIL-STD-810, Method 514.4 shall be used as a guideline. The product shall be powered and continuously running the ping or traffic test during the test. Fixturing the product to the vibration table shall insure that the product follows the input amplitude.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Excessive exterior damage such that the product is considered unsalable;
  2. Structural, power or other system damage that render the unit to be unsalable;
  3. Failure of test unit to perform ping or traffic test.

**8.6.2 Non-Operational**

After minimum of 50 insertion/removal cycles the SFP module shall be plugged into an SFP port of a Gigabit Ethernet switch and subjected to the following test conditions.
- Test description: The test shall be run at standard room conditions. The product shall be fixtured to the table of the vibration test machine in each of 3 mutually perpendicular axes and subjected to a random vibration input for a period of 30 minutes per axis. The input acceleration level shall be 1.12 Grms over the frequency band of 3 to 500 Hz with spectral break points of 0.0065 $G^2$/Hz at 10 Hz and 100 Hz and 5dB/octave roll off at each end. MIL-STD-810, Method 514.4 shall be used as a guideline.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Excessive exterior damage such that the product is considered unsalable;
  2. Structural, power or other system damage that render the unit to be unsalable;
  3. Failure of test unit to perform ping or traffic test.

**8.7 Altitude**

During the altitude test, an SFP module is plugged into an SFP port of a Gigabit Ethernet switch.

**8.7.1 Operational**

- Test description: The product shall be subjected to an altitude of 3000 meters for 2 hours. The rate of change to and from 3000 meters shall be 10 m/s maximum, as referenced in MIL-STD-810, Method 500.3. The chamber temperature shall be set to 25 deg C.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Failure of test unit to perform ping or traffic test;
  2. Visible delamination or other physical effect rendering the unit unsalable.

**8.7.2 Non-Operational**

- Test description: The product shall be subjected to an altitude of 4570 meters for 20 hours. The rate of change to and from 4570 meters shall be 10 m/s maximum, as referenced in MIL-STD-810, Method 500.3. The chamber temperature shall be set to 25 deg C +/- 5 deg C and uncontrolled relative humidity.
- Failure criteria: The product is considered to have failed this test if any of the following occurred:
  1. Failure of test unit to perform ping or traffic test;
  2. Visible delamination or other physical effect rendering the unit unsalable.

**8.8 Fire Spread Test**

The SFP module shall be compliant to the GR-63-CORE, Section 5.2.3.


7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149

**8.9 Reliability**

Below is the MTBF calculation based on Bellcore TR-332, Section 6 Parts Count analysis.

All calculation are based on a unit environment factor ($\pi_E$) = $G_B$ for Ground, Fixed, Controlled, an operating temperature of 40 degree C and an electrical stress of 50%.

Quality level II is assumed for all devices except connectors, which are assigned quality level I.

$\lambda$ = Failure rate expressed in FIT (Failures In Time/$10^9$ hours):
$\lambda_{SS} = \pi_E \Sigma N\lambda_{SSi}$ = unit steady-state failure rate.
$\pi_E$ = Environment factor = $G_B$ = 1.0.
$\lambda_{SSi} = \lambda_G \pi_Q \pi_S \pi_T$ = part (device) steady-state failure rate.
$\lambda_G$ = Generic steady state failure rate, from TR-332 table 11-1 unless noted.
$\pi_Q$ = Quality factor = 1.0 for all level II devices and 3.0 for level I.
$\pi_S$ = Electrical stress factor = 1.0 for 50%.
$\pi_T$ = Temperature factor = 1.0 for 40 degree C.

| Item | N (Quantity) | $\lambda_G$ (Generic stead-state failure rate) | $\pi_Q$ (Quality factor) | $\lambda_{SSi}$ (N X $\lambda_G$ X $\pi_Q$ Device steady-state failure rate) |
|---|---|---|---|---|
| [1]Marvell # 88E1111 | 1 | 10.0 | 1.0 | 10.0 |
| EEPROM, AT24C02A | 1 | 17.0 | 1.0 | 17.0 |
| Regulator, EL7535C | 2 | 3.0 | 1.0 | 6.0 |
| [2]Oscillator, 310-SDF | 1 | 72.0 | 1.0 | 72.0 |
| Resistors, SMT chip | 25 | 1.0 | 1.0 | 25.0 |
| Capacitors, 0.01 µfd | 16 | 1.0 | 1.0 | 16.0 |
| Capacitors, 0.10 µfd | 9 | 1.0 | 1.0 | 9.0 |
| Capacitors, 10.00 µfd | 4 | 5.0 | 1.0 | 20.0 |
| Inductors | 2 | 19.0 | 1.0 | 38.0 |
| Magnetics | 4 | 4.0 | 1.0 | 16.0 |
| Connector, RJ45 | 8 pins | 0.2 per pin | 3.0 | 4.8 |
| Connector, SFP | 20 pins | 0.2 per pin | 3.0 | 12.0 |
| PCB, SMT/PTH | 1 | Excluded | | |
| $\Sigma N \lambda_{SSi}$ (Total) | | | | 245.8 |

$\lambda_{SS} = \pi_E \Sigma N\lambda_{SSi}$ = 1.0 X 493.8 = 245.8 failures /$10^9$ hours.

MTBF (Mean Time Between Failures) = $1/\lambda_{SS}$ = $10^9$/245.8 = 4,068,349 hours.

[1] Failure rate obtained from Marvell for $T_J$ = 70 degree C, $P_d$ = 0.75 watt.
[2] Failure rate obtained from Epson.

**8.10 Reliability Determination Testing**
Sixty-four transceiver units shall be placed under default mode traffic testing at an elevated temperature of 50 degrees C for 9 weeks. Testing shall be continuous. There shall be no loss of link or lost frames.

**9.0 References**

**[1]** *Small Form Factor Pluggable Transceiver MultiSource Agreement (MSA)*, Sep 14, 2000;
**[2]** IEEE 802.3z, *Carrier Sense Multiple Access with Collision Detection Access Method and Physical Layer Specification*, 1998, Standard;
**[3]** IEEE, 802.3ab/D6.0, *Physical Layer Parameters and Specification for 1000Mb/s Operation over 4 Pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T*, March 99, Standard Draft;
**[4]** ATMEL, *2-Wire Serial EEPROM for AT24C01A/02/04/08/16 Devices, Rev. 0180D,* June 98, Data Sheet;


7401 West Wilson Avenue
Chicago, IL 60706
Phone: 708-867-6777 Fax: 708-867-3149