DesignCon® 2014

Intra-pair "Unaccounted" Skew – Effects and Suppression

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January 28-31, 2014 | Santa Clara Convention Center | Santa Clara, CA

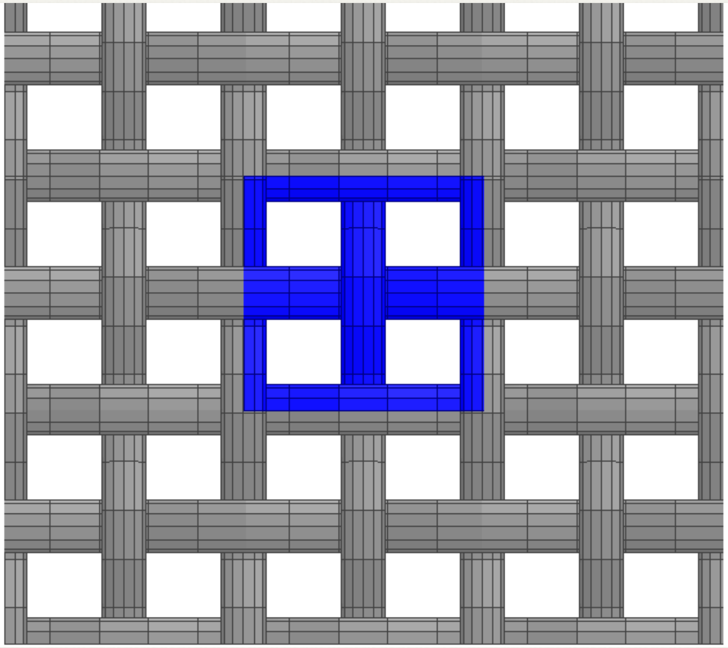
UBM Tech

Contents

Introduction

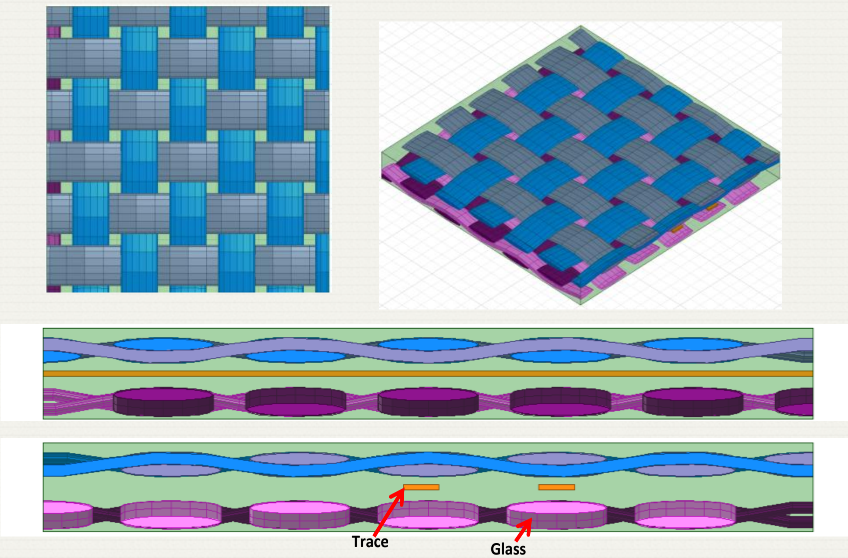
- **Goal**
  - Characterize skew generated from glass weave structures in PCB laminates.
  - Investigate possible techniques to reduce glass weave effect .
  - Assess the effect of skew in transmission quality of a simple link of known length/loss.
- **Methodology**
  - Find skew through construction of glass weave unit cell and utilization of a 3D full wave simulation tool.
  - Run statistical eye algorithm on constructed channels of known loss and skew..

3D Full-wave Modeling

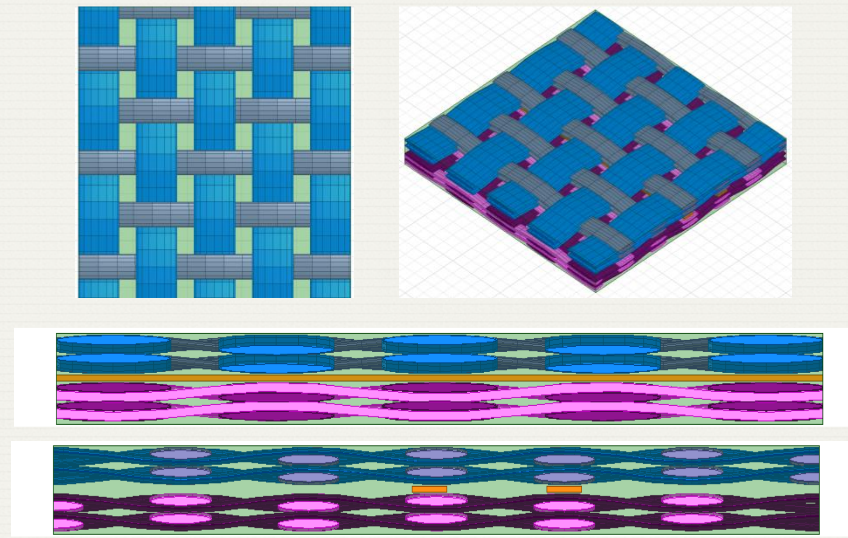


The definition of glass weave unit cell (blue geometry).

3D Full-wave Modeling- Glass weave Models



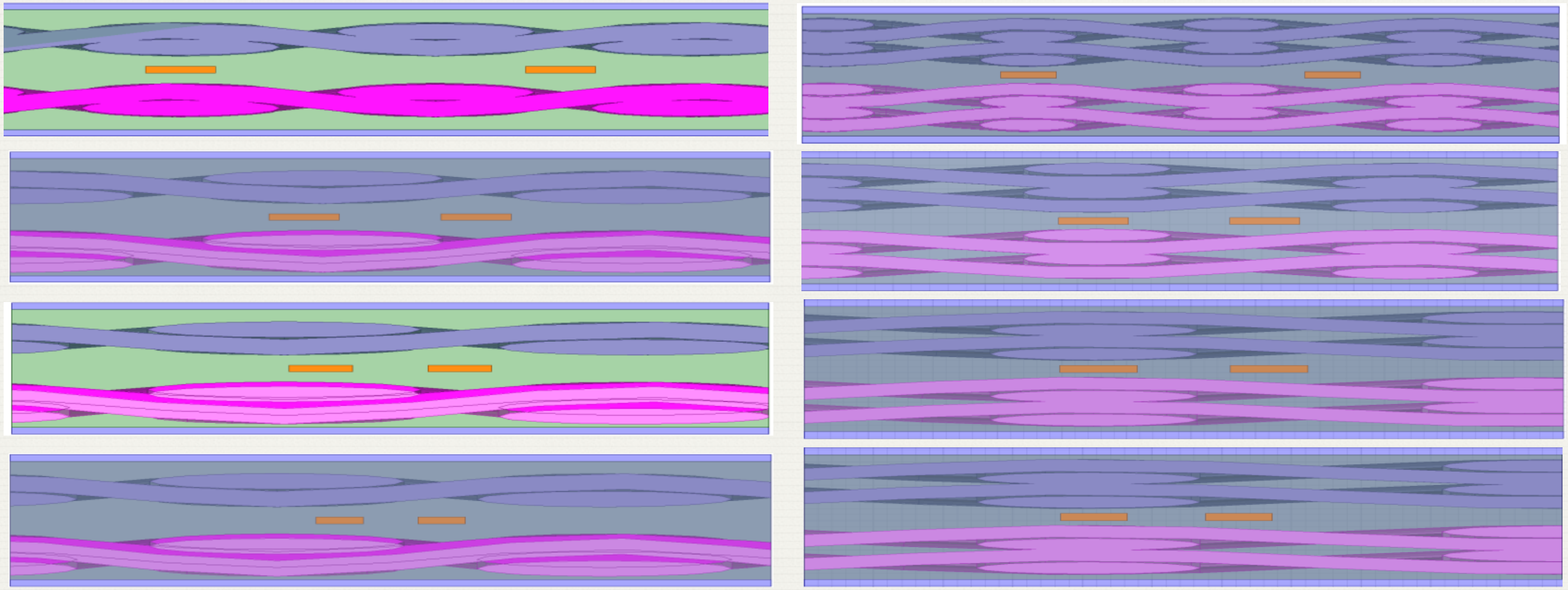
2116 glass weave based symmetrical differential trace laminates



2x1080 glass weave based symmetrical differential trace laminates

(Parametric geometry provided in ANSYS HFSS software)

3D Full-wave Modeling- Trace configurations



Trace configurations for common mode impedances of 25 (single ended), 30, 35, and 40 ohms (from top to bottom respectively) in symmetrical laminates of Megtron6 and 1x2116 (Left) / 2x1080 (Right) laminates.

3D Full-wave Modeling- Results

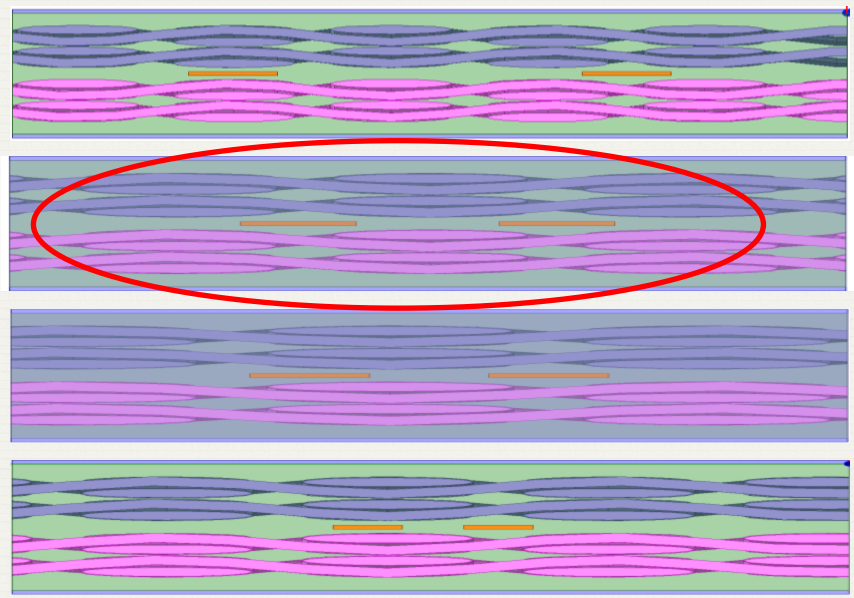
Glass type 1x2116	Width/Spacing (mil)	Loss per in (dB) @ 12.5 GHz	Skew per inch (ps)
Comm25	4.6/13	0.71	4.9765
Comm30	3.8/5.5	0.76	4.8974
Comm35	3.0/3.6	0.85	4.5657
Comm40	2.4/2.8	0.94	3.55

5mil core
5mil prepreg

Glass type 2x1080	Width/Spacing (mil)	Loss per in (dB) @ 12.5 GHz	Skew per inch (ps)
Comm25	4.6/13	0.71	8.8371
Comm30	3.8/5.5	0.76	9.0338
Comm35	3.0/3.6	0.85	8.8390
Comm40	2.4/2.8	0.94	7.6014

Trace width, spacing, loss/inch, and skew/inch for several common mode impedances of a 100 ohms differential strip lines embedded in Megtron6.

3D Full-wave Modeling- Results



Glass type 2x2116	Width/Spacing (mil)	Loss per in (dB) @ 12.5 GHz	Skew per in (ps)
Comm25	9.4/30	0.54	0.9093
Comm30	7.7/9.5	0.57	0.0006
Comm35	6.3/6.3	0.62	1.2515
Comm40	5.3/4.7	0.68	3.0047

2x2116 glass weave

9.6mil core
9.6mil prepreg

3D Full-wave Modeling- Results

Offset	0mil	1mil	2mil	3mil	4mil	5mil	6mil	7mil	8mil
Skew per inch (ps)	0.0006	0.0174	0.0606	0.0982	0.1171	0.1344	0.1250	0.0847	0.0171
Offset	9mil	10mil	11mil	12mil	13mil	14mil	15mil	16mil	17mil
Skew per inch (ps)	0.0636	0.1114	0.145	0.353	0.1181	0.072	0.0393	0.027	0.0104

Skew results of parametric sweep for differential trace of Zcomm=30 ohms as a function of translational position .

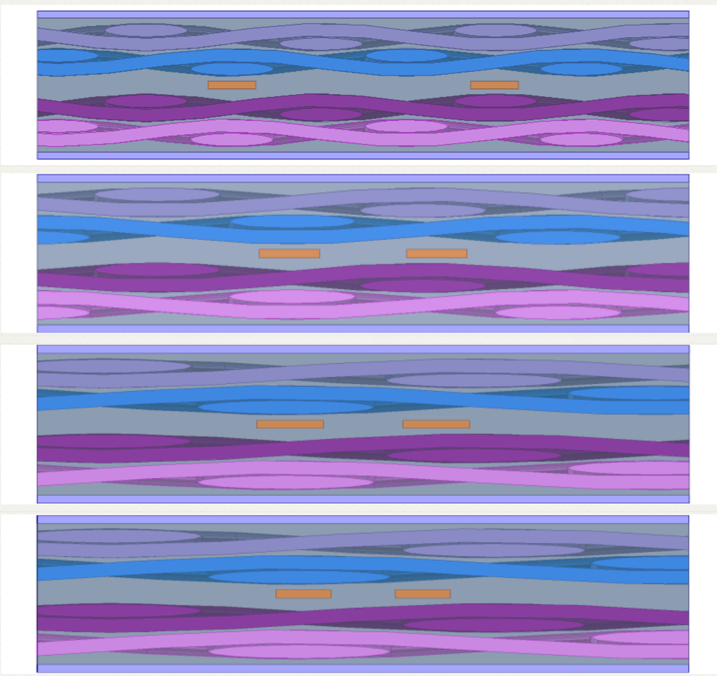
Skew Minimization techniques- Glass Weave Rotation

Case Glass type 1x2116	Skew per in (ps) Original	Skew per in (ps) Rotate 45 deg
Comm25	4.9765	2.5408
Comm30	4.8974	2.8129
Comm35	4.5657	2.5637
Comm40	3.5500	1.9253

Comparison of skew per inch for a 45 degrees angular rotation of prepreg glass type 1x2116.

Skew Minimization techniques- Offsetting

Glass to Glass Position

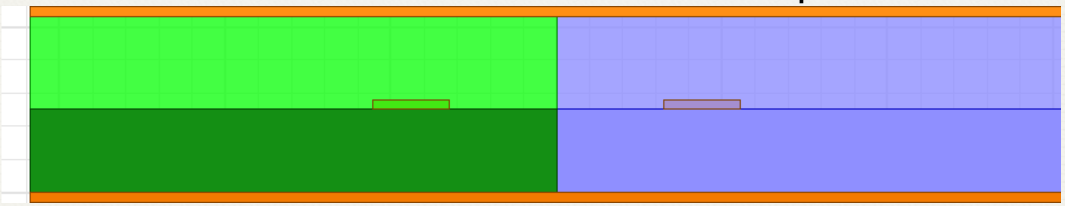


2x1080 glass weave peak and valley (locked) positions.

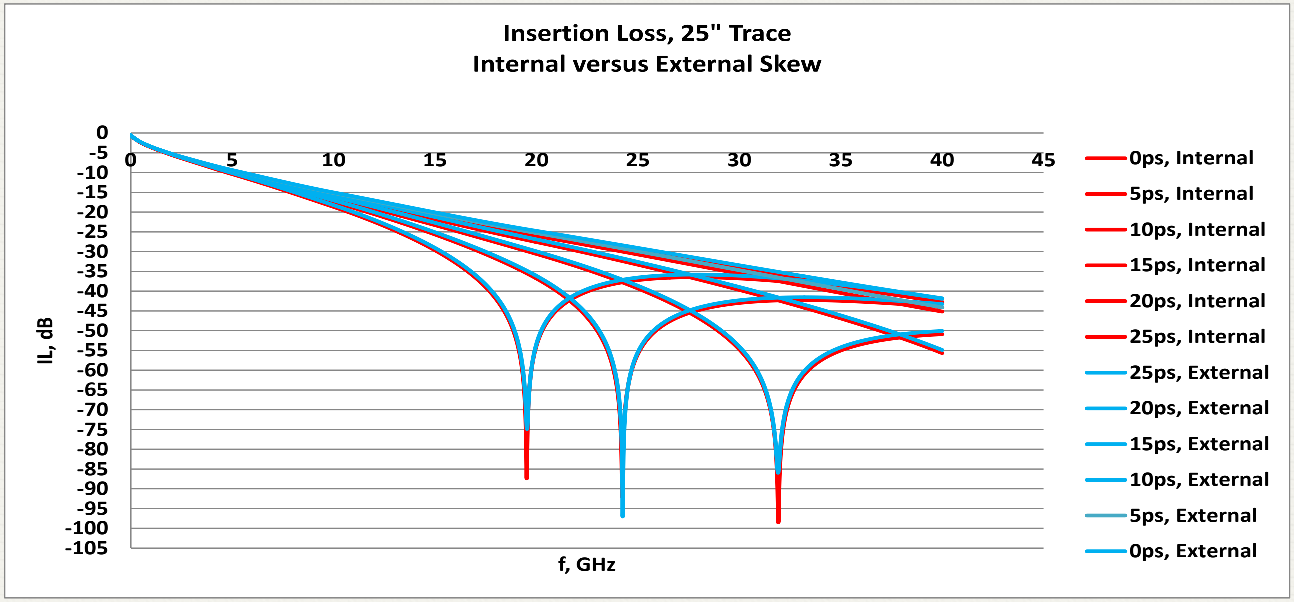
Case Glass type 2x1080	Skew per in (ps) Original	Skew per in (ps) With offset average
Comm25	8.8371	0.0033
Comm30	9.0338	0.1203
Comm35	8.8390	0.4060
Comm40	7.6014	1.0298

Skew for symmetrical vs. offset glass positioning.

Channel Simulation- S-parameter Models

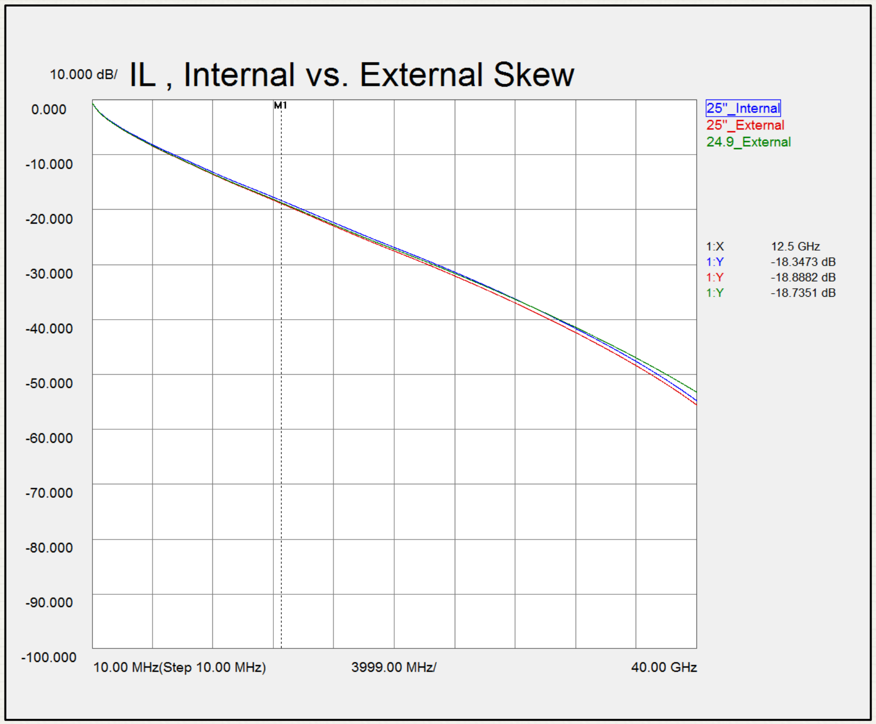


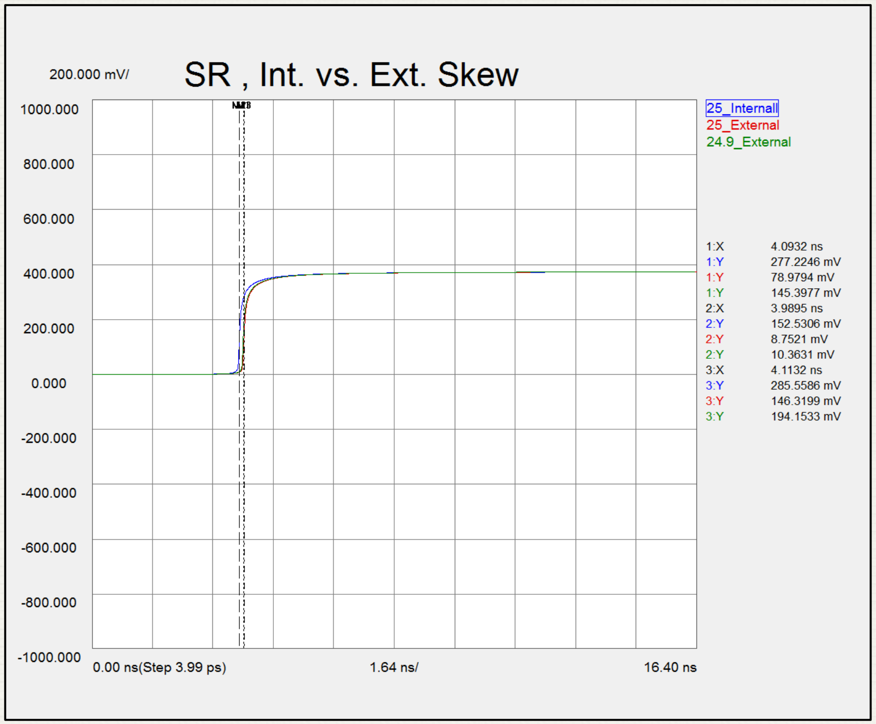
Cross sectional view of a differential stripline with separate effective Dk regions.



Insertion loss characteristics of a differential stripline model with internally (red) versus externally (blue) added skew.

Channel Simulation- S-parameter Models



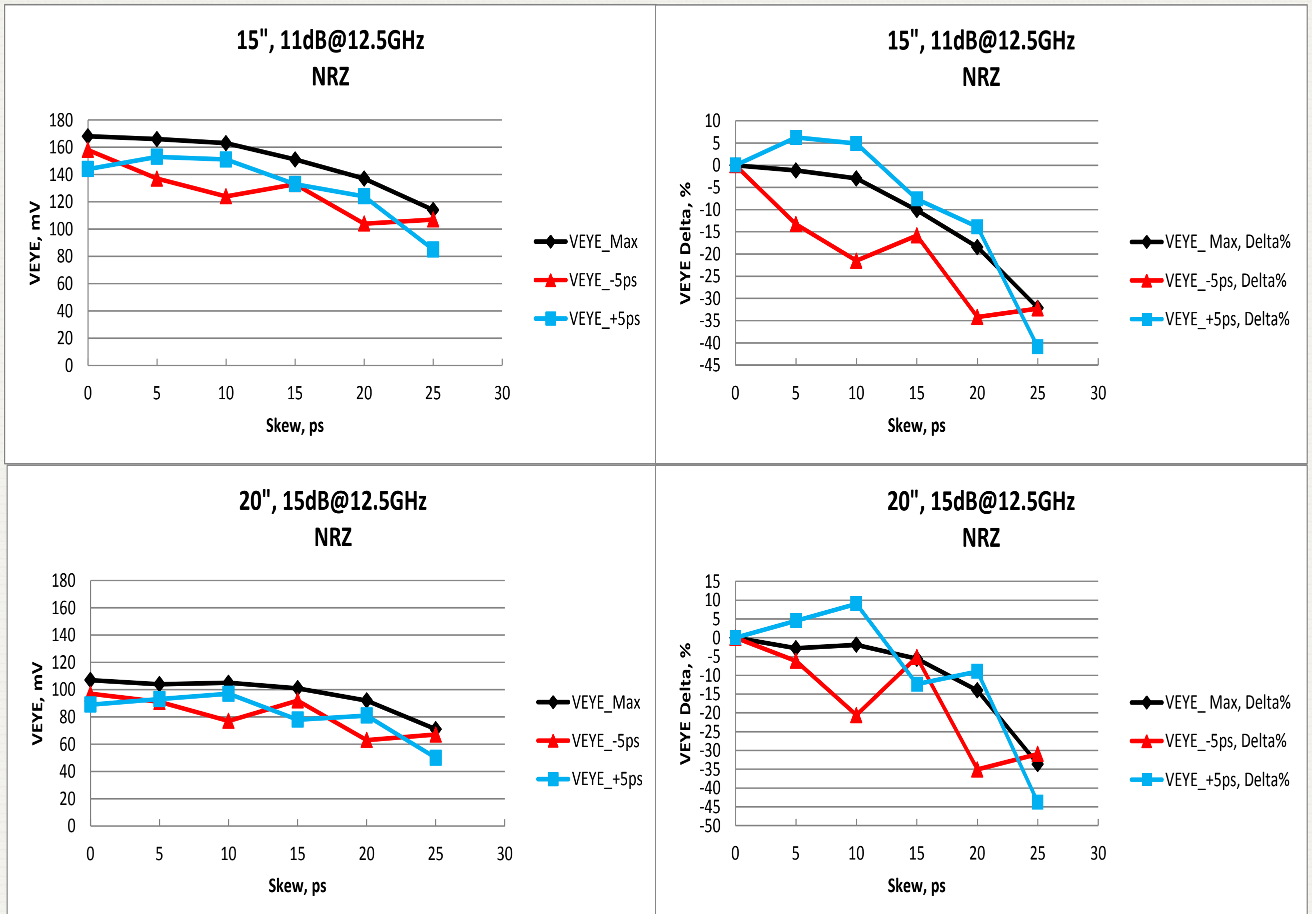


IL (left) and delay (right) differences and equalization between internal and external skew models.

Channel Simulation- Link Simulation

25Gbps

8 DFE

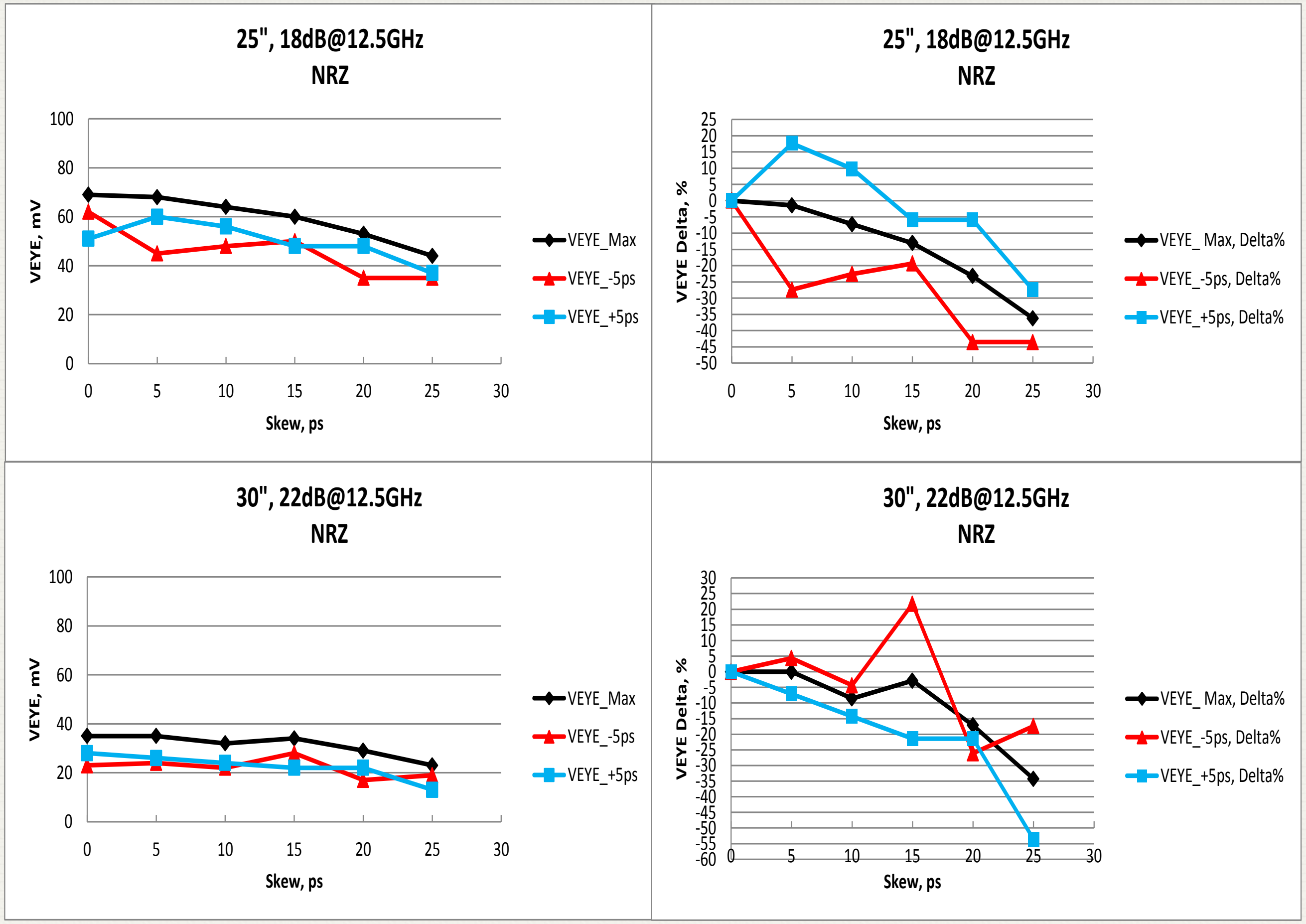


Absolute and relative eye eight (VEYE) as a function of skew for 15" (top) and 20"(bottom) Megtron6 channels.

Channel Simulation- Link Simulation

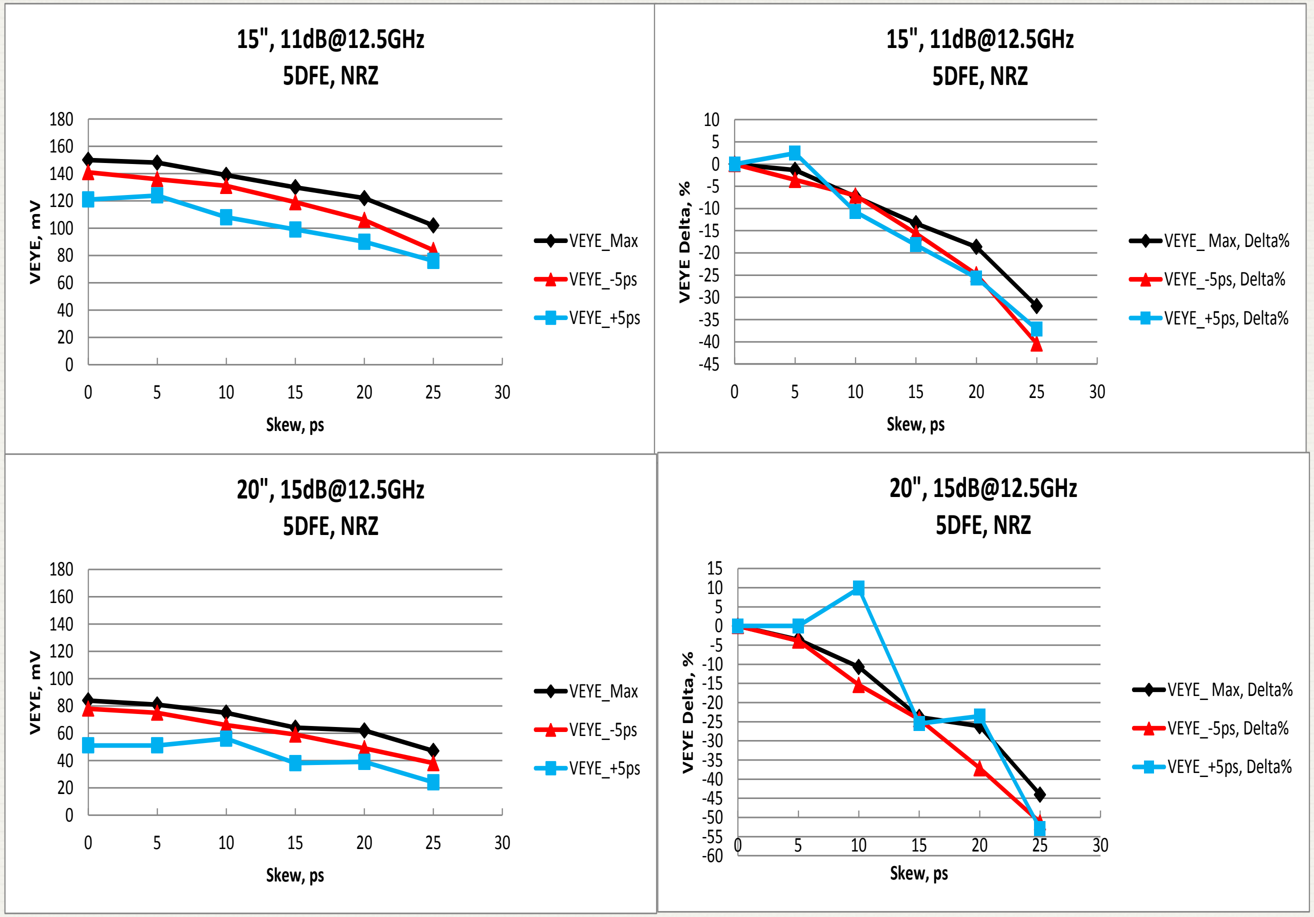
25Gbps

8 DFE



Absolute and relative eye eight (VEYE) as a function of skew for 25” (top) and 20”(bottom) Megtron6 channels.

Channel Simulation- Link Simulation

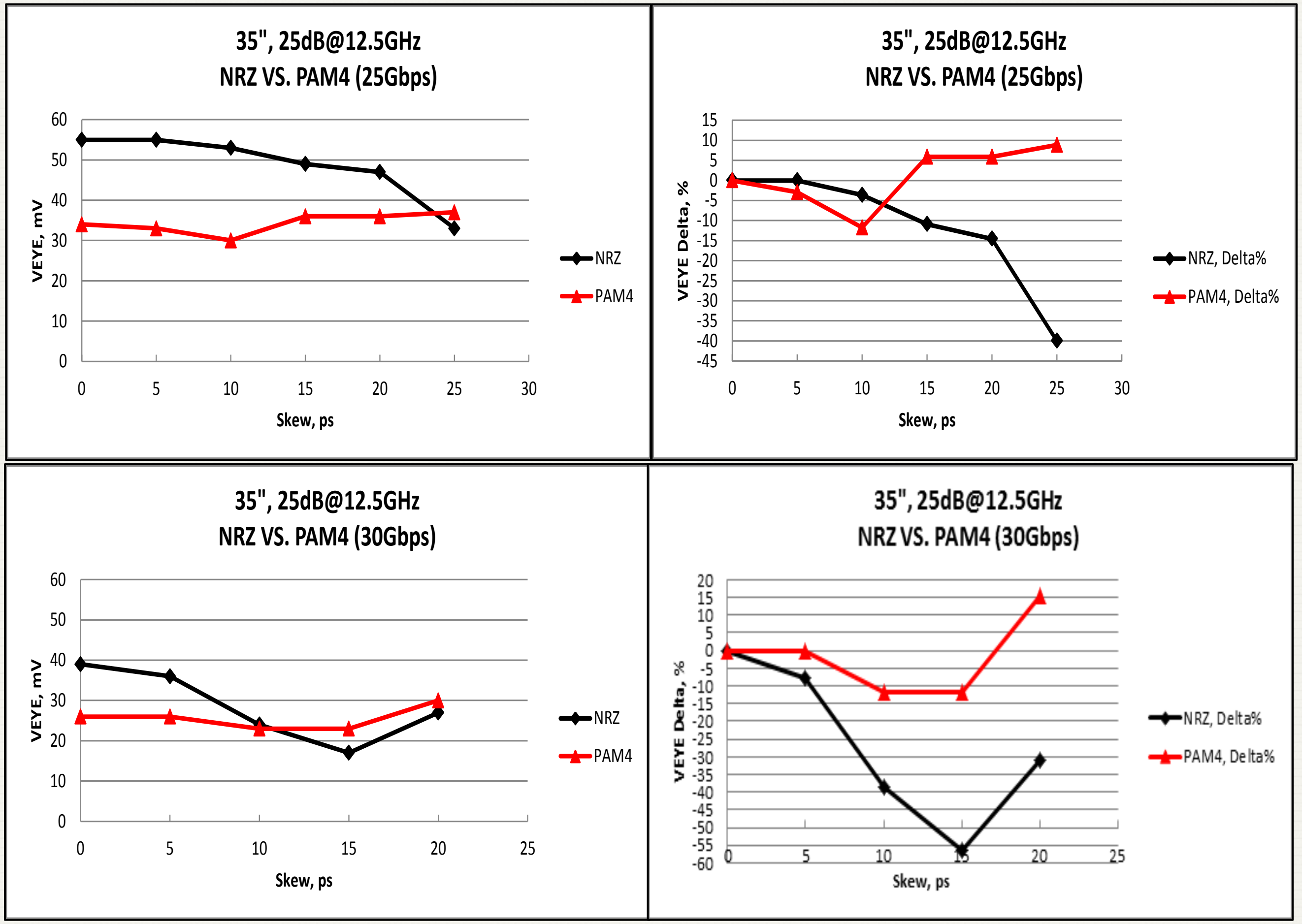


Absolute and relative eye eight (VEYE) as a function of skew for 20” Megtron6 channel simulated with 5 DFE taps.

Channel Simulation- Link Simulation

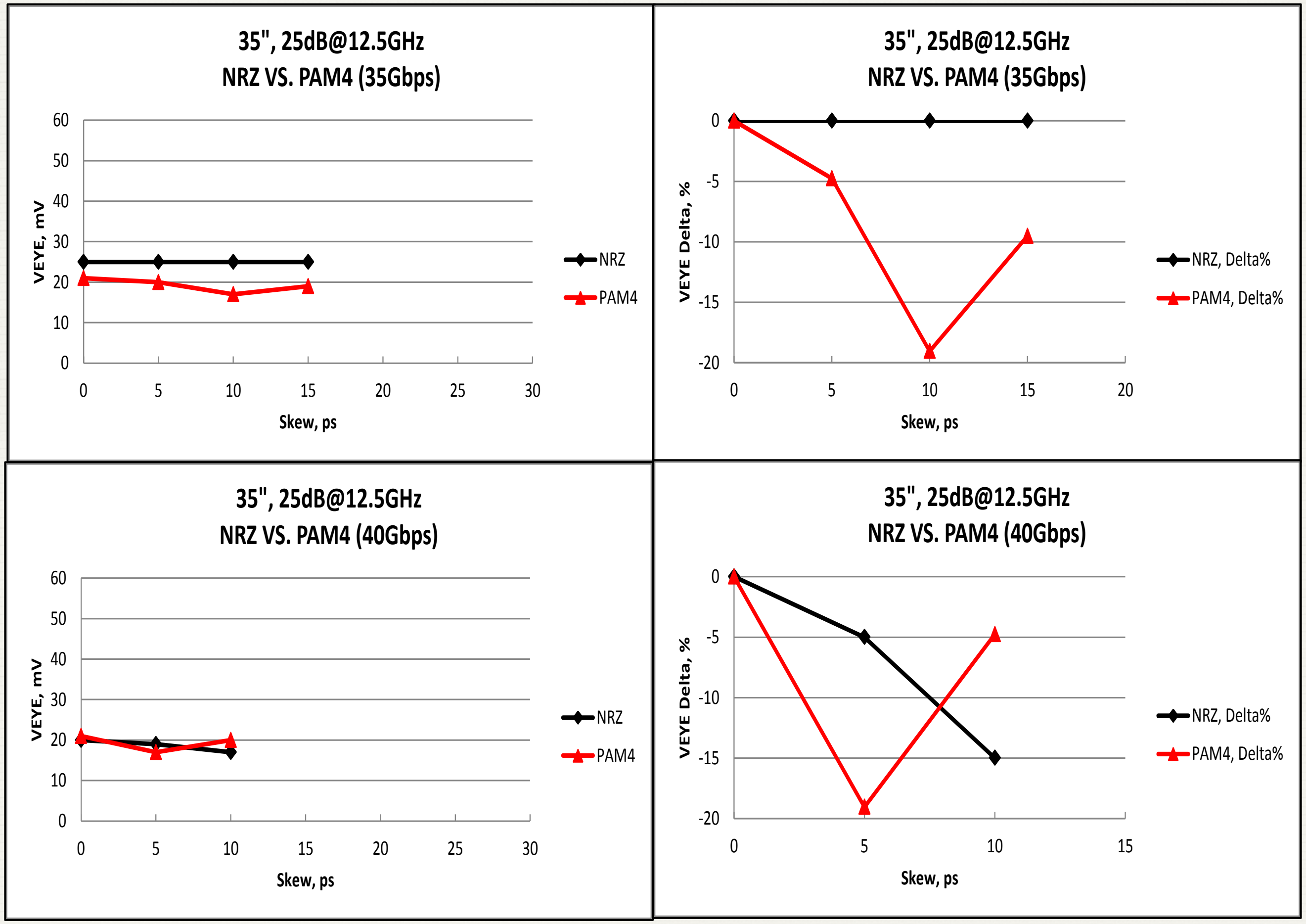
4 DFE

6dB CTLE gain



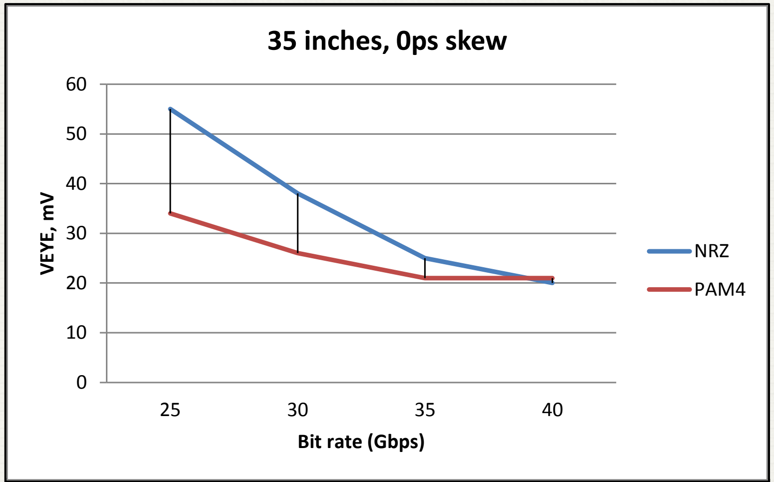
Skew effect in 35” channel operating at 25 Gbps (top) and 30 Gbps (bottom) with NRZ (black) and PAM4 (red).

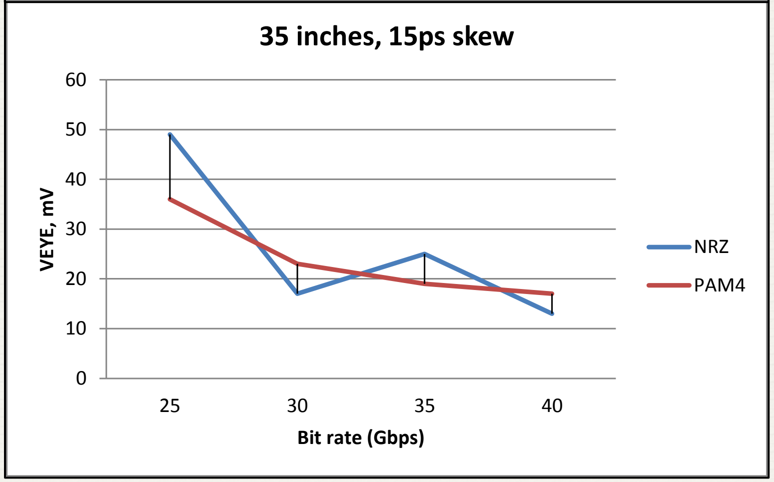
Channel Simulation- Link Simulation



Skew effect in 35” channel operating at 35 Gbps (top) and 40 Gbps (bottom) with NRZ (black) and PAM4 (red).

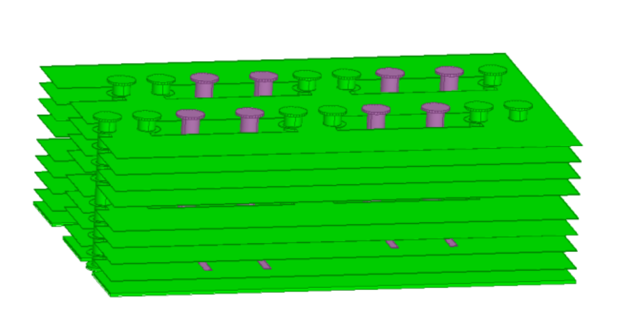
Channel Simulation- Link Simulation

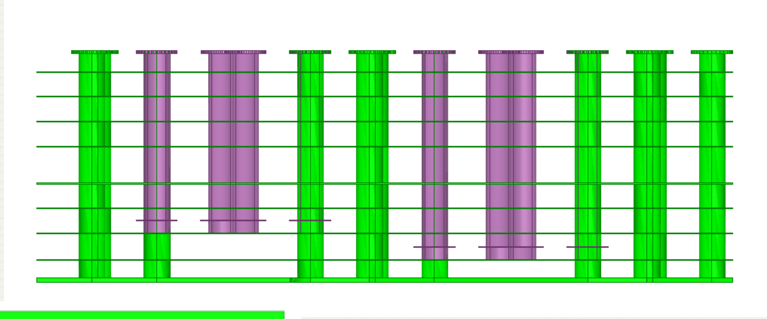




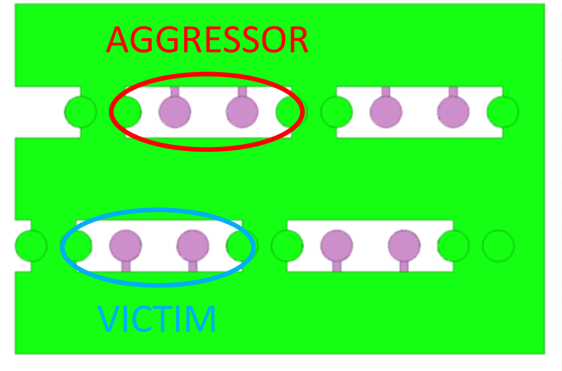
Eye height vs. data rate for 35” channel of 0 (top) and 15 ps (bottom) skew for NRZ (Blue) and PAM4 (red).

Channel Simulation- Link Simulation



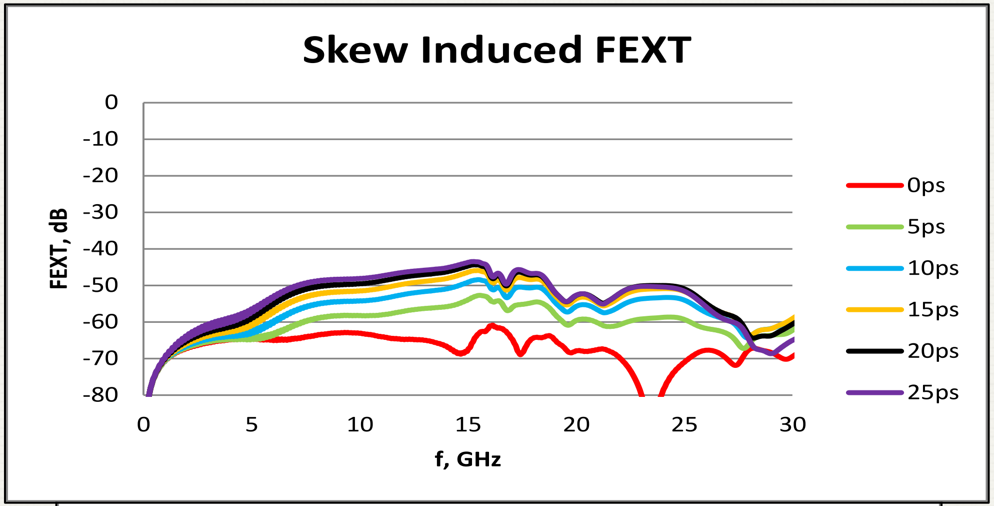


# of Total layers: 20
# of Signal Layers: 8
Height: 3.9mm
Drill Size: 0.45mm
PCB material: Megtron6

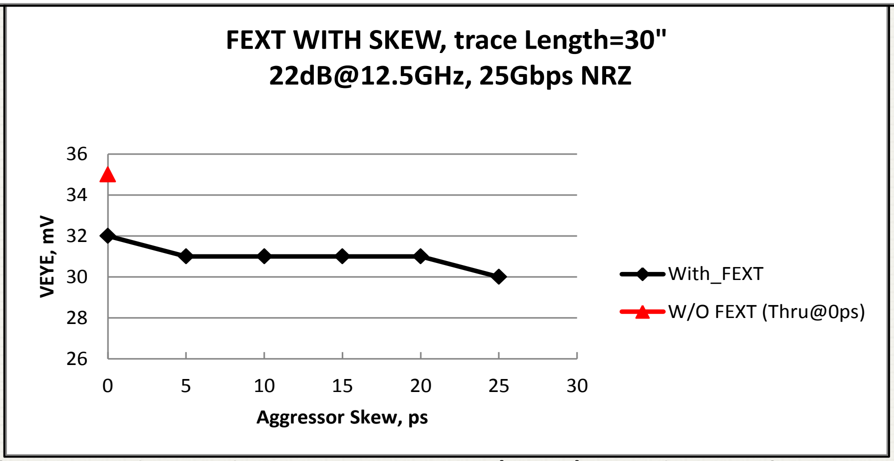


Via and victim/aggressor configurations used for studying the effect of skew in crosstalk.

Channel Simulation- Link Simulation



DC: 5in
BP: 20in



Skew induced excess FEXT (top) and resulting VEYE (bottom) for DC→via→BP→via→DC channel.

Conclusion

- "Unit cell" concept was used to model several configurations of stripline traces.
- Skew from unit cell was scaled up to obtain ps/inch directly from "group delay" values. No S-parameter cascading was necessary.
- Worst case placements of trace over glass laminates were studied.
- For all cases analyzed, a wide range of 0.0006 to 9 ps/inch values for skew were obtained.
- Higher Zcomm reduced skew unless it was countered by the match between trace spacing and weave pitch.
- The lowest skew value was resulted when trace spacing matched the glass weave repetition period.
- Laminate rotation to reduce skew was modeled and re-confirmed to be effective.
- Predicted skew values are far larger than what has ever been measured historically by the authors. This needs to be investigated further.
- 25 Gbps eye height and width simulations suggested that 20 ps of skew can be tolerated, assuming the channels consist of simple traces and low via crosstalk. Effect of CM noise injection, and the consequence of its conversion, was not considered.
- 5ps off max sampling of the eye did produce significant VEYE variations/degradations.
- At 25 Gbps, there may be an advantage in applying PAM 4 over NRZ with respect to the change in signal degradation but not absolute VEYE.
- Skew increased the crosstalk noise between two offset coupled differential via structures, but the eye degradation was insignificant for sufficient S/N margin.

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