Cable Testing up to and including 4Gbps Data Rates

Between any Transmitter and Receiver (or two Transceivers where applicable) lie various possibilities to mess up your signal. Aside from the straight forward resistive losses (of the cable or printed circuit board trace) that reduce the voltage level of the signal, there lurk many other unwanted perturbations to the transmitted signal that may render it unrecognizable to the receiver. These include frequency dependent reflections of you interconnects, frequency dependent losses of the dielectric media surrounding the traces or cable wires, impedance mis-matches at every separable interconnect not to mention electromagnetic interferences of various degrees.

At Smiths Connectors we understand all these issues and strive to offer as many solid design choices to engineers so that you can optimize your design with confidence. To that end we have characterized many of the cables used in the assemblies of our connector/contact systems.

The following eye pattern diagrams will show qualitatively the expectant results of a well terminated cable contact system.

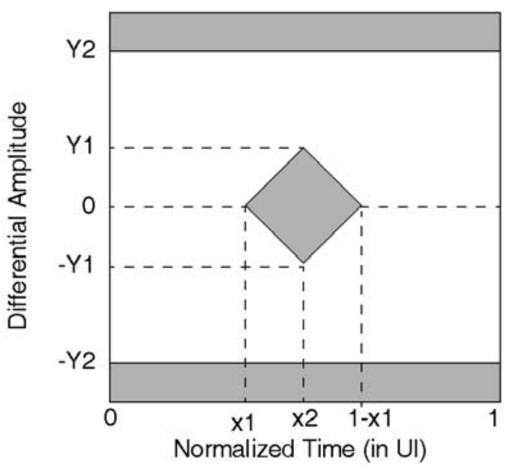


Figure 31 – Eye diagram mask at point-R'

Table 12 – Eye diagram mask at point-R'

	Bit rate (MBaud)	X1	X2	Y1 (mV)	Y2 (mV)
Intra-enclosure	132,818 5	0,29	0,5	200	800
	265,625	0,29	0,5	200	800
	531,25	0,29	0,5	200	800
	1 062,5	0,29	0,5	200	800
Inter-enclosure	132,818 5	0,28	0,5	200	1000
	265,625	0,28	0,5	200	1000
	531,25	0,28	0,5	200	1000
	1 062,5	0,28	0,5	200	1000

Using the Fibre Channel EPD mask as a reference (shown above) we will show the various length of cables that "pass" the spec for 1Gb/s rate.

Note: it is important to understand the Receiver sensitivity limits to design a robust system. Commercial specifications like FC are intentionally written more strictly defined so that interoperability issues between various manufacturers can be tolerated.

So that the test setup may be understood, we will describe it here. The signal generation and measurement were performed on an Tektronics CSA8000 Communications Signal Analyzer. A pair of phase matched 50 Ohm SMA high speed coax cables brought the differential signal from the test head to an 'SMA to Quadrax' pcb interface board or an equivalent 'SMA to twinax' pcb interface board depending on the type of contact/cable to be evaluated. A fifty foot section of cable was appropriately terminated, then measurements were made and recorded starting at

4Gbps; 3Gbps; 2Gbps and finally 1Gbps. The cable was then reduced by 10 feet, re-terminated and the same measurements taken again.

Since weight and volume are both significant design considerations, we tested three different cables:

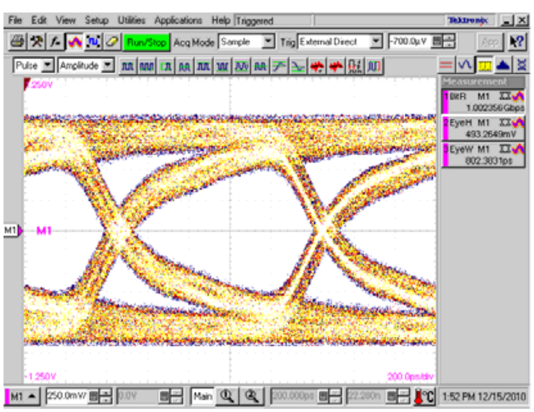
- [A] 24 AWG Quadrax
- [B] 24 AWG Twinax
- [C] 26 AWG Twinax

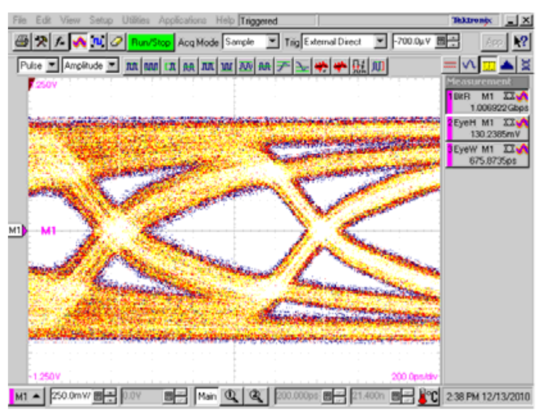
Note: As with any high speed interconnect care was taken in the cable preparation and termination to ensure that the cable-contact-cable transition was optimized.

What is interesting to note and not unexpected is that the 24 AWG Twinax performed the best of the 3 cable assemblies we tested. The raw data is charted in table 1 below.

	Center Eye Height in mVolts						Eye Width in psec				
	10 ft	20 ft	30 ft	40 ft	50 ft		10 ft	20 ft	30 ft	40 ft	50 ft
24 AWG Quad	**1400**	**1000**	**650**	**450**	100		**925**	**865**	**755**	**585**	275
24 AWG Twin	**1400**	**1100**	**800**	**600**	**400**		**930**	**880**	**800**	**715**	**675**
26 AWG Twin	**1300**	**1000**	**700**	**450**	375		**920**	**850**	**735**	**710**	370

Comparing this data to the FC Normalized Eye Diagram mask we can see the colored cells meet or exceed the specification. Since the data includes a mated connector pair and a length of printed circuit board on each end the specific performance in your design should correlate very well. A brief evaluation of the data shows excellent performance for Gigabit data rates on 24 AWG Twinax cable well out to fifty feet. Interestingly the 26 AWG Twinax cable performed as well or better than the 24 AWG Quadrax across all lengths. The data was culled from a visual inspection of the resultant EPD for each cable, at each data rate. As a reference the thirty foot and fifty foot, 24 AWG Twinax cable EPD's are shown side by side below.





What is of particular interest is the lack of reflections, caused by any impedance discontinuities in the entire signal path. This shows a well thought out and executed design strategy. Also both the Eye height voltage and the Eye width jitter components are very well behaved.

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Of course depending upon the particular driver and receiver characteristics the cable lengths and data rates attained will be able to be improved upon. In addition, with various signal conditioning tools widely available in the industry (like the passive equalization contacts from Sabritec) even longer cable lengths and faster data rates could be achieved.

In the following pages we will list the test results for higher data rate testing in tabular format only, for reference we maintained the structure of comparing the data to a "projected FC" data rate of 2Gbps; 3Gbps and 4Gbps(actual data rate of 2.125, 3.1875 and 4.25 Gbps respectively).What this means is that the Eye Height was required to exceed a 400mV differential limit, while we held the Unit Interval (UI) mask requirement at [UI*.58]

Note is that the 24 AWG Twinax assembly passed a valid FC mask requirement at 10 feet length for all data rates up to 4 Gbps. The 24 AWG Quadrax and 26 AWG Twinax had a valid voltage level at the 4Gbps rate, though the UI eye width missed complying with the specification by only 10pSec. (125ps measurement versus a 135ps requirement).

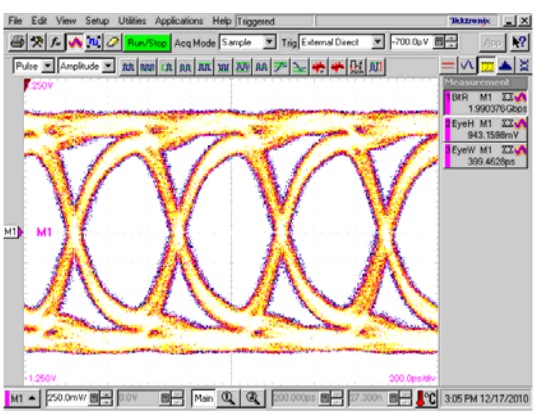
The results, though not linear, do track with the 1Gbps data as expected.

What this means for the designer of high speed I/O is that for shorter distances (<3m) and data rates below 4 Gbps there are many options when selecting a contact-cable assembly. In addition, Sabritec offers extremely well designed tightly controlled assemblies for those systems where high speed data rates are necessary.

Higher data rates

Shown below for all data rates will be a picture of an example EPD for the 10 foot, 24 AWG Twinax assembly, along with the tabulated data measured across all three assemblies.

2Gbps



	Center Eye Height in mVolts						Eye Width in psec				
	10 ft	20 ft	30 ft	40 ft	50 ft		10 ft	20 ft	30 ft	40 ft	50 ft
24 AWG Quad	**1100**	**500**	**100**	**--**	--		**390**	**310**	**155**	**--**	--

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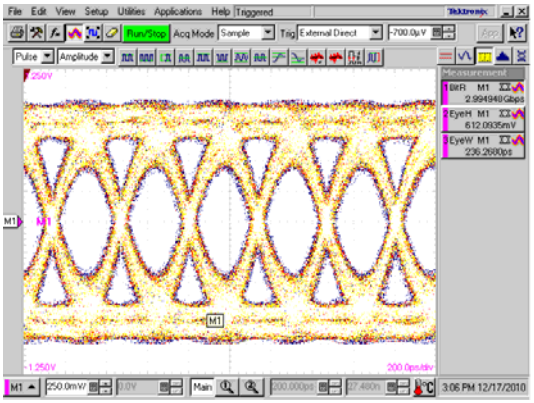
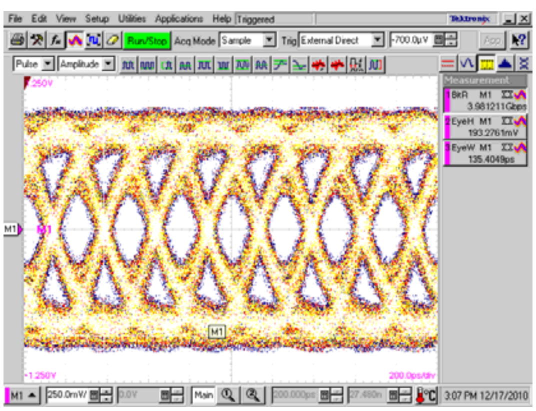
24 AWG Twin	**1100**	**800**	**400**	**--**	**--**		**395**	**390**	**255**	**--**	**--**
26 AWG Twin	**1050**	**600**	**200**	**--**	--		**385**	**330**	**165**	**--**	--

3Gbps



	Center Eye Height in mVolts						Eye Width in psec				
	10 ft	20 ft	30 ft	40 ft	50 ft		10 ft	20 ft	30 ft	40 ft	50 ft
24 AWG Quad	**700**	175	0	---	---		**220**	150	0	---	---
24 AWG Twin	**700**	**400**	150	---	---		**235**	**186**	25	---	---
26 AWG Twin	**650**	250	0	---	---		**220**	125	0	---	---

4Gbps



	Center Eye Height in mVolts						Eye Width in psec				
	10 ft	20 ft	30 ft	40 ft	50 ft		10 ft	20 ft	30 ft	40 ft	50 ft
24 AWG Quad	**400**	0	---	---	---		125	0	---	---	---
24 AWG Twin	**500**	100	---	---	---		**135**	60	---	---	---
26 AWG Twin	**400**	0	---	---	---		120	0	---	---	---