Considerations for high speed copper interconnect specifications

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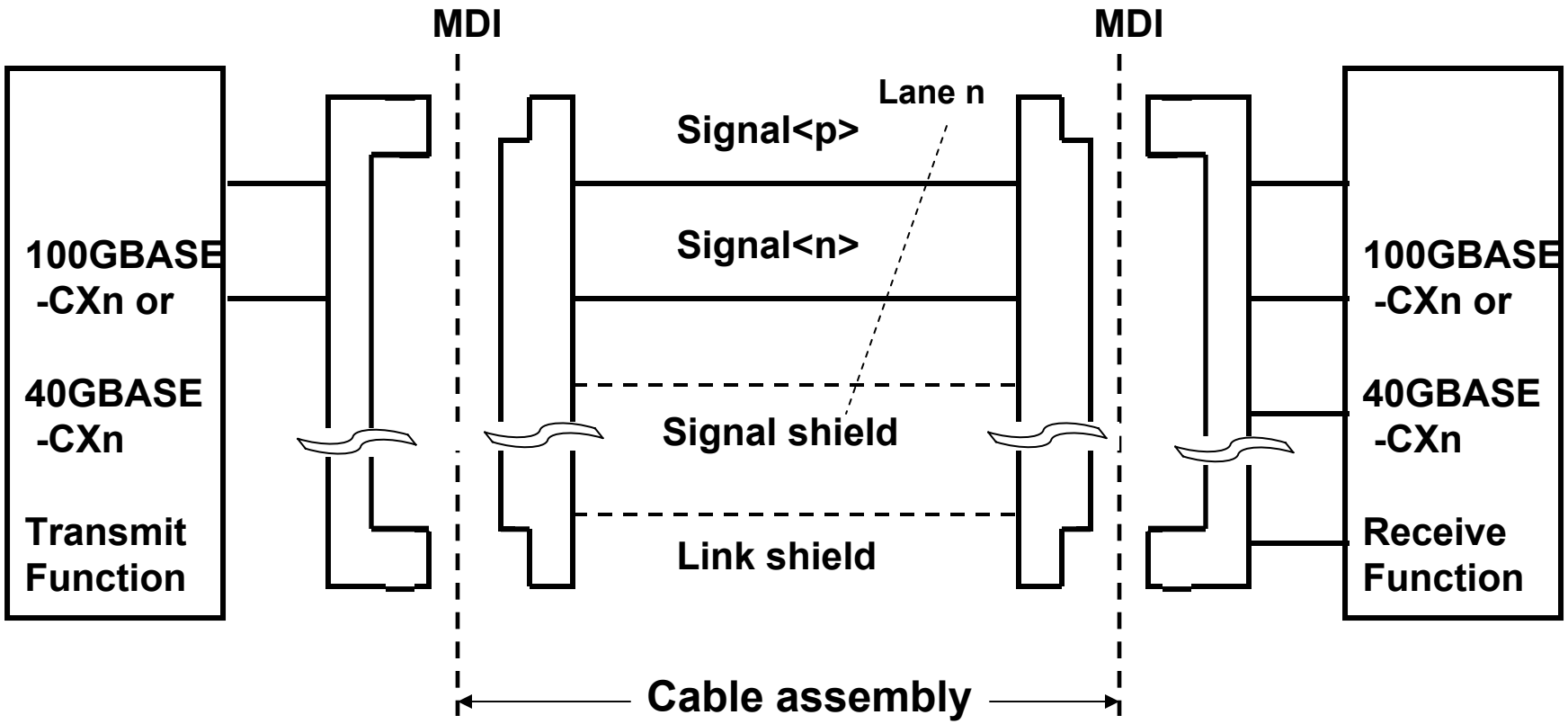
Presentation objectives

- Considerations for high speed copper interconnect specifications

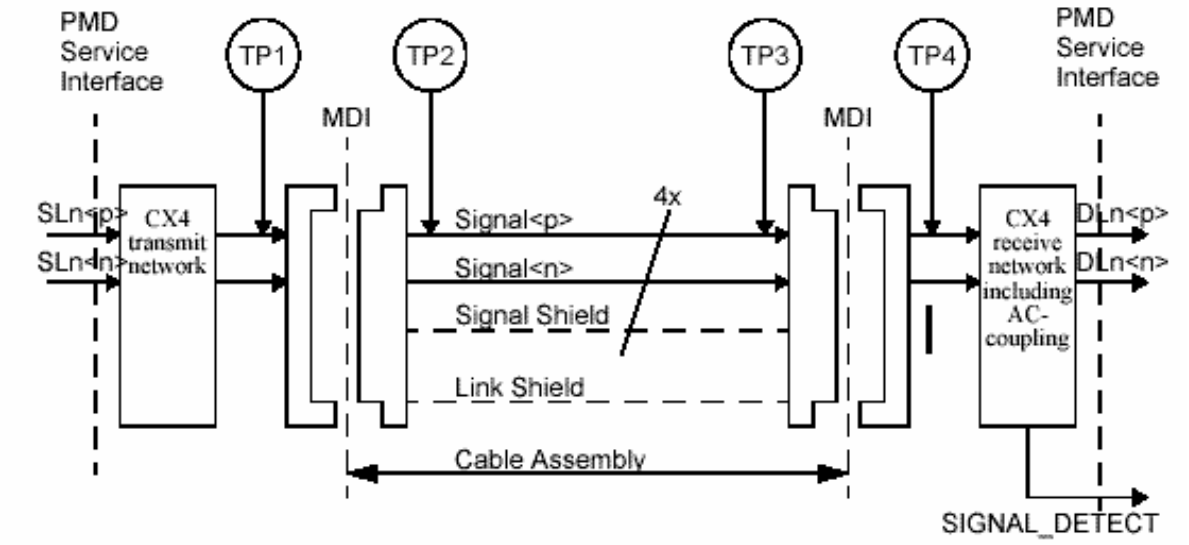
100GBASE-CXn and 40GBASE-CXn link



S-parameter interconnect specifications

- S-parameters are sufficient to specify interconnect-induced signal impairments e.g.,
- Measured:
  - -Insertion loss
  - -Return loss
  - -Crosstalk
    - -NEXT
    - -FEXT
- Computed:
  - -PSNEXT
  - -PSELFEXT
- Limits:
  - -Measurement based
  - -InfiniBand

10GBASE-CX4 Cable assembly



For 10GBASE-CX4 - All cable assembly measurements are to be made between TP1 and TP4 as shown in the Figure illustrated above.

802.3ap Channel Parameters

- Channel measurement reference: TP1 to TP4.

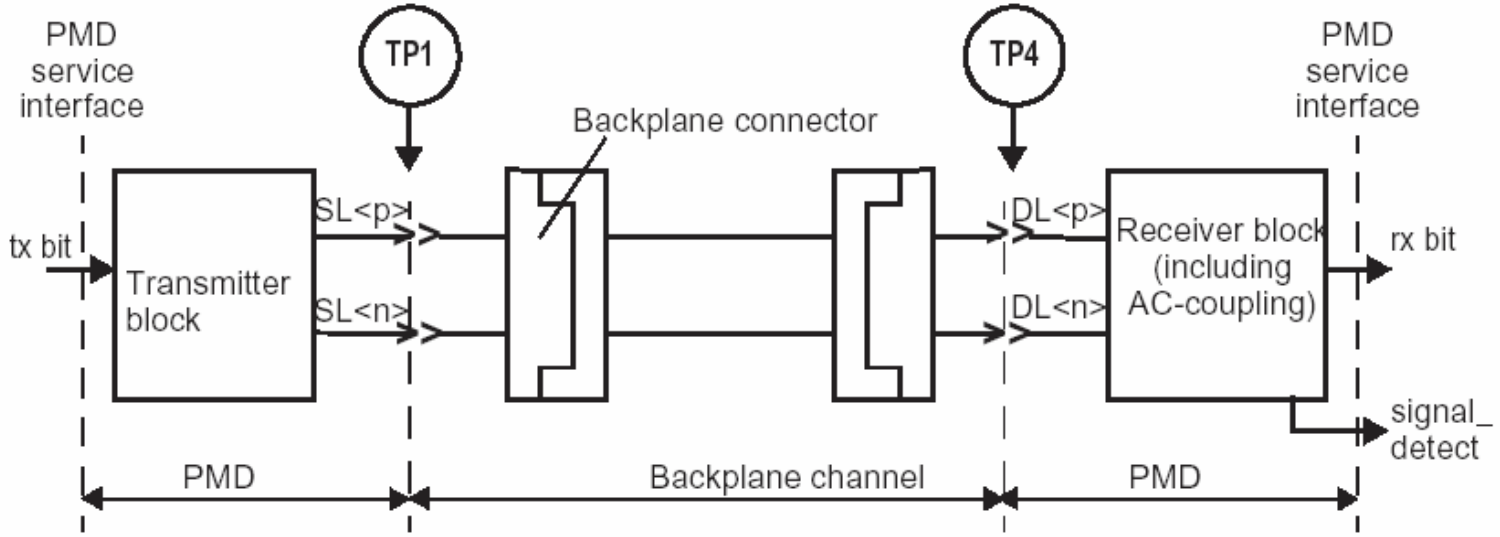


Figure 70–1—Link block diagram

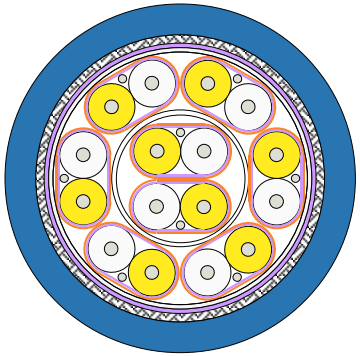
- Measured
  - Insertion Loss
  - NEXT
  - FEXT
  - Return Loss
- Computed
  - Insertion loss deviation
  - Insertion loss to crosstalk ratio
  - PSNEXT, PSFEXT, PSXT
- Limits
  - To support existing platforms (ATCA)

802.3ba lane rates under discussion

100GBASE-CXn	lane rates Gb/s	Length (m) Passive cable
parallel	10 x 10	at least 10 m
parallel	5 x 20	at least 10 m
parallel	4 x 25	at least 10 m
40GBASE-CXn	**lane rates Gb/s**	**Length (m) Passive cable**
parallel	4 x10	at least 10 m

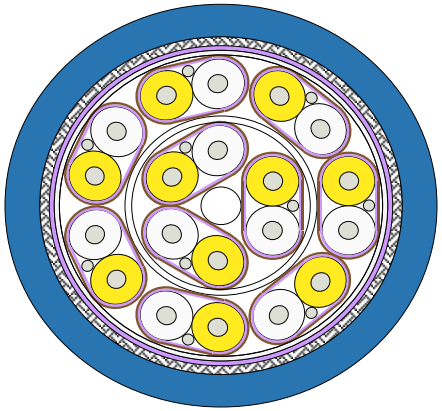
Twinaxial media for lane options

4x – 8 pairs



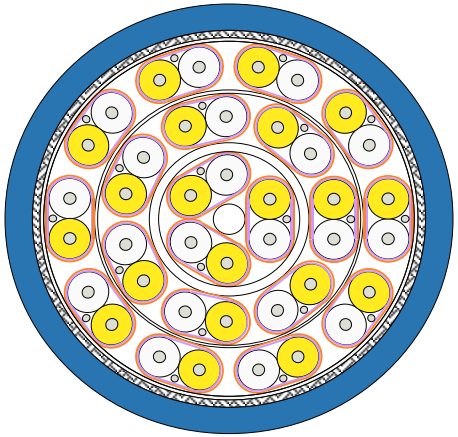
8.19 mm
0.322”

5x – 10 pairs



8.94 mm
0.352”

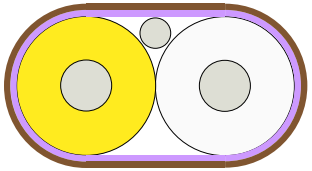
10x – 20 pairs



11.79 mm
0.464”

10x – cents

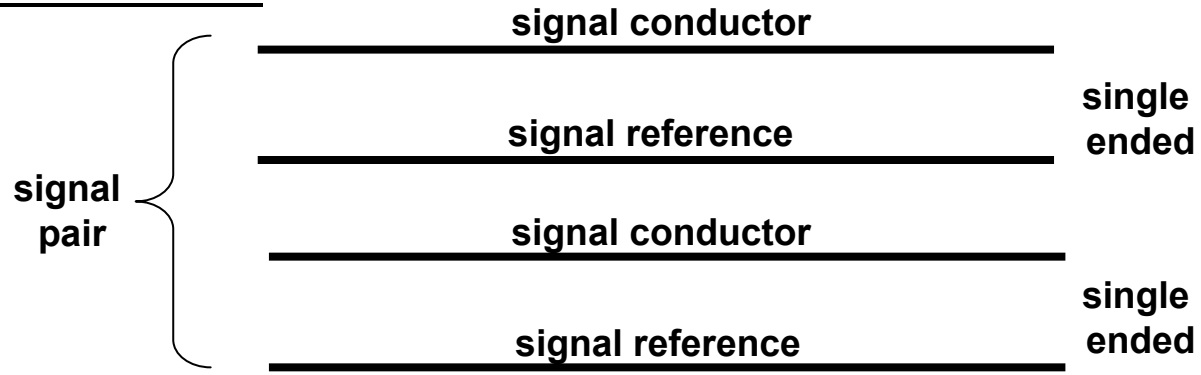
17.41 mm



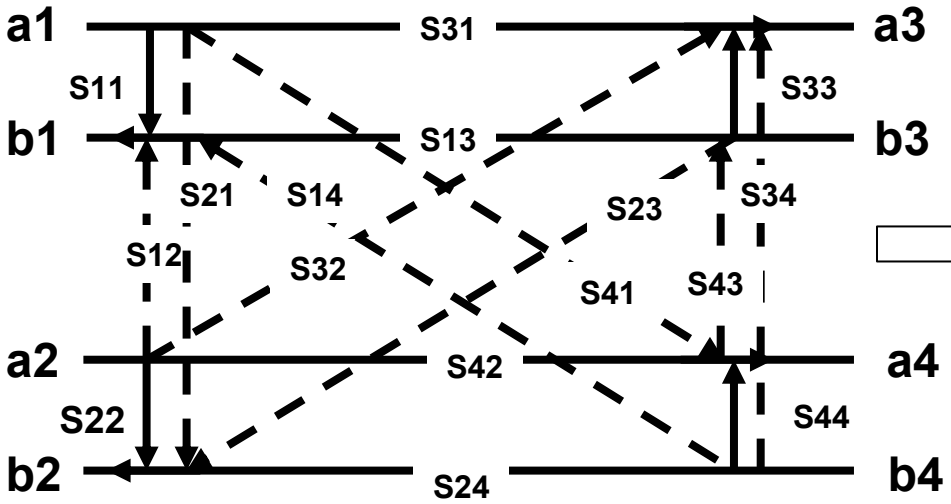
- **Differential parallel pair**
- **Drain wire**
- **Aluminum shield**

S-parameters – 4 port network

Physical network



Signal flow graph

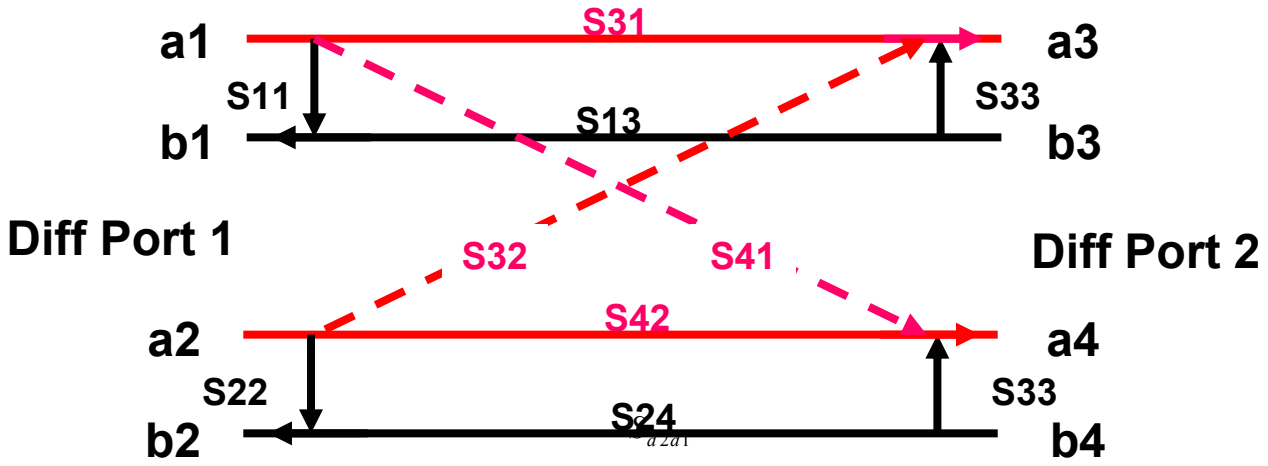


$$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{221} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix}$$

S-parameter matrix of single ended measurements

S-parameter mapping to differential and common mode

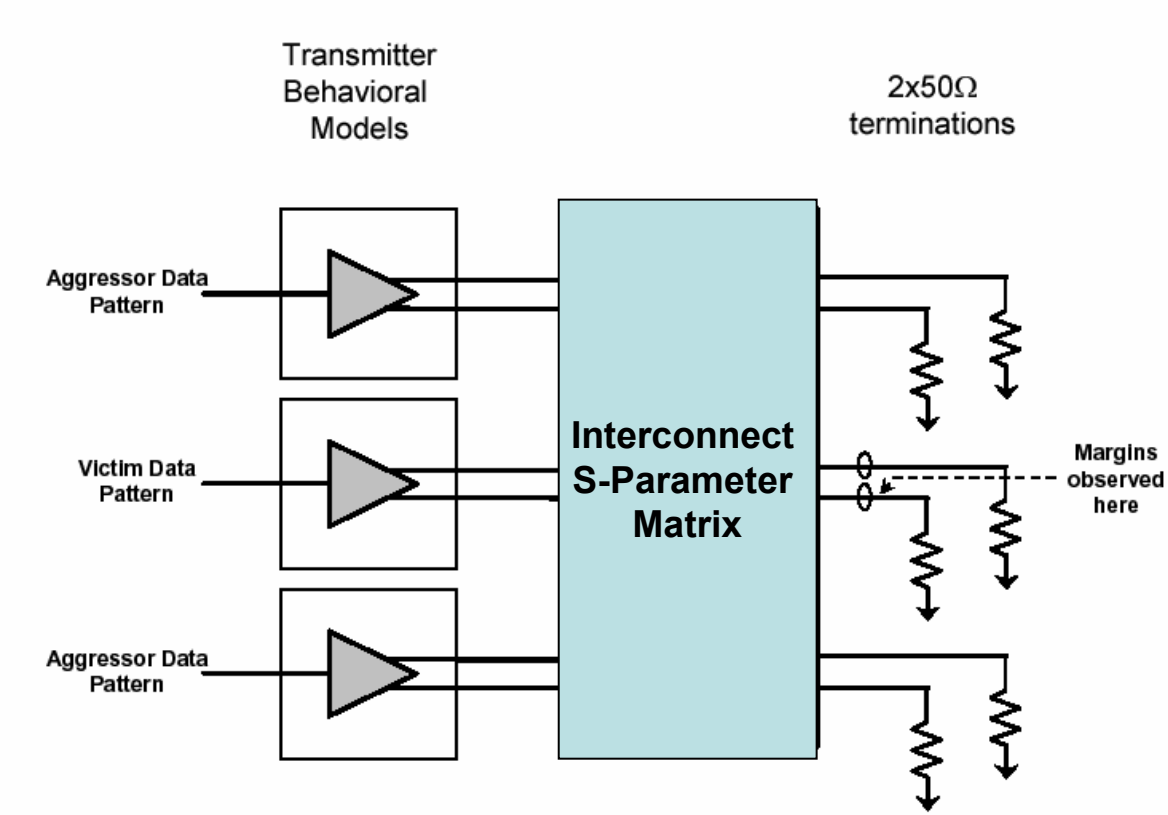
signal flow graph example S_{d2d1} mapping from single ended measurements



$$\begin{bmatrix} b_{d1} \\ b_{d2} \\ b_{c1} \\ b_{c2} \end{bmatrix} = \begin{bmatrix} S_{d1d1} & S_{d1d2} & S_{d1c1} & S_{d1c2} \\ S_{d2d1} & S_{d2d2} & S_{d2c1} & S_{d2c2} \\ S_{c1d1} & S_{c1d2} & S_{c1c1} & S_{c1c2} \\ S_{c2d2} & S_{c2d2} & S_{c2c1} & S_{c2c2} \end{bmatrix} \begin{bmatrix} a_{d1} \\ a_{d2} \\ a_{c1} \\ a_{c2} \end{bmatrix}$$

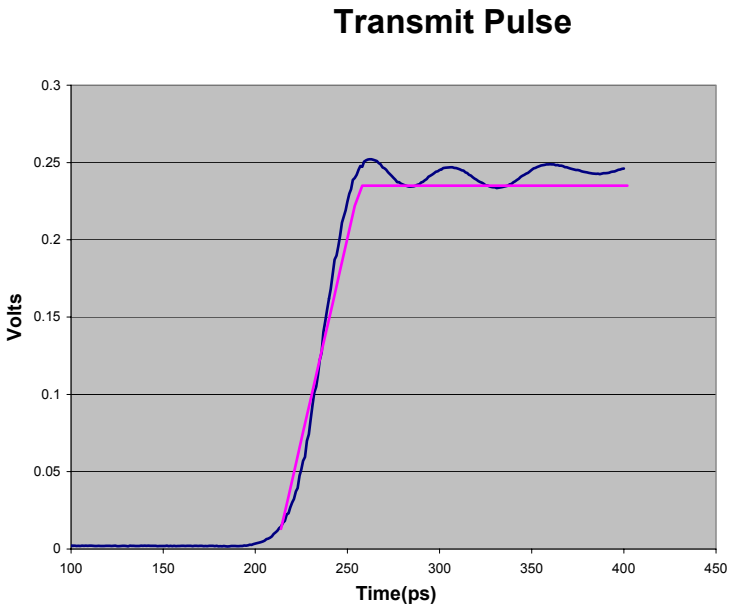
$$S_{d2d1} = \frac{1}{2}\left(S_{31} - S_{32} + S_{42} - S_{41}\right)$$

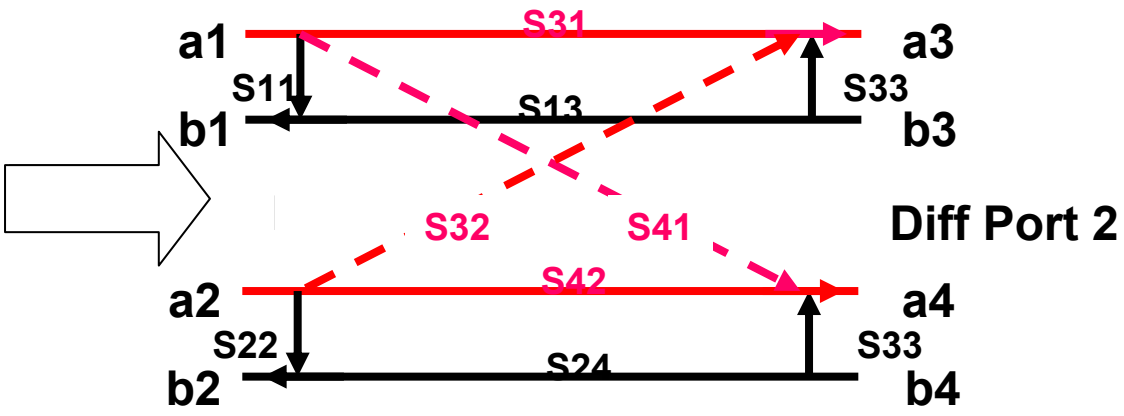
PCIe Interconnect - Simulation Environment

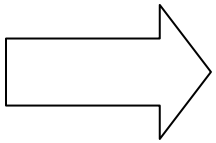


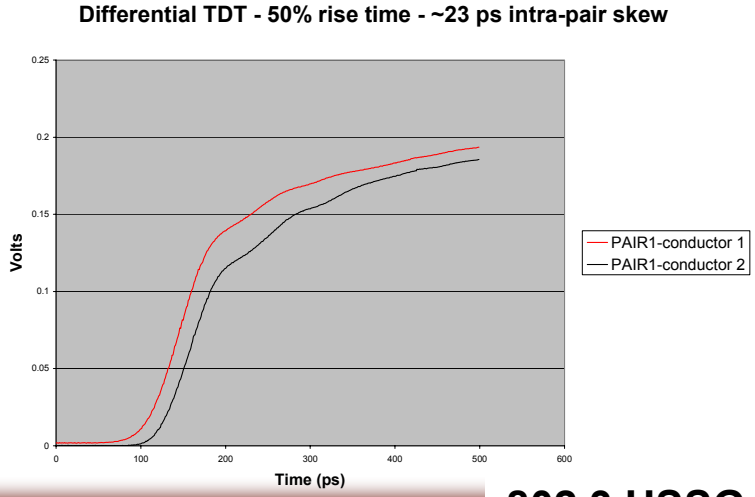
- Convolve the interconnect's response with a worst case transmitter behavioral model and a worst case data pattern. The resulting time domain results, represented via an eye diagram, can then be compared against the VRX_EYE and TRX_EYE parameters defined in the receiver specification..

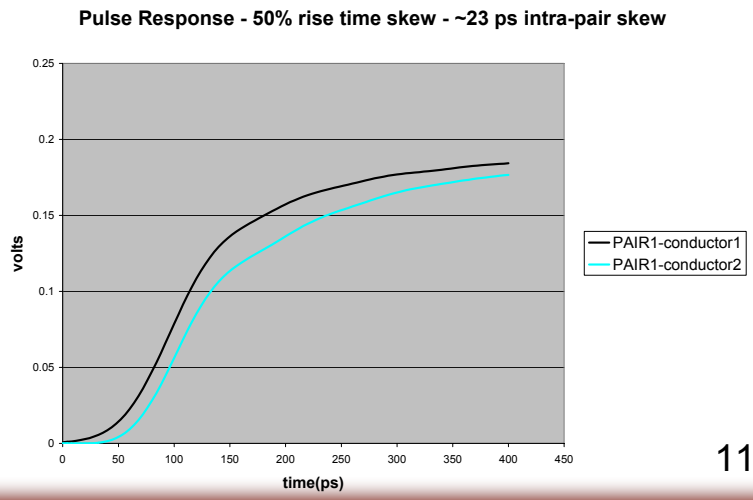
Intra-pair skew











Summary

- **S-parameters are sufficient to specify interconnect-induced signal impairments.**

BACKUP SLIDES

Lane Rate, Signaling rate, channel bandwidth

10 m cable + connectors @ 6 dB Margin

Maximum Lane rate	Maximum signaling rate	Info bits/baud/dim	Channel bandwidth	Copper Gauge	Code gain	Length
Mb/s	Mbaud		MHz	AWG	dB	meters
10889.28	8180.00	1.33	4090.00	28	0	10
13984.52	10140.00	1.38	5070.00	28	2	10
17555.24	11360.00	1.55	5680.00	28	4	10
>24950.75	>17290.00	1.44	8645.00	24	0	10
>30727.91	>17400.00	1.77	8700.00	24	2	10
>36785.11	>19000.00	1.94	9500.00	24	4	10
>17212.31	>13210.00	1.30	6605.00	28 ADVD	0	10
>22044.24	>14580.00	1.51	7290.00	28 ADVD	2	10
>27147.01	>15460.00	1.76	7730.00	28 ADVD	4	10

Source: George Zimmerman, Solarflare Communications, Chris DiMinico, MC Communications

Lane Rate, Signaling rate, channel bandwidth

10 m cable + connectors @ 6 dB Margin

maximum achievable lane rate for each coding gain

Maximum Lane rate	Maximum signaling rate	Info bits/baud/dim	Modulated Info bits/baud/dim (2)	Channel bandwidth (1)	Copper Gauge	Code gain	Length	Modulation
Mb/s	Mbaud			MHz	AWG	dB	meters	
10889.28	8180.00	1.33	1.33	4090.00	28	0	10	PAM-3
13984.52	9476.64	1.38	1.48	4738.32	28	2	10	PAM-4
17555.24	10097.78	1.55	1.74	5048.89	28	4	10	PAM-4
24950.75	17290.00	1.44	1.44	8645.00	24	0	10	PAM-4
30727.91	16261.68	1.77	1.89	8130.84	24	2	10	PAM-4
36785.11	16888.89	1.94	2.18	8444.44	24	4	10	PAM-5
17212.31	13210.00	1.30	1.30	6605.00	28 ADVD	0	10	PAM-3
22044.24	13626.17	1.51	1.62	6813.08	28 ADVD	2	10	PAM-4
27147.01	13742.22	1.76	1.98	6871.11	28 ADVD	4	10	PAM-4

(1)Channel bandwidth=.5*(Maximum signaling rate)

(2)Infor/bits/baud/dim adjusted for coding gain

maximum achievable lane rate for each coding gain that yields 1 bit/baud

Maximum Lane rate	Maximum signaling rate	Info bits/baud/dim	Modulated Info bits/baud/dim	Channel bandwidth	Copper Gauge	Code gain	Length	Signaling
Mb/s	Mbaud			MHz	AWG	dB	meters	
10439.00	10439.00	1.00	1.00	5219.50	28	0	10	PAM-2/NRZ
12630.13	13580.00	0.93	1.00	6790.00	28	2	10	PAM-2/NRZ
14857.53	16690.00	0.89	1.00	8345.00	28	4	10	PAM-2/NRZ
21639.98	21639.98	1.00	1.00	10819.99	24	0	10	PAM-2/NRZ
23439.51	25170.00	0.93	1.00	12585.00	24	2	10	PAM-2/NRZ
24885.04	27950.00	0.89	1.00	13975.00	24	4	10	PAM-2/NRZ
16224.36	16224.36	1.00	1.00	8112.18	28 ADVD	0	10	PAM-2/NRZ
18748.43	20159.60	0.93	1.00	10079.80	28 ADVD	2	10	PAM-2/NRZ
21194.44	23813.98	0.89	1.00	11906.99	28 ADVD	4	10	PAM-2/NRZ

Source: George Zimmerman, Solarflare Communications, Chris DiMinico, MC Communications