PARALIGHT* Active Cable Assembly, 4 Lane PN 2123287

1. INTRODUCTION

1.1. Purpose

Qualification tests were performed on, QSFP 10 Gbs, 4 lane Active Cable assembly to determine their conformance to the requirements of Product Specification 108-2397, Revision B. These qualification tests were limited to the Active Cable assemblies produced by TE Connectivity (TE), Harrisburg, PA. No changes in process, materials or manufacturing locations are permitted without prior approval of Quality Engineering/Reliability Group of TE.

1.2. Scope

This report covers the electrical, mechanical, and environmental performance of the PARALIGHT* Active Cable QSFP 4x10, manufactured by TE, Harrisburg, PA. Testing was performed between November 2010 and March 2011. The test file numbers for this testing are B126326-004 and B126326-006.

1.3. Conclusion

Fiber Optic PARALIGHT Active Cable Assembly, QSFP 10Gbs,4 Lanes, listed in paragraph 1.5, meets the environmental, electrical and mechanical performance requirements of Product Specification 108-2397, Revision B. After subjecting to each environmental test, mechanical, or parametric test, evidence of damage or failure to meet the specification shall constitute a failure. Failure to meet the 20% Lot Tolerance Percent Defective (LTPD) Acceptance Criteria in paragraph 1.5 shall also constitute a failure.

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 Gbs active cable assemblies will operate over a data rate of 2.5 to 10 Gbs per lane with an aggregate data rate of 40 Gbs in each direction.

1.5. Test Specimens

Specimens shall be manufactured 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.

Test Group	1	2	3	4	5	6	7	8
Cable Assembly Part Number	2123287-2 QSFP 10Gbs							
Test Specimen Quantity/Failures Allowed	18/1	18/1	32/3	32/3	18/1	11/0	5/0	1/0
Control Cable Required	Yes	Yes	Yes	Yes	Yes	Yes	No	No

1.6. Product Qualification Test Sequence

	Test Group (a)							
	1	2	3	4	5	6	7	8
	Test Sequence (b)							
Examination of product	1	1	1	1	1	1	1	1
RX output eye width	2,6,8,10	2,6,10,12	2,6	2,6	2,6,8,11	2,7,9,11	2,6	2
RX output eye height	3	3,7,13	3,7	3,7	3,9,12	3	3	3
Supply current per cable end	4	4,8,14	4,8	4,8	4	4	4	4
ESD, human body							5	
EMI test								5
Vibration, variable frequency	5							
Mechanical shock	7							
Durability					5			
Flex					7			
Twist					10			
Insertion force						5		
Withdrawal force						6		
Retention force						8		
Off-axis load capability						10		
Thermal shock	9							
Thermal operation (4 corners test)		5						
Temperature cycling, non-operating		9						
Moisture resistance		11						
Humidity (life test)			5					
Accelerated aging (life test)				5				

NOTE

(a) See paragraph 1.5.
(b) Numbers indicate sequence in which tests are performed.

2. SUMMARY OF TESTING

2.1. Examination of Product

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

2.2. Initial Performance - All Test Groups

All electrical measurements from a quantity of 135 QSFP 10Gbs samples met the specification requirements for new product.

Table 1, New Product Performance, QSFP 10 Gbs

Performance Criteria	Requirements	Actual
Eye Width (picoseconds)	65 minimum (see Note)	65.28 minimum 74.71 median
Eye Height (millivolts)	200 minimum 1000 maximum	305 minimum 334 median 359 maximum
Supply Current (milliamperes)	600 maximum	256 maximum 245 median

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

2.3. 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 10 Gbs

Test Group	Condition	Requirements		Actual	
		During	After	During	After
	Vibration				63 (W_{min}) 74 (W_{med}) 11.9 % (W_{Δ})
1	Mechanical shock	NA	58 (W_{min}) <15% (W_{Δ})	NA	66 (W_{min}) 76(W_{med}) 10.5 % (W_{Δ})
	Thermal shock				66 (W_{min}) 76 (W_{med}) 11.6 % (W_{Δ})
	Thermal operation and 4 corners test	See Table 3			
2	Temperature cycling		58 (W_{min})	NA	70 (W_{min}) 76 (W_{med})
	Moisture resistance				63 (W_{min}) 74.1 (W_{med})
3	Humidity		1000 hours: 200 (H_{min}) 1000 (H_{max}) 58 (W_{min}) 600 (C_{max})	500 hours: 61 (W_{min}) 255 (C_{max})	292 (H_{min}) 361 (H_{max}) 64 (W_{min}) 254 (C_{max})
4	Accelerated aging		1000 hours: 200 (H_{min}) 1000 (H_{max}) 58 (W_{min}) 600 (C_{max})	569 hours: 64(W_{min}) 255 (C_{max})	297 (H_{min}) 351 (H_{max}) 63 (W_{min}) 258(C_{max})
	Durability	NA	58 (W_{min}) <15% (W_{Δ})		66 (W_{min}) 76 (W_{med}) 4.2 % (W_{Δ})
5	Flex		200 (H_{min}) 1000 (H_{max}) 58 (W_{min}) <15% (W_{Δ})	NA	306 (H_{min}) 334 (H_{med}) 360 (H_{max}) 67 (W_{min}) 77 (W_{med}) 7.4 % (W_{Δ})
	Twist		200(H_{min}) 1000 (H_{max}) 58 (W_{min}) <15% (W_{Δ})		297 (H_{min}) 330 (H_{med}) 360 (H_{max}) 66 (W_{min}) 76 (W_{med}) 9.7 % (W_{Δ})
	Insertion force	No parametric requirements		Results given in Table 4	
	Withdrawal force				
6	Retention force	200 (H_{min}) 1000 (H_{max}) 15% (W_{Δ})	58 (W_{min}) <15% (W_{Δ})	295 (H_{min}) 334 (H_{med}) 358 (H_{max}) 9.2 % (W_{Δ})	69 (W_{min}) 76 (W_{med}) 7.7 % (W_{Δ})
	Off-axis load capability	200 (H_{min}) 1000 (H_{max}) 15% (W_{Δ})	58 (W_{min}) <15% (W_{Δ})	221 (H_{min}) 337 (H_{med}) 356 (H_{max}) 10.0 % (W_{Δ})	70 (W_{min}) 76 (W_{med}) 5.0 % (W_{Δ})
7	ESD	NA	58 (W_{min}) <15% (W_{Δ})	NA	71 (W_{min}) 2.9 % (W_{Δ})
8	EMI	No parametric requirements			Passed

NOTE

(W_{min}) - Minimum Eye Width in picoseconds
(W_{med}) - Median Eye Width in picoseconds
(W_{Δ}) - 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
(C_{max}) - Maximum Supply Current per cable end in milliamperes.

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

Test Condition	Requirements		Actual	
	During	After	During	After
25°C + Trise, 3.3 volts	58 (W_{min}) 200 (H_{min}) 1000 (H_{max}) 600(C_{max})	58 (W_{min})	67 (W_{min}) 74 (W_{med}) 249 (H_{min}) 292 (H_{max}) 256 (C_{max})	67 (W_{min}) 75 (W_{med})
0°C, 3.13 volts	58 (W_{min}) 200 (H_{min}) 1000 (H_{max}) 600 (C_{max})		59 (W_{min}) 70 (W_{med}) 227 (H_{min}) 287 (H_{max}) 246 (C_{max})	
0°C, 3.47 volts			62 (W_{min}) 70 (W_{med}) 210 (H_{min}) 295(H_{max}) 247 (C_{max})	
70°C, 3.13 volts			62 (W_{min}) 73 (W_{med}) 225 (H_{min}) 286(H_{max}) 260 (C_{max})	
70°C, 3.47 volts			63 (W_{min}) 78 (W_{med}) 246(H_{min}) 295 (H_{max}) 268 (C_{max})	

NOTE

(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	34.8 [7.8] maximum
Withdrawal force	30.0 [6.7] maximum	28.1 [6.3] maximum

3. TEST METHODS

Initial electrical performance was recorded by verifying eye width, eye height, and supply current, then the sequential testing was performed.

Eye width is measured with a Centellax TGB1A BERT. A bathtub curve is generated by sampling points between a BER of 1e-4 and 1e-10 on each side of the eye and then extrapolating in order to compute the eye width at a BER of 1e-12.

Eye height is measured using an Agilent 86100A DCA. The measurement is made halfway between the two crossing points and extrapolates the vertical eye opening by fitting a Gaussian probability density curve to the upper and lower rails and extrapolating inward to 3 standard deviations. This measurement is part of the DCAs built in functionality

Supply current is measured once at the start of a test using a calibrated programmable power supply (HP 6624A) with all 8 VCSELS being modulated.

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 [.06 in] 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 was 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 temperature extremes was 10 seconds. Performance data of the specimens was 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 was 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. Humidity

Specimens were preconditioned in a dry oven at 40 ± 5°C for 24 hours. Initial performance data was recorded after preconditioning. Specimens were powered and exposed to 85 ± 2°C and 85 ± 2% RH for 1000 hours. Interim performance data were recorded after 168 and 500 hours. Interim and final performance data was recorded as soon as possible after the samples were at room ambient for 1 hour. In order to shorten the time of test to accurately determine Failure In Time (FIT) and Mean Time To Failure (MTTF), TE elected to perform certain of our qualification tests at stress levels in excess of design margin of some PARALIGHT components. While this accelerates the time to achieve FIT and MTTF data, it increases the probability of stress-related failures. In the limited cases where such overstress failures occur, they were discounted and were not included in qualification or reliability calculations.

3.9. Accelerated Aging (Life Test)

Specimens were powered and exposed to 85 ± 2°C, low humidity for 1000 hours. Interim performance data was recorded after 500 hours. Interim and final performance data was recorded as soon as possible after the samples were at room ambient for 1 hour. In order to shorten the time of test to accurately determine FIT and MTTF, TE elected to perform certain of our qualification tests at stress levels in excess of design margin of some PARALIGHT components. While this accelerates the time to achieve FIT and MTTF data, it increases the probability of stress-related failures. In the limited cases where such overstress failures occur, they were discounted and were not included in qualification or reliability calculations.

3.10. Durability (EIA-364-09C)

One connector end of each specimen was manually mated to and unmated from a corresponding socket, which was mounted to a PCB. A total of 250 durability cycles were performed at a maximum rate of 500 cycles per hour. Performance data of the specimens was recorded before and after the test.

3.11. Flex (TIA/EIA-455-1B)

Using automated equipment, 1 connector end of each specimen was subjected to 200 flexing cycles; 100 cycles with the connector mounted in a 0 degree orientation (cable flexing toward the top and bottom of the connector) and 100 cycles with the connector mounted in a 90 degree orientation (cable flexing toward the sides of the connector). Specimens were tested at a rate of approximately 30 cycles per minute. A 7.62 cm [3 in] mandrel was used to apply a tensile load of 4.9 N [1.1 lbf] to the specimen cable at a point 30.5 cm [12 in] from the strain relief boot of the connector under test. The flex arc was ± 90 degrees from a vertical position. Performance data of the specimens was recorded before and after the test.

3.12. Twist (TIA-455-36A)

Using automated equipment, 1 connector end of each specimen was subjected to 500 twist cycles. The specimen cables were twisted at a rate of approximately 30 cycles per minute. A 7.62 cm [3 in] mandrel was used to apply a tensile load of 14.7 N [3.3 lbf] to the specimen cable at a point 25.4 cm [10 in] from the strain relief boot of the connector under test. The twist arc was ± 90 degrees from a vertical (normally untwisted) position. Performance data of the specimens was recorded before and after the test.

3.13. Insertion Force 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.

3.14. 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 was recorded before applying the load, at least 1 minute after applying the load, and after removing the load.

3.15. 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.

3.16. Electrostatic Discharge (ESD)

Testing was performed in accordance with JEDEC JESD22-A114D. Class 1B,human body model. ESD shall be tested on each I/O pin relative to power and ground.

3.17. Electromagnetic Interference (EMI)

EMI Testing was performed with the Device under Test (DUT) connected to a Mellanox Host Card Adapter installed in a PC. The DUT and the PC was placed in a semi-anechoic chamber on a turntable allowing the test platform to be rotated 360 degrees. A log-periodic antenna measured emissions from 30 MHZ to 1 GHz 3 meters away from the test system. A horn antenna measured emissions from 1 to 7 GHz 1 meter away from the test system. Both antennas were positioned horizontally and vertically at 1 meter heights measured from the chamber floor.