# QSFP 10 Gb\s, 4 Lane Active Cable Assembly PN 2123287

## 1. INTRODUCTION

### 1.1. Purpose

Tests were performed on the TE Connectivity (TE) QSFP 10 Gb\s, 4 lane Active Cable assembly part number 2123287. These tests were performed to determine conformance to the manufacturing processes and control procedures specified in the assembly drawings 2123287-2 and their conformance to the requirements of Product Specification 108-2397, Revision B. These tests were limited to the Active Cable assemblies produced by TE, Waigaoqiao, China.

### 1.2. Scope

This report covers the electrical, mechanical, and environmental performance of the PARALIGHT* Active Cable QSFP 4x10, manufactured by TE at the Shanghai, Waigaoqiao, China manufacturing site. Testing was performed between November 2010 and January 2011 on finished goods part number 2123287-2. The test file number for this testing is B126326-005.

### 1.3. Conclusion

After subjecting product to each environmental, mechanical, or parametric test, evidence of damage or failure to meet the specification shall constitute a failure. Failure to meet the Lot Tolerance Percent Defective (LTPD) Acceptance Criteria in paragraph 1.5 shall also constitute a failure. PARALIGHT Active Cable Assembly, QSFP 10G,4 Lanes built in Shanghai, Waigaoqiao TE manufacturing site is considered qualified by performance , listed in paragraph 1.5. These cable assemblies meet the environmental, electrical and mechanical performance requirements of Product Specification 108-2397, Revision B.

### 1.4 Product Description

TE PARALIGHT active optical cable assemblies use state-of-the-art technology to provide cost effective high data throughput interconnects. The cables incorporate E/O and O/E conversion built into the connector shell to yield a dramatic improvement in PCB real estate utilization. Using 850 nm VCSEL technology, the 10 Gb/s active cable assemblies will operate over a data rate of 2.5 to 10 Gb/s per lane with an aggregate data rate of 40 Gb/s in each direction.

### 1.5. Test Specimens

Test specimens were produced in Shanghai, Waigaoqiao, China using normal production means and shall be selected at random from current production. The same specimens may be used for more than one test group.

| Component Description | Test Group | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| LTPD | 20% | 20% | 20% |
| Cable Assembly Part Number | 2123287-2 QSFP | | |
| Test Specimen Quantity/Failures Allowed | 18/1 | 18/1 | 11/0 |
| Control Cable Required | Yes | Yes | Yes |


| Indicates Change

1.6. Product Qualification Test Sequence - QSFP 10Gb/s

| Test or Examination (c) | Test Groups (a) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| | Test Sequence (b) | | |
| Examination of product | 1 | 1 | 1 |
| RX output eye width | 2,6,8,10 | 2,6,10,14 | 2,6,9,12 |
| RX output eye height | 3 | 3,7,11,15 | 3,7,10,13 |
| Supply current per cable end | 4 | 4,8,12,16 | 4 |
| Vibration, variable frequency | 5 | | |
| Mechanical shock | 7 | | |
| Thermal operation (4 corner test) | | 5 | |
| Insertion/withdraw | | | 5 |
| Retention force | | | 8 |
| Off-axial load capability | | | 11 |
| Thermal shock | 9 | | |
| Temperature cycling, non-operating | | 9 | |
| Moisture resistance, biased (except for -10°C) | | 13 | |

**NOTE**

*(a) See paragraph 1.5.*
*(b) Numbers indicate sequence in which tests are performed.*
*(c) A subset of tests from Product Specification 108-2397 Rev. B, all other tests are qualified by similarity to test file B126326-004.*

## 2. SUMMARY OF TESTING

### 2.1. Examination of Product

All specimens submitted for testing were manufactured by Shanghai, Waigaoqiao TE using normal production processes, and were inspected and accepted by the Product Assurance Department.

### 2.2. Initial Performance - Groups 1, 2 and 3

Parametric Test Requirements from quantity of 48 QSFP original samples. A random selection of 48 assemblies was used for test groups 1, 2 and 3. All electrical measurements met the specification requirements for new product.

Table 1, New Product Performance QSFP

| Performance Criteria | Requirements | Actual |
|---|---|---|
| Eye Width (picoseconds) | 65 minimum<br>(see Note) | 67 minimum<br>76 median |
| Eye Height (millivolts) | 200 minimum<br>1000 maximum | 297 minimum<br>326 median<br>390 maximum |
| Supply Current (milliamperes) | 600 maximum | 260 maximum<br>246 median |

**NOTE** *65 picoseconds eye width corresponds to 0.65 U.I.*

Test Results

All specimens met the 20% lot tolerance percent defective (LTPD) for tests performed per Product Specification 108-2397 Revision B. There was no evidence of physical damage to the cable assembly during and after test.

Table 2 Parametric Test Results During and After Test QSFP

| Test Group | Condition | Requirements | | Actual | |
|---|---|---|---|---|---|
| | | During | After | During | After |
| 1 | Vibration | NA | 58 ($W_{min}$)<br><15% ($W_{\Delta}$) | NA | 68 ($W_{min}$)<br>76 ($W_{med}$)<br>10.8% ($W_{\Delta}$) |
| | Mechanical shock | | 58 ($W_{min}$)<br><15% ($W_{\Delta}$) | | 67 ($W_{min}$)<br>76 ($W_{med}$)<br>6.8% ($W_{\Delta}$) |
| | Thermal shock | | 58 ($W_{min}$)<br><15% ($W_{\Delta}$) | | 67 ($W_{min}$)<br>77 ($W_{med}$)<br>5.8% ($W_{\Delta}$) |
| 2 | Thermal operation and 4 corners test | See Table 3 | | | |
| | Temperature cycling | NA | 58 ($W_{min}$) | NA | 68 ($W_{min}$)<br>76 ($W_{med}$) |
| | Moisture resistance | | 58 ($W_{min}$) | | 61 ($W_{min}$) see Note 1<br>75 ($W_{med}$) |
| 3 | Insertion force | No parametric requirements | | Results given in Table 4 | |
| | Withdrawal force | | | | |
| | Retention force | 200 ($H_{min}$)<br>1000 ($H_{max}$)<br>15% ($W_{\Delta}$) | 58 ($W_{min}$)<br><15% ($W_{\Delta}$) | 309 ($H_{min}$)<br>335 ($H_{med}$)<br>356 ($H_{max}$)<br>5.1% ($W_{\Delta}$) | 66 ($W_{min}$)<br>77 ($W_{med}$)<br>6.0% ($W_{\Delta}$) |
| | Off-axis load capability | 200 ($H_{min}$)<br>1000 ($H_{max}$)<br>15% ($W_{\Delta}$) | 58 ($W_{min}$)<br><15% ($W_{\Delta}$) | 305 ($H_{min}$)<br>331 ($H_{med}$)<br>354 ($H_{max}$)<br>9.7% ($W_{\Delta}$) | 67 ($W_{min}$)<br>77 ($W_{med}$)<br>5.7% ($W_{\Delta}$) |

**NOTE**

*(1) One sample failed Moisture Resistance, see paragraph 4.1. for failure analysis.*

*(2) Key:*

*($W_{min}$) - Minimum Eye Width in picoseconds*
*($W_{med}$) - Median Eye Width in picoseconds*
*($W_{\Delta}$) - Maximum Percent Decrease in Eye Width*
*($H_{min}$) - Minimum Eye Height in millivolts*
*($H_{med}$) - Median Eye Height in millivolts*
*($H_{max}$) - Maximum Eye Height in millivolts*

Table 3, Thermal Operation/4 Corners Test, QSFP 10Gbs

<table>
<tr><th rowspan="2">Test Condition</th><th colspan="2">Requirements</th><th colspan="2">Actual</th></tr>
<tr><th>During</th><th>After</th><th>During</th><th>After</th></tr>
<tr><td>25°C + Trise, 3.3 volts</td><td>58 ($W_{min}$)<br>200 ($H_{min}$)<br>1000 ($H_{max}$)<br>600($C_{max}$)</td><td rowspan="5">58 ($W_{min}$)</td><td>67 ($W_{min}$)<br>75 ($W_{med}$)<br>245 ($H_{min}$)<br>287 ($H_{max}$)<br>259 ($C_{max}$)</td><td rowspan="5">66 ($W_{min}$)<br>75 ($W_{med}$)</td></tr>
<tr><td>0°C, 3.13 volts</td><td rowspan="4">58 ($W_{min}$)<br>200 ($H_{min}$)<br>1000 ($H_{max}$)<br>600 ($C_{max}$)</td><td>59 ($W_{min}$) see Note 1<br>70 ($W_{med}$)<br>241 ($H_{min}$)<br>286 ($H_{max}$)<br>241 ($C_{max}$)</td></tr>
<tr><td>0°C, 3.47 volts</td><td>58 ($W_{min}$)<br>70 ($W_{med}$)<br>244 ($H_{min}$)<br>290($H_{max}$)<br>250 ($C_{max}$)</td></tr>
<tr><td>70°C, 3.13 volts</td><td>66 ($W_{min}$)<br>76 ($W_{med}$)<br>235 ($H_{min}$)<br>279 ($H_{max}$)<br>264 ($C_{max}$)</td></tr>
<tr><td>70°C, 3.47 volts</td><td>68 ($W_{min}$)<br>79 ($W_{med}$)<br>239 ($H_{min}$)<br>290 ($H_{max}$)<br>273 ($C_{max}$)</td></tr>
</table>

**NOTE**

*(1) One sample failed Thermal Operation/4-Corners, see paragraph 4.2. for failure analysis.*

*(2) Key:*

*($W_{min}$) - Minimum Eye Width in picoseconds; 65 ps corresponds to 0.65 U.I. and 58 ps corresponds to 0.58 U.I.*

*($W_{med}$) - Median Eye Width in picoseconds*

*($H_{min}$) - Minimum Eye Height in millivolts*

*($H_{med}$) - Median Eye Height in millivolts*

*($H_{max}$) - Maximum Eye Height in millivolts*

*($C_{max}$) - Maximum Supply Current per cable end in milliamperes*

Table 4, Insertion and Withdrawal Forces, QSFP 10Gbs

| Test Condition | Requirement (N [lbf]) | Actual (N [lbf]) |
|---|---|---|
| Insertion force | 40.0 [9.0] maximum | 28.3 [6.4] maximum |
| Withdrawal force | 30.0 [6.7] maximum | 26.6 [6.0] maximum |

## 3. TEST METHODS

Initial electrical performance was recorded by verifying eye width, eye height (if required), and supply current, then the sequential testing was performed. The procedure for calculating the eye opening at each test interval is to test each lane 3 times and record the average of the 3 readings in order to normalize any measurement errors in the readings.

### 3.1. Visual and Mechanical Inspection (TIA/EIA-455-13A)

Product drawings and inspection plans were used to examine the specimens. They were examined visually and functionally.

### 3.2. Vibration

Specimens were secured to the vibration platform and subjected to 4 sweeps of simple harmonic motion with a 1.5 mm peak-to-peak displacement (10%) below the crossover frequency and 20 G (+20%,-0%) acceleration above the crossover frequency in each of 3 mutually perpendicular axes. Each sweep consisted of logarithmically varying the frequency from 20 to 2000 and back to 20 Hz during a 4-minute period. Exposure time in each axis was 16 minutes. Total exposure time was 48 minutes. Performance data of the specimens were recorded before and after the exposure.

### 3.3. Mechanical Shock

Specimens were secured to the mechanical shock platform and subjected to 500 G (distortion $\leq$ 20%), 1 millisecond (tolerances of the greater, 0.1 ms or 30%) half-sine shock pulses. Five shock pulses were applied in 6 mutually perpendicular axes. The total number of shock pulses was 30. Performance data of the specimens was recorded before and after the exposure.

### 3.4. Thermal Shock

Specimens were exposed to 15 thermal shock cycles. Each cycle consisted of a 30-minute dwell at 100 +10/-2°C followed by a 30-minute dwell at 0 +2/-10°C. Maximum transfer time between the 2 temperature extremes was 10 seconds. Performance data of the specimens were recorded before and after the exposure.

### 3.5. Thermal Operation and 4 Corners Test

Specimens were exposed at operating (case) temperature extremes (0 and 70°C) at minimum and maximum power supply voltage. In addition, test at nominal voltage and room ambient plus Trise temperature, for a total of 5 sets of data. TX differential input voltage level was set to minimum value. Record RX output eye width, RX output eye height, and supply current for each combination of temperature and voltage conditions.

### 3.6. Temperature Cycling, Non-operating

Specimens were exposed to 100 temperature cycles between -40 +0/-10°C and 85 +10/-0°C. The dwell time at each temperature extreme was 30 minutes. The ramp time was 12 minutes for a ramp rate $\geq$ 10°C per minute. Performance data of the specimens were recorded before and after the exposure.

3.7. Moisture Resistance

Specimens were exposed without any prior conditioning to 20 cycles between 25 +10/-2°C and 65 ± 2°C with humidity between 90 and 100% RH during the ramp to and dwell at 65°C. During the ramp to and dwell at 25°C, the humidity was between 80 and 100% RH. Starting with the 2nd cycle and repeating every other cycle, a cold temperature sub-cycle at -10 +2/-5°C and uncontrolled humidity was performed. The specimens were powered except during the cold temperature sub-cycles. Performance data of the specimens was recorded before the exposure. Final performance data was recorded within 48 hours after the specimens returned to ambient conditions.

3.8. Insertion and Withdrawal Force (EIA/ECA-364-13D)

Using automated equipment, the force necessary to mate each specimen to a corresponding socket at a maximum rate of 12.7 mm [0.5 in] per minute was measured. The force necessary to unmate each specimen from the corresponding socket at a maximum rate of 12.7 mm [0.5 in] per minute was measured. One connector end of each specimen was tested. Performance data was recorded before and after the test.

3.9. Retention Force (EIA-364-38B)

One connector end of each specimen was mated to the corresponding socket of a test board and subjected to a sustained axial load of 89 N [20 lbf]. Using a 7.62 cm [3 in] mandrel, the load was manually applied to the cable at a point 30.5 cm [1 ft] from the strain relief boot of the connector under test. Performance data were recorded before applying the load, at least 1 minute after applying the load, and after removing the load.

3.10. Off-axis Load Capability

One connector end of each specimen was mated to the corresponding socket of a test board and subjected to a sustained load of 22.2 N [5 lbf]. Using a 7.62 cm [3 in] mandrel, the load was manually applied to the cable at a point 30.5 cm [1 ft] from the strain relief boot of the connector under test and at a 90 degree angle to the axis orientation of the connector. Performance data was recorded before applying the load and at least 1 minute after applying the load. The load was manually removed, the orientation of the connector rotated 90 degrees and the test repeated. The test was performed in a total of 4 directions (with load applied parallel and perpendicular to the I/O plate). Performance data was recorded after completing the test.

## 4. FAILURE ANALYSIS

### 4.1. Moisture Resistance

Eighteen cable assemblies were exposed to Moisture Resistance testing. One cable assembly failed the post end-of-life measurement requirement for eye width of 58 picoseconds, measuring -999 picoseconds. Development and Manufacturing Engineering performed a thorough analysis on the failed engine in an attempt to identify root cause. Analysis indicated that there was contamination on the contact pads that led to the cause for the part failure. This failure was found to be intermittent as observed by the varying passing and failing data during re-testing of the sample. In addition, the failure could be replicated by intentional manipulation of the connector within the test fixture. Root cause of the contamination cannot be determined; however it is suspected that dried chemicals (used in processing of the board assembly) may have migrated onto the contact pads. Normally the manufacturing process would not cause chemicals (e.g. no-clean flux) to migrate to the contact pads; however it is possible that during the Moisture Resistance testing condensation may have allowed re-hydration of any possible dried chemical residue on the board which may have migrated to the contact pads. Based on this investigation, there is no evidence that this part was assembled incorrectly. Since no failures of this type have been previously reported, this is determined to be an isolated condition. The LTPD sampling requirement was met in this test - allowing for one failure in a sample size of 18.

### 4.2. 4-Corners

Eighteen cable assemblies were exposed to 4 corner testing. One cable assembly failed the eye width requirement for 0° at 3.13 volts with a reading of 56 picoseconds for Lane B3. Development engineering performed a thorough analysis on the failed engine to identify the root cause of the failure. Failure analysis indicated that the sample failed at 0 degrees C at all voltages (BER eye opening as low as 45 ps). Using the power supply's ammeter from the test station, it was possible to monitor the RX power of one half of the cable while cooling the TX end of the failed lane to 0°C. The ammeter on the test station's power supply is only accurate to 1/10ths of mA (or 100s of µA) but this setup could measure the change in optical power at the receiver at lower temperatures compared to room temperature. The RX current for the failed lane measured 0.7 mA (or 700 µA) at room temperature on all lanes, and dropped to 0.5 mA on the "good" lanes, but dropped to 0.3 mA on the failed lane. This indicated that the failure mode seemed to reduce the optical power at the receiver only when the TX end was at low temperature. As an experiment, the transmitter of the failed lane was reprogrammed with the same temperature compensation profile that is now used on the equalized PCBs. (Background: because of the poor performance at low temperature in DVT and Qualification on the non-Equalized PCBs tests, the temperature profile for the Equalized PCBs was modified to drive the VCSELs a little harder at low temperature to improve the low Temperature optical modulation amplitude.) The reprogrammed lane passed at 0°C with a low reading of 62 ps at 3.135 V. Corrective action has been implemented with the new Equalized PCBs temperature profile that is currently being used in production. The LTPD sampling requirement was met in this test-allowing for one failure in a sample size of 18.