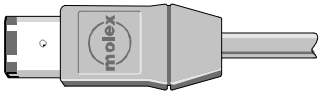
Molex 1394-95 6 ckt. I/O Differential/Single Ended Electrical Performance

IEEE 1394 Meetings
September 25-26, 1997
Natick, MA

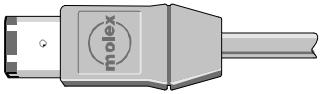
Max Bassler - Molex representative- IEEE 1394a + b groups
Dave Brunker - presenter



Molex 1394-95 6ckt. I/O

Connector Only; Introduction

- Data presented is for the connector only; no 1394 cable is attached. This allows for a focused and detailed review of connector only performance.
- The differential electrical performance for impedance, crosstalk, propagation delay, and risetime degradation is included.



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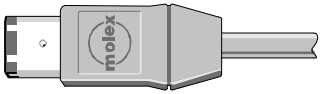
Connector only Test Fixture

- Time domain based empirical evaluation
- The test fixture is constructed as follows:
  - Semi-rigid coax feeds (100 ohms differential) to provide an interface to the PCB
  - Printed circuit board (110 ohms differential traces) to provide an interface to the receptacle connector including the effects of pad/via loading
  - Plug terminations
    - TDR - time domain reflectometry measurement resistive terminations (110 ohms differential)
    - TDT - time domain through measurement semi-rigid coax (100 ohms differential) interface



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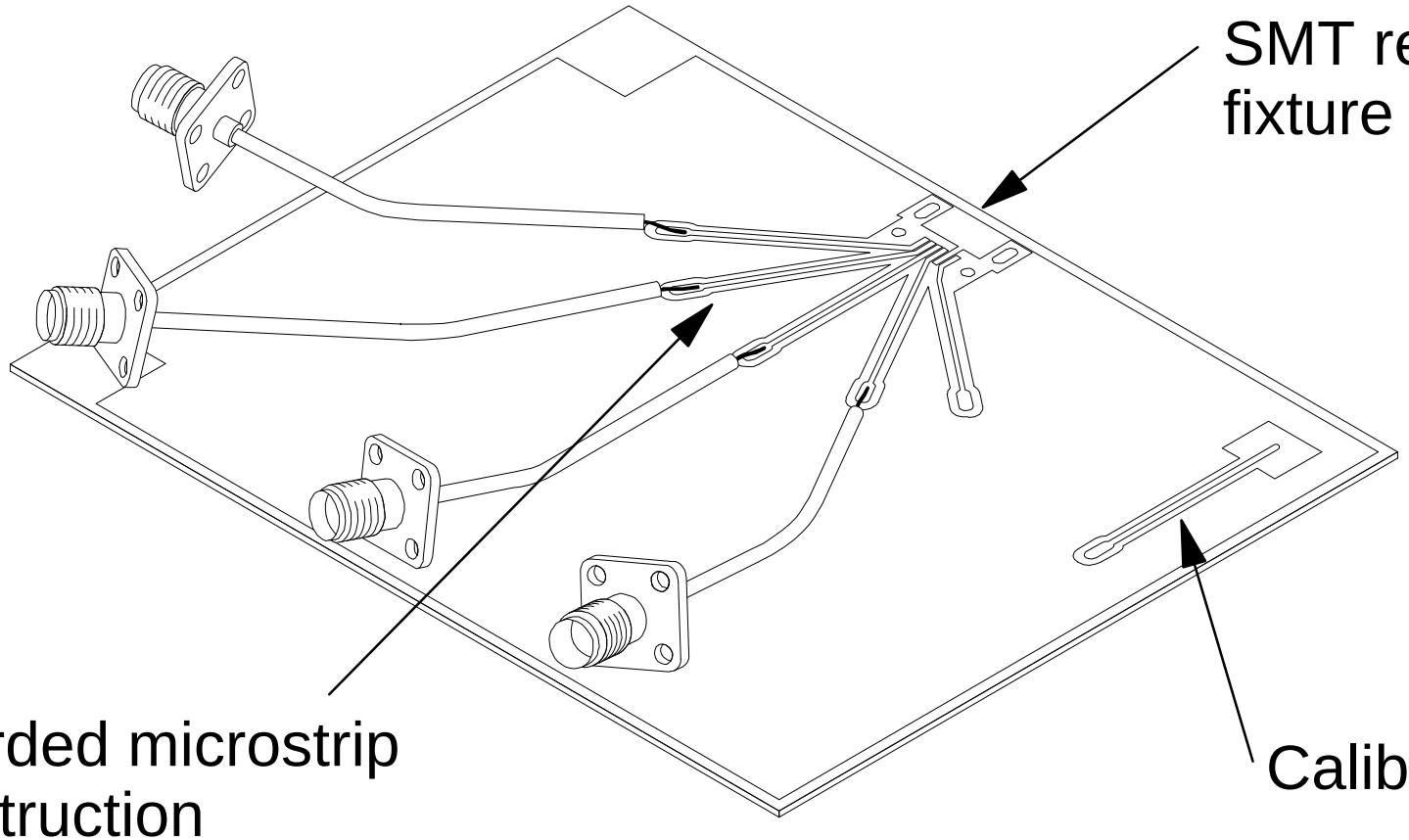
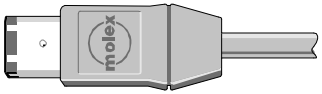
Connector only Test Fixture





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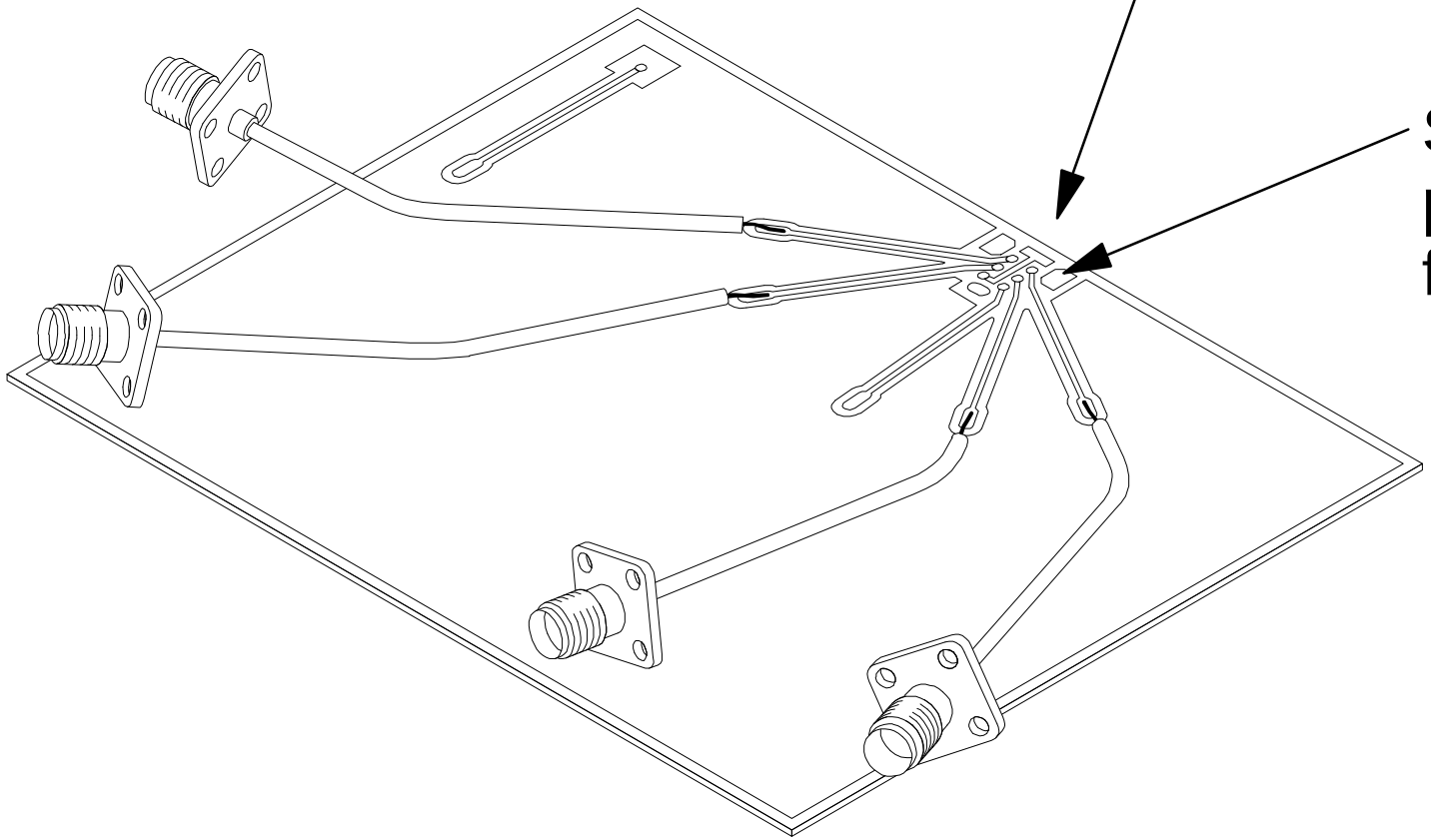
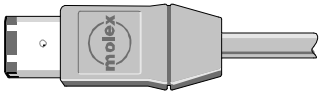
Connector only Test Fixture





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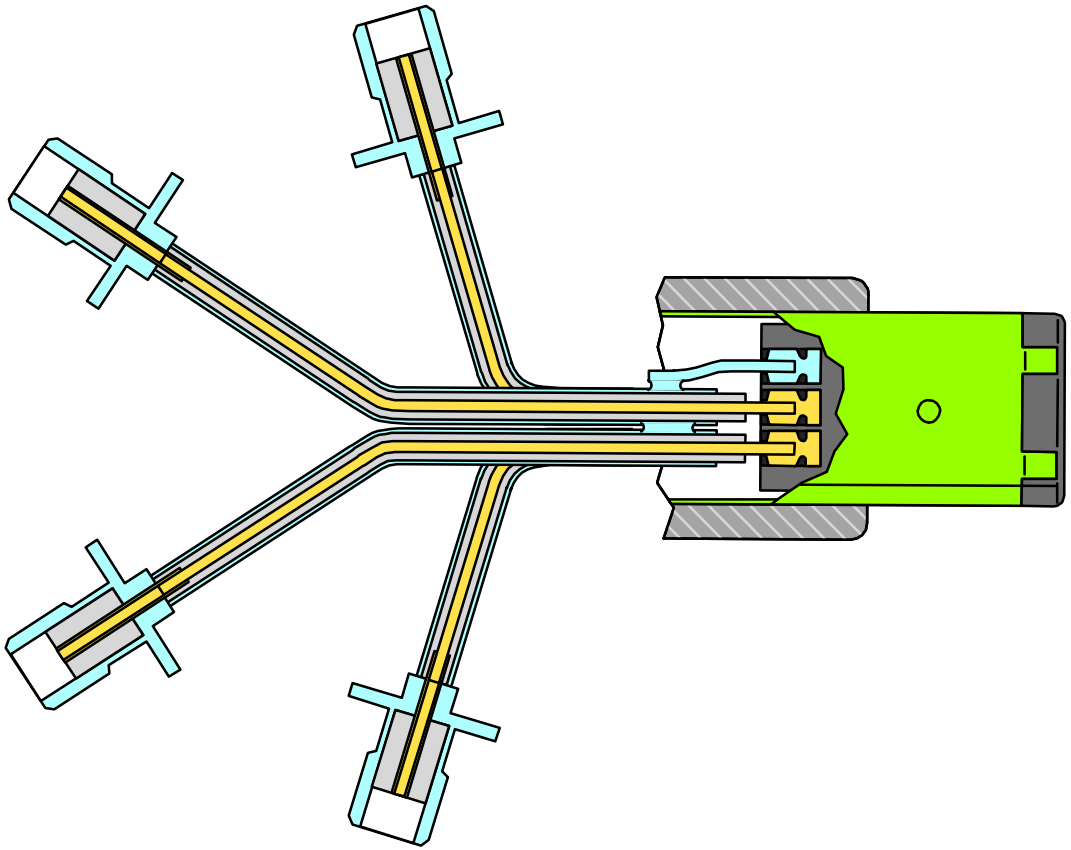
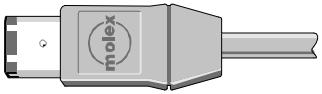
Connector only Test Fixture

Color Key

Color	Function
green	outer shield
yellow	signal lines
blue	signal return





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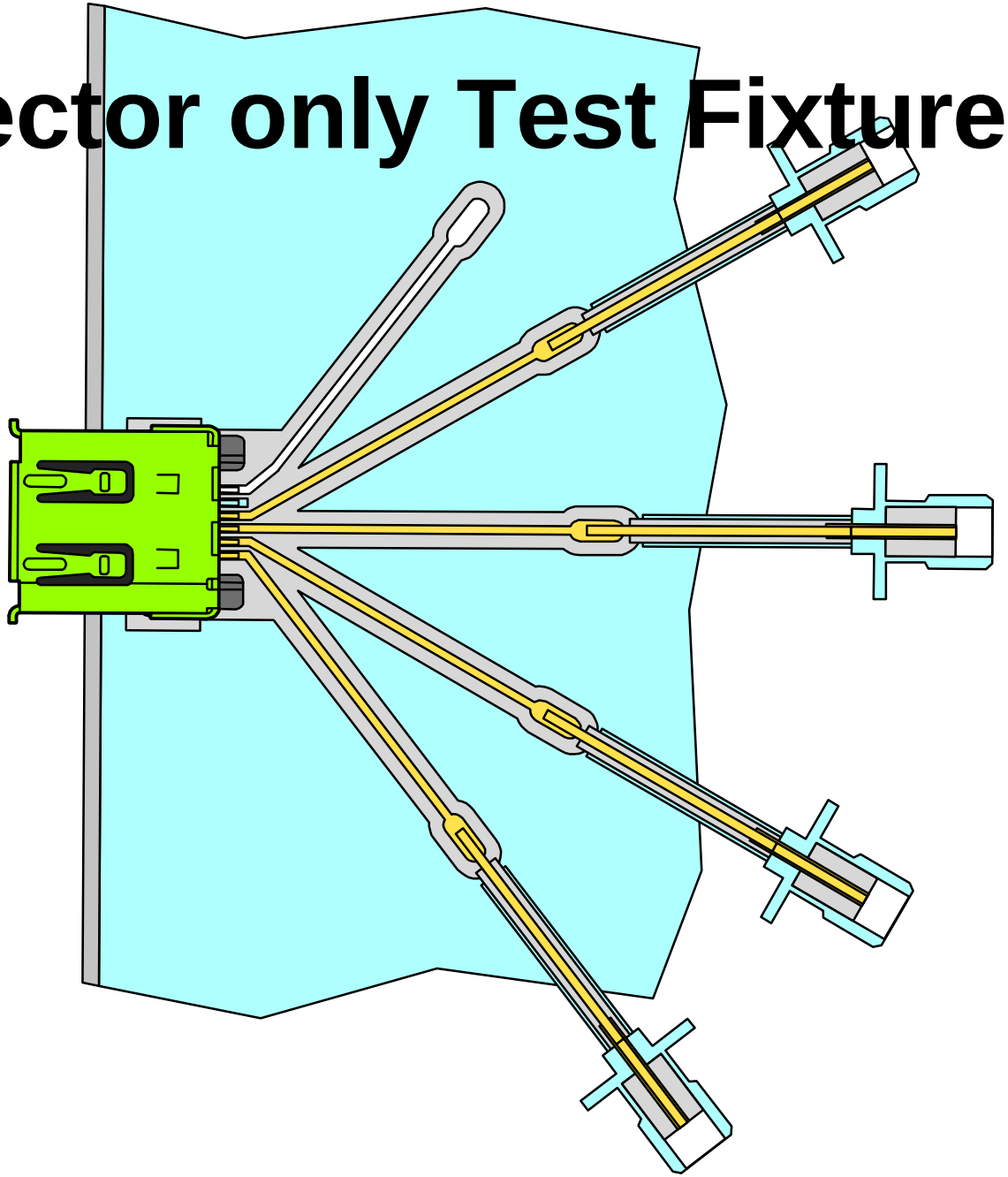

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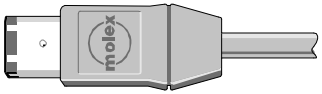
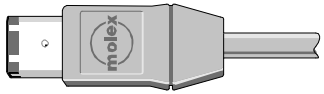


Molex 1394-95 6ckt. I/O

Test Conditions; Differential Impedance

Load Impedance	110 ohms differential (resistive load)
Source impedance	110 ohms differential (2 x 55 ohm PCB)
Test Risetime (10% - 90%) (Equipment used was the Tektronix 11801B Digital Sampling Oscilloscope with SD-24 TDR/DTDR heads) (The filtering function on the 11801B was used to generate the noted risetimes)	26ps*, 150ps, 250ps, 500ps*, 1000ps (*The maximum and minimum impedance values are listed for these risetimes in the results tables)
Vg and Vp configuration	Both receptacle and plug side are terminated with 30 ohms between Vg and Vp. Coax are shields tied to Vg.
External Shield (Receptacle to PCB ground plane network)	R = 1 Megohm shunt C = 2 x 0.05 microfarad parallel ceramic chips @ 50 DCWV shunt



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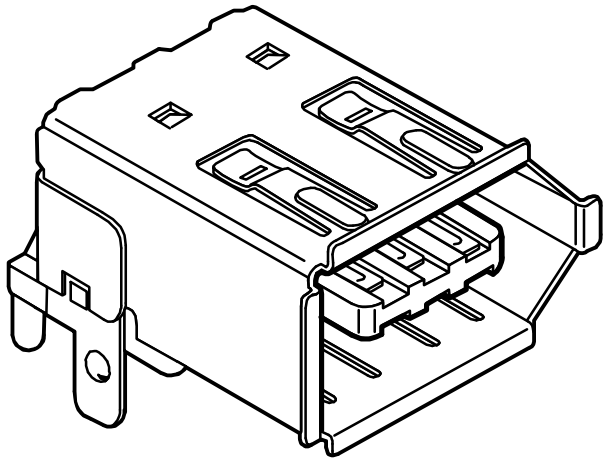
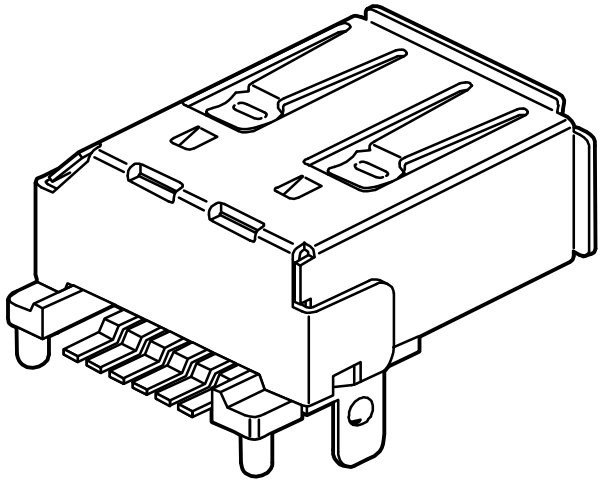
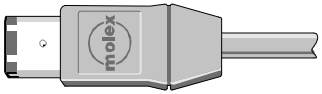
SMT/Flat Differential Impedance Results

	Drive Pair A		Drive Pair B	
Risetime (ps)	**Maximum Differential Z (ohms)**	**Minimum Differential Z (ohms)**	**Maximum Differential Z (ohms)**	**Minimum Differential Z (ohms)**
tr = 26 ps	102.5 ohms	61.4 ohms	105.9 ohms	62.4 ohms
tr = 500 ps	110.2 ohms	88.8 ohms	100.9 ohms	88.8 ohms



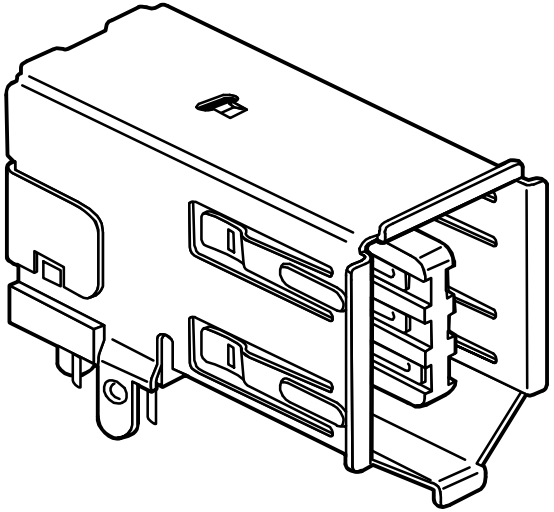


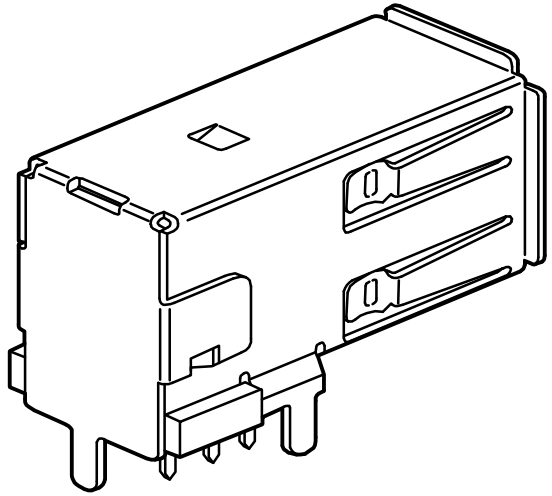


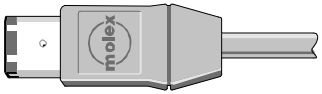
Molex 1394-95 6ckt. I/O

Through Hole/Upright Differential Impedance Results

	Drive Pair A		Drive Pair B	
Risetime (ps)	**Maximum Differential Z (ohms)**	**Minimum Differential Z (ohms)**	**Maximum Differential Z (ohms)**	**Minimum Differential Z (ohms)**
tr = 26 ps	126.0 ohms	60.1 ohms	146.3 ohms	63.4 ohms
tr = 500 ps	102.1 ohms	93.5 ohms	101.6 ohms	94.6 ohms



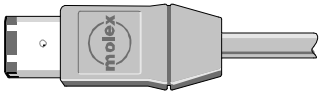




Molex 1394-95 6ckt. I/O

Test Conditions; Differential Crosstalk

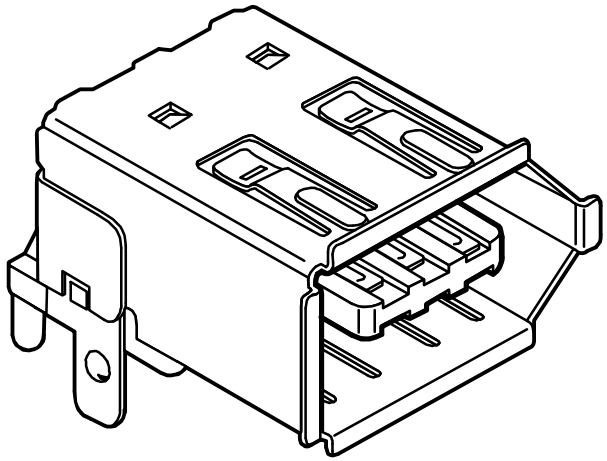
Load Impedance	100 ohms differential (2 x 50 ohm coax)
Source impedance	110 ohms differential (2 x 55 ohm PCB)
Test Risetime (10% - 90%) Vapplied = 500 mV p-p (Equipment used was the Tektronix 11801B Digital Sampling Oscilloscope with SD-24 TDR/DTDR and SD-22 sampling heads)	150ps 250ps 433ps
Vg and Vp configuration	Both receptacle and plug side are terminated with 30 ohms between Vg and Vp. Coax shields are tied to Vg.
External Shield (Receptacle to PCB ground plane network)	R = 1 Megohm shunt C = 2 x 0.05 microfarad parallel ceramic chips @ 50 DCWV shunt

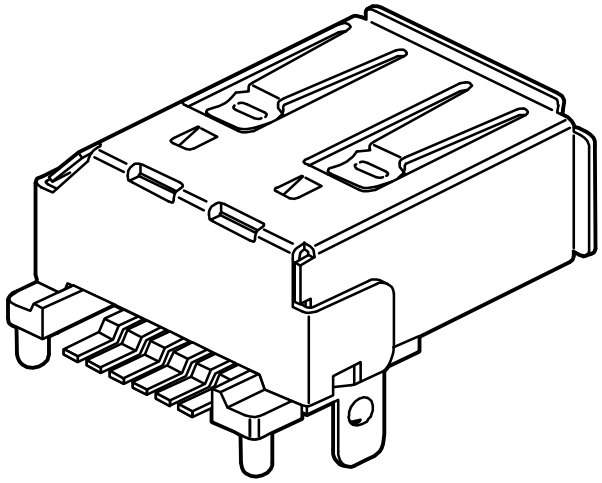


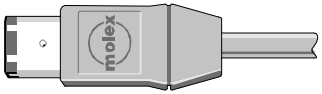
Molex 1394-95 6ckt. I/O

SMT/Flat
Differential Crosstalk Results

Risetime	Near End (NEXT)	Far End (FEXT)
150 ps	4.2%	2.0%
250 ps	3.6%	1.0%
433 ps	1.9%	0.5%



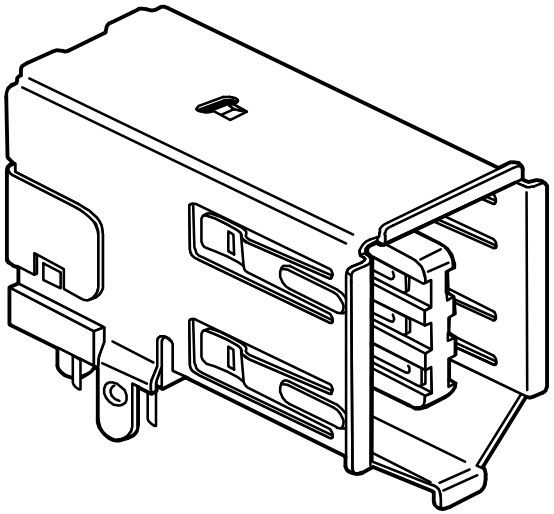


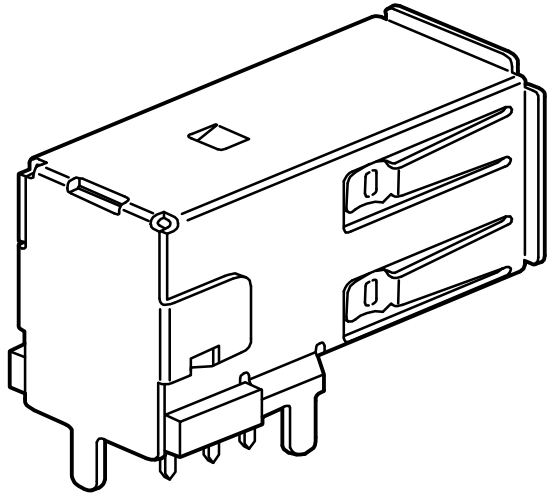


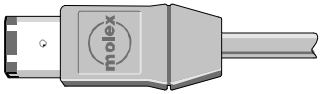
Molex 1394-95 6ckt. I/O

Through Hole/Upright Differential Crosstalk Results

Risetime	Near End (NEXT)	Far End (FEXT)
150 ps	5.6%	2.0%
250 ps	5.2%	1.3%
433 ps	3.8%	0.9%



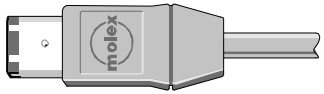




Molex 1394-95 6ckt. I/O

Test Conditions; Differential Risetime Degradation and Propagation Delay

Load Impedance	100 ohms differential (2 x 50 ohm coax)
Source impedance	110 ohms differential (2 x 55 ohm PCB)
Test Risetime (10% - 90%) Vapplied = 500 mV (Equipment used was the Tektronix 11801B Digital Sampling Oscilloscope with SD-24 TDR/DTDR and SD-22 sampling heads)	26ps
Vg and Vp configuration	Both receptacle and plug side are terminated with 30 ohms between Vg and Vp. Coax shields tied to Vg.
External Shield (Receptacle to PCB ground plane network)	R = 1 Megohm shunt C = 2 x 0.05 microfarad parallel ceramic chips @ 50 DCWV shunt



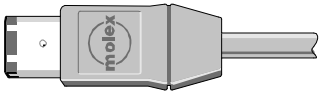
Molex 1394-95 6ckt. I/O

Test Conditions; Differential Risetime Degradation and Propagation Delay

- The risetime degradation data was calculated using the 10% to 90% levels of the input and output pulse to the connector. Where:

  tr,connector = [(tr,DUT + test system)e2 - (tr,test system)e2]e1/2

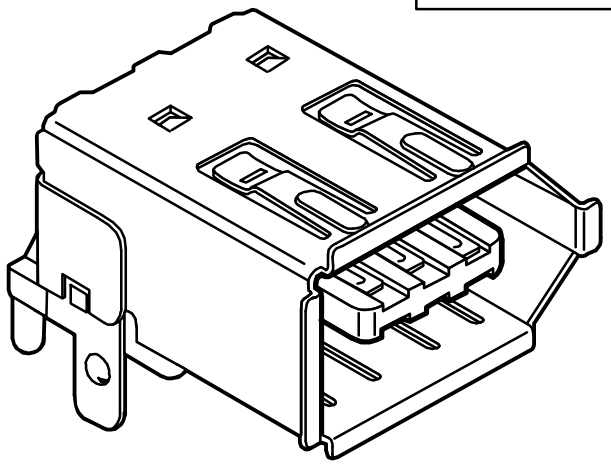
- From the generated connector risetime degradation value, a first order filter approximation was used (BW = 0.35/tr) to convert this risetime value to a bandwidth (-3dB cutoff).
- The propagation delay measurements were taken at both the 10% and 50% levels with 10% levels minimizing filter effects.

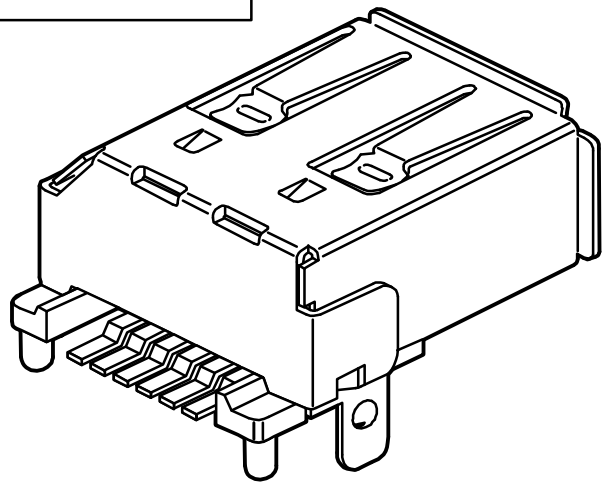


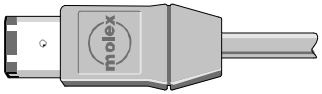
Molex 1394-95 6ckt. I/O

SMT/Flat Differential Risetime Degradation Results

	Connector Risetime Degradation; 10%-90% (psec)	Connector Bandwidth (GHz)
Pair A	40.3 ps	8.7 GHz
Pair B	47.9 ps	7.3 GHz



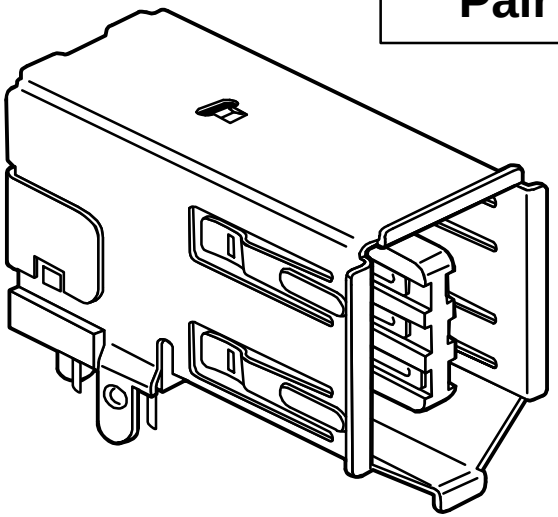


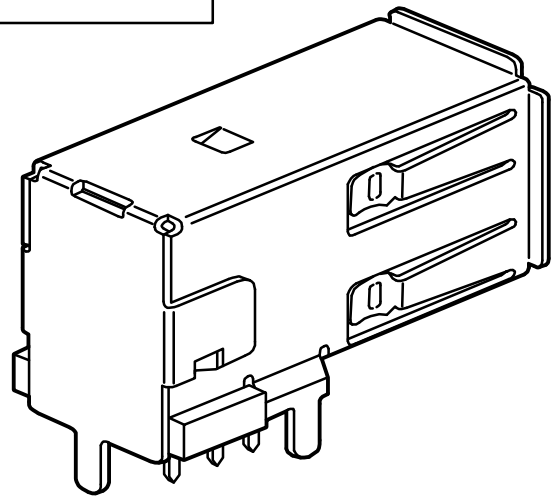


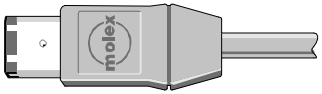
Molex 1394-95 6ckt. I/O

Through Hole/Upright Differential Risetime Degradation Results

	Connector Risetime Degradation; 10%-90% (psec)	Connector Bandwidth (GHz)
Pair A	113.8 ps	3.1 GHz
Pair B	114.1 ps	3.1 GHz



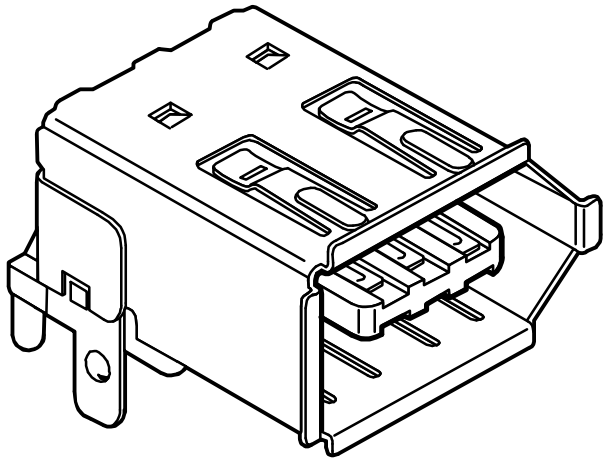


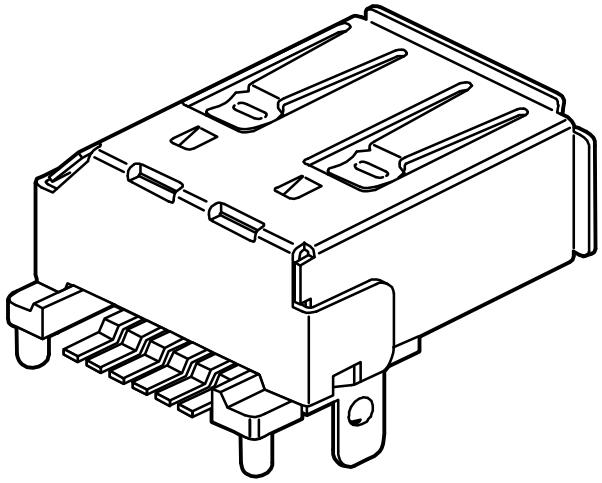


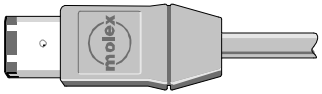
Molex 1394-95 6ckt. I/O

SMT/Flat Differential Propagation Delay Results

	Connector Differential Propagation Delay 10%	Connector Differential Propagation Delay 50%
Pair A	178.7 ps	183.2 ps
Pair B	176.1 ps	183.7 ps



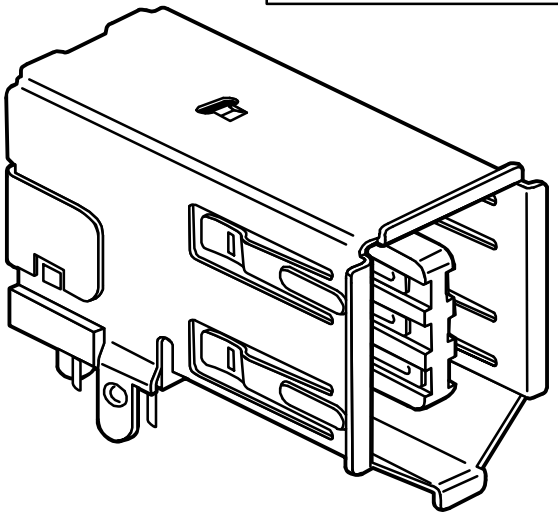


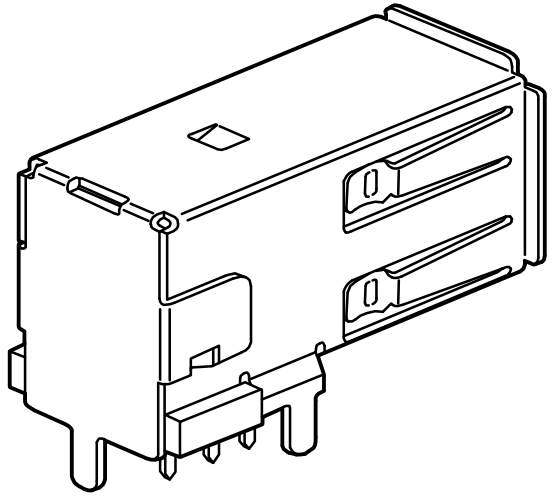


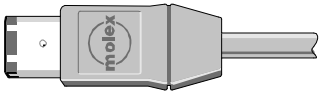
Molex 1394-95 6ckt. I/O

Through Hole/Upright Differential Propagation Delay Results

	Connector Differential Propagation Delay 10%	Connector Differential Propagation Delay 50%
Pair A	169.4 ps	180.4 ps
Pair B	181.5 ps	199.6 ps



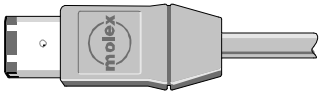




Molex 1394-95 6ckt. I/O

Recommendations/Conclusions

- Differential specification
  Limit 1394.a differential system risetimes to no faster than **0.5 nanoseconds**
- Single-ended specification
  Given that only 10-20 ns risetimes are necessary to service the "Speed Signaling" function, limit 1394.a single-ended (Speed Signaling) system risetimes to no faster than **3 nanoseconds**



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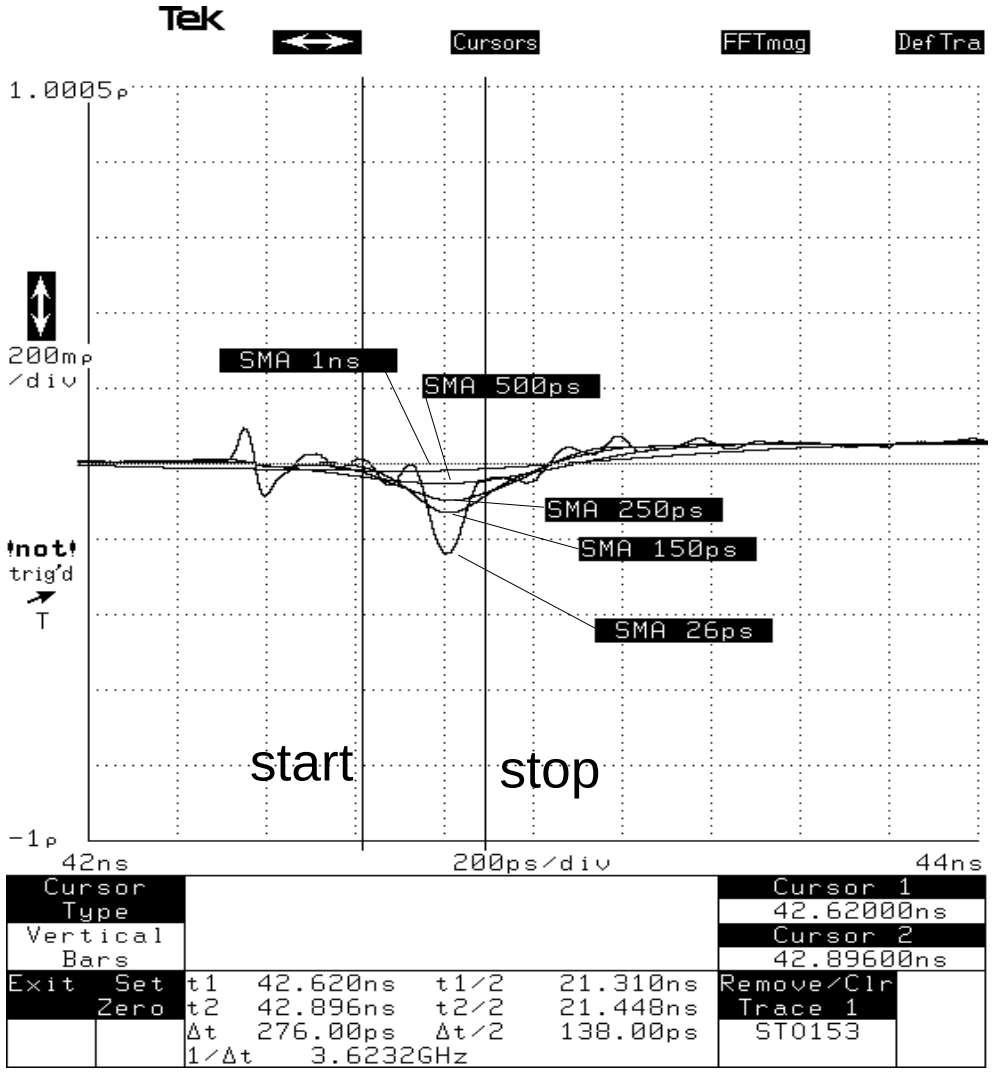
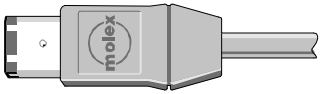
SMT Receptacle mated with plug (TPA-TPA*)
Differential Impedance





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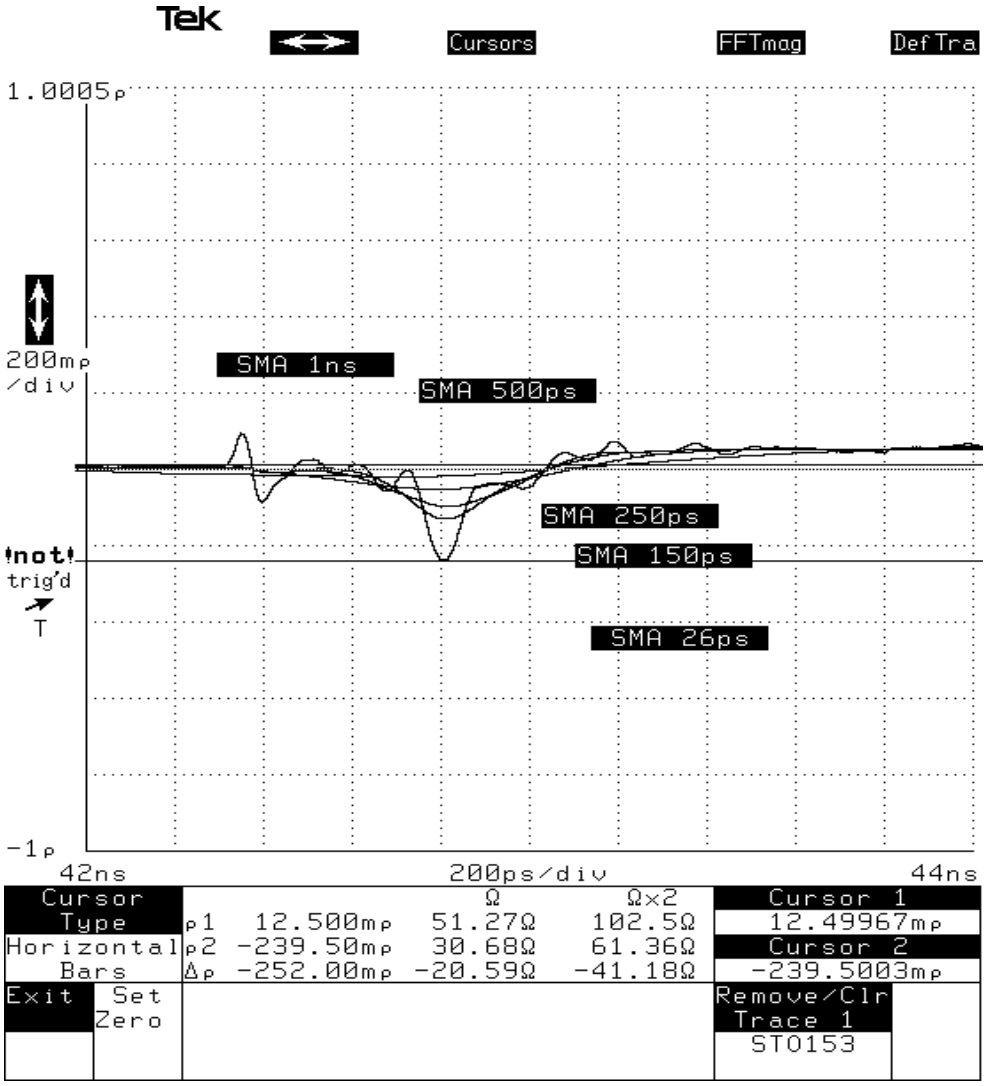
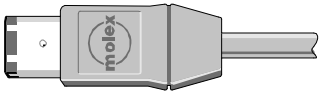
SMT Receptacle mated with plug (TPA-TPA*)
Differential Impedance @ tr = 26 ps





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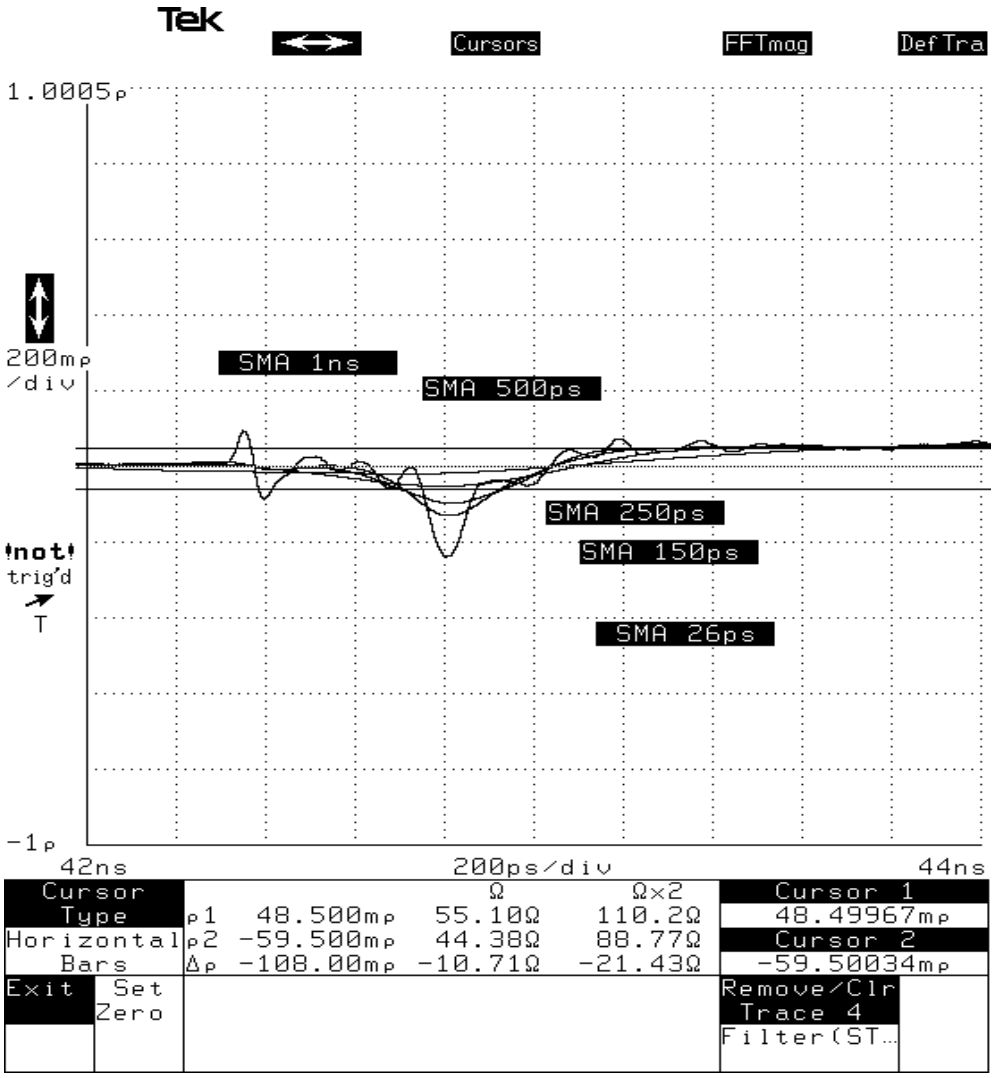
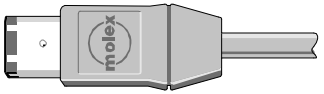
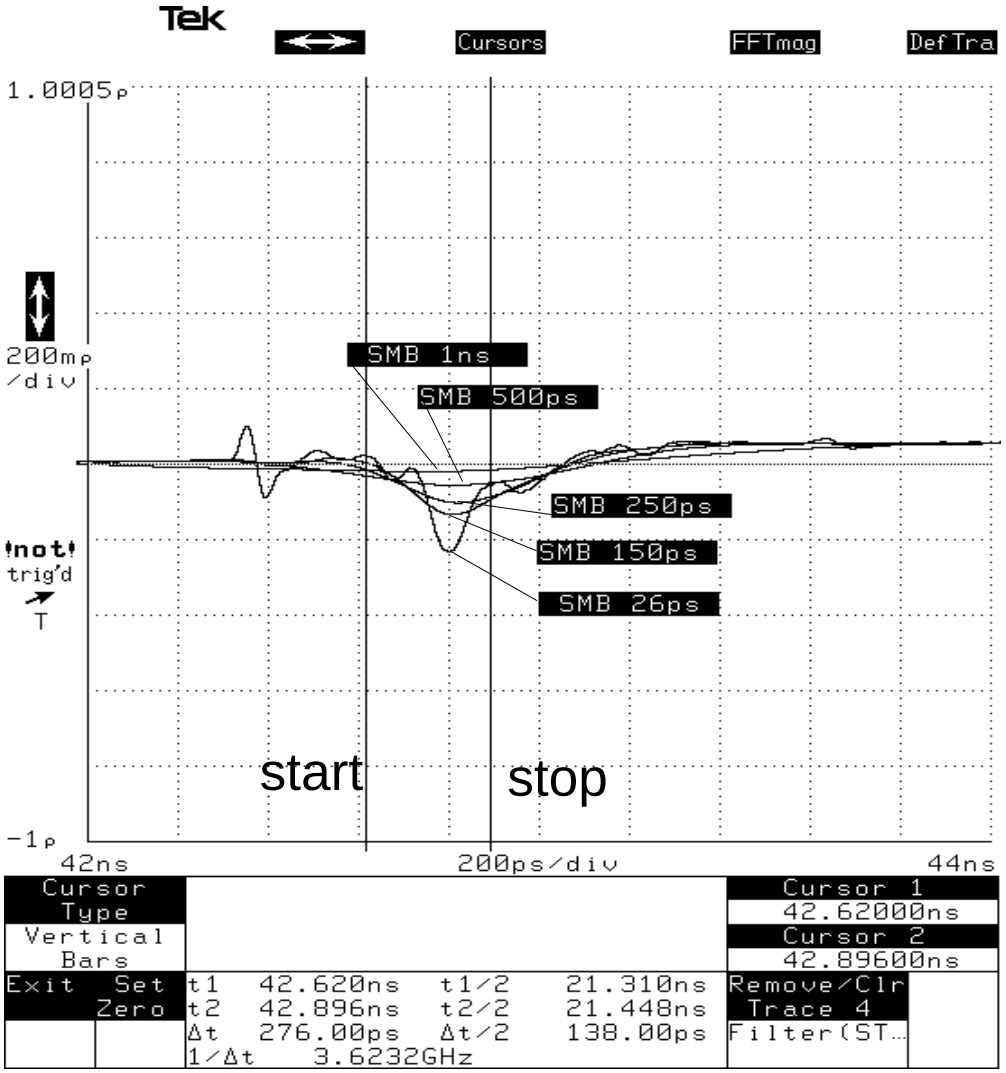
SMT Receptacle mated with plug (TPA-TPA*)
Differential Impedance @ tr = 500 ps

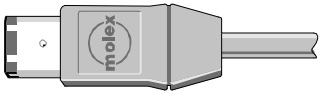




Molex 1394-95 6ckt. I/O

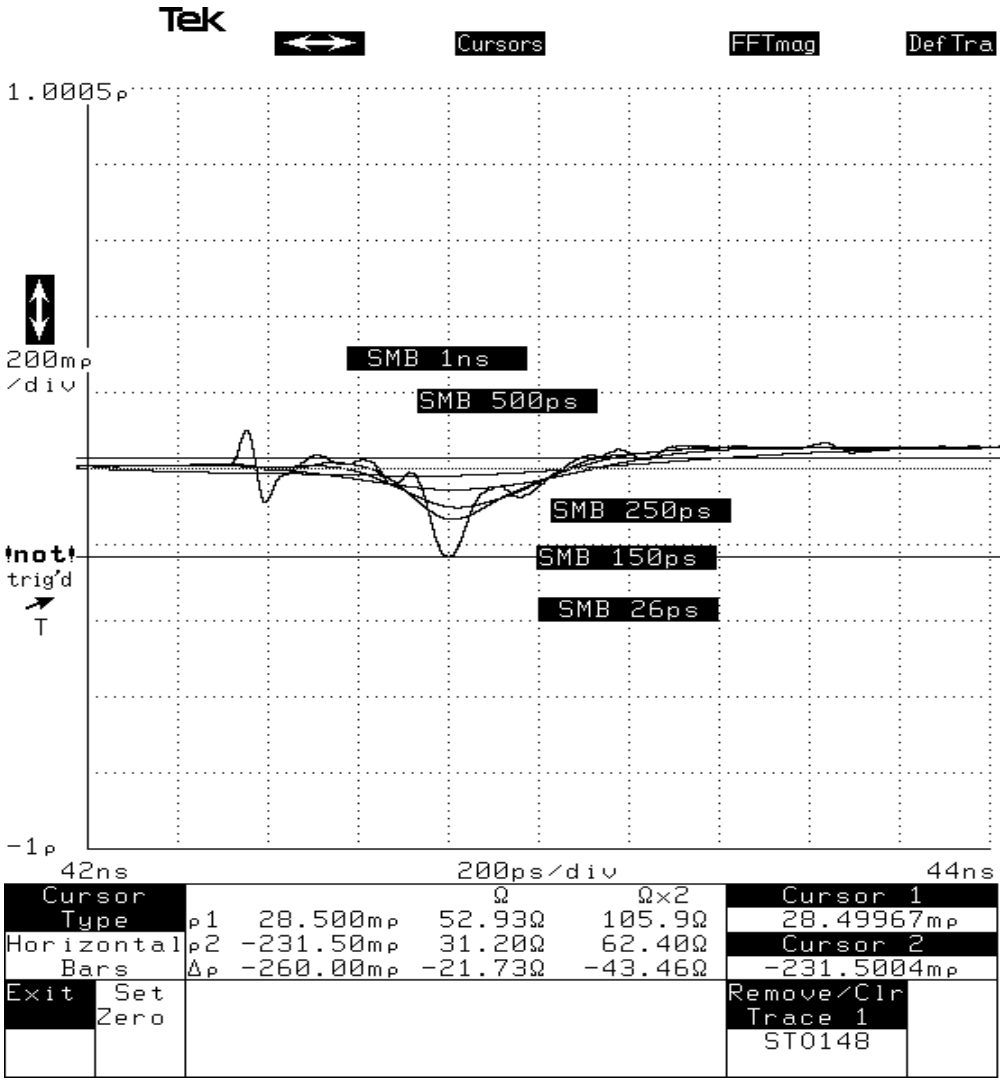
SMT Receptacle mated with plug (TPB-TPB*)
Differential Impedance

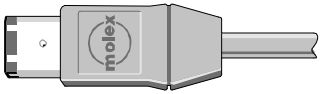




Molex 1394-95 6ckt. I/O

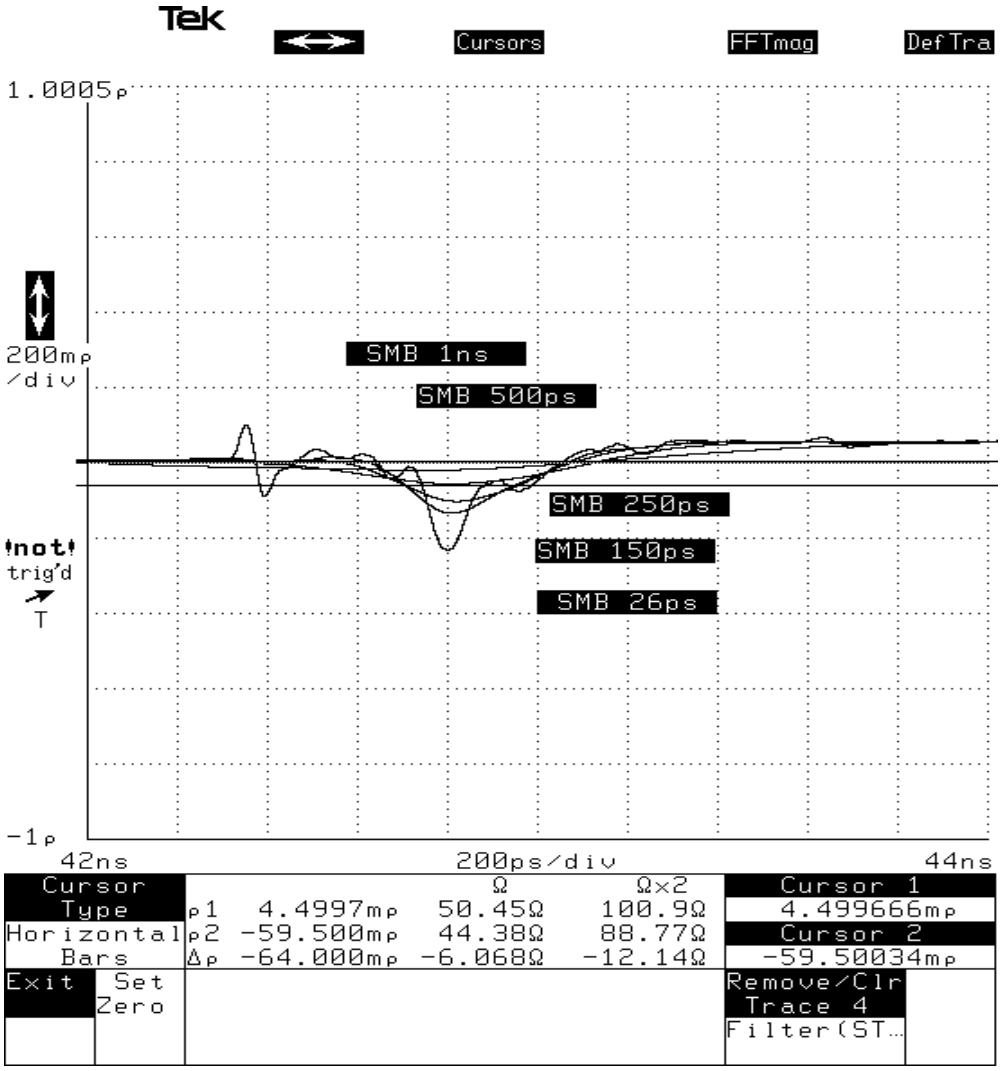
SMT Receptacle mated with plug (TPB-TPB*)
Differential Impedance @ tr = 26 ps

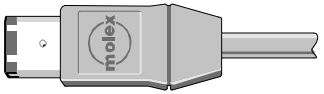




Molex 1394-95 6ckt. I/O

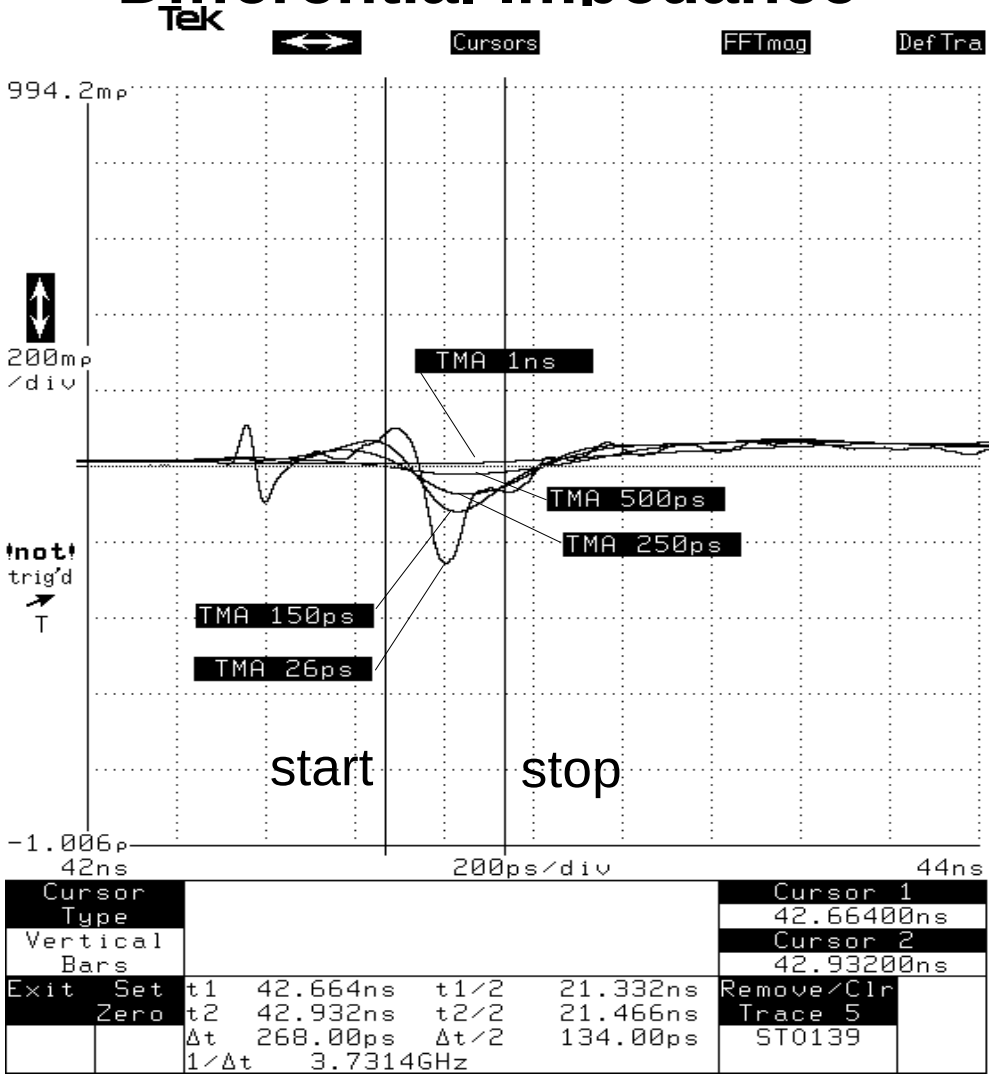
SMT Receptacle mated with plug (TPB-TPB*)
Differential Impedance @ tr = 500 ps

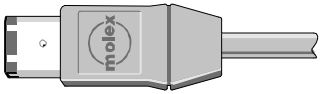




Molex 1394-95 6ckt. I/O

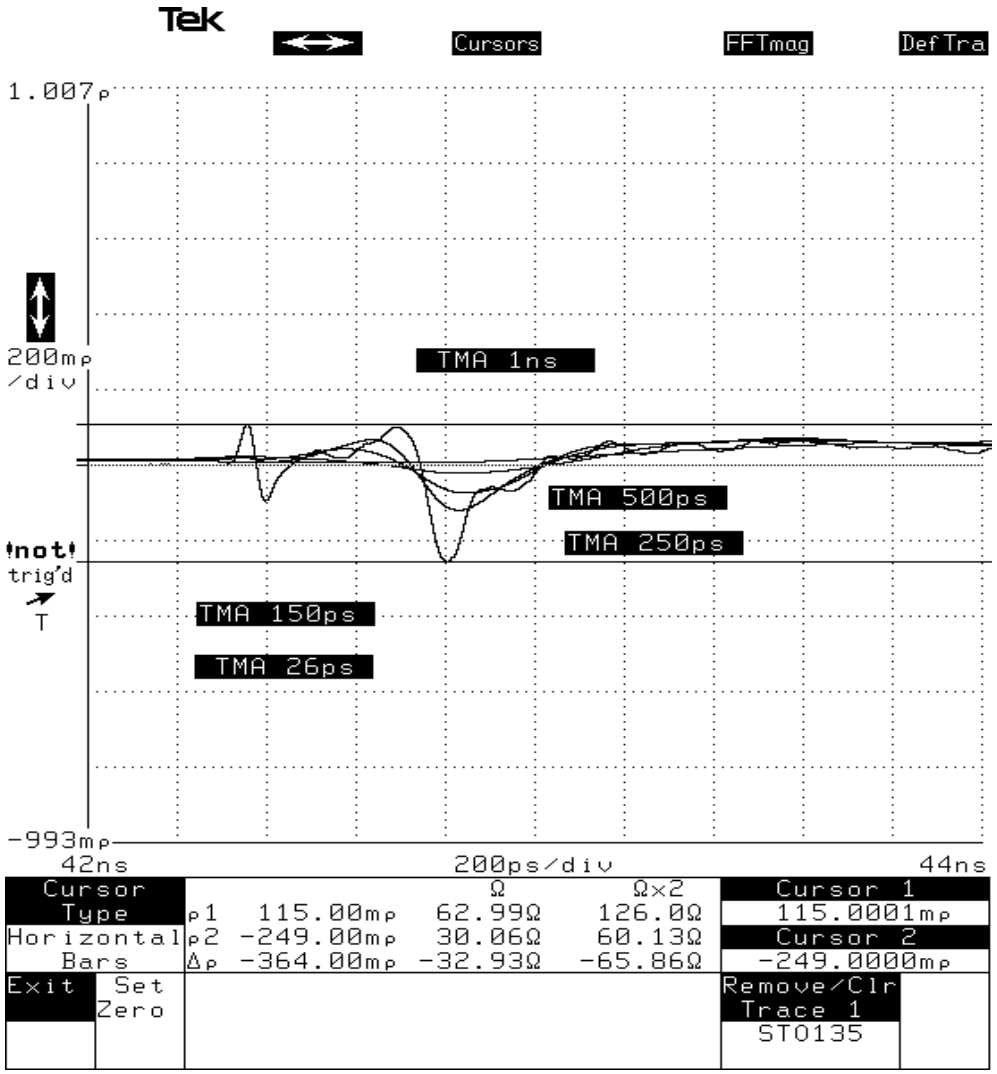
Through-hole Receptacle mated with plug (TPA-TPA*) Differential Impedance

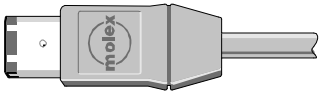




Molex 1394-95 6ckt. I/O

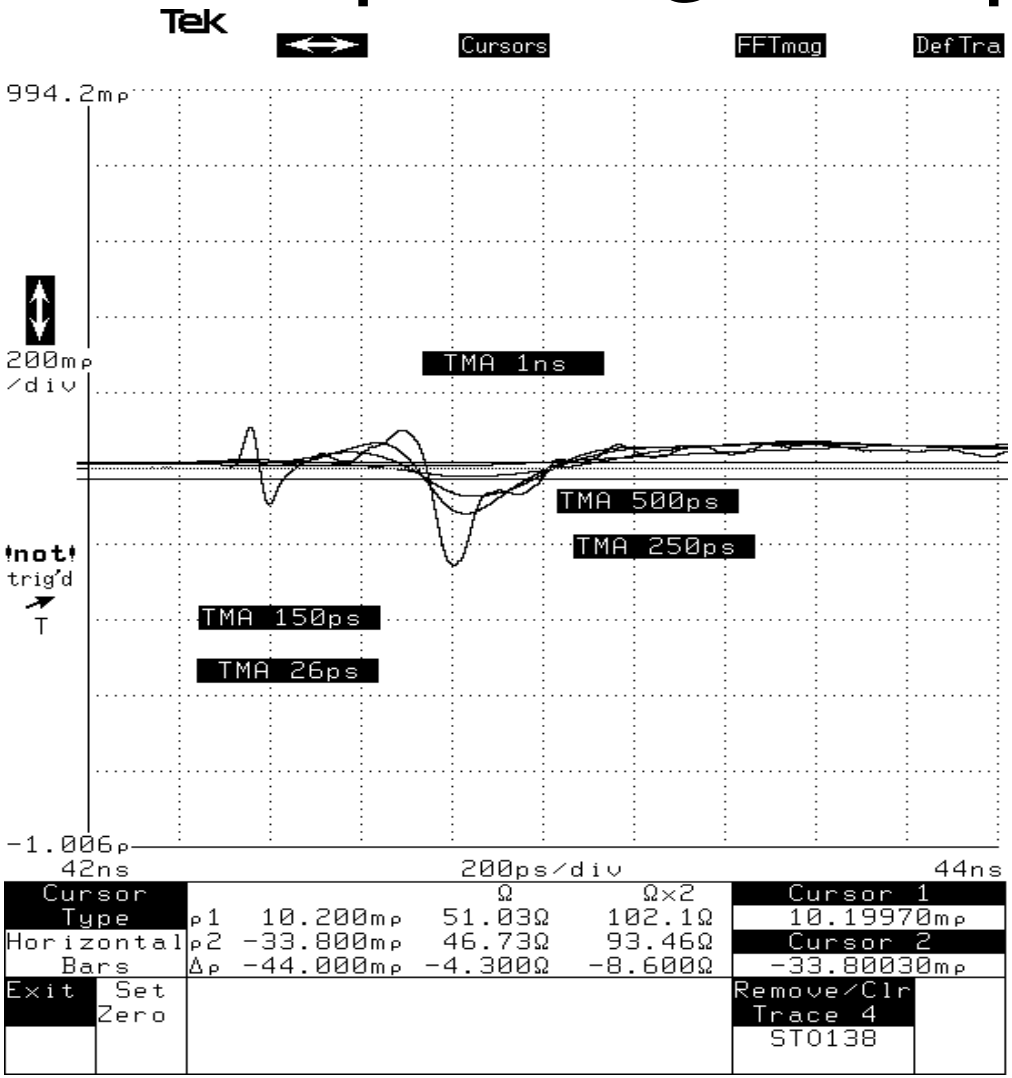
Through-hole Receptacle mated with plug (TPA-TPA*)
Differential Impedance @ tr = 26ps

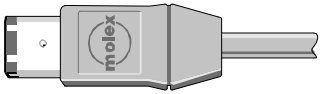




Molex 1394-95 6ckt. I/O

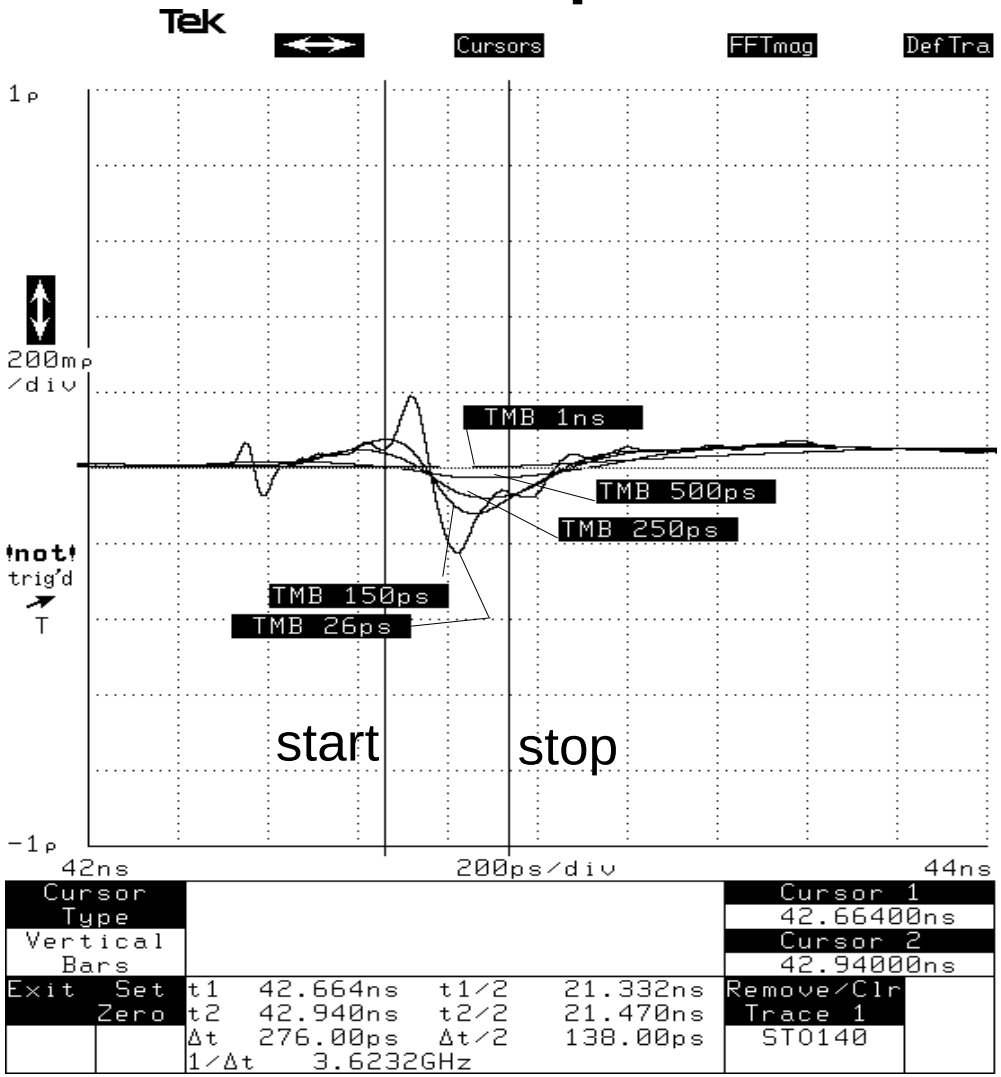
Through-hole Receptacle mated with plug (TPA-TPA*)
Differential Impedance @ tr = 500ps

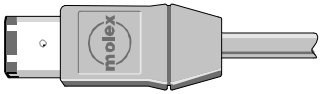




Molex 1394-95 6ckt. I/O

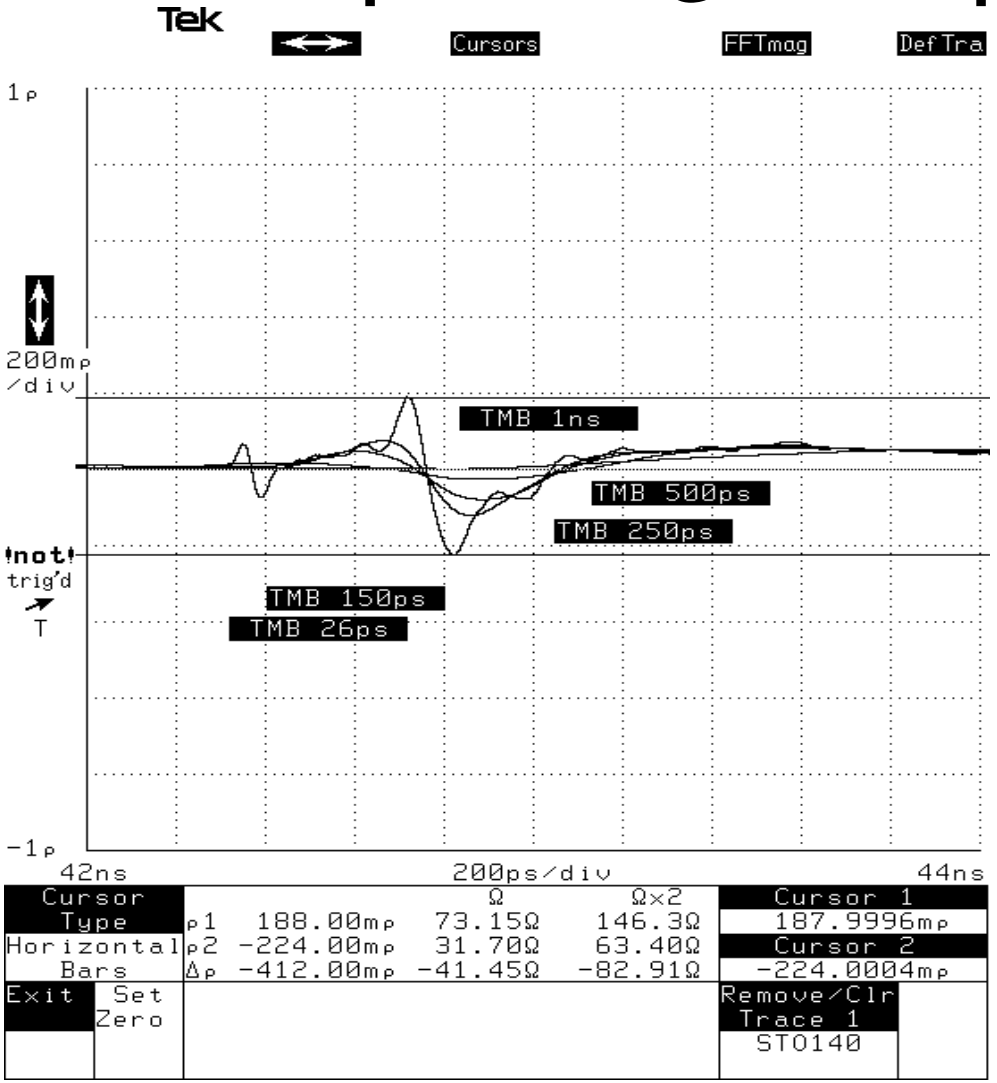
Through-hole Receptacle mated with plug (TPB-TPB*) Differential Impedance

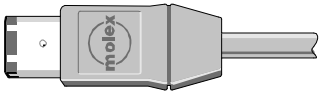




Molex 1394-95 6ckt. I/O

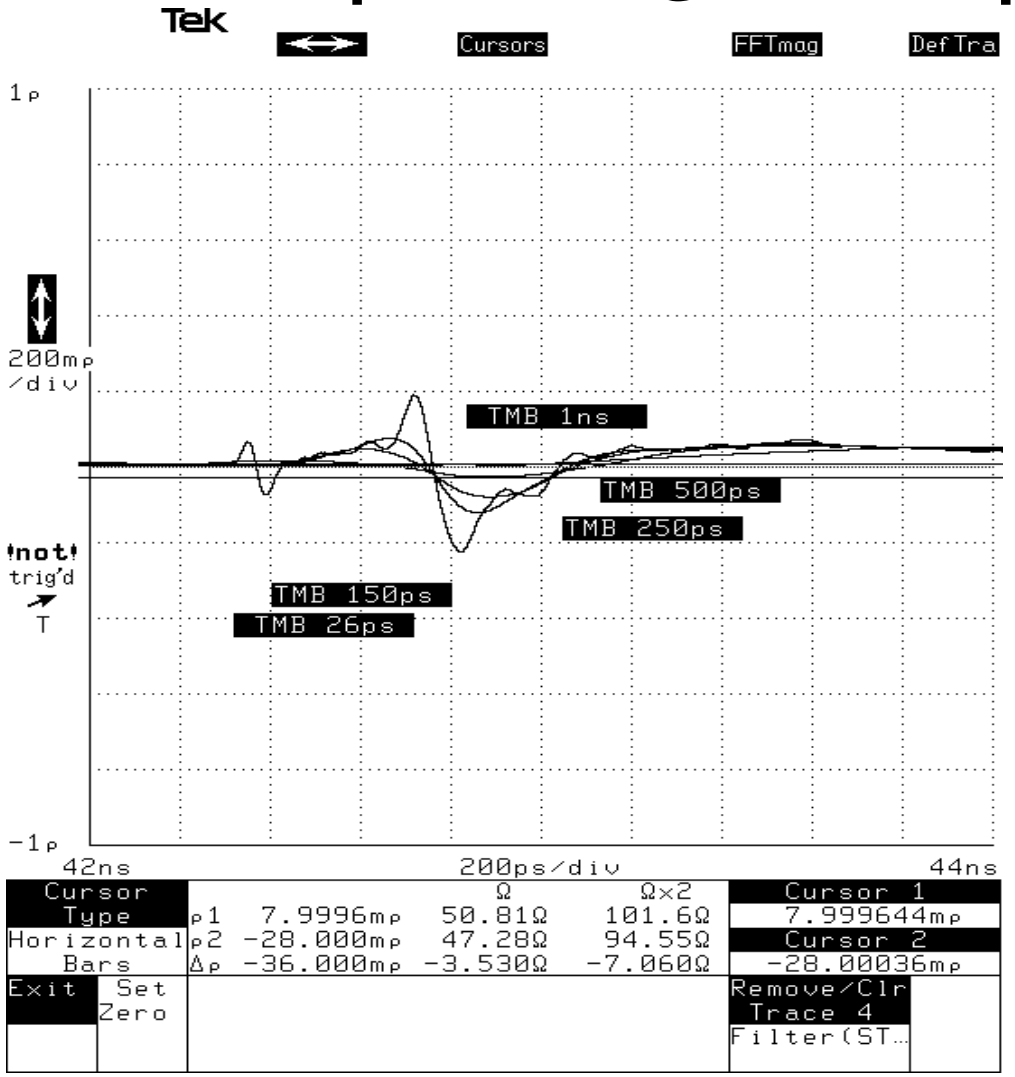
Through-hole Receptacle mated with plug (TPB-TPB*)
Differential Impedance @ tr = 26 ps

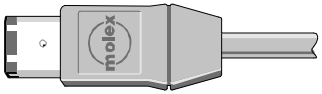




Molex 1394-95 6ckt. I/O

Through-hole Receptacle mated with plug (TPB-TPB*)
Differential Impedance @ tr = 500 ps



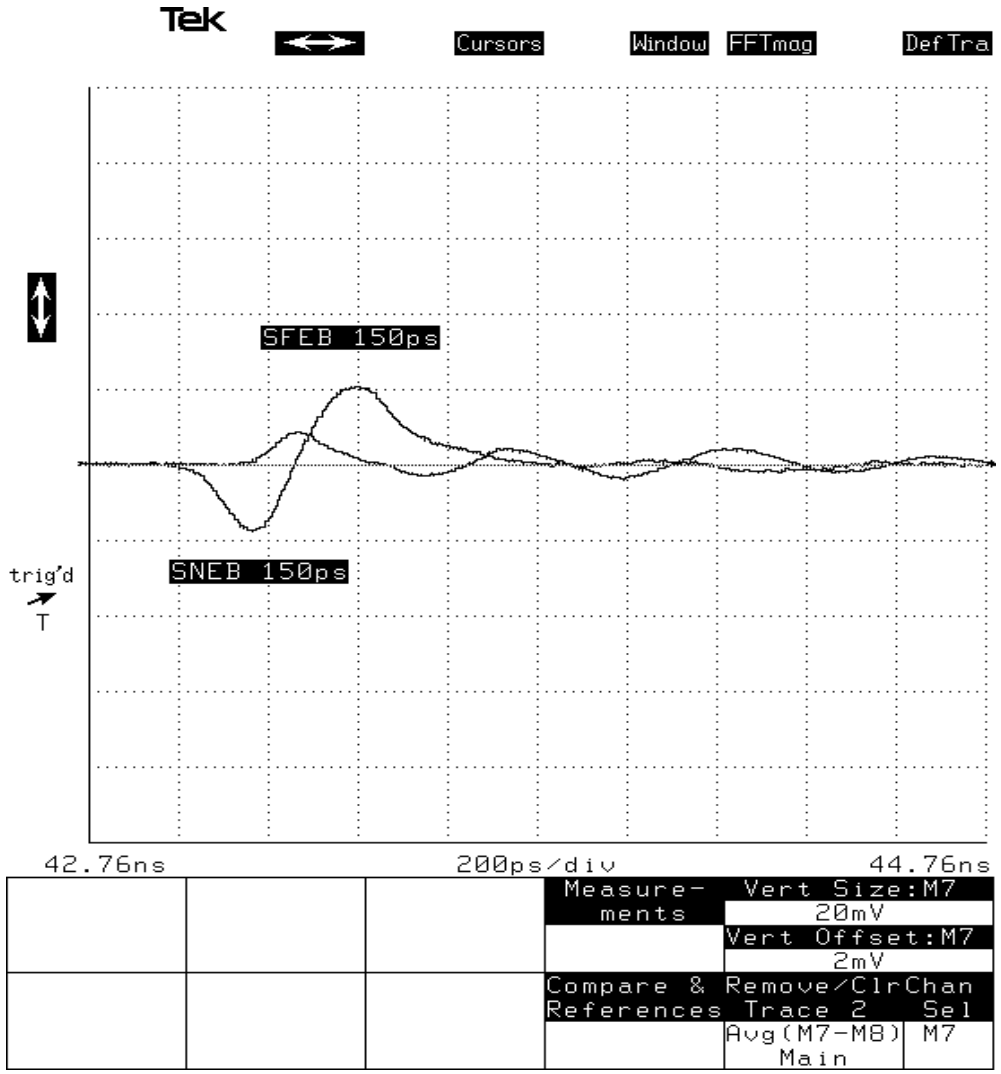


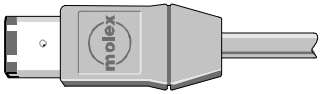
Molex 1394-95 6ckt. I/O

Differential Crosstalk for SMT Connector

tr = 150 ps

NEXT = +21 mV (4.2%), FEXT = +10mV (2.0%)



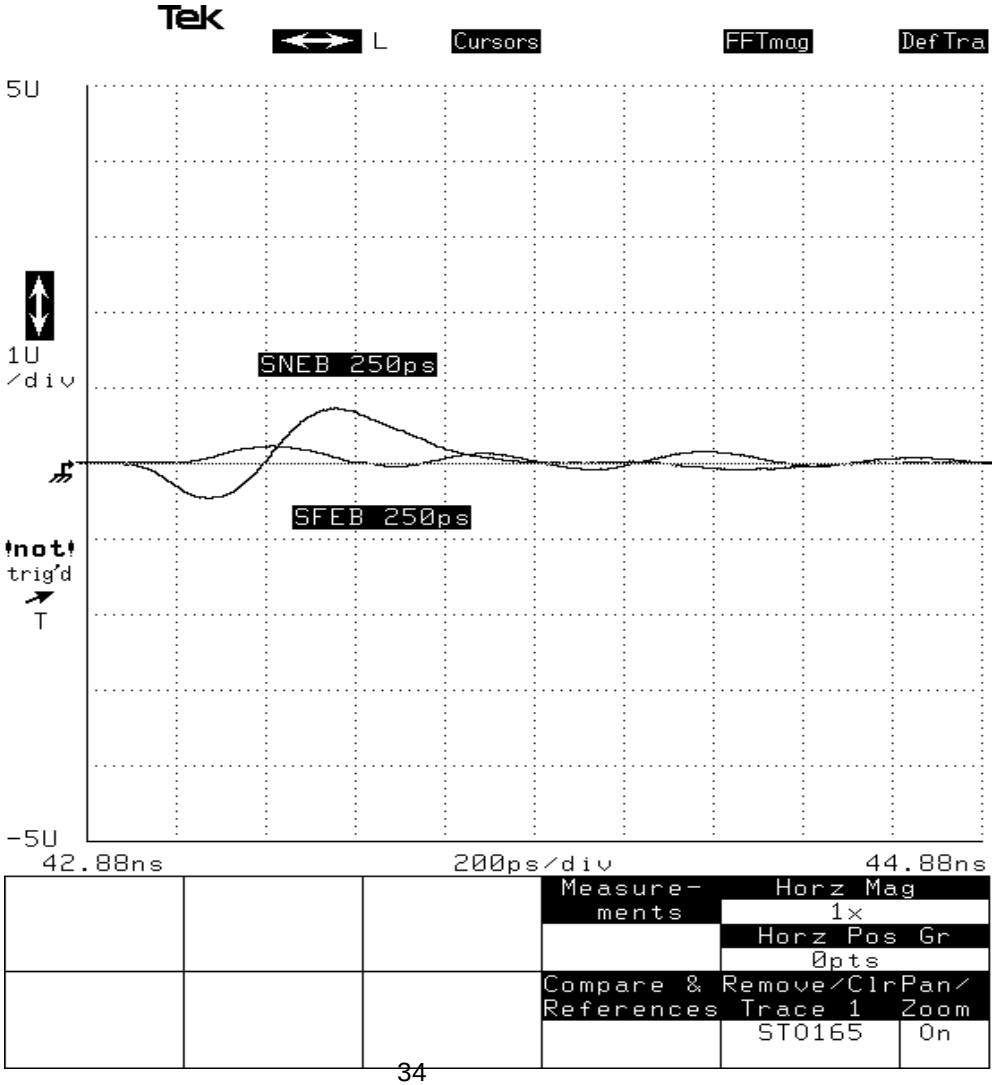


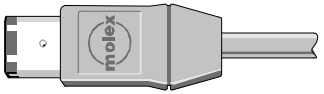
Molex 1394-95 6ckt. I/O

Differential Crosstalk for SMT Connector

tr = 250 ps

NEXT = +18 mV (3.6%), FEXT = +4.9 mV (1.0%)



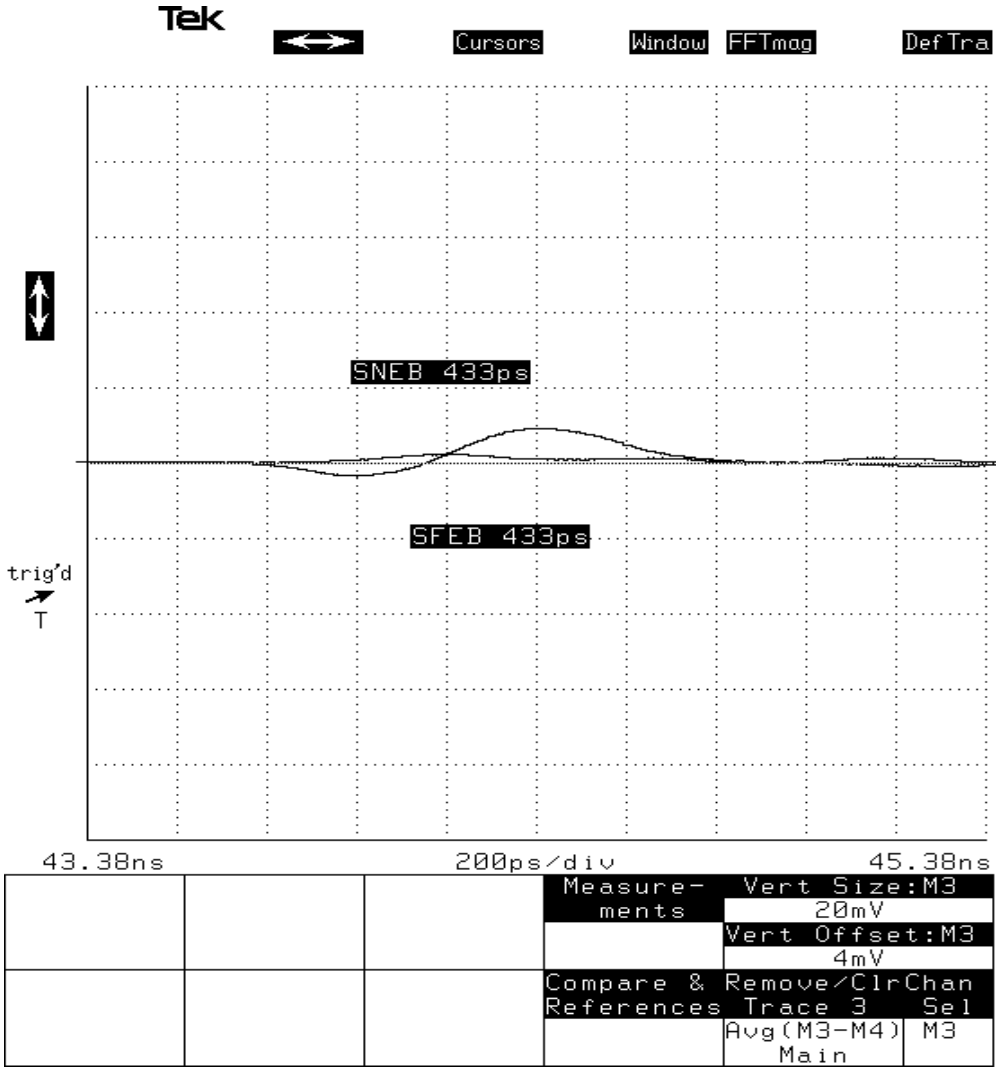


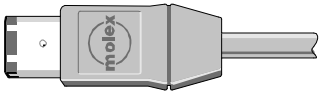
Molex 1394-95 6ckt. I/O

Differential Crosstalk for SMT Connector

tr = 433 ps

NEXT = +9.7 mV (1.9%), FEXT = +2.5 mV (0.5%)



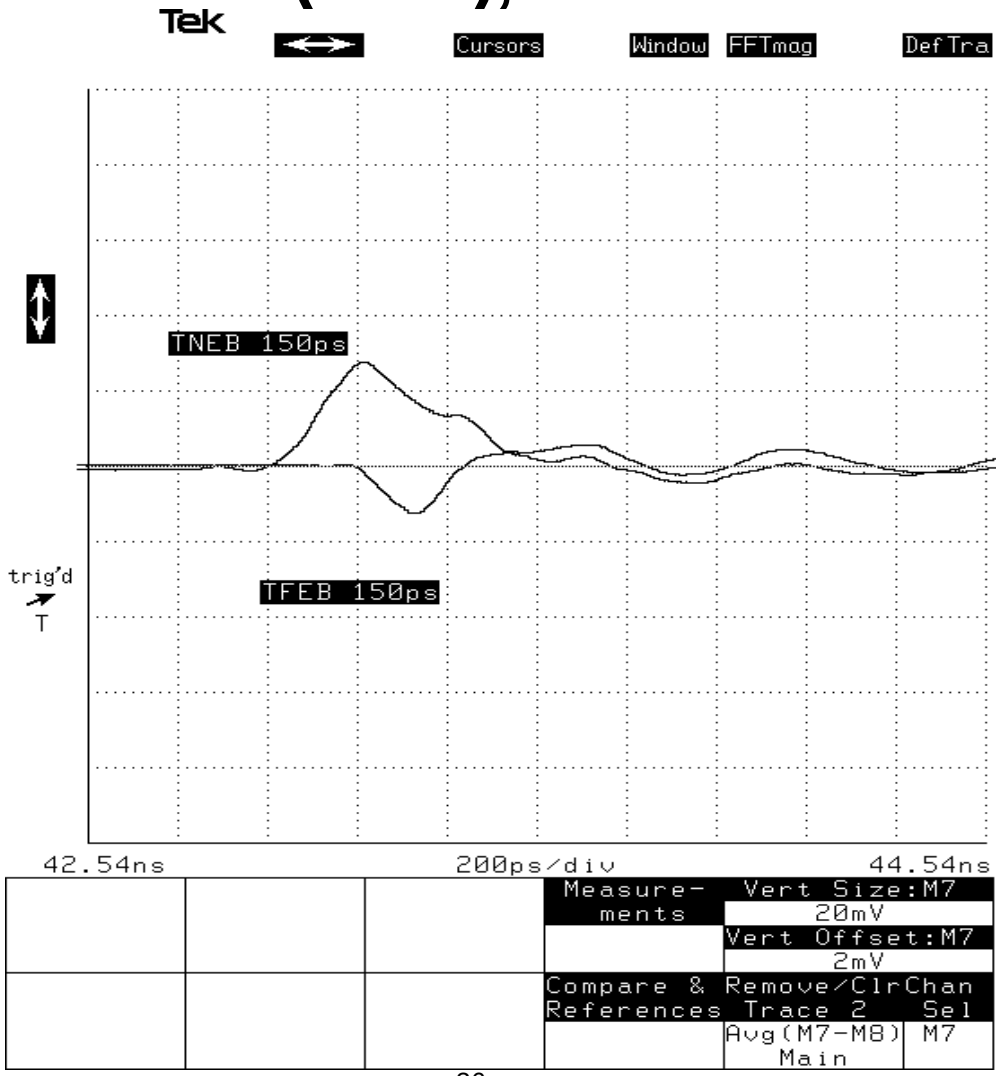


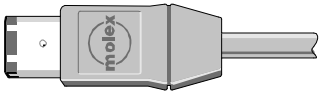
Molex 1394-95 6ckt. I/O

Differential Crosstalk for Through-hole Connector

tr = 150 ps

NEXT = +28 mV (5.6%), FEXT = -10 mV (2.0%)



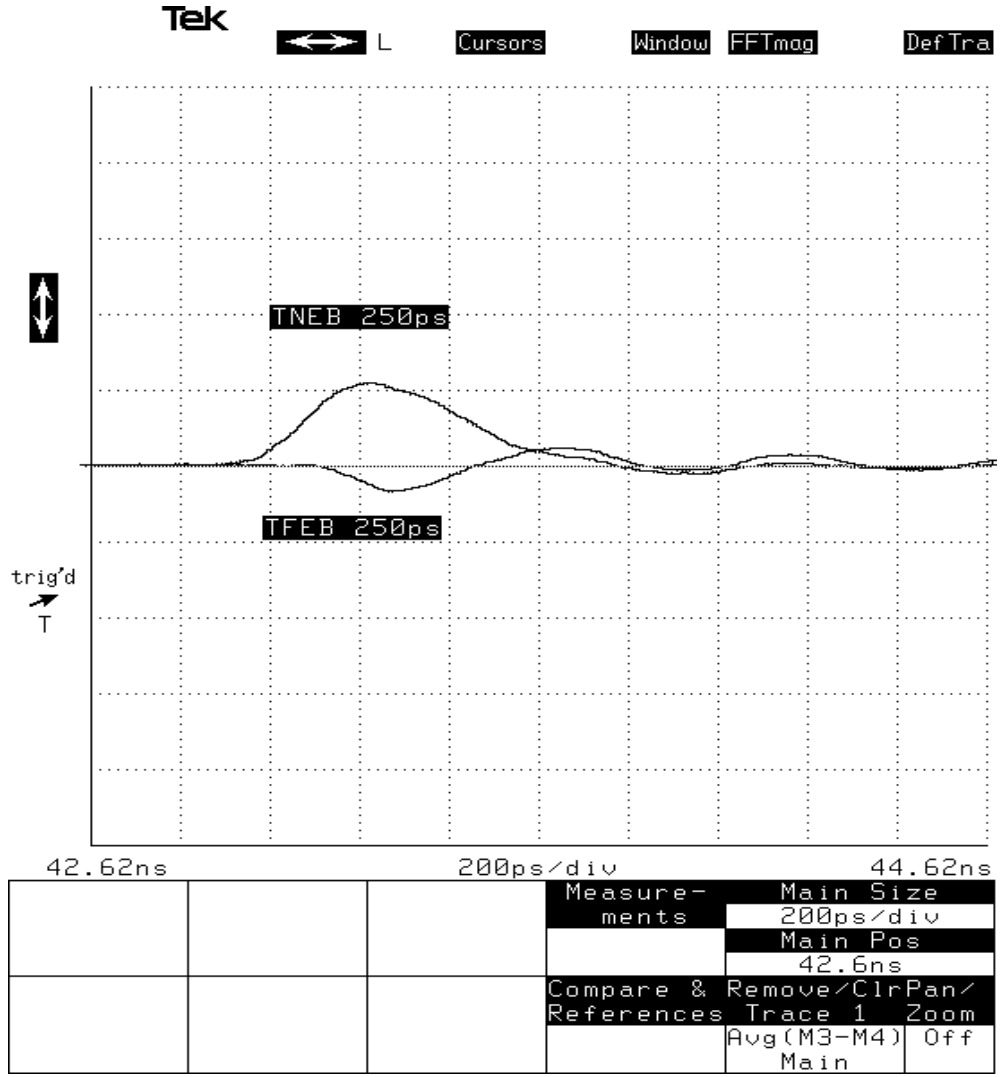


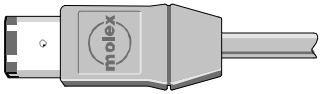
Molex 1394-95 6ckt. I/O

Differential Crosstalk for Through-hole Connector

tr = 250 ps

NEXT = +26 mV (5.2%), FEXT = -6.7 mV (1.3%)



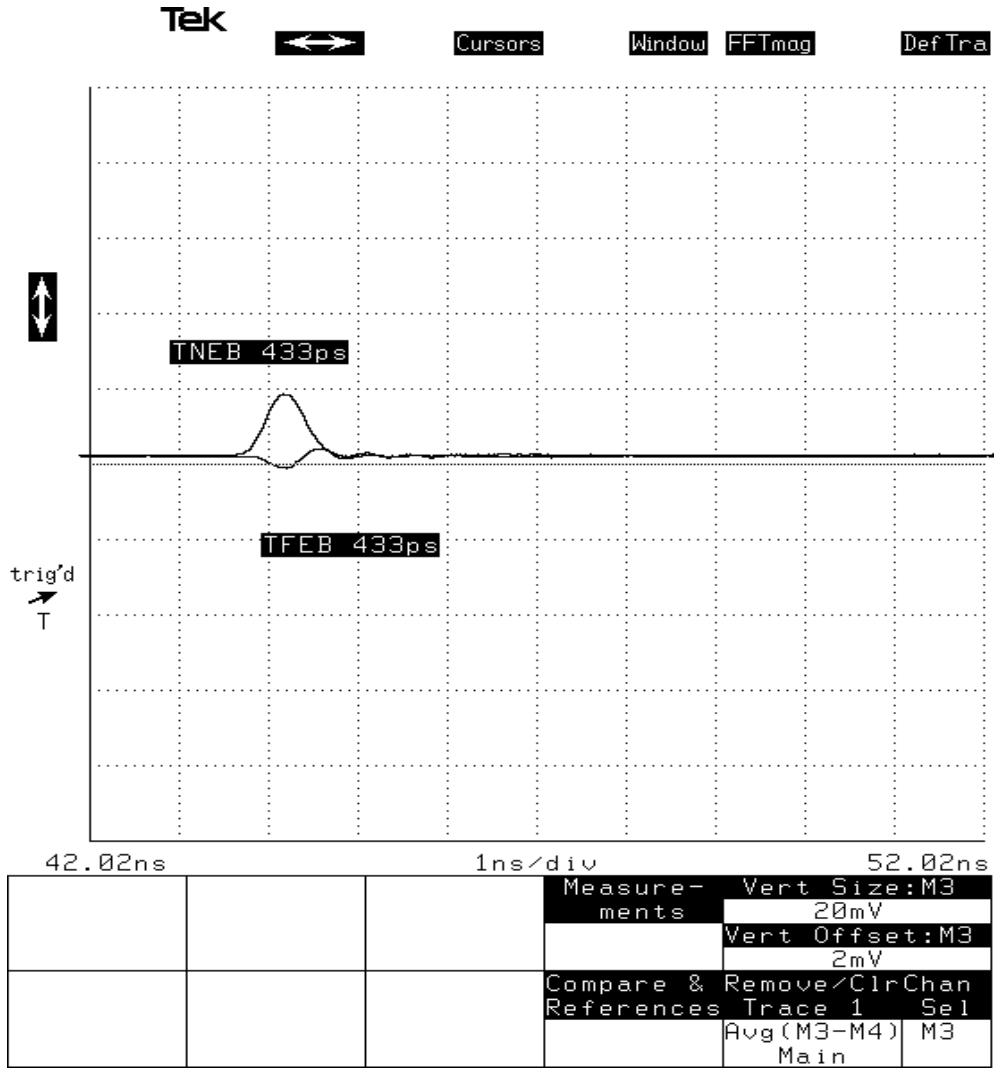


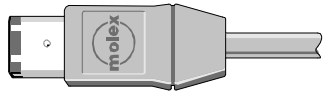
Molex 1394-95 6ckt. I/O

Differential Crosstalk for Through-hole Connector

tr = 433 ps

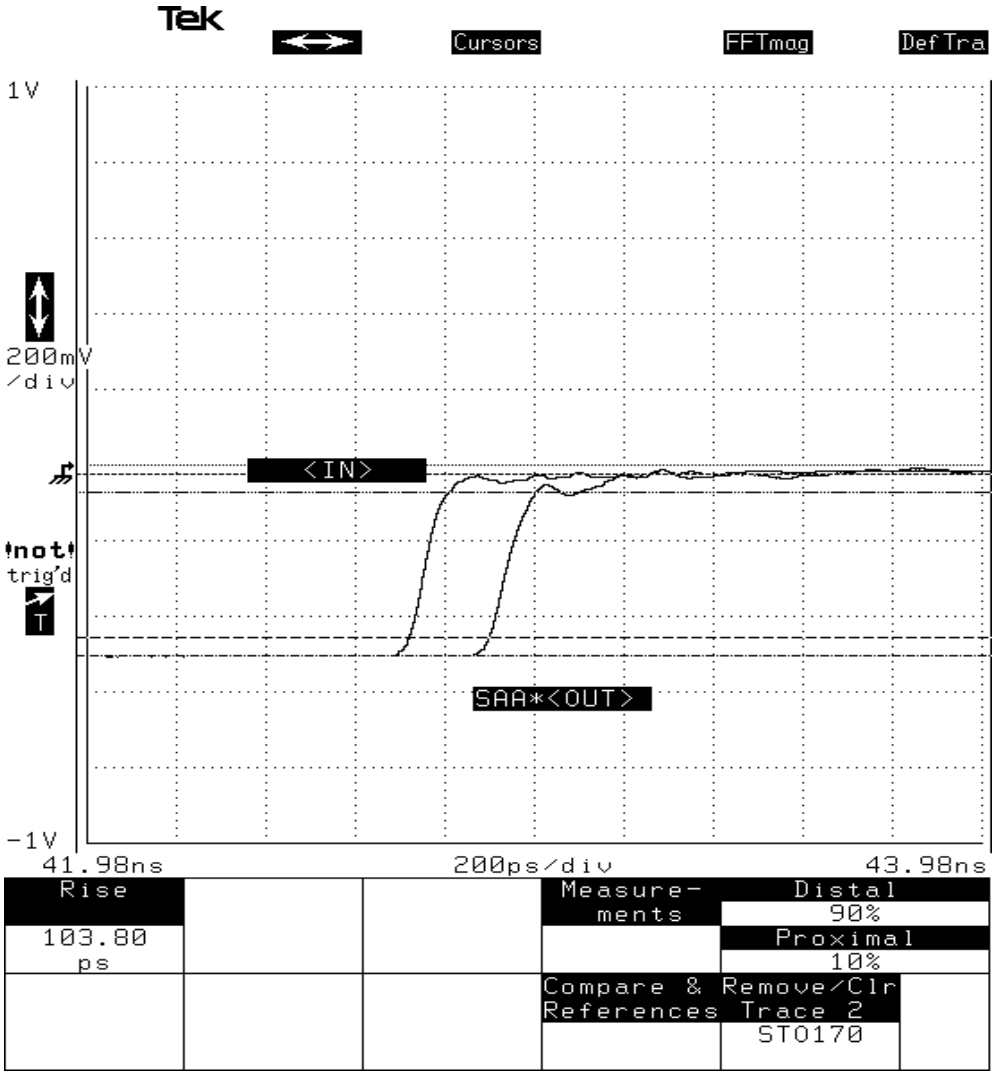
NEXT = +18.9 mV (3.8%), FEXT = +4.3 mV (0.9%)

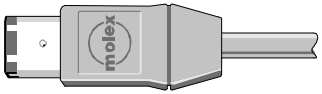




Molex 1394-95 6ckt. I/O

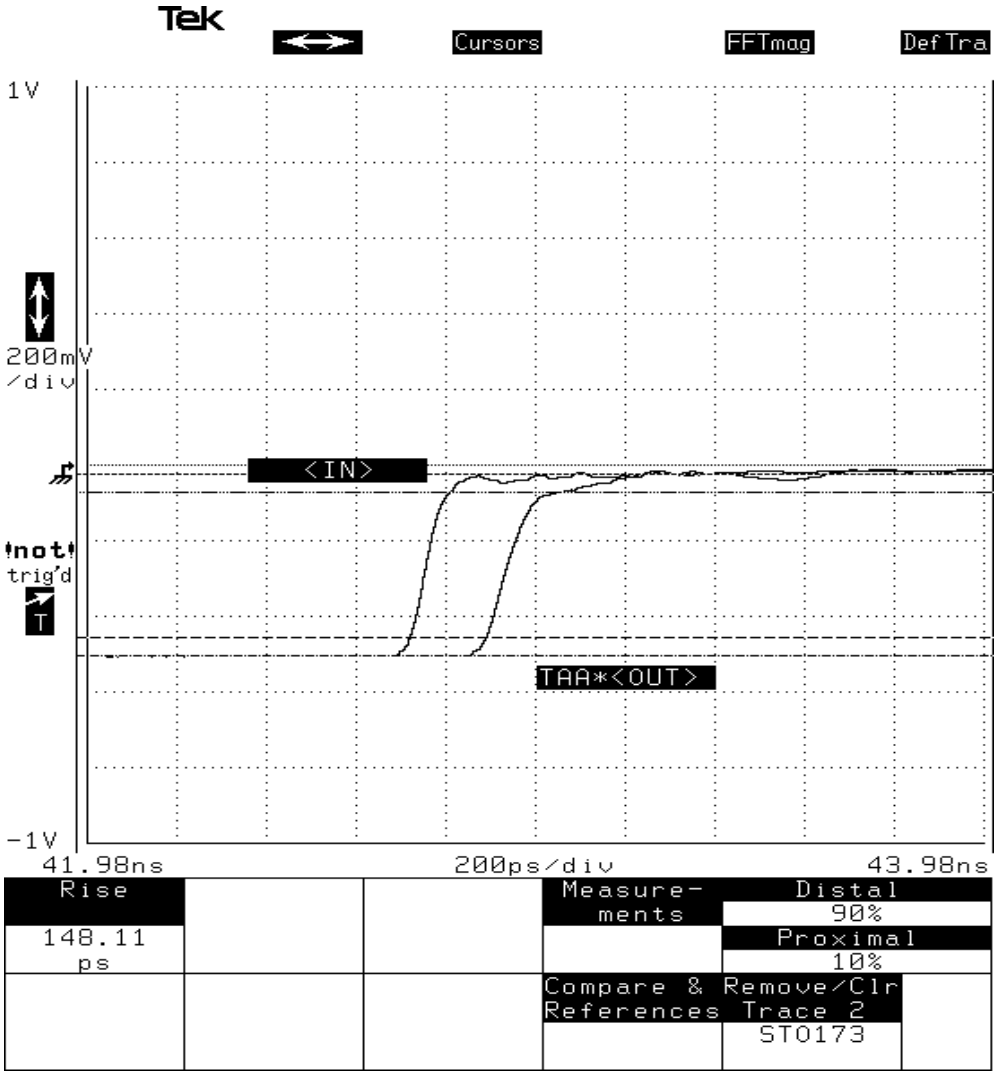
SMT Connector
Typical Transmission Through

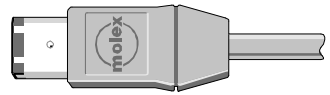




Molex 1394-95 6ckt. I/O

Through-hole Connector
Typical Transmission Through

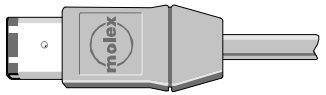




Molex 1394-95 6ckt. I/O

Test Conditions; Single Ended Crosstalk

Load Impedance	A, A*, B, B*; 50 ohms
Source impedance	A, A*, B, B*; 50 ohms
Test Risetime (10% - 90%)	tr = 3 ns
Vg and Vp configuration	Near End Crosstalk: Vg - 0 ohms to signal ground Vp - open Far End Crosstalk: Vg - 0 ohms to signal ground Vp - 50 ohms to signal ground
External Shield (Receptacle to PCB ground plane network)	R = 1 Megohm shunt C = 2 x 0.05 microfarad parallel ceramic chips @ 50 DCWV shunt
Crosstalk Ratio	Ratio of the maximum voltage peak to the input voltage. Crosstalk % = V_{peak} / V_{input}



Molex 1394-95 6ckt. I/O

Assembly Performance; Single Ended Crosstalk

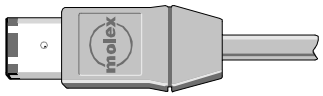
Far End Crosstalk

Cable Type	Cable Assembly Length	XAB	XAB*	XA*B	XA*B*
D8D	0.07 m	2.7%	2.5%	2.7%	2.5%
D8D	0.7 m	2.9%	2.7%	2.7%	2.7%
D8D	2.0 m	2.7%	3.1%	2.9%	2.7%
D8D	4.5 m	2.7%	3.1%	2.7%	2.5%

Near End Crosstalk

Cable Type	Cable Assembly Length	XAB	XAB*	XA*B	XA*B*
D8D	0.07 m	3.5%	3.3%	2.7%	3.1%
D8D	0.7 m	4.7%	4.3%	4.7%	4.7%
D8D	2.0 m	3.5%	3.3%	1.9%	3.7%
D8D	4.5 m	2.9%	4.1%	2.7%	4.3%

Molex D8D cable construction employs internal pair shelds which are isolated from the external shield and internal pair shields are commoned to each other.

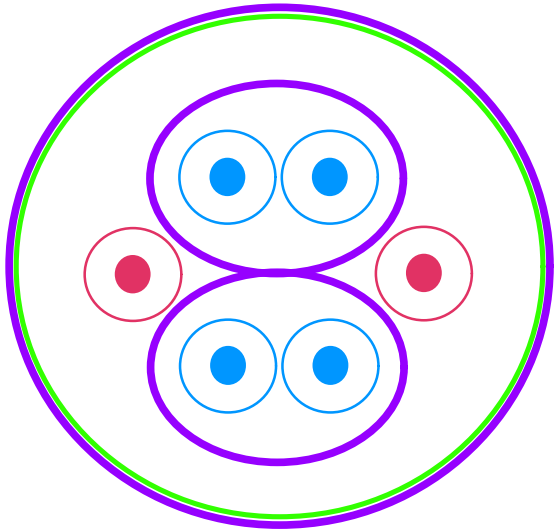


Molex 1394-95 6ckt. I/O

Cable Construction A vs. Cable Construction X; Crosstalk Comparison

Construction A	Near End Single Ended Crosstalk
100 MHz	-26.9 dB (4.5 %)
200 MHz	-25.3 dB (5.4 %)
400 MHz	-15.8 dB (16.2 %)

Construction X	Near End Single Ended Crosstalk
100 MHz	-53.7 dB (0.2 %)
200 MHz	-48.4 dB (0.4 %)
400 MHz	-24.4 dB (6.0 %)



Construction A per 1394-95 specification