

***Method* Electronics**



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

✓ISO 9001 Certified

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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.

3.0 Block Diagram

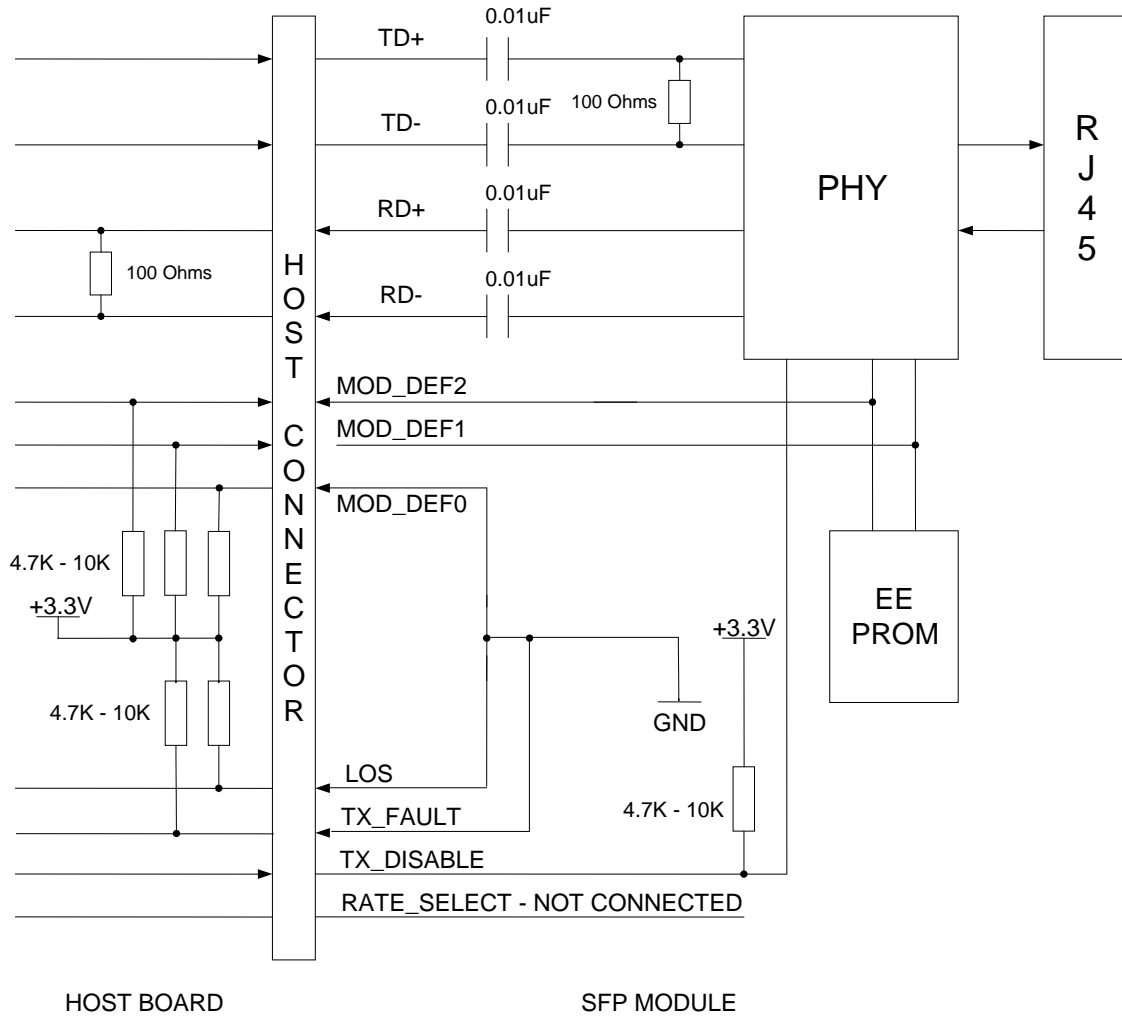


Figure 3-1 1000Base-T SFP Transceiver Block Diagram

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	3.135	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.

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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)}

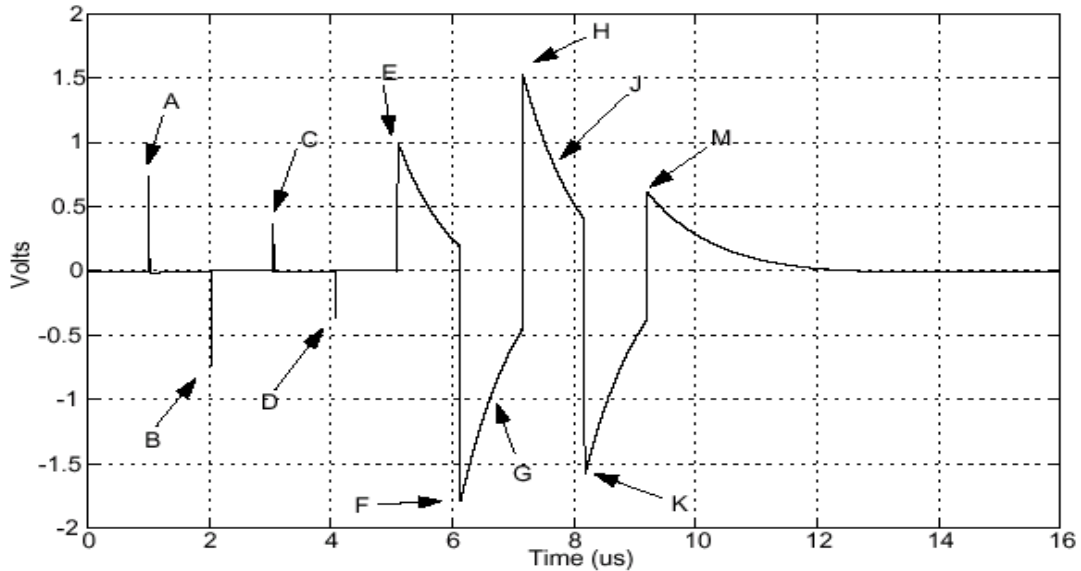


Figure 5-1 Transmitter Waveform Example

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.

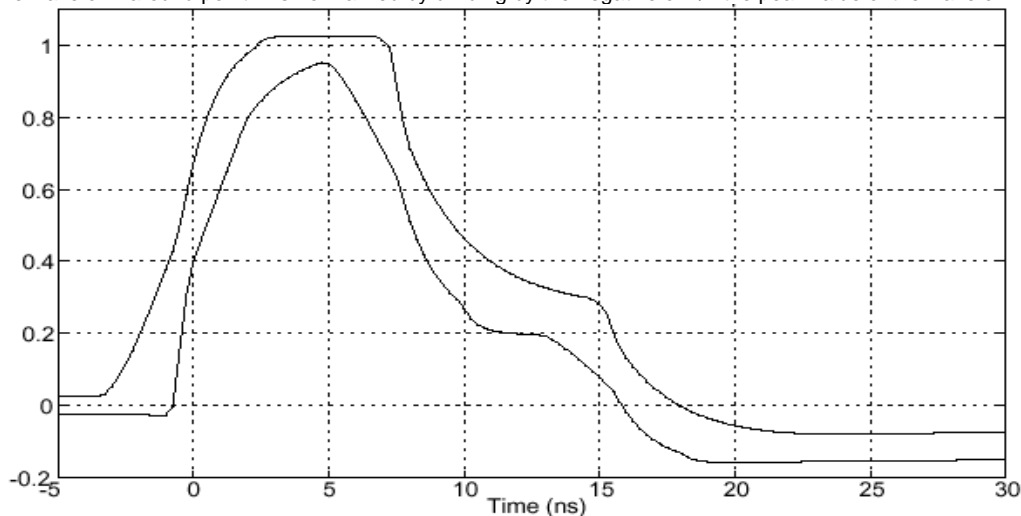


Figure 5-2 Normalized Time Domain Transmit Template 1

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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.

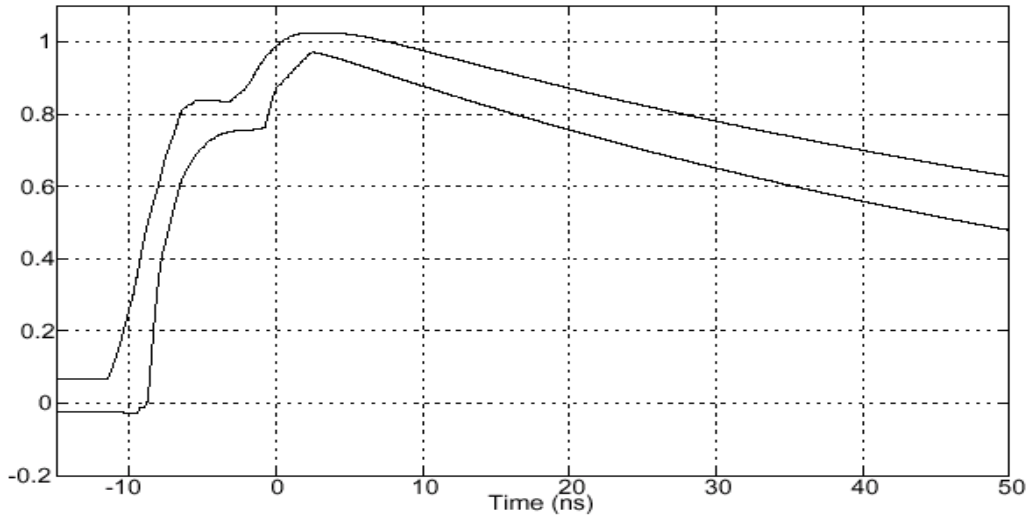


Figure 5-3 Normalized Time Domain Transmit Template 2

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
$(1 + \text{Point A} / \text{Point B}) * 100\%$	+0.25%	-1	0.59	1	%
$(1 - (0.5 * (\text{Point A} + \text{Point B}) / 2) / \text{Point C}) * 100\%$	+0.5%	-2	-0.48	2	%
$(1 - (0.5 * -(\text{Point A} + \text{Point B}) / 2) / \text{Point D}) * 100\%$	+0.5%	-2	-0.15	2	%

40.6.1.2.3 Differential Output Template 1

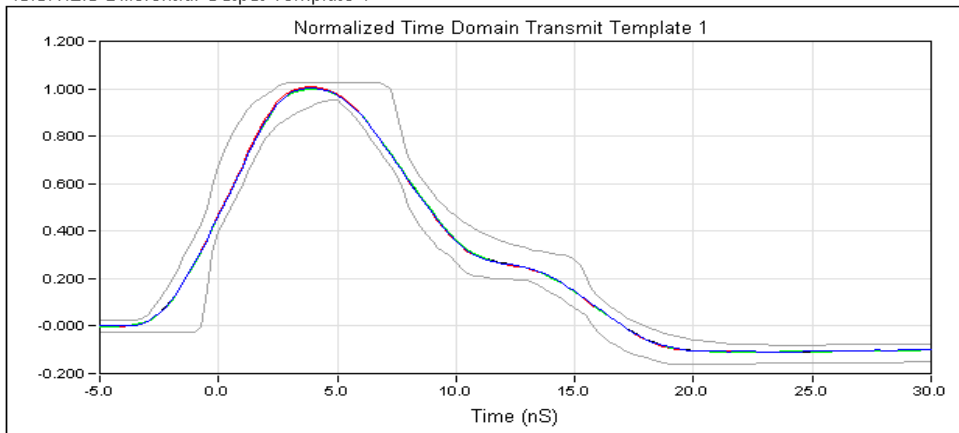


Figure 4-4 Measured Normalized Waveform at A,B,C and D

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

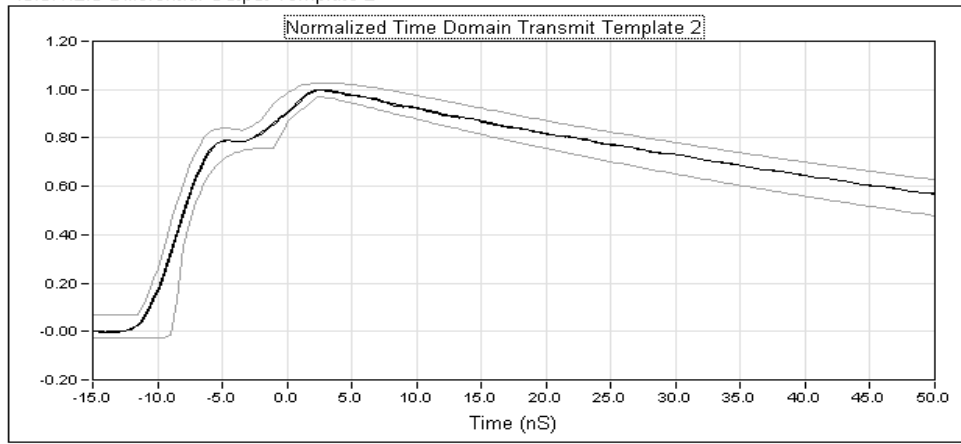


Figure 5-5 Measured Normalized Waveform at F,G,H and J

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

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100Base-T: The differential impedance shall be such that the return loss is greater than 16dB from 2MHz to 30MHz, greater than $(16-20\log(f/30 \text{ MHz}))$ 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 \pm 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 $10 - 20\log 10(f/80)$ 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

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

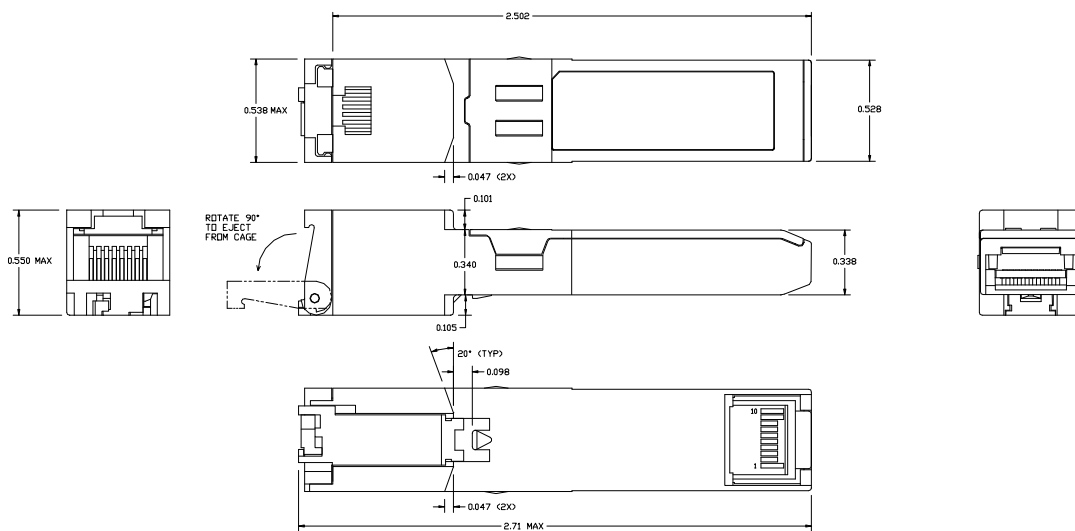


Figure 6-1 Mechanical Dimensions of Transceiver

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 1) Retention force is within the spec listed in row 3 of this table; 2) The performance at the operation temperature range after minimum insertion/removal cycles; 3) Module pass shock and vbe test in Section 7.
SFP transceiver extraction	N/A	11.5	Newtons	Insertion force should ensure that 1) Retention force is within the spec listed in row 3 of this table; 2) The performance at the operation temperature range after minimum insertion/removal cycles; 3) Module pass shock and vbe 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 vbe tests in Section 7.

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

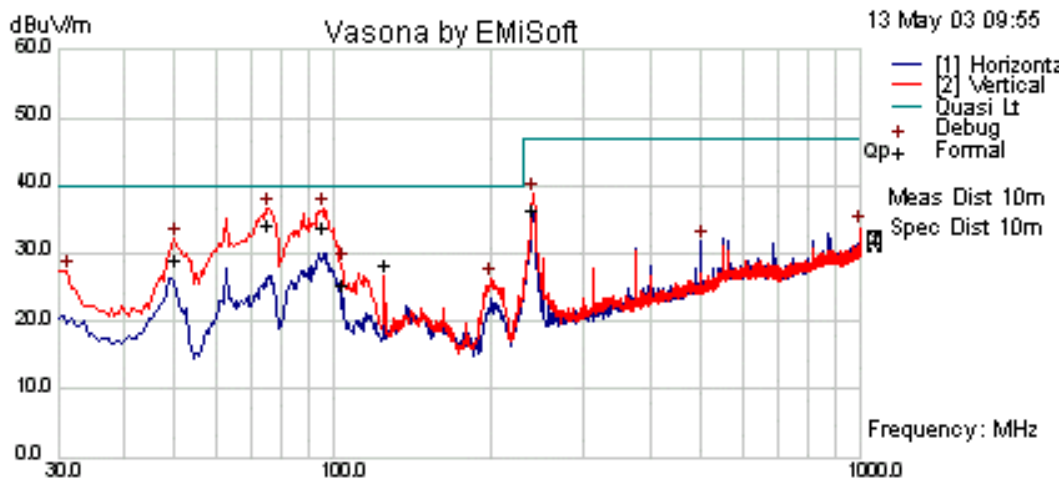
7.0 Regulatory Requirements

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.



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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.



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 -40* to +85 deg C case temperature with 100 LFM airflow over the SFP module.

*May require warmup period from a cold start below 0C.

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.

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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 G²/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 G²/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.

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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 (π_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.

λ = Failure rate expressed in FIT (Failures In Time/ 10^9 hours):

$\lambda_{SS} = \pi_E \sum N \lambda_{SSi}$ = unit steady-state failure rate.

π_E = Environment factor = $G_B = 1.0$.

$\lambda_{SSi} = \lambda_G \pi_Q \pi_S \pi_T$ = part (device) steady-state failure rate.

λ_G = Generic steady state failure rate, from TR-332 table 11-1 unless noted.

π_Q = Quality factor = 1.0 for all level II devices and 3.0 for level I.

π_S = Electrical stress factor = 1.0 for 50%.

π_T = Temperature factor = 1.0 for 40 degree C.

Item	N (Quantity)	λ_G (Generic steady-state failure rate)	π_Q (Quality factor)	λ_{SSi} (N X λ_G X π_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 μ fd	16	1.0	1.0	16.0
Capacitors, 0.10 μ fd	9	1.0	1.0	9.0
Capacitors, 10.00 μ fd	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		
$\sum N \lambda_{SSi}$ (Total)				245.8

$\lambda_{SS} = \pi_E \sum N \lambda_{SSi} = 1.0 \times 245.8 = 245.8$ 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;

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有毒, 有害物质和元素

部件名称	铅 (Pb)	汞 (Hg)	(Cd)	六价铬 (Cr6+)	多溴联苯 (PBB)	多溴代二苯醚 (PBDE)
金属机箱	○	○	○	○	○	○
塑料部件/ 隔板	○	○	○	○	○	○
印刷电路组件	○	○	○	○	○	○
电子部件	X	○	○	○	○	○
焊锡	X	○	○	○	○	○

O: 表示此部件使用的所有同类材料中次种有毒或有害物质的含量均低于SJ/T11363-2006 规定的限制要求

X: 表示此部件使用的至少一种同类材料中, 此种有毒或有害物质的含量高于SJ/T11363-2006 规定的限制要求

FIGURE A1-MATERIAL DISCLOSURE CHART



FIGURE A2-China RoHS EPUP Mark