# MM SFP ESCON/SBCON Data Links

1 Scope

1.1 Content

This specification covers the performance, tests and qualification of the AMP MM SFP datalink transceiver for fiber optic communications.

1.2 Qualification

When tests are performed on the subject product line, the procedures specified in AMP 109 series specifications shall be used. All inspections shall be performed using applicable Quality Inspection Plans and product drawings.

2 Applicable Documents

The following documents form a part of this specification to the extent specified herein. In the event of a conflict between the requirements of this specification and the product drawing, the product drawings shall take precedence. In the event of a conflict between the requirements of this specification and the referenced documents, this specification shall take precedence.

2.1 AMP Documents

2.1.1 Applicable AMP Customer/Product Drawing
2.1.2. 109-1: General requirements for test specifications
2.1.3. 102-55224: Acceptance Standards for Fiber Optic Devices

2.2 Other Standards

2.2.1. MIL-STD-883E: Test Methods and Procedures for Microelectronics
2.2.2. MIL-STD-202F: Test Methods for Electronic and Electrical Components
2.2.3. EIA-455: Standard Test Procedures for Fiber Optic Cables, Transducers, Connecting and Terminating Devices (FOTP-XXX)
2.2.4 ANSI X3.296-1997 SBCON
2.2.5 IBM P/N 04P9704 ESCON
2.2.6 SFP MSA Specification

3 Requirements

3.1 Design, Construction and Materials

Product shall be of the design, construction, materials and physical dimensions specified on the applicable AMP Customer/Product Drawing.

3.2 Ratings

See applicable AMP Customer/Product Drawing for supply voltage, storage temperature and lead soldering temperature and time ratings.

3.3 Performance and Test Description

The products are designed to meet the electrical, mechanical and environmental performance requirements specified in Table 1 as tested per the sequence in Table 4 (transceivers). All tests are performed at ambient environmental conditions per AMP Specification 109-1 unless







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otherwise specified. For tests performed over the full range of temperature and supply voltages, the data shall be taken at the minimum/maximum conditions. Data taken in between these ranges is optional.

3.3.1 Test Fiber

The fiber used for qualification of product under this specification will be 62.5 micron core, 125 micron cladding (or 50 micron core, 125 micron cladding as specified on applicable AMP Customer Drawing). All electrical and optical test cables are to be of length specified per section 3.4.

3.3.2 Test Connector

The fiber optic connector used for qualification of product under this specification will be the AMP MTRJ Connector P/Ns 1278398-2 or 1278750-2.

3.4 Test Requirements and Procedures Summary

| Test Description | Requirement | Procedure |
|---|---|---|
| Examination of product | Meets applicable AMP Customer Drawing and AMP Specification 102-55224 | Visual, dimensional and functional. |
| Electrical/Optical | | |
| Power Supply Maximum Ratings | Meets applicable AMP Customer Drawing | Apply absolute maximum forward biased supply voltage as specified on the applicable AMP Customer Drawing for 10 seconds, then reduce voltage back to nominal. Apply maximum operating temperature specified on applicable AMP Customer Drawing. |
| Supply Current | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range and temperature range and other test conditions (i.e. data pattern) as specified on Customer Drawing. | Measure at maximum specified operating voltage (not absolute maximum voltage limit) and maximum specified operating temperature. |
| Receiver Optical Sensitivity (BER) | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, temperature range and other test conditions (i.e. data pattern) as specified on the Customer Drawing. | Measured per ESCON/SBCON Specifications. |

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|---|---|---|
| Receiver Maximum Input power (saturation) | Same method as above running at maximum optical input power instead of minimum input power. | Same procedure as Receiver Optical Sensitivity (BER). |
| Receiver Output Data and Signal Detect Voltage Levels | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, temperature range and other test conditions (i.e. data pattern) as specified on Customer Drawing. | Measure over temperature range, supply voltage range and at other test and load conditions specified on applicable AMP Customer Drawing. |
| Receiver Electrical Rise and Fall Times | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, temperature range and other test conditions (i.e. data pattern) as specified on Customer Drawing. | Measure over temperature range, supply voltage range and at other test and load conditions specified on applicable AMP Customer Drawing. |
| Receiver Total Jitter | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, and other test conditions as specified on Customer Drawing. | Measured per ESCON/SBCON Specifications. Supply verified at room temperature only and voltage range as specified on applicable Customer Drawing. |
| Receiver Signal Detect Timing (SFP Data Links Only) | Meet specification requirements of applicable AMP Customer Drawing over nominal voltage, room temperature, and other test conditions as specified on Customer Drawing. | Measure per SFP MSA |
| Receiver Signal Detect Optical Power Levels | Meet specification requirements of AMP Customer Drawing over supply voltage range, temperature range and other test conditions (the data pattern) as specified on Customer Drawing. | Begin test by applying a 50% duty cycle optical input signal of sufficient power to ensure that the presence of signal is detected ("Logic Level High"). Reduce optical input power while monitoring signal detect output to determine the optical power at which the Signal Detect output changes to "Logic Level Low" (Signal Deassert Level). Begin increasing optical input power until the Signal Detect output changes to "Logic Level High" again (Signal Assert Level). |

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|---|---|---|
| Transmitter Optical Output Power | Meet specification requirements of applicable AMP Customer Drawing over supply voltage, temperature and other test conditions (i.e. data pattern) as specified on the Customer Drawing. | Measure per FOTP-95. The measurement is to be made using the optical fiber specified on the applicable Customer Drawing terminated with the appropriate optical connector. On transmitters with a transmit disable feature, optical power is also to be measured with the transmitter disabled and while drive the data inputs. |
| Transmitter Optical Wavelength and Spectral Width | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, temperature range and other test conditions (i.e. data pattern) as specified on Customer Drawing. | Using an optical spectrum analyzer, measure optical center wavelength and the Full Width Half Maximum (FWHM) spectral width. Use FOTP 127, except for spectral width. |
| Transmitter Optical Output Rise and Fall Times | Meet specification requirements over temperature and power supply extremes. | Measure per OFSTP4. |
| Extinction Ratio | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range and other test conditions as specified on Customer Drawing. | Measure per EIA/TIA OFSTP-4A with a repeating K28.7 data pattern. |
| Coupled Power Ratio | Meet specification requirements of applicable AMP Customer Drawing over nominal voltage and other test conditions as specified on Customer Drawing. | Measure per EIA/TIA OFSTP-14A with valid 8B/10B data pattern. |
| Transmitter Total Jitter | Meet specification requirements of applicable AMP Customer Drawing over supply voltage range, temperature range and other test conditions (i.e. data pattern) as specified on Customer Drawing. | Measured per ESCON/SBCON Specifications. |
| Serial Identification Information Verification (SFP Data Links Only) | Verify the correct information that is stored on the EPROM | Using the automated test set, query the information on the EPROM and verify that it correct per the SFP MSA. |
| Mechanical Integrity | | |
| Vibration / Variable Frequency (unpowered) | See note (a) | MIL-STD 883, Method 2007, Condition A: 20G, 20-2000-20 Hz, 4 cycles each on three |

| | | |
|---|---|---|
| | | planes |
| Mechanical Shock (unpowered) | See note (a) | MIL-STD 883, Method 2002, Condition B: 1500G, 5 shocks each on three planes |
| Thermal Shock (unpowered) | See note (a) | MIL-STD 883, Method 1011, Condition A (air to air): 0°C to 100°C, 15 cycles |
| Endurance | | |
| Moisture Resistance | See note (a) | MIL-STD 883, Method 1004, 0-95% RH, 25°C to 65°C to (-10°C), 10 days, power cycled during test |
| Accelerated Aging | The reliability (expected median life failure rate, MTTF) shall be calculated from the test. | 70° C or 85° C, nominal PS bias, Tx modulated with 50% Duty Cycle input pulse, 5000 hrs. minimum |
| Temperature Cycle (unpowered) | See note (a) | MIL-STD 883, Method 1010, Condition A: (-40°C) to 85°C, 30 minute dwell time, 100 cycles |
| Temperature Soak (unpowered) | See note (a) | MIL-STD 883, Method 1008.2: 100°C, 1000 hours |
| Accelerated Temperature/Humidity Test | See note (a) | MIL-STD-202, Method 103, 85° C/85% RH, bias, 1000 hrs |
| Connector Repeatability | Pass<br>500 Cycles | Connect and disconnect MTRJ connector for 500 cycles, testing parameters per Table 3 after each 100 cycles. |
| ESD | 500V Min | MIL-STD-883E Method 3015 The ESD shall be tested from each I/O PIN or PCB pad relative to all other PINs or PCB pads. |

(a) Shall meet visual requirements, show no physical damage, and shall meet requirements of additional tests as specified in the test sequence in 3.5, 4.1, and 5.

Table 1 (end)

3.5 Product Qualification and Requalification Tests (MVT)

| Test or Examination (c) | | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| | | | | |
| Examination of Product | 1,13,24 | 1,12,23 | 1,12 | 1, 12 |
| Transmitter Optical Output Power (nominal voltage, 25°C) | 2,14,25 | 2,13,24 | 2,13 | 2, 13 |
| Transmitter Rise and Fall Time (nominal voltage, 25°C) | 3,15,26 | 3,14,25 | 3,14 | 3,14 |
| Transmitter Extinction Ratio (nominal voltage, 25°C) | 4,16,27 | 4,15,26 | 4,15 | 4,15 |
| Transmitter Eye Mask (nominal voltage, 25°C) | 5,17,28 | 5,16,27 | 5,16 | 5,16 |
| Receiver Sensitivity (nominal voltage, 25°C) | 6,18,29 | 6,17,28 | 6,17 | 6,17 |
| Receiver Signal Detect Assert & Deassert Optical Power Levels (nominal voltage, 25°C) | 7,19,30 | 7,18,29 | 7,18 | 7,18 |
| Receiver Signal Detect Hysteresis (nominal voltage, 25°C) | 8,20,31 | 8,19,30 | 8,19 | 8,19 |
| Receiver Rise and Fall Times (nominal voltage, 25°C) | 9,21,32 | 9,20,31 | 9,20 | 9,20 |
| Receiver Total Jitter (nominal voltage, 25°C) | 10,22, 35 | 10,21, 32 | 10,21 | 10,21 |
| Vibration | 11 | | | |
| Mechanical Shock | 12 | | | |
| Thermal Shock | 23 | | | |
| Temperature Cycling | | 11 | | |
| Moisture Resistance | | 22 | | |
| Transmitter Optical Output Power | | 33 | | |
| Transmitter Optical Wavelength | | 34 | | |
| Transmitter Rise and Fall Times | | 35 | | |
| Transmitter Extinction Ratio | | 36 | | |
| Transmitter Total Jitter | | 37 | | |
| Receiver Sensitivity | | 38 | | |
| Receiver Signal Detect Hysteresis | | 39 | | |
| Temperature Soak | | | 11 | |
| Accelerated Humidity | | | | 11 |

Table 2 (end) See paragraph 4.1

(a) See paragraph 4.1
(b) Numbers indicate sequence in which tests are performed
(c) Test over full range of voltage and temperature specified on applicable AMP customer drawing unless otherwise specified.

3.6 Product Design Verification Tests (DVT)

| Test (c) | Test Group (a) | |
|---|---|---|
| | 1 | 2 |
| | Test Sequence (b) | |
| Power Supply Maximum Ratings | 1 | |
| Supply Current | 2 | |
| Receiver Optical Sensitivity (BER) | 3 | |

| | | |
|---|---|---|
| Receiver Maximum Input Power (saturation) | 4 | |
| Receiver Output Data and Signal Detect Voltage Levels | | 11 |
| Receiver Electrical Rise and Fall Times | 5 | |
| Receiver Total Jitter | 6 | |
| Receiver Signal Detect Timing (nominal voltage, ambient temperature) | | 12 |
| Receiver Signal Detect Optical Power Levels | 7 | |
| Transmitter Optical Output Power | 8, 15 | |
| Transmitter Optical Wavelength and Spectral Width | 9 | |
| Transmitter Optical Rise and Fall Times | 10 | |
| Extinction Ratio | 11 | |
| Coupled Power Ratio | | 13 |
| Transmitter Total Jitter | 12 | |
| Serial ID Information Verification (nominal voltage, ambient temperature) (SFP Data Links Only) | | 10, 15 |
| Transmitter Optical Output Power (nominal voltage, ambient temperature) | | 1, 16 |
| Transmitter Rise and Fall Time (nominal voltage, ambient temperature) | | 2, 17 |
| Transmitter Extinction Ratio (nominal voltage, ambient temperature) | | 3, 18 |
| Transmitter Eye Mask (nominal voltage, ambient temperature) | | 4, 19 |
| Receiver Sensitivity (nominal voltage, ambient temperature) | 13, 16 | 5, 20 |
| Receiver Signal Detect Assert & Deassert Optical Power Levels (nominal voltage, ambient temperature) | | 6, 21 |
| Receiver Signal Detect Hysteresis (nominal voltage, ambient temperature) | | 7, 22 |
| Receiver Rise and Fall Times (nominal voltage, ambient temperature) | | 8, 23 |
| Receiver Total Jitter (nominal voltage, ambient temperature) | | 9, 24 |
| Connector Repeatability (Use 5 of the 11 units) | 14 | |
| ESD | | 14 |

Table 3 (end) See paragraph 5.1

(a) See paragraph 5.1
(b) Numbers indicate sequence in which tests are performed
(c) Test over full range of voltage and temperature specifified on applicable AMP customer drawing unless otherwise specified

4. Quality Assurance Provisions

4.1 Qualification Testing

Sample Selection

Datalinks shall be prepared in accordance with the applicable assembly documentation. They

shall be selected at random from current inventory or selected from current manufacturing process by the Quality Engineer.

Test Group 1 shall consist of 11 units

Test Group 2 shall consist of 11 units

Test Group 3 shall consist of 11 units

Test Group 4 shall consist of 11 units

4.1.1 Accelerated Aging Testing shall be an ongoing evaluation and shall be reported separately from the Product Qualification Sequence. The sample size is 50 units.

4.2 Retention of Qualification

If in a two year period, no changes to the product or process occur, the product shall be subjected to the three groups (1, 2, 3) of testing in 3.5, 4.1. Justification for exceeding this limit shall be documented and approved by the business unit manager.

4.2.1 Accelerated Aging Test in 4.1.1 will be repeated on 22 samples once every six months for reliability monitor, for a minimum of 1000 hours.

4.3 Requalification Testing

If changes significantly affecting form, fit or function are made to the product or to the manufacturing process, product assurance shall coordinate requalification testing, consisting of all or part of the original testing sequence as determined by development/product, quality and reliability engineering.

4.4 Acceptance

Acceptance is based on verification that the product meets the requirements of Table 1. The failure criterion for qualification tests is a 1.0 dB decrease in initial optical output power and a 1.0 dB change in the initial sensitivity of the receiver. Measurement error is included. There does not need to be a specific value for the number of "failures" allowed for the Accelerated Aging Test. However expected life calculations for the product and failure analysis results shall be provided at the completion of the Accelerated Aging Test. The end-of-life criterion for life tests is a 2.0 dB decrease in the initial optical output power and a 2.0 dB change in the initial sensitivity of the receiver. Failures attributed to equipment, test setup, or operator deficiencies shall not disqualify the product. When product failure occurs, corrective action shall be taken and samples resubmitted for qualification. Testing to confirm corrective action is required before resubmittal.

4.5 Quality Conformance Inspection

The applicable AMP Quality Inspection Plan will specify the sampling acceptable quality level to be used. Dimensional and functional requirements shall be in accordance with applicable product drawing and specification.

5. Quality Assurance Provisions

5.1 Design Verification Testing

Sample Selection

Datalinks shall be prepared in accordance with the applicable assembly documentation. They shall be selected at random from the current manufacturing process.

Test Group 1 shall consist of 11 units

Test Group 2 shall consist of 5 units

5.2 Design Verification Re-testing

If changes significantly affecting form, fit or function are made to the product or to the manufacturing process, product assurance shall coordinate re-testing, consisting of all or part of the original testing sequence as determined by development/product, quality and reliability engineering.

5.3 Acceptance

Acceptance is based on verification that the product meets the requirements of Table 1. Failures attributed to equipment, test setup, or operator deficiencies shall not disqualify the product. When product failure occurs, corrective action shall be taken and samples resubmitted for design verification testing.

6. Receiver Sensitivity Calculations

Receiver sensitivity is specified at a bit error rate (BER) which is too low to directly characterize in a reasonable amount of time ($2.5x10^{-10}$, $10^{-12}$, etc). For reasons of practicality then, an abbreviated test is run at higher bit error rates. Optical input power vs BER data is collected for BER between approximately $10^{-4}$ and $10^{-8}$. This data is fitted to a curve so that optical input power at the desired BER can be extrapolated.

The mathematical relationship between the optical input power (in watts) and the BER has been shown, in the references and elsewhere, to be:

$$BER = \frac{1}{2} * erfc\left( k * \frac{P - P\_Signal}{RMS\_Noise} \right)$$

The complementary error function is an open integral and cannot be directly solved. Therefore, several approximations have been developed that can be used in a curve fitting algorithm. These approximations can be rearranged into transformation functions which will facilitate a linear least squares curve fit of the measured data. The resulting fitted equation can be used to extrapolate the receiver sensitivity.

Two transformation functions that have previously been presented are as follows:

$$T(BER) = 10^{0.526966*\log(-1.837794*\log(1.8839*2*BER))}$$

or

$$T(BER) = \frac{-C_2 + \sqrt{C_2^2 - 4C_1(C_3 + \ln(2 * BER))}}{2C_1}$$

Where: C1 = 0.4926119
C2= 0.2498322
C3 = 0.7912445

The latter transformation has been shown to be more accurate than the first.

The curve fit process is performed using the following steps. First, the collected data arrays are constructed:

X = Optical Power (in watts, not dBm)

Y = T(BER) (transformed BER data)

The least squares curve coefficients are calculated:

$$m = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sum X^2 - \frac{\left(\sum X\right)^2}{N}} \qquad c = \frac{\sum Y - m\sum X}{N}$$

These coefficients are used to assemble the least squares curve:

$$T(BER) = m(Optical\_Power) + c$$

The receiver sensitivity can now be extrapolated at the desired bit error rate by rearranging the above equation:

$$Optical\_Sensitivity = \frac{1}{m}\left(T(Spec * BER) - c\right)$$

The same curve fit procedure can be used to characterize the eye window performance of optical receivers. Clock position/phase vs. BER data points are collected for each "side" of the eye. Each of these data sets are then curve fit with the above procedure to determine the clock position at the desired BER. The difference between the two resulting clock positions is the clear eye.

References:

1. Engineering Report: Improved Curve Fit Algorithm for Receiver Sensitivity and Eye Window Extrapolation, AMP/Lytel Report ER:94-3634-037R, by Alan Wolke, October 17, 1994.
2. Engineering Report: Curve Fitting for Sensitivity and Eye Window Extrapolation, AMP/Lytel report ER:94-3634-016R, by Alan Wolke, June 13, 1994.
3. D. Chan, 'the Extrapolation of Error Rate Performances of Broadband Digital Communications Systems," Tech. Report TR 1E90-6-73, Bell-Northern Research, October, 1973.
4. P. Palacharla, C.S Bernard, P. Myslinski, J. Chrostowski, R. Neumann, R. Khalil, "Bit Error Rate Analysis of Optical Data Links for Computer Communications," Draft of OFSTP on Ultralow BER Measurement, submitted to TIA FO-2.1/6.6 Joint Subcommittee on Single-Mode Systems, June, 1995.