

SPACEWIRE CABLE AND CONNECTOR VARIATIONS

Session: SpaceWire Components

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SpaceWire Connector Issues

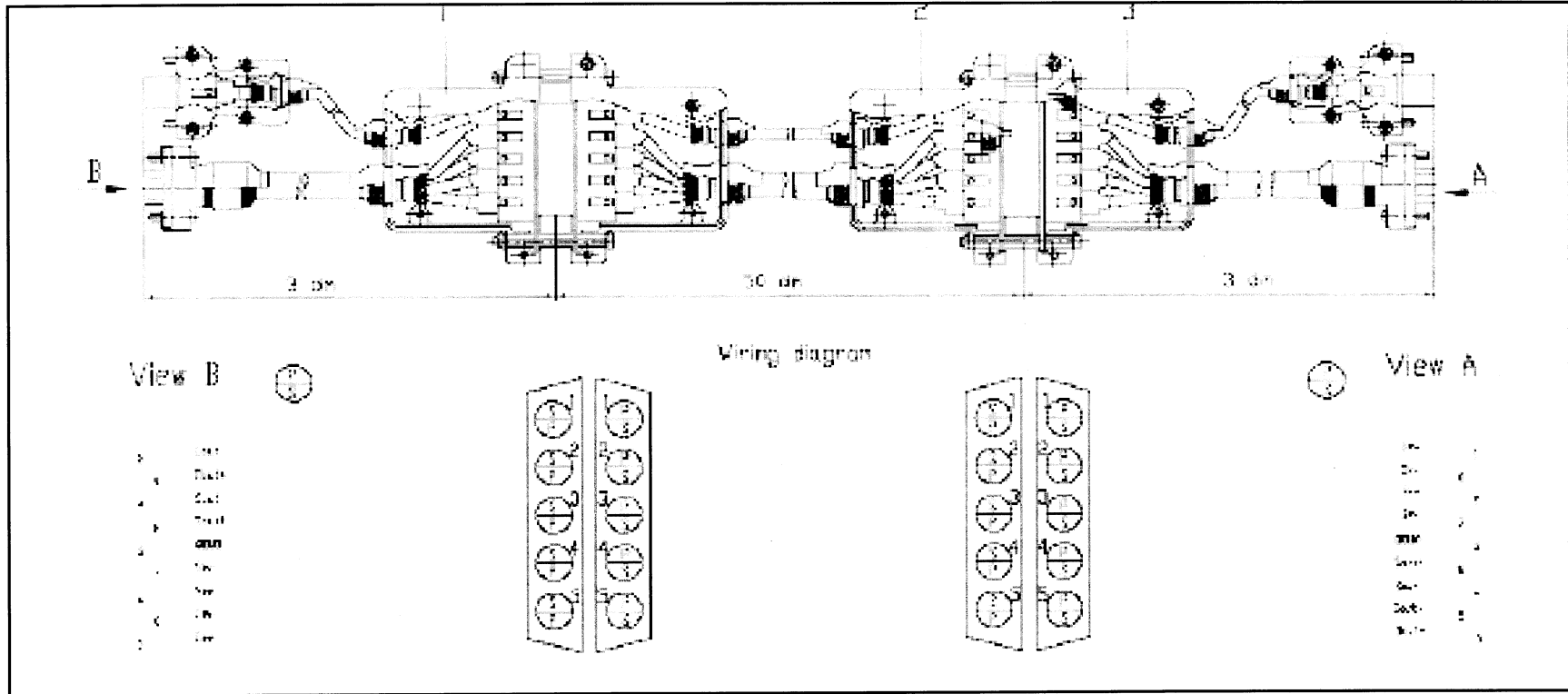
▪ Connector Specification

- SpaceWire connectors have known issues
 - Not impedance matched to the cable
 - Handling (Mechanical) issues
- Need space-qualified matched impedance connector
 - alternative space-qualified connector
- Electrical Issues
 - Only a single ground pin which does not pass through
 - Near-end Crosstalk (NEXT) at the SpaceWire connector

▪ Cable Specification

- Use of larger gauge cable in non-standard applications or to meet tight specifications

Test Assembly



Connector Testing

Final Production Tests IR, Continuity - 4 Samples

Visual inspection - 4 Samples

Eye-pattern - 3 Samples

Initial Differential Impedance - 3 Samples

Initial Inpair Skew - 3 Samples

Insertion Loss at $23 \pm 2^\circ\text{C}$ - 3 Samples

Return Loss at $23 \pm 2^\circ\text{C}$ - 3 Samples

Thermal Cycle, -40°C to $+60^\circ\text{C}$ - 3 Samples

Insertion Loss at $23 \pm 2^\circ\text{C}$ - 3 Samples

Return Loss at $23 \pm 2^\circ\text{C}$ - 3 Samples

Initial DWV Insulation Resistance 300 V DC

Vibration (Sine, Parts 1&2, + Random) - 3 Samples

Vibration (Sine, Part 1 only) - 3 Samples

Shock - 3 Samples

Insertion Loss vs. Temperature - 3 Samples

Return Loss vs. Temperature - 3 Samples

Shell to Shell Conductivity - 3 Samples

EMC - 3 Samples (IEC-60966-1)

Eye pattern - 3 Samples

Final Differential Impedance - 3 Samples

In pair skew - 3 Samples

Final Elect. Test - DWV , IR 300V DC - 3 Samples

Final visual Inspection - 3 Samples

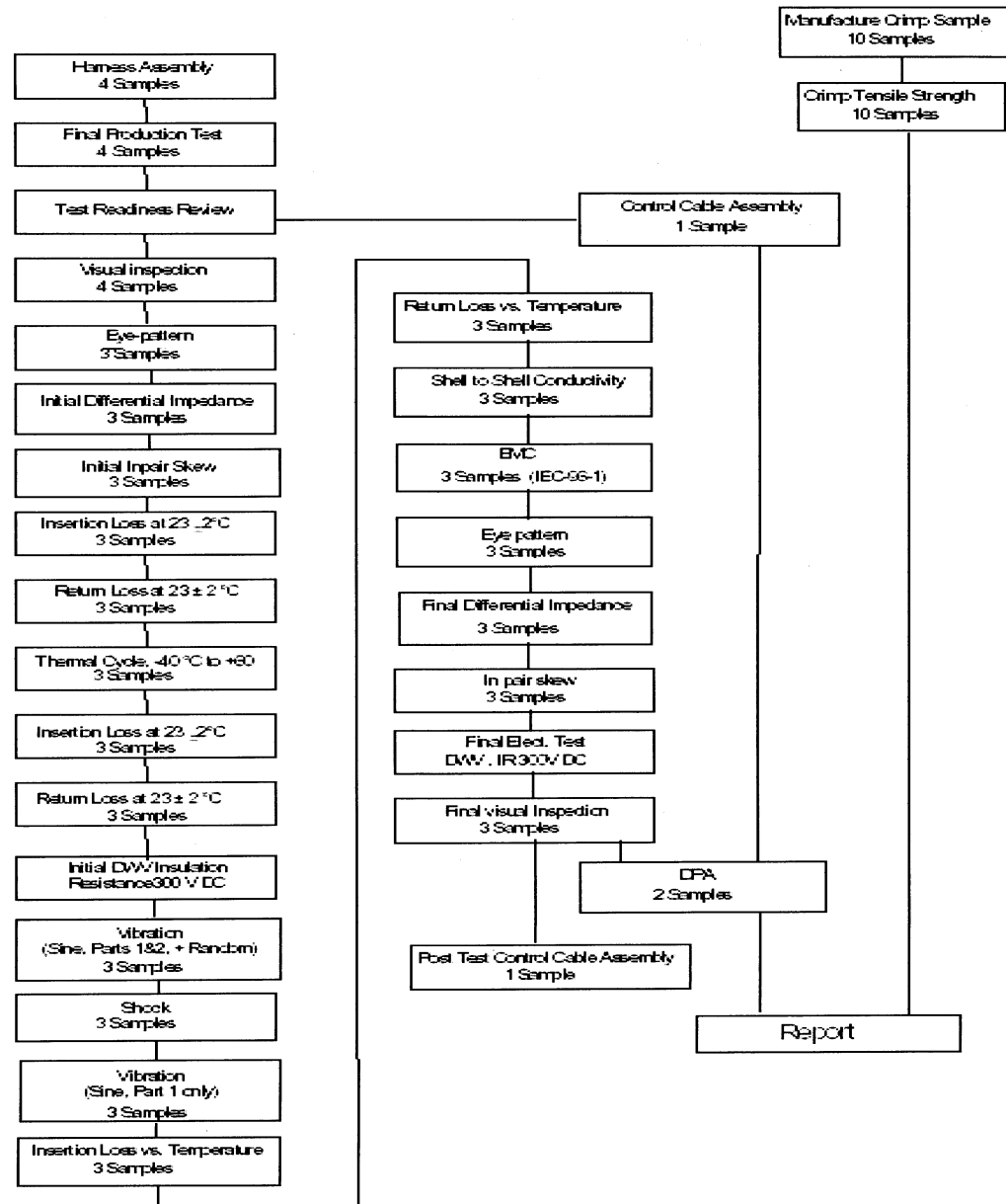
DPA - 2 Samples

Post Test Control Cable Assembly - 1 Sample

Manufacture Crimp Sample - 10 Samples

Crimp Tensile Strength - 10 Samples

Test Flow



Final Production Tests IR, Continuity

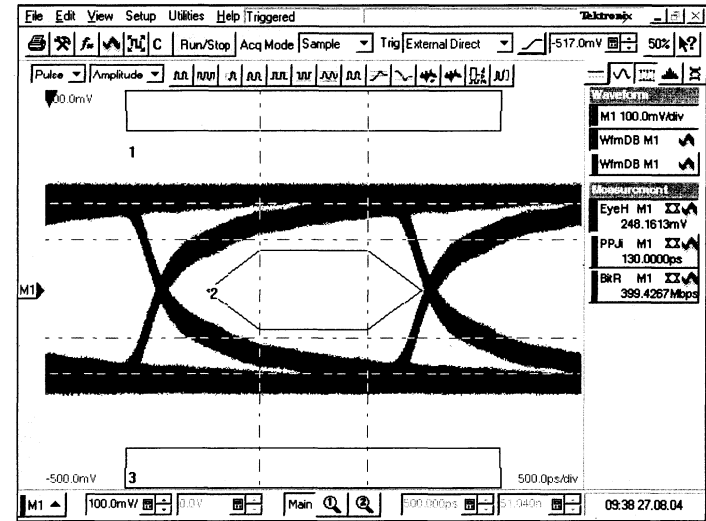
- Insulation resistance was tested between each insulated conductor. A test voltage of 300 VDC was applied for a time period of 1 minute. Requirement: Measured value shall be: 100MΩ
- Continuity was measured out according to QTP GSC-10-82715-00 section 6.2.3 wit a Micro-Ohm-Meter. Test temperature: 22°C

Final Production Tests	SN01	SN02	SN03	SN04
Final Physical Inspection	Passed	Passed	Passed	Passed
Mass	Measured	Measured	Measured	Measured
Insulation	Passed	Passed	Passed	Passed
Continuity	Measured	Measured	Measured	Measured

Eye-pattern

- The applied input voltage was 540mV peak to peak.
- **Requirement:** Eye height = 200 mV
- Peak to peak jitter = $0.2 * \text{bit time}$

	65Mbit/s	100Mbit/s	200Mbit/s	400Mbit/s
Jitter pp	3086ps	2000ps	1000ps	500ps



	Eye Height [mV]	Jitter pp [ps]	Eye Height [mV]	Jitter pp [ps]	Eye Height [mV]	Jitter pp [ps]	Eye Height [mV]	Jitter pp [ps]
SN Q001	65Mbit/s		100Mbit/s		200Mbit/s		400Mbit/s	
Pair 1	436	123	401	120	333	120	248	130
Pair 2	443	123	410	80	343	100	269	110
Pair 3	436	123	402	80	332	120	252	130
Pair 4	437	123	402	120	330	120	248	130
SN Q002	65Mbit/s		100Mbit/s		200Mbit/s		400Mbit/s	
Pair 1	445	123	412	80	344	100	268	120
Pair 2	435	123	401	120	331	140	245	160
Pair 3	436	123	402	120	330	120	251	160
Pair 4	435	123	401	120	331	120	250	140
SN Q003	65Mbit/s		100Mbit/s		200Mbit/s		400Mbit/s	
Pair 1	436	123	399	120	331	100	249	140
Pair 2	437	123	402	80	330	120	248	130
Pair 3	437	123	403	120	332	120	246	140
Pair 4	445	123	413	120	345	100	268	120

Initial Differential Impedance

- Requirement: $100 \pm 6 \Omega$

SN Q001	GSC-10-82789-003	GSC-10-82794-050	GSC-10-82787-003
Pair 1	99.2	102.2	101.8
Pair 2	99.2	101.9	102.2
Pair 3	101.4	105.4	100
Pair 4	102.7	102.7	98.65
SN Q002	GSC-10-82789-003	GSC-10-82794-050	GSC-10-82787-003
Pair 1	99.5	102.4	100.5
Pair 2	100	102.7	101.9
Pair 3	101.1	102.7	98.4
Pair 4	102.7	105.7	100
SN Q003	GSC-10-82789-003	GSC-10-82794-050	GSC-10-82787-003
Pair 1	103.5	104.9	101.8
Pair 2	101.3	102.4	102.2
Pair 3	101.6	102.4	100
Pair 4	100.8	102.4	98.7

Initial In-Pair Skew

- Test was carried out differentially in S21 configuration. Precision baluns and appropriate a calibration kit was used. A two full port calibration was done.

	CH 1	CH 2
Centre frequency:	70MHz	323MHz
Span frequency:	1MHz	156MHz
Number of points:	1601	1601
IF-BW:	100Hz	100Hz
Sweep time:	15.8s	15.8s
Marker:	70MHz	250MHz / 400MHz

- Requirement: 80ps/m**

SN Q001	70MHz	250MHz	400MHz
Pair 1	0.7	3.6	3.5
Pair 2	1.7	6.6	6.8
Pair 3	1.5	0.4	2.4
Pair 4	14.3	6.3	5.2
Pair 5	19.8	15.1	12.7
SN Q002	70MHz	250MHz	400MHz
Pair 1	9.3	7.1	7.5
Pair 2	3.2	1.9	1.7
Pair 3	10.3	14.9	6.2
Pair 4	8.5	2.8	4.2
Pair 5	19.8	18.7	14.8
SN Q003	70MHz	250MHz	400MHz
Pair 1	6.9	5.6	4.8
Pair 2	0.5	3.6	0.5
Pair 3	3.4	12.5	8.7
Pair 4	5.7	10.5	5
Pair 5	2.8	4.1	2.5

Insertion Loss at 23 °C

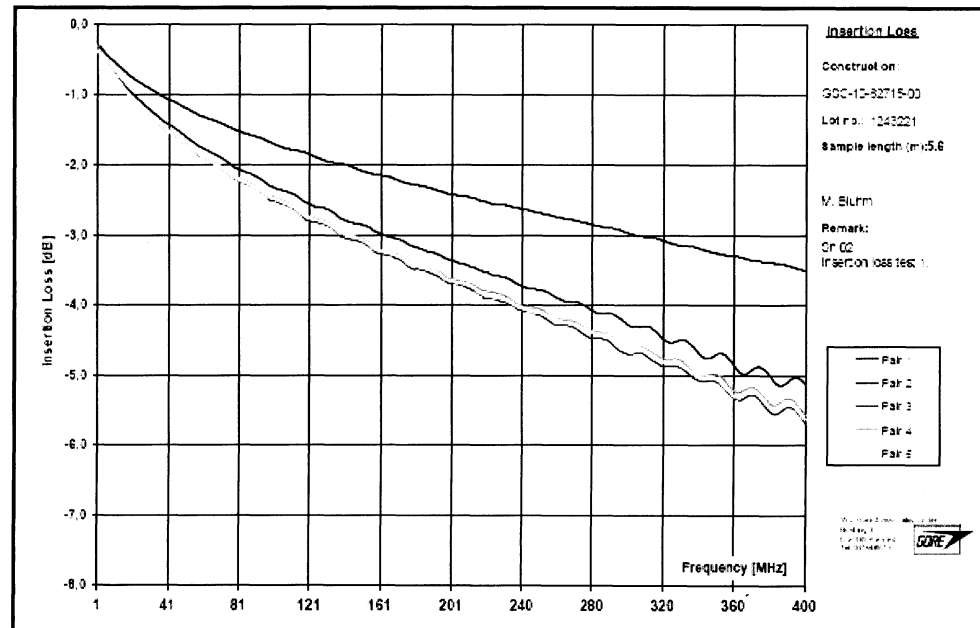
- Test was carried out differentially in a frequency range from 1MHz to 400MHz. Precision baluns and an appropriate calibration kit were used. A two full port calibration was done on the interface of the used baluns.

Start frequency:	1MHz	Stop frequency:	400MHz
Number of points:	401	IF-BW:	100Hz
Measurement:	S21	Sweep time:	5s

SN Q001	33MHz	70MHz	100MHz	400MHz
Pair 1	-0.94	-1.37	-1.67	-3.41
Pair 2	-1.34	-2.02	-2.48	-5.58
Pair 3	-1.27	-1.9	-2.33	-5.19
Pair 4	-1.34	-2.02	-2.48	-5.66
Pair 5	-1.35	-2.03	-2.48	-5.7

SN Q002	33MHz	70MHz	100MHz	400MHz
Pair 1	-0.95	-1.4	-1.7	-3.5
Pair 2	-1.27	-1.89	-2.32	-5.13
Pair 3	-1.36	-2.05	-2.52	-5.68
Pair 4	-1.34	-2.01	-2.46	-5.56
Pair 5	-1.35	-2.03	-2.48	-5.62

SN Q003	33MHz	70MHz	100MHz	400MHz
Pair 1	-0.95	-1.39	-1.687	-3.44
Pair 2	-1.35	-2.03	-2.49	-5.63
Pair 3	-1.34	-2.02	-2.48	-5.7
Pair 4	-1.35	-2.03	-2.49	-5.63
Pair 5	-1.27	-1.9	-2.33	-5.16

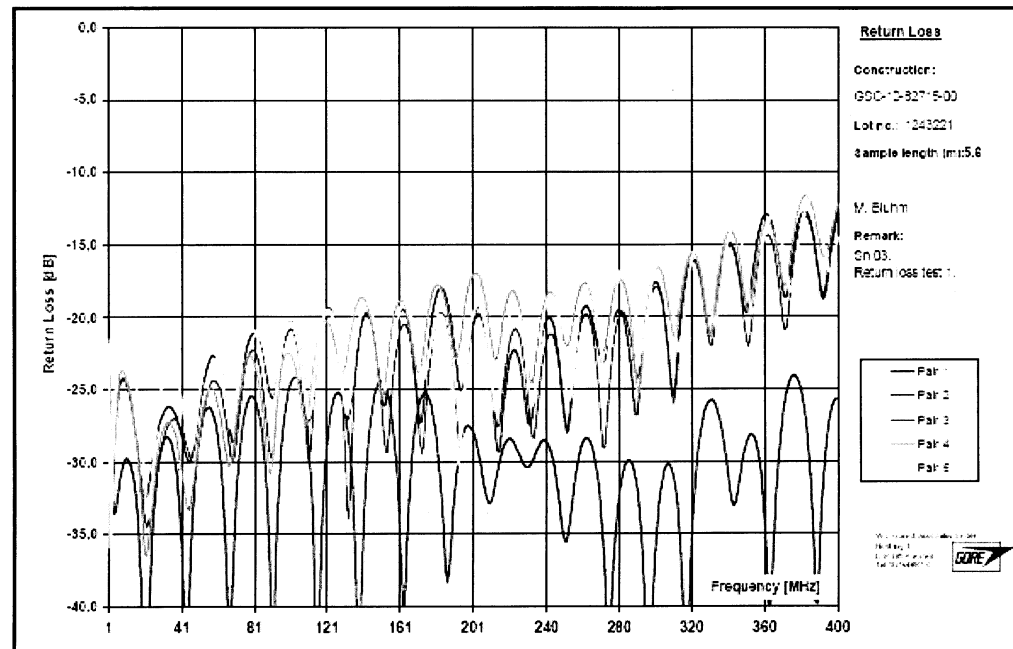


Return Loss Measurements at 23 °C

- Test was carried out differentially in a frequency range from 1MHz to 400MHz. Precision baluns and an appropriate calibration kit were used. A two full port calibration was done on the BNO interface of the used baluns.

Start frequency:	1MHz	Stop frequency:	400MHz
Number of points:	401	IF-BW:	100Hz
Measurement:	S21	Sweep time:	5s

SN Q001	100MHz	200MHz	400MHz
Pair 1	-26.9	-26.6	-27.9
Pair 2	-21.3	-18	-12.8
Pair 3	-20.5	-21.9	-13.9
Pair 4	-21	-20.1	-12.5
Pair 5	-21.6	-18.7	-12.1
SN Q002	100MHz	200MHz	400MHz
Pair 1	-23.7	-25.4	-22.2
Pair 2	-20	-21.1	-15.3
Pair 3	-21	-21.4	-12.9
Pair 4	-22	-18.6	-12.5
Pair 5	-22.3	-18.3	-12.9
SN Q003	100MHz	200MHz	400MHz
Pair 1	-25	-27.7	-25.7
Pair 2	-20.4	-21.1	-13
Pair 3	-20.9	-20.8	-12.5
Pair 4	-22.5	-17.3	-12.3
Pair 5	-20.4	-20.3	-14.6



Physical/Mechanical Tests

- Requirement: There shall be no electrical interruptions exceeding 1 microsecond. There shall be no disengagement of the mated connectors, evidence of cracking, breaking or loosening of parts.**

- Resonance Search	20 - 2000 Hz	0.25 g	
	Sweep rate	4.0 oct/min	
- Sine Qualification	Frequency range:	5 - 100 Hz	
	Level:	5 - 21,3 Hz	+11 mm
		21,3 - 100 Hz	20 g
	Sweep rate:	2.0 oct/min	
	Duration:	1 sweep per axis	
- Random Qualification	Frequency range:	20 - 2000 Hz	
	Level:	20 Hz	0.026 g ² /Hz
		50 Hz	0.16 g ² /Hz
		800 Hz	0.16 g ² /Hz
		2000 Hz	0.026 g ² /Hz
	Total:	14.1 g _{RMS}	
	Duration:	180 sec per axis	
- Resonance Search	20 - 2000 Hz	0.25 g	
	Sweep rate:	4.0 oct/min	
- Shock:	Shape:	Half-sine	
	Acceleration:	500 g	
	Duration:	1 ms	
	Number of shocks:	1 per direction (2 per axis) total 6 shocks	

Shell To Shell Conductivity

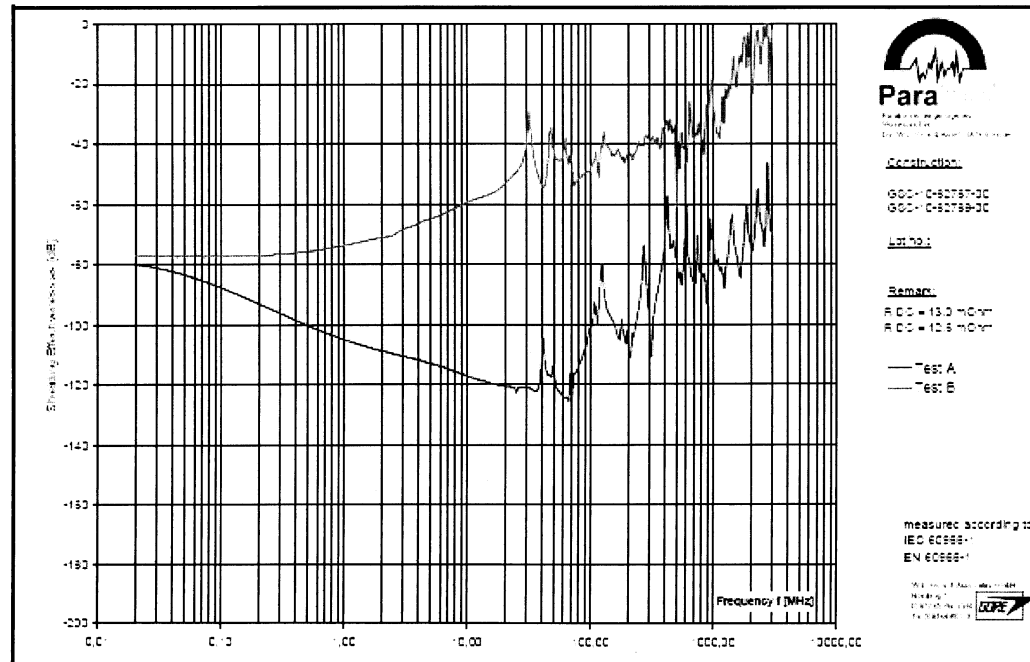
- Applied DC current was 1 ampere. Shell to shell conductivity was tested from backshell surface to backshell surface across the mated cascade assembly.
- Requirement: Measurement shall not exceed 65 mOhm.
- 9-pin MDM Connector: Backshell. 500T10M09H08
- Twinax Interconnect: Backshell. DW 214-09-1-82822-6-0314

	500T10M09H08	DW 214-09-1-82822-6-0314
SN Q001	47.093	57.037
SN Q002	46.247	56.334
SN Q003	46.357	57.274

Electromagnetic Compatibility (Shielding Effectiveness)

- Shielding effectiveness will be measured in accordance with IEC-60966-1, Appendix C: Shielding Effectiveness, Transfer Impedance line injection method.
- EMC at 100 MHz: - 45 dB with respect to the signal

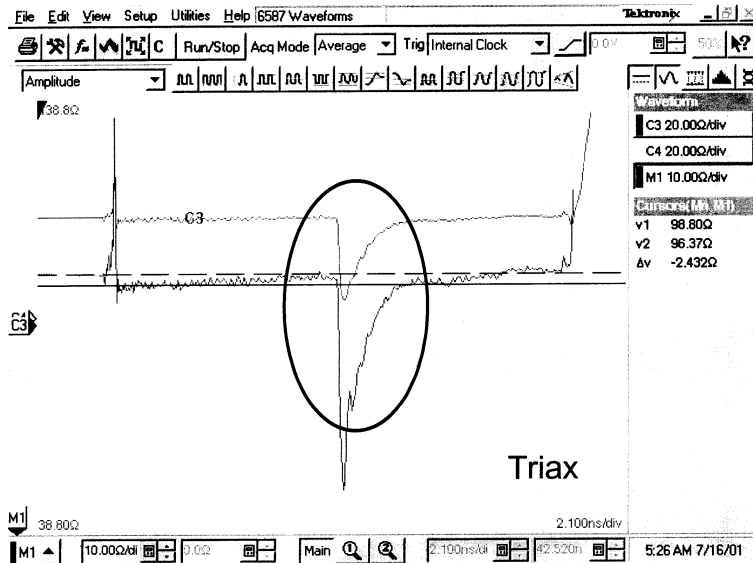
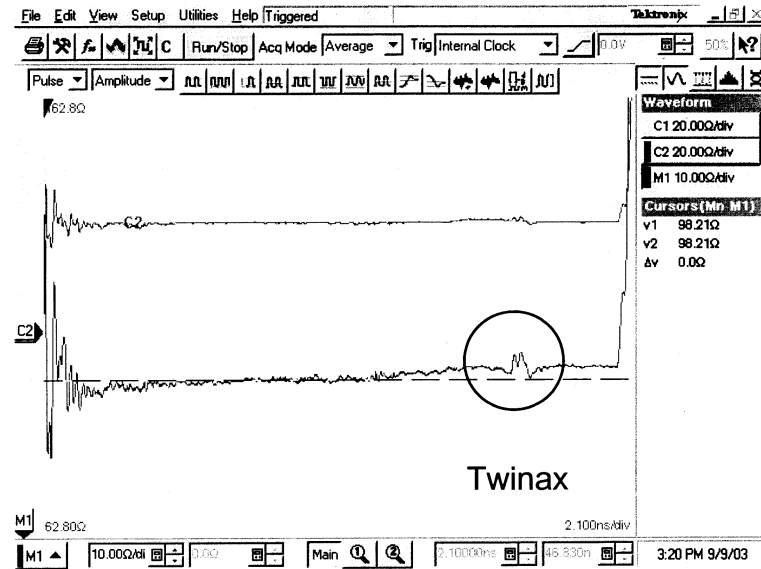
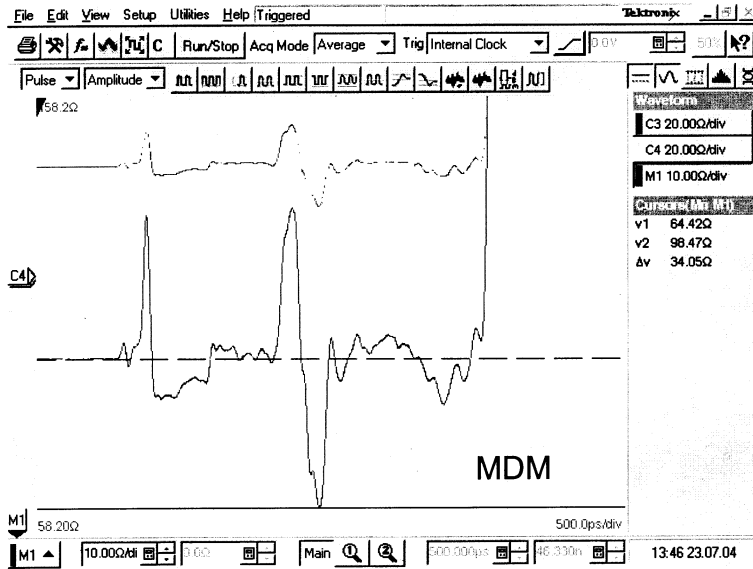
	DC Resistance [mohms]		EMC at 100MHz	
	Test A	Test B	Test A	Test B
SN Q001	12.6	13	-101	-48
SN Q002	12.6	12.8	-105	-45
SN Q003	12.6	12.8	-103	-46



Testing Summary

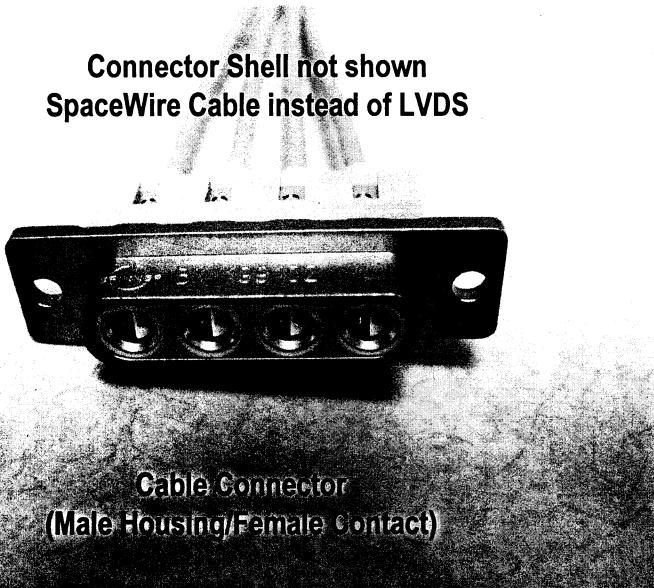
Visual Inspection	Passed	Passed	Passed
Eye Pattern Measurements	Passed	Passed	Passed
Initial Differential Impedance	Passed	Passed	Passed
Initial In-Pair Skew	Passed	Passed	Passed
Insertion Loss at 23 °C	Passed	Passed	Passed
Return Loss Measurements at 23 °C	Passed	Passed	Passed
Thermal Cycling	Performed	Performed	Performed
Insertion Loss at 23 °C after thermal cycling	Passed	Passed	Passed
Return Loss Measurements at 23 °C after thermal cycling	Passed	Passed	Passed
Initial DWV Insulation Resistance Test	Passed	Passed	Passed
Sinusoidal Vibration, Part 1: Low-Level Sweep	Passed	Passed	Passed
Sinusoidal Vibration, Part 2	Passed	Passed	Passed
Random Vibration	Passed	Passed	Passed
Shock	Passed	Passed	Passed
Insertion Loss versus Temperature	Passed	Passed	Passed
Return Loss versus Temperature	Passed	Passed	Passed
Shell To Shell Conductivity	Passed	Passed	Passed
Electromagnetic Compatibility (EMC)	Passed	Passed	Passed
Eye Pattern Measurements			
Final Differential Impedance	Passed	Passed	Passed
In-Pair Skew	Passed	Passed	Passed

Connector Impedance Comparison



4-way Twinax Connector

Connector Shell not shown
SpaceWire Cable instead of LVDS

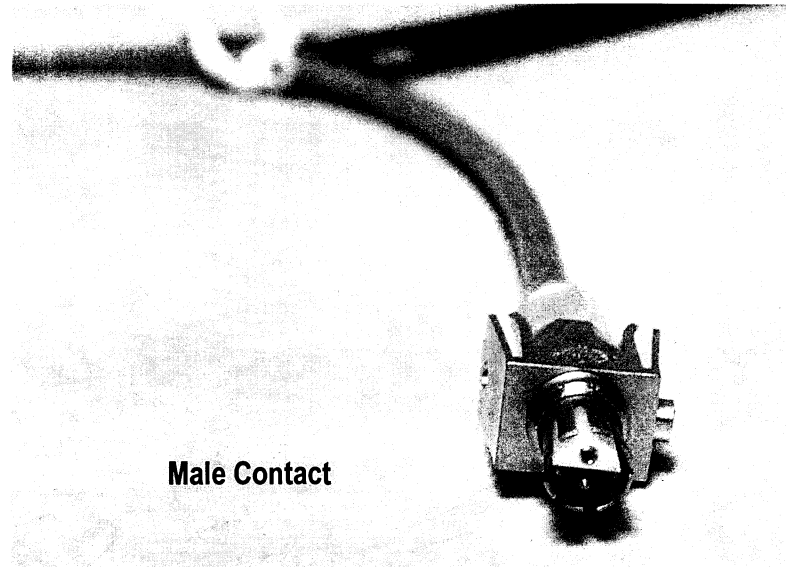


Cable Connector
(Male Housing/Female Contact)



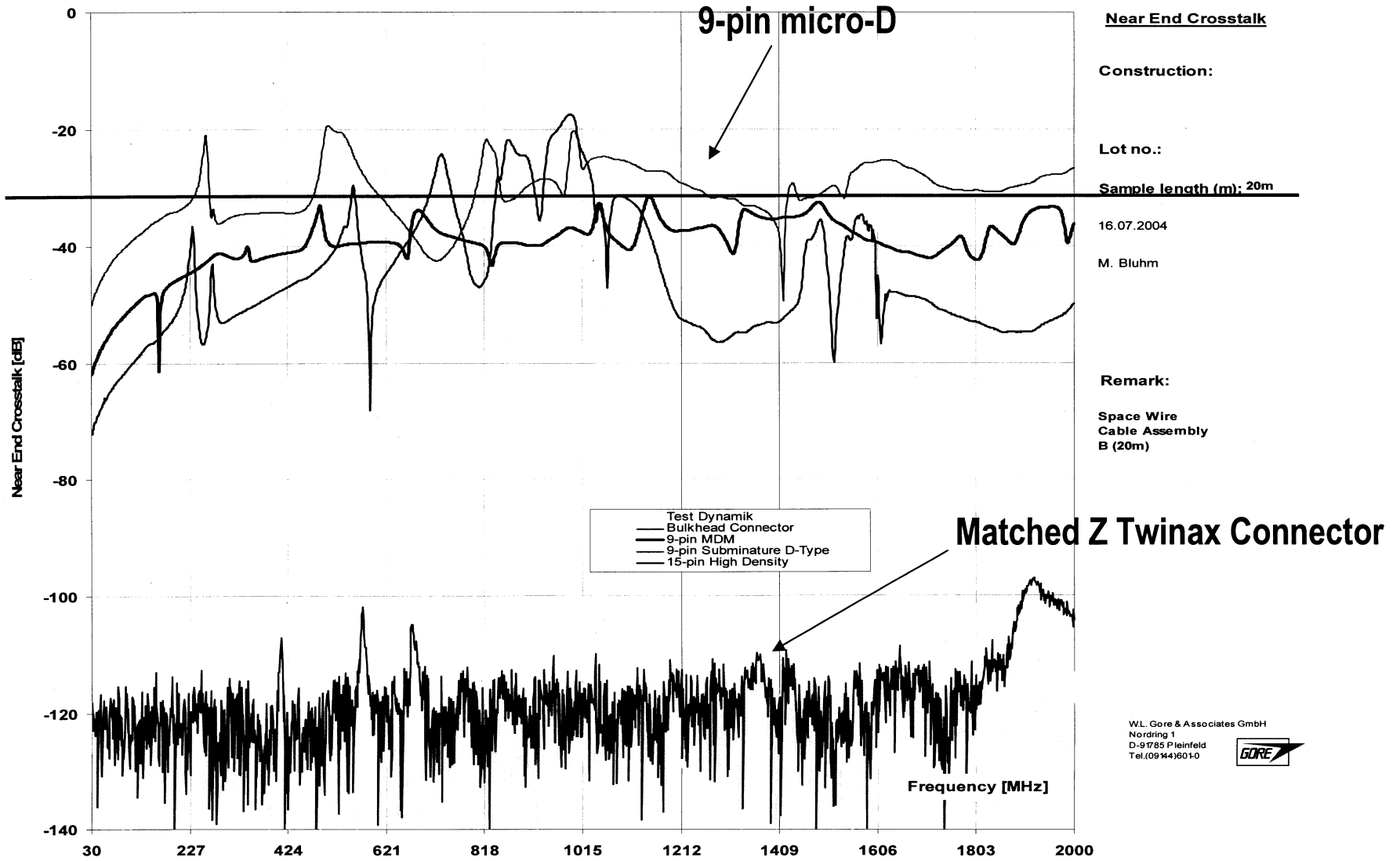
Unit Connector
(Female Housing/Male Contact)

Contacts snap into housing



Male Contact

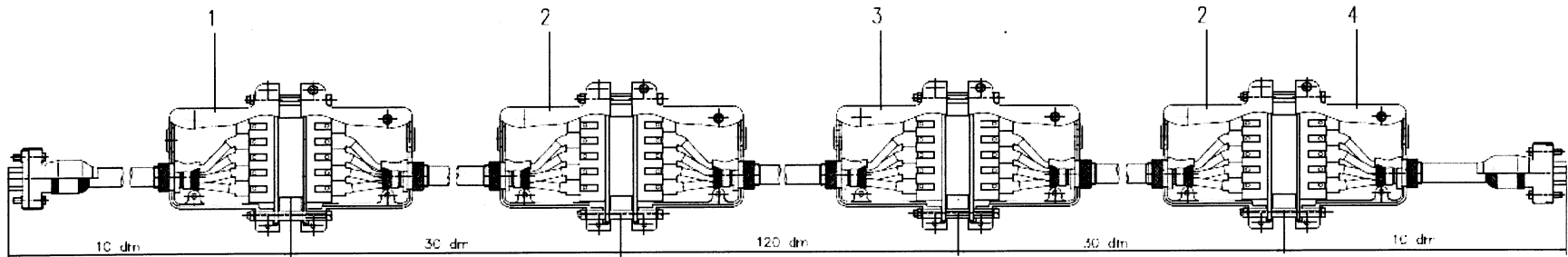
Near-end Crosstalk (NEXT):



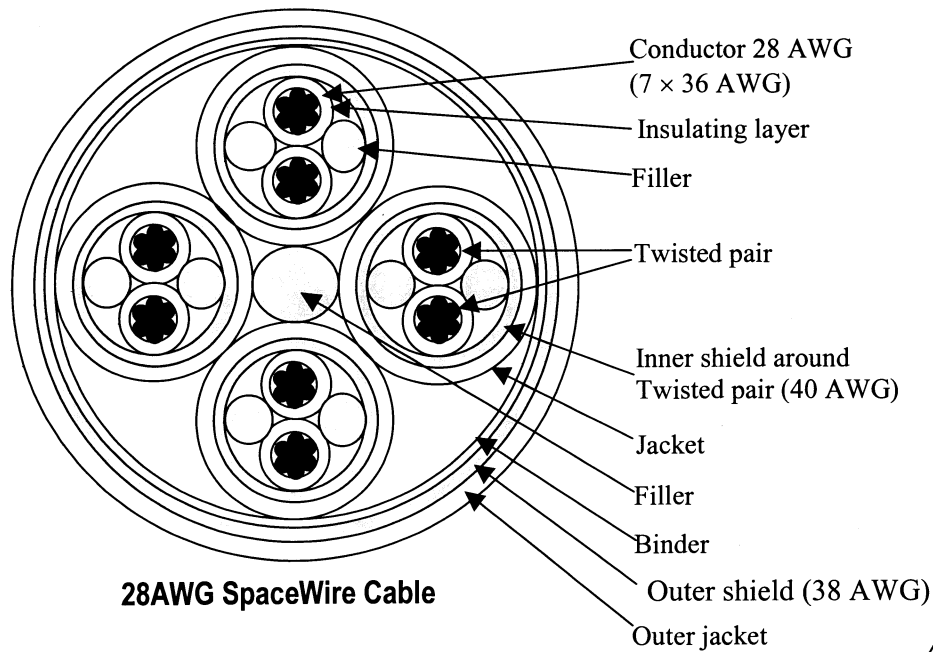
(5,9) Driven; (1,6) Quiet

Cable Comparison (20m cascade)

- 20m cascade utilizing 5-way Twinax connector



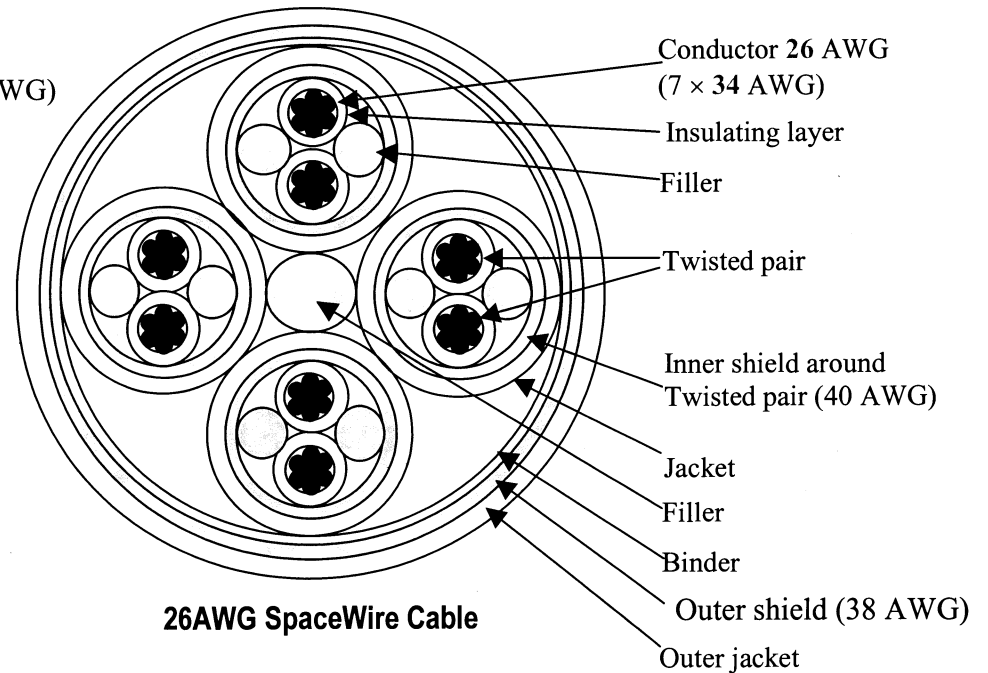
SpaceWire Cable



28AWG SpaceWire Cable

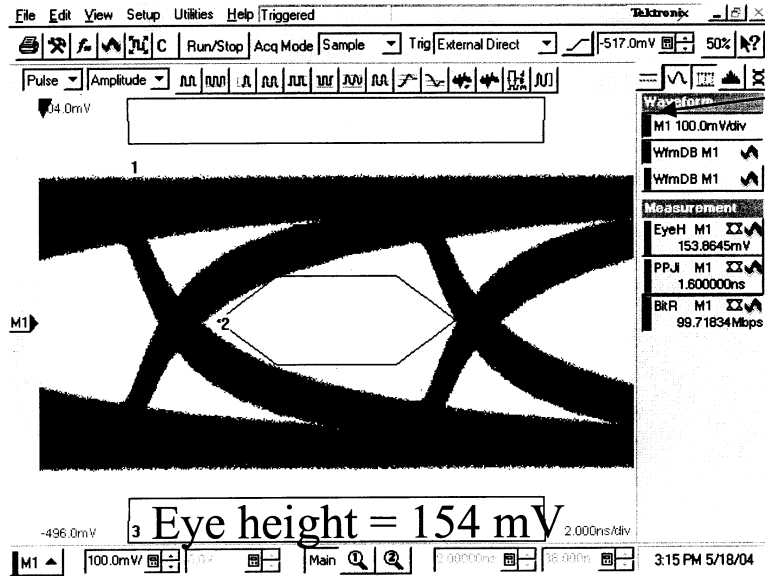
- SpaceWire cable specified in ECSS-E-50-12A Paragraph 5.2

- Non-standard applications or tight requirements
- Increased technical margin



26AWG SpaceWire Cable

Eye Pattern at 100 Mbps



GSC-10-82636-00

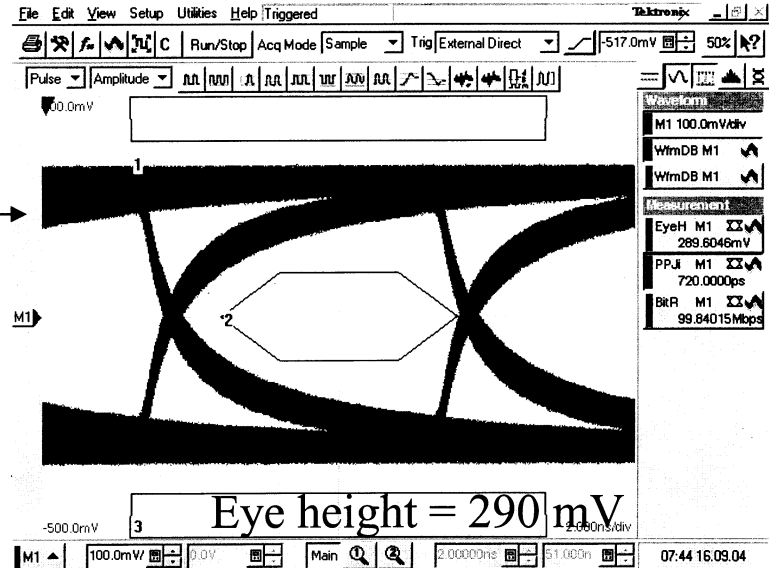
with standard SpaceWire cable

GSC-05-81757-00

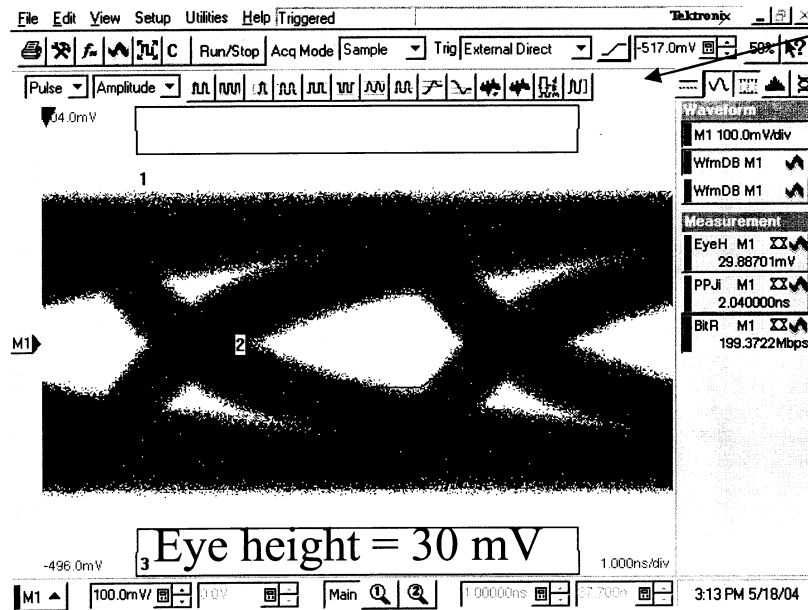
GSC-10-82738-00

with AWG 26 SpaceWire cable

GSC-05-82730-00



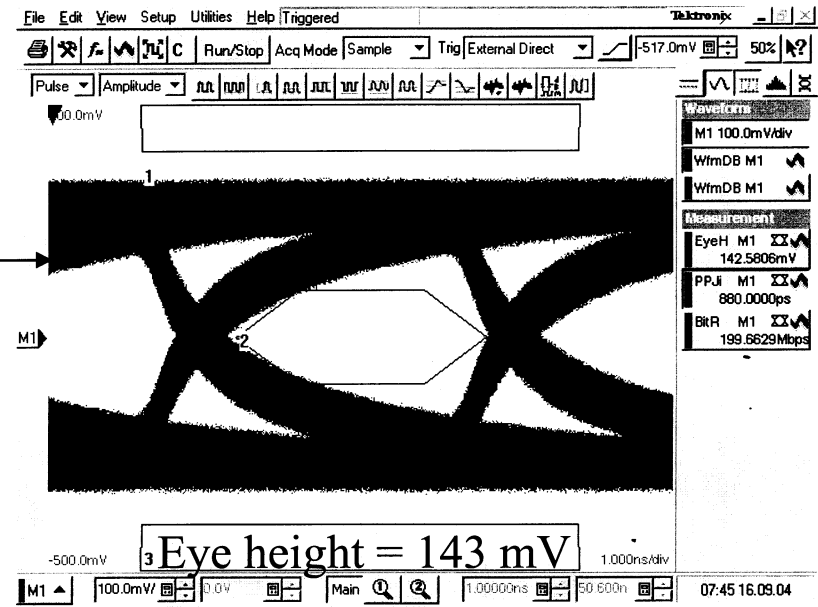
Eye Pattern at 200 Mbps



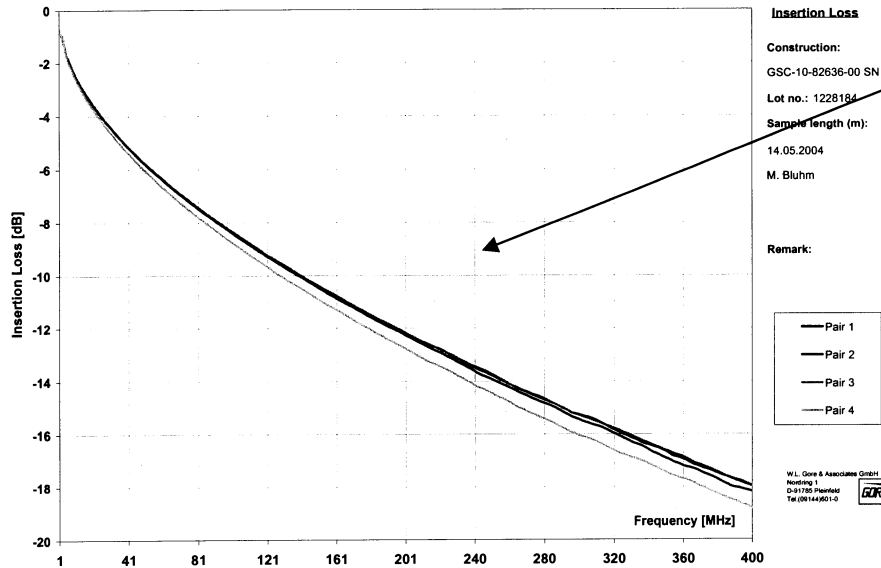
GSC-10-82636-00
with standard SpaceWire cable
GSC-05-81757-00

GSC-10-82738-00
with AWG 26 SpaceWire cable
GSC-05-82730-00

Change of wire guage improves performance.



Insertion Loss



GSC-10-82636-00

with standard SpaceWire cable

GSC-05-81757-00

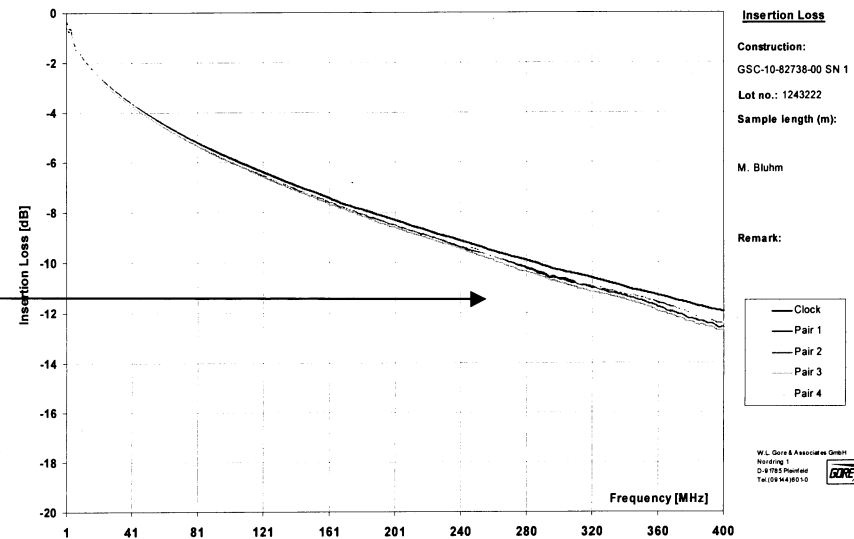
Insertion Loss [dB/20m]

f [MHz]	<u>70</u>	<u>250</u>	<u>400</u>
AWG 26	-4.96	-9.69	-12.71
AWG 28	-7.23	-14.46	-18.81

GSC-10-82738-00

with AWG 26 SpaceWire cable

GSC-05-82730-00



Summary

- **AWG 26 SpaceWire cable has improved technical performance**
- **Twinax connector configurations useful in some applications**
- **Testing indicates good performance of Twinax Connectors**
- **Mass and size should be weighed against technical gains**