CAUI-4 Chip to Chip Simulations

IEEE 802.3bm Task Force

Ali Ghiasi

Broadcom Corporation

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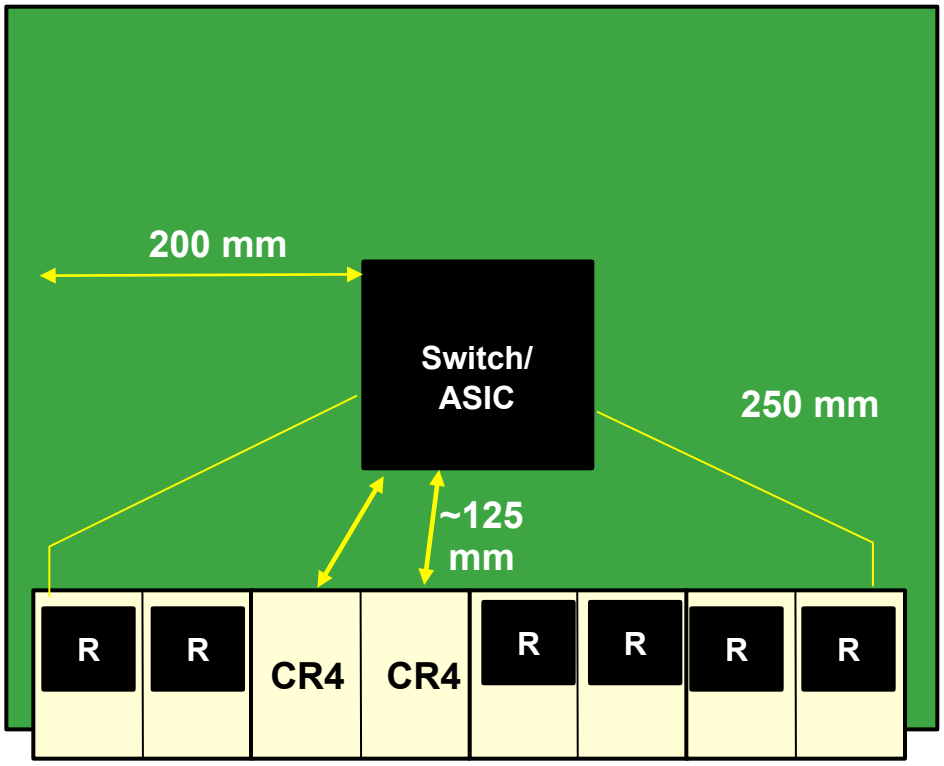
Phoenix

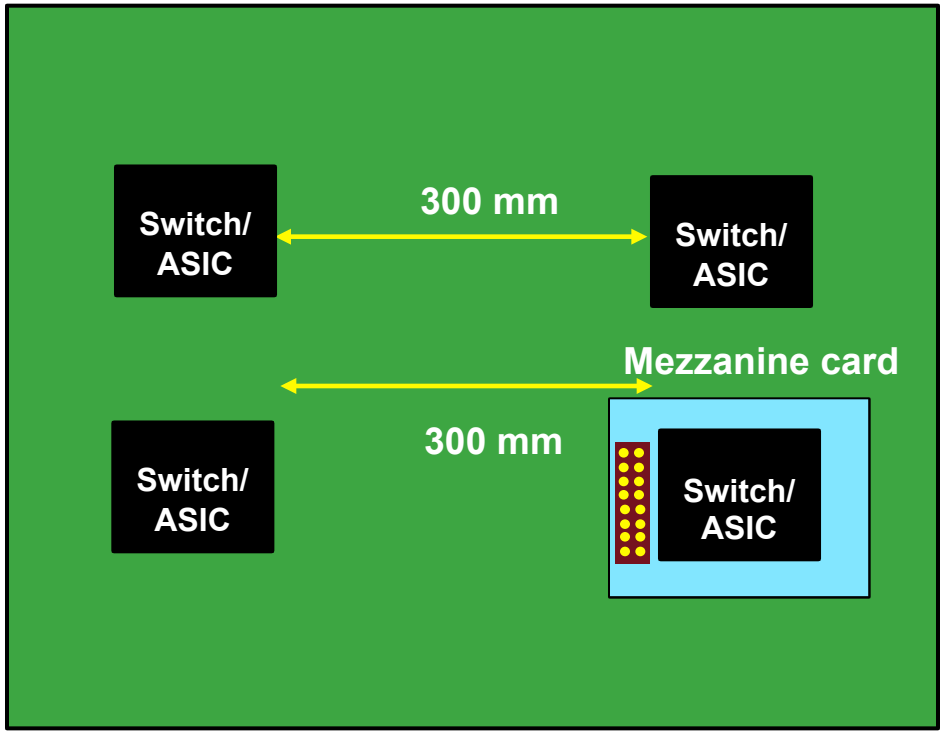
Overview

- A CAUI-4 chip to chip link with 20 dB loss budget require DFE receiver and to avoid MTTFPA capability similar to 100Gbase-K4 is required
  - Based on the above limitation turning down some of the bj KR4 capability is the best option
  - MTTFPA was studied in great details in the bj group http://www.ieee802.org/3/bj/public/may12/cideciyan_01_0512.pdf
- The CAUI adhoc conclusion has been if FEC is required for the 20 dB channel based on DFE receiver to address MTTFPA then turning off KR4 capability is better choice than defining another KR4 like interface
  - Based on these limitation and the market need for higher than 10 dB loss budget, a CTLE receiver with up to 15 dB loss is explored.

CAUI-4 Applications and Background

- http://www.ieee802.org/3/bj/public/jul12/ghiasi_02a_0712.pdf identified CAUI-4 applications as well as limitations
  - As result of MTTFPA, non-symmetrical interface is not an option unless module retiemr has FEC capability
  - Supporting 300 mm link require SerDes with bj KR4 capability
  - Is it really worth defining bj-KR4 link with 20 dB loss budget?





PCB Reach for Various Interfaces

- PCB loss estimate assumptions and tools for calculation
  - IEEE 803.bj spreadsheet http://www.ieee802.org/3/bj/public/tools/DkDf_AlgebraicModel_v2.02a.xlsm for N4000-13SI and Megtron-6 calculation
  - Rogers Corp impedance calculator (free download but require registration) https://www.rogerscorp.com/acm/technology/index.aspx for FR4-6 and N4000-13
  - Stripline ~ 50 Ω, trace width is 5 mils, and with ½ oz Cu
  - Surface roughness med per IEEE spreadsheet or 2.8 um RMS
  - FR4-6 DK=4.2 and DF=0.02, N4000-13 DK=3.6 and DF=0.014, N4000-13SI and Meg-6 per IEEE spreadsheet

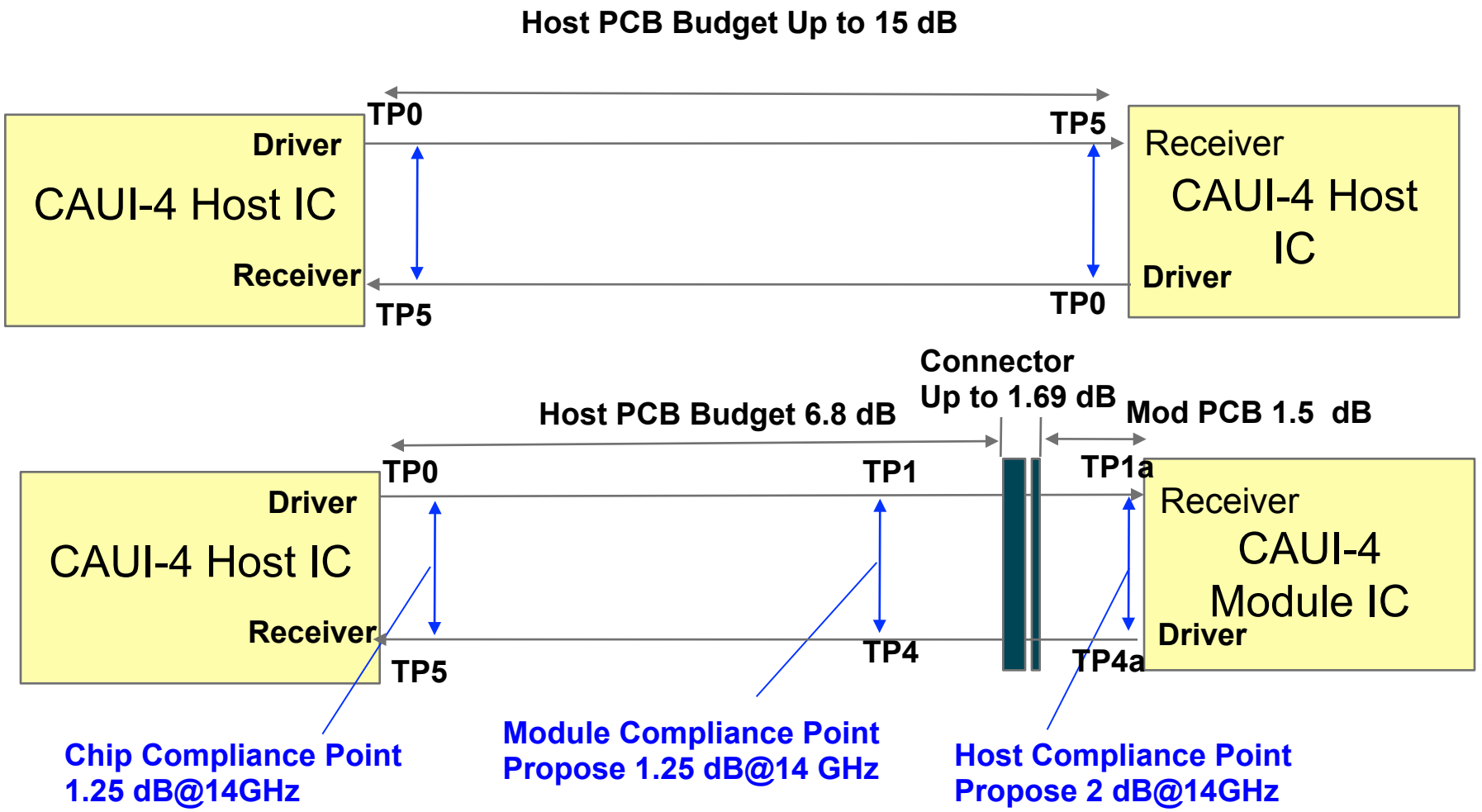
Host Trace Length (in)	Total Loss (dB)	Host Loss(dB)	FR4-6	N4000-13	N4000-13SI	Megtron 6
Nominal PCB Loss/in at 5.15 GHz	N/A	N/A	1.00	0.79	0.56	0.43
Nominal PCB Loss/in at 12.89 GHz	N/A	N/A	2.00	1.60	1.25	0.92
CAUI Classic	10.5	6.81	6.8	8.6	12.2	15.8
PPI CL85A/86A with one connector & HCB#	6.5	4.37	4.4	5.5	7.8	10.2
CAUI-4 with one connector & HCB*	10.5	6.81	3.4	4.3	5.4	7.4
802.3bj CL92A with one connector & HCB *	10.5	6.81	3.4	4.3	5.4	7.4
CAUI-4 Chip to Module	10	10	5.0	6.3	8.0	10.9
CAUI-4 Chip to Chip	13	13	6.5	8.1	10.4	14.1
CAUI-4 Chip to Chip	15	15	7.5	9.4	12.0	16.3
OIF 28G-MR	20	20	10.0	12.5	16.0	21.7

Assumes connector loss is 0.87 dB and HCB loss is 1.26 dB at 5.5 GHz.

* Assumes connector loss is 1.69 dB and HCB loss is 2.0 dB at 12.89 GHz.

CAUI-4 Architecture and Reference Points

- The bm group need to further study CAUI-4 chip to chip application

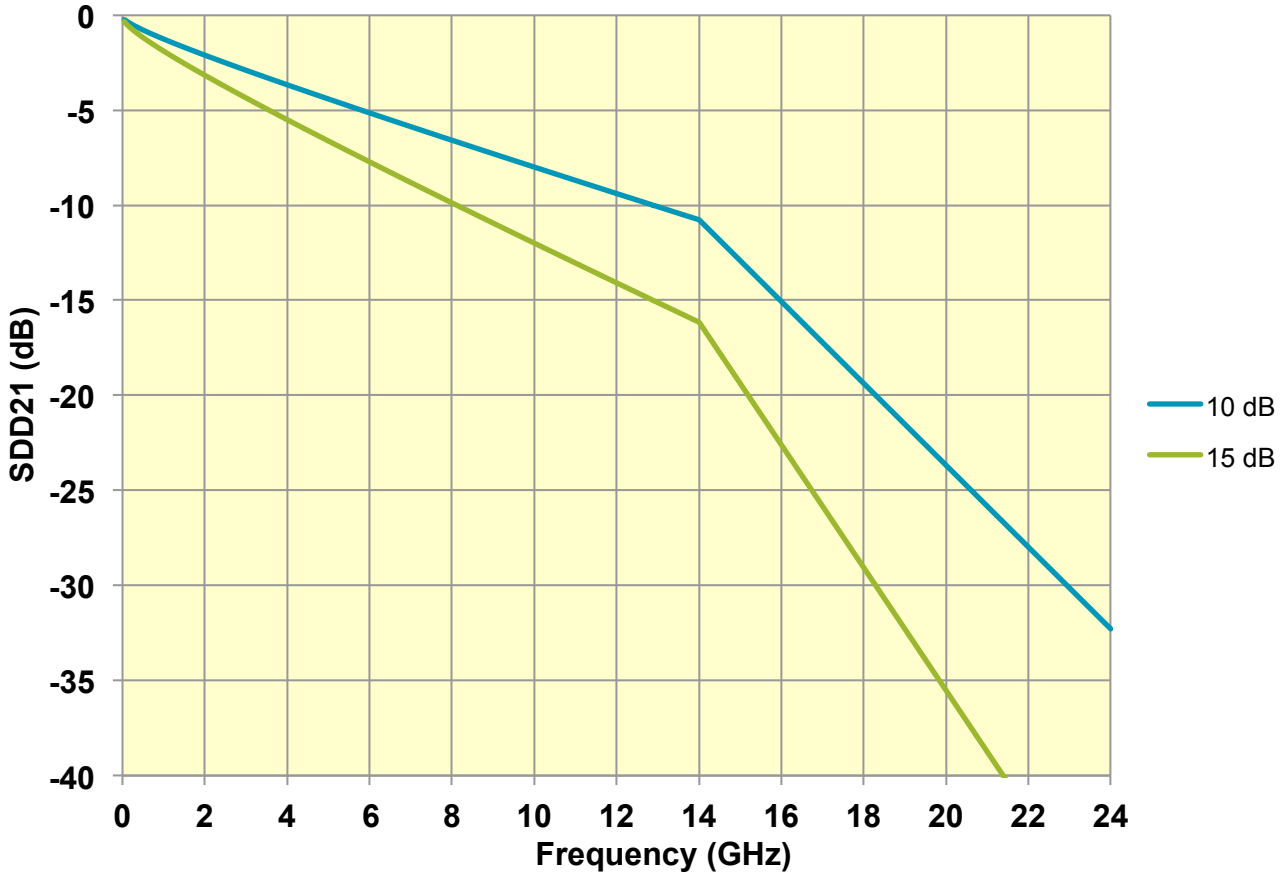


Increasing CAUI-4 Chip to Chip Reach

- Parameters that can increases CAUI-4 chip to chip reach
- Transmitter parameters and exact parameter that can be improved is dependent if this is large ASIC or PHY
  - Rise/fall time – can be made as fast as the min rise/fall time
  - Jitter - could lowered by ~0.1 UI
  - Amplitude - min value can be increased up to 900 mV
  - Return loss – no change
- Channel parameters
  - ILD – template to trade off loss vs ILD
  - ICN – template to trade off loss vs ICN
  - Loss a1 coefficient – needs to be control and only an issue with fat traces on low loss material or super low loss PTFE material
  - Return loss – no change
- Receiver parameters
  - CTLE gain 1-9 dB – no change
  - Sensitivity – to be studied if it needs to improved from 100 mV
  - Return loss – no change

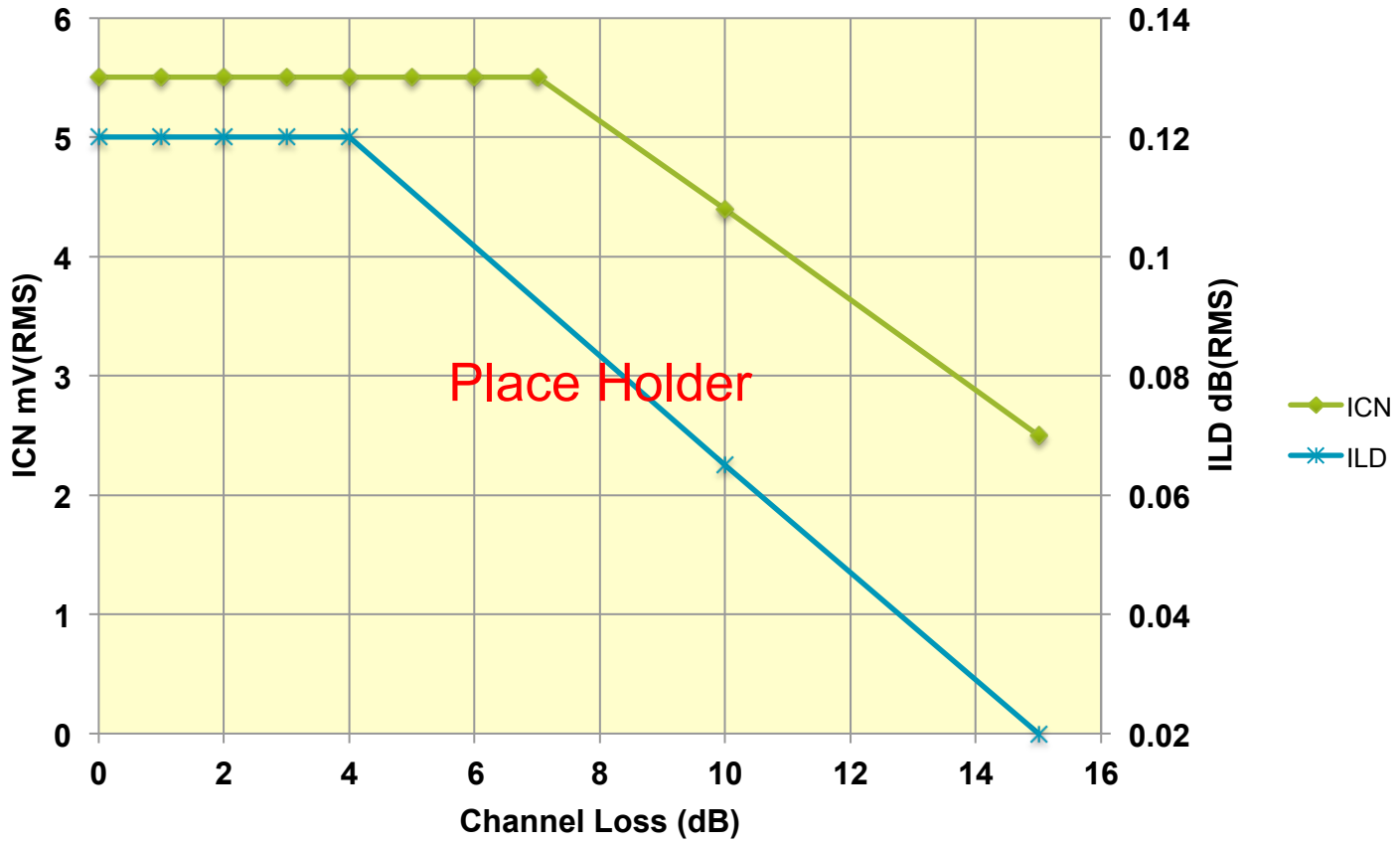
CAUI-4 Chip to Chip Informative Channel

- CAUI-4 chip to chip loss budget
  - By improving some of the transmitter parameters and operating the link where naturally has lower ICN/ILD the loss budget can be 15 dB



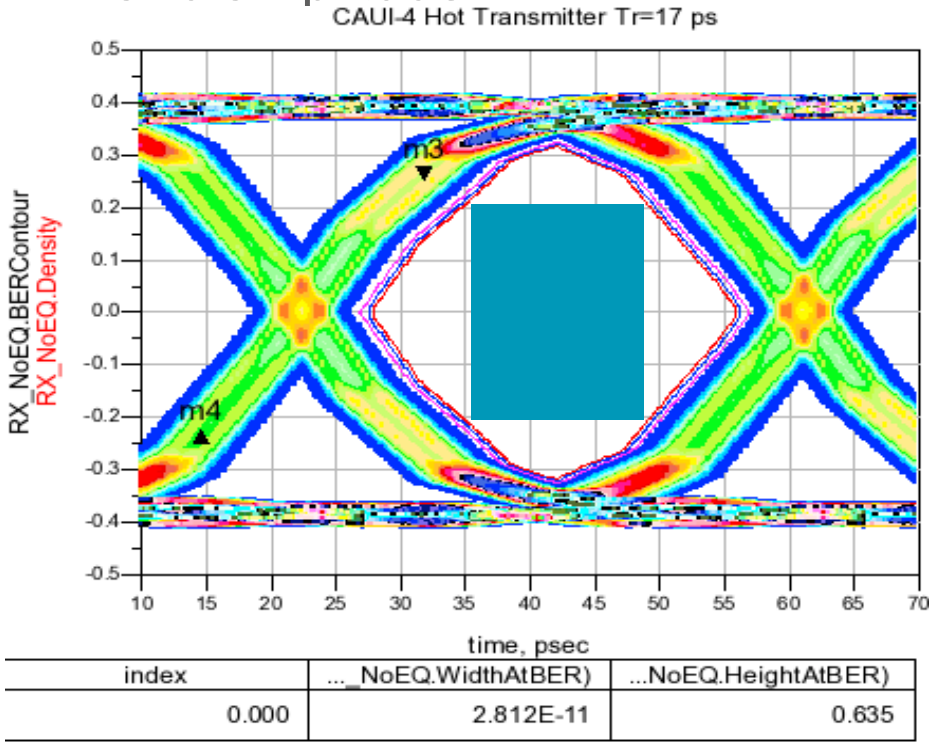
Do we need ILD and ICN?

- Far end eye simulation using commercial tools or COM could determine channel compliance instead of individual parameters not always guaranteeing far end compliance



CAUI-4 Driver

- Define Hot driver with standard jitter but 800 mV output
  - Tr=17 ps TJ=0.28 UI@1E-15
- Define Fast-low jitter with 600 mV output
  - Tr=13ps TJ=0.18 UI@1E-15
- Eye mask at TP0a can provide flexibility to trade off rise time, jitter, and amplitude



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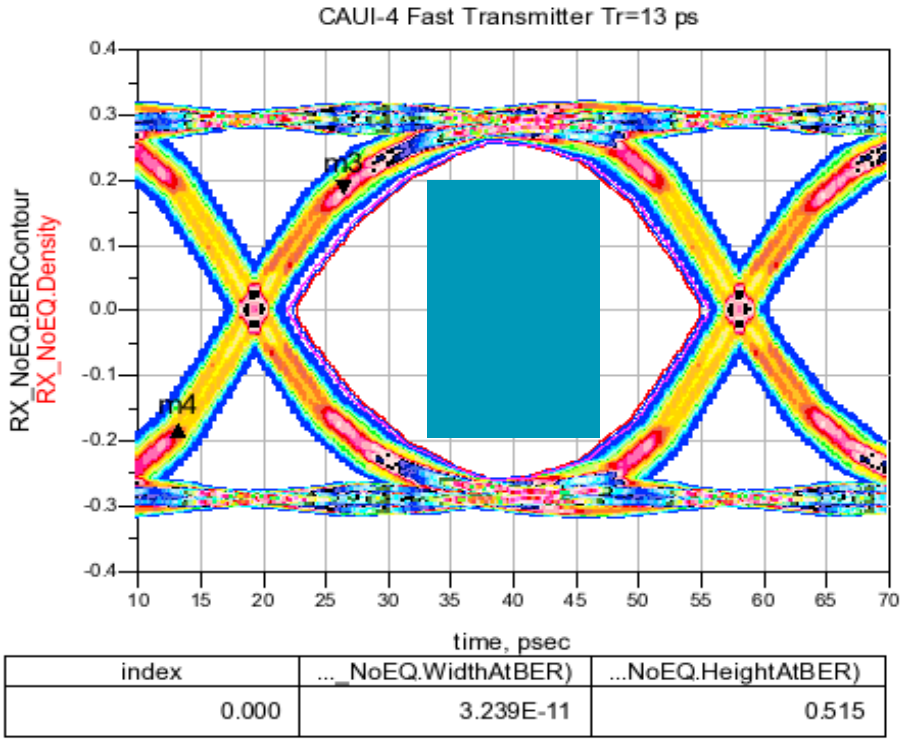

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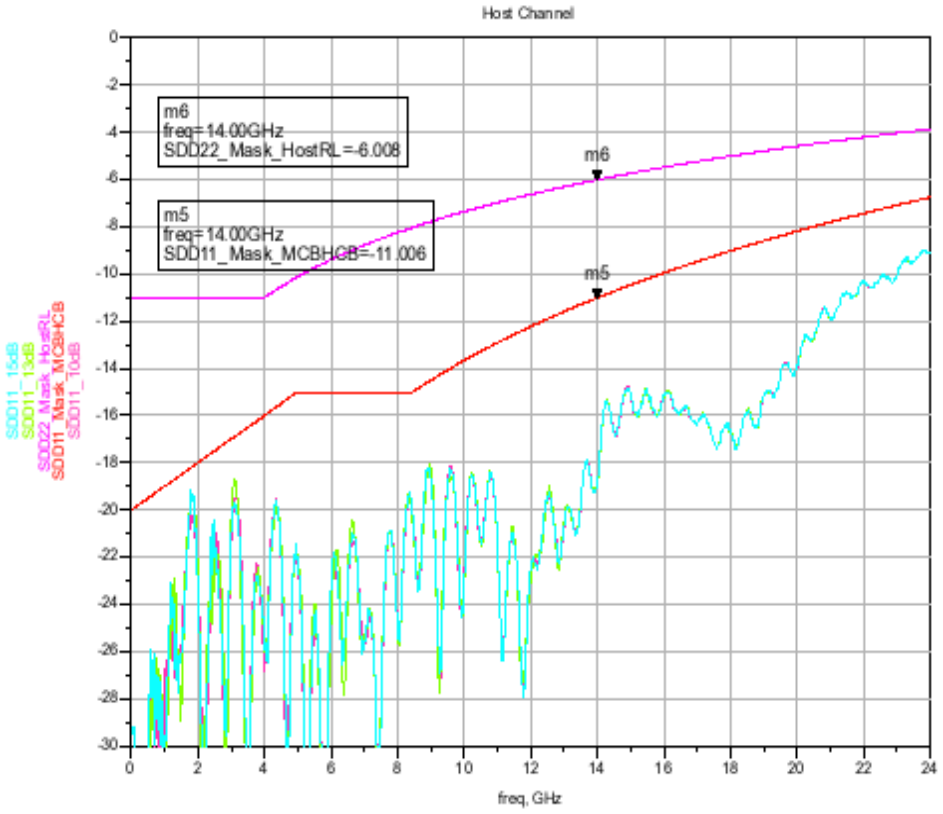
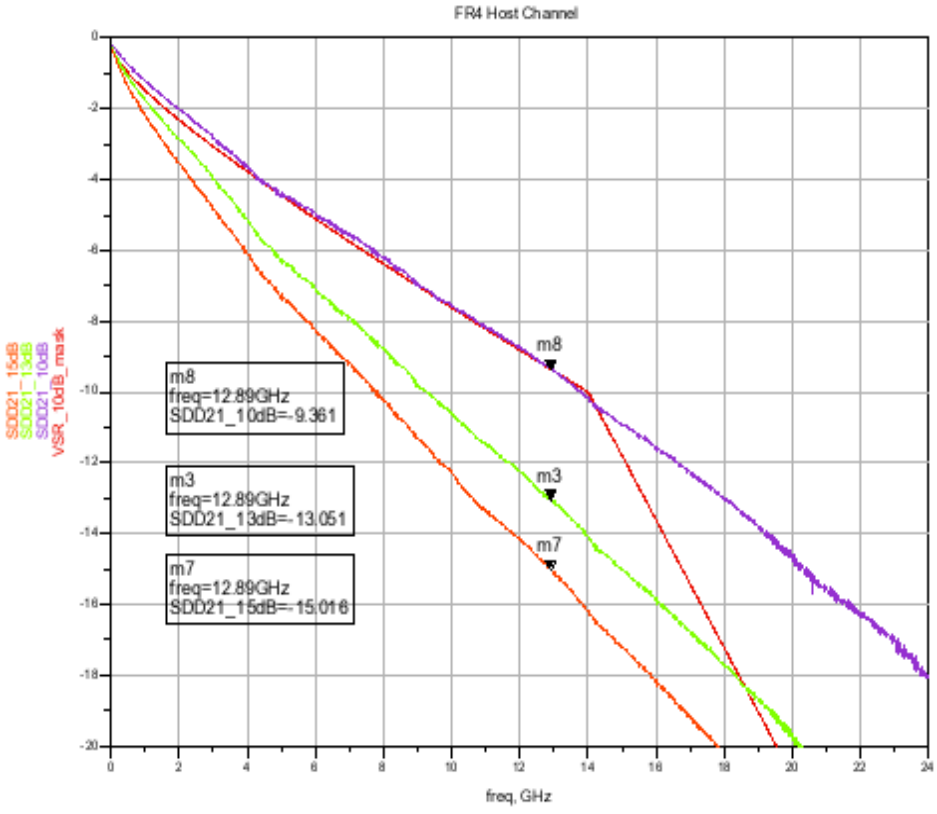
FR4 Channel Response

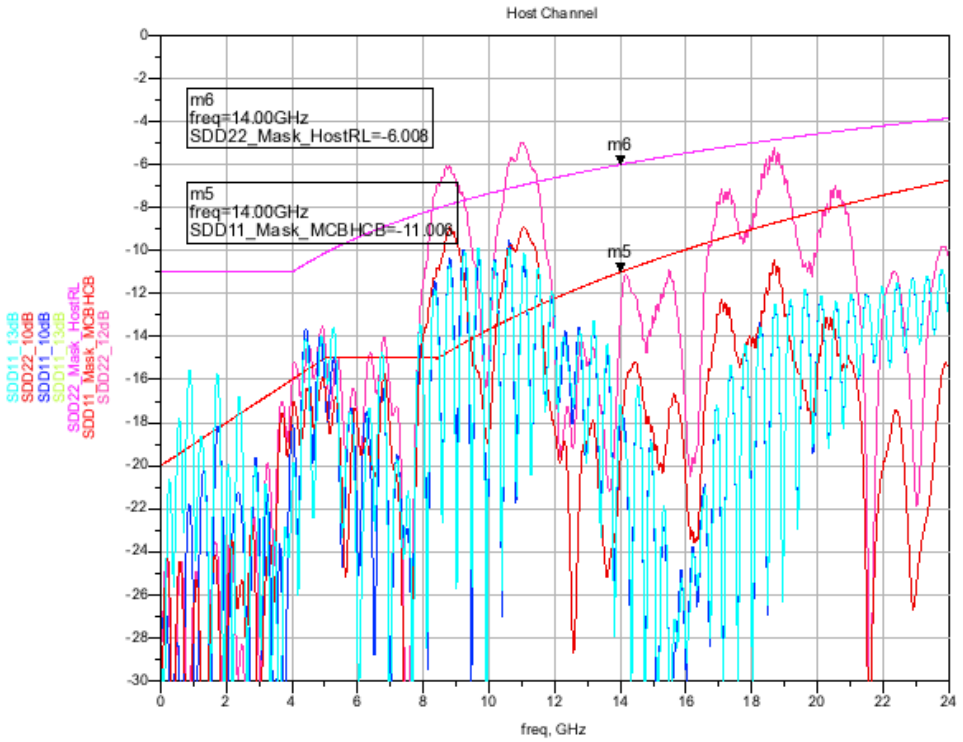
- Channels are
  - 5” FR4 Channel with two long (80 mils) vias and 2 12 mils stub
  - 5” FR4 + 3” Meg6 Channel
  - 5” FR4 + 5” Meg 6 Channel

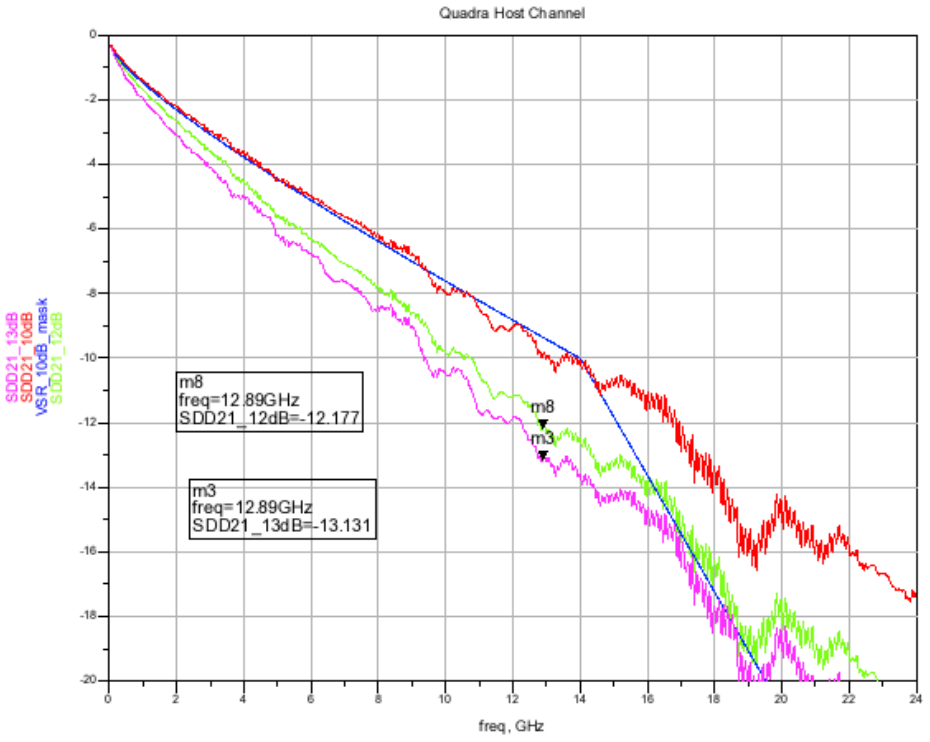




TE 7” Quadra Channel Response

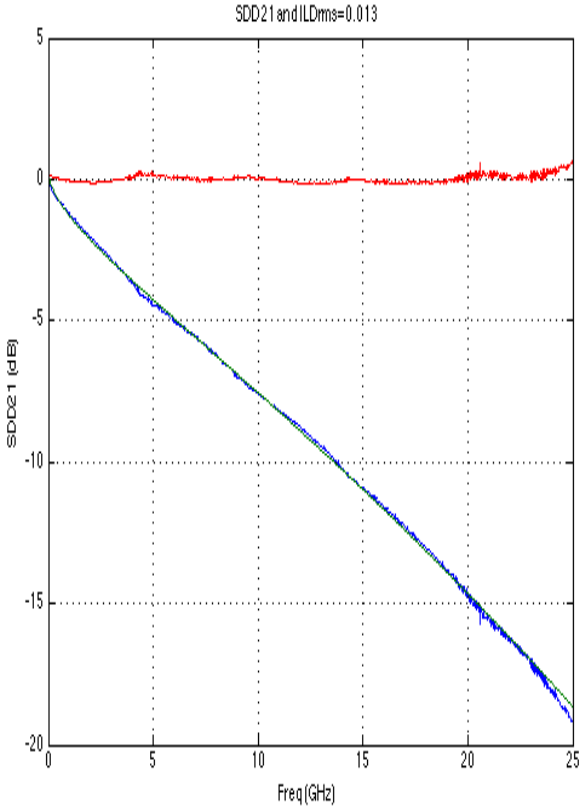
- Channels are
  - TE Quadra channel with 10 dB loss
  - TE 7” Quadra + 1.25” plug board+ 2” Meg6 Channel
  - TE 7” Quadra + 1.25” plug board + 2” FR4 Channel

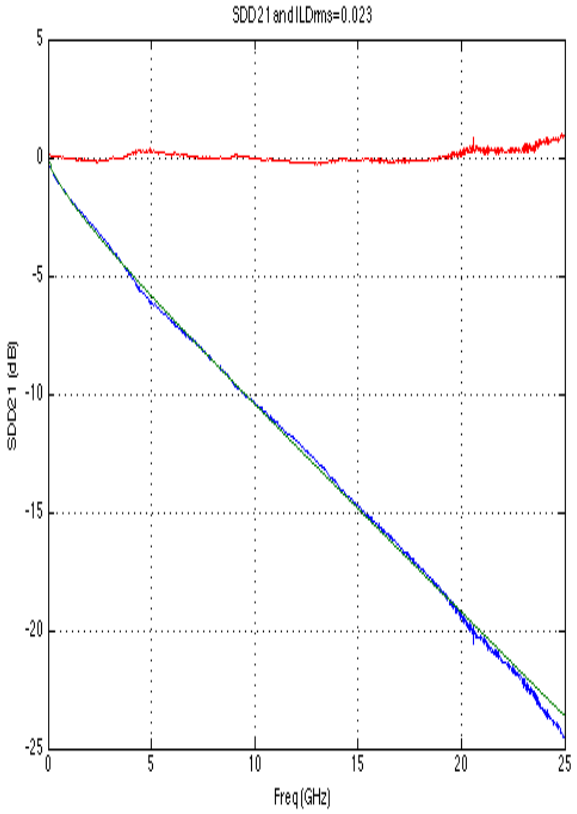


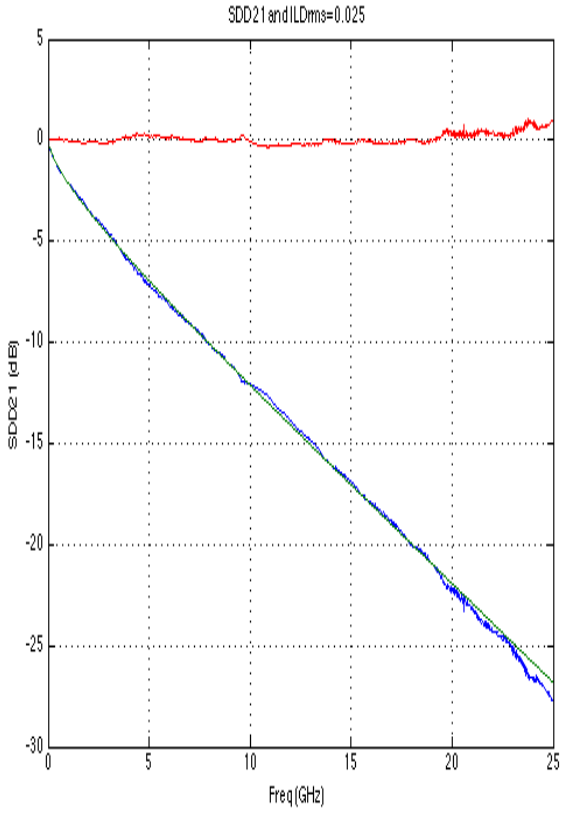


FR4 Channel ILD and Fit

- 10 dB channel has ILDrms=0.013 and a1/a0=0.23
- 13 dB channel has ILDrms=0.023 and a1/a0=0.59
- 15 dB channel has ILDrms=0.025 and a1/a0=0.46

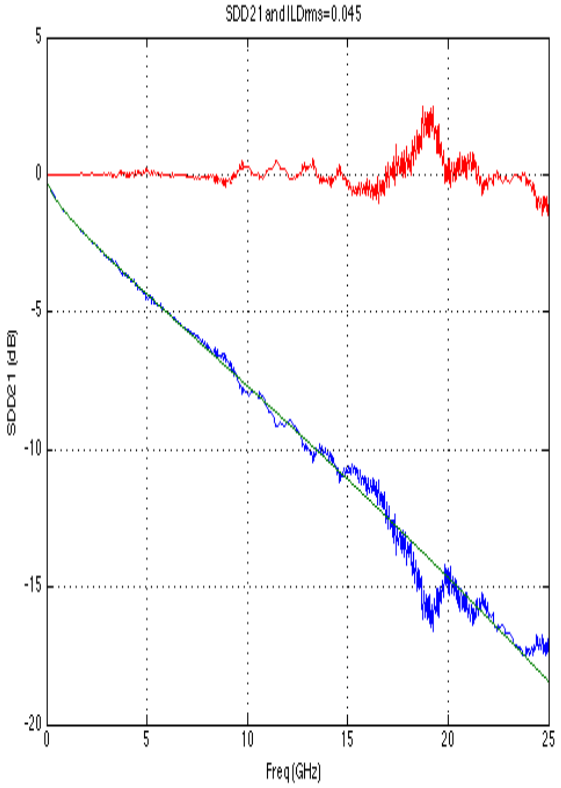


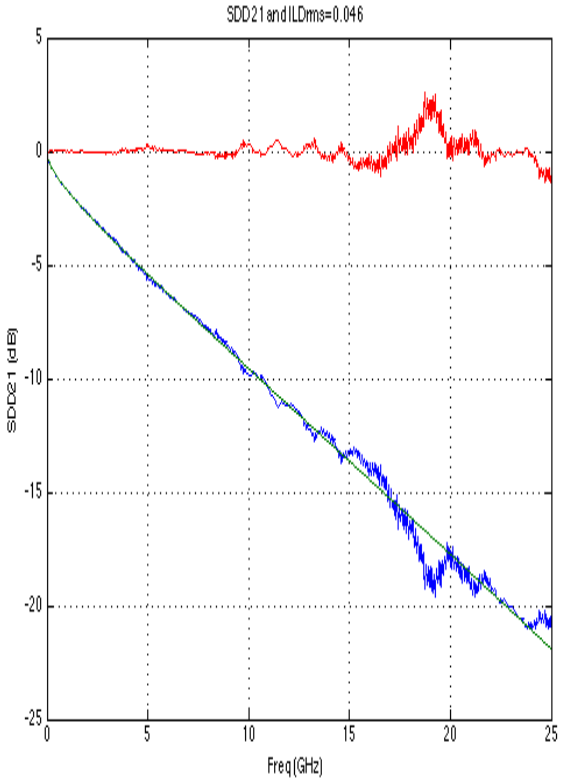


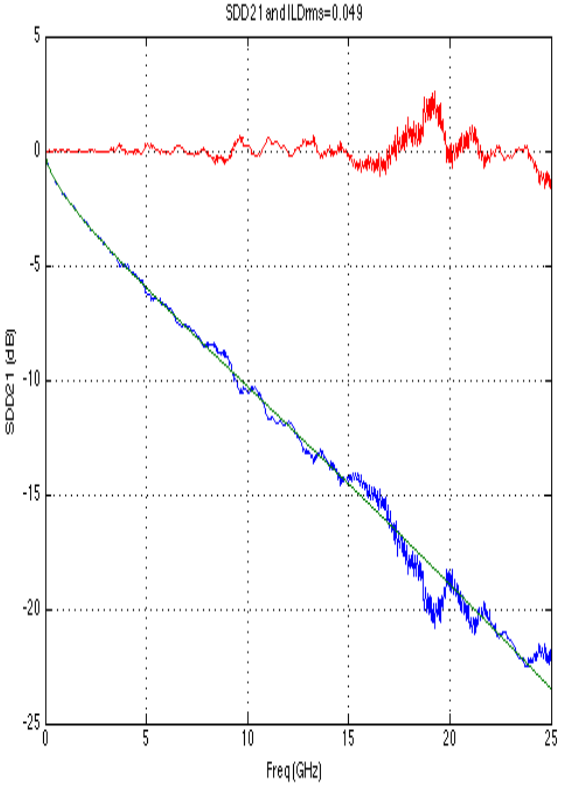


TE Quadra Channel ILD and Fit

- 10 dB channel has ILDrms=0.045 and a1/a0=0.45
- 12 dB channel has ILDrms=0.046 and a1/a0=0.62
- 13 dB channel has ILDrms=0.049 and a1/a0=0.34

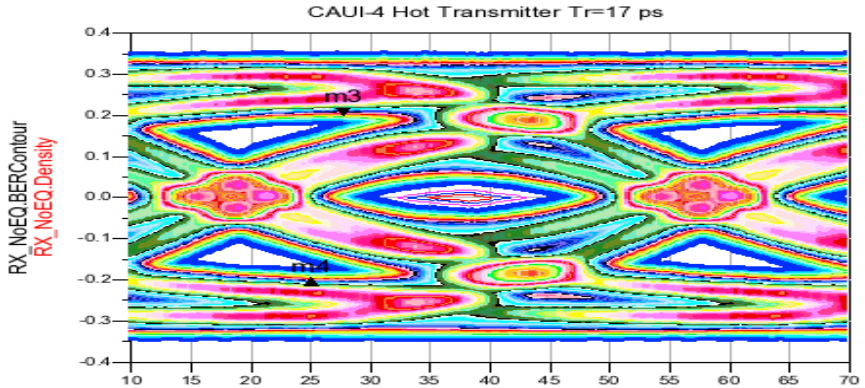






10 dB FR4 Channel with Hot and Fast Transmitter

- Optimum TX de-emphasis 1 dB for both TX



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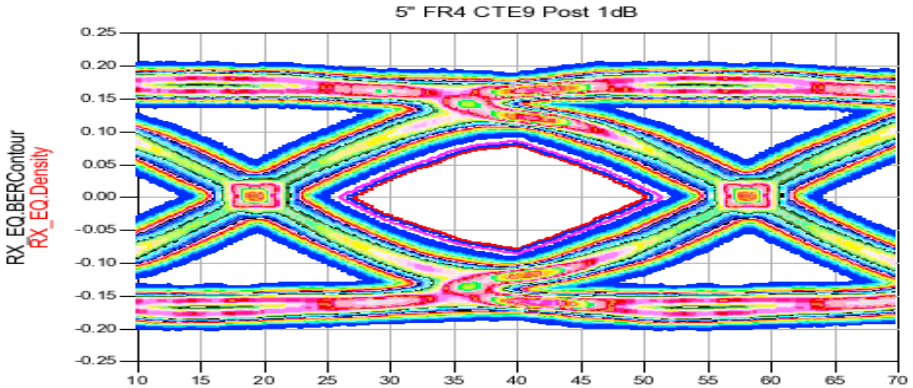

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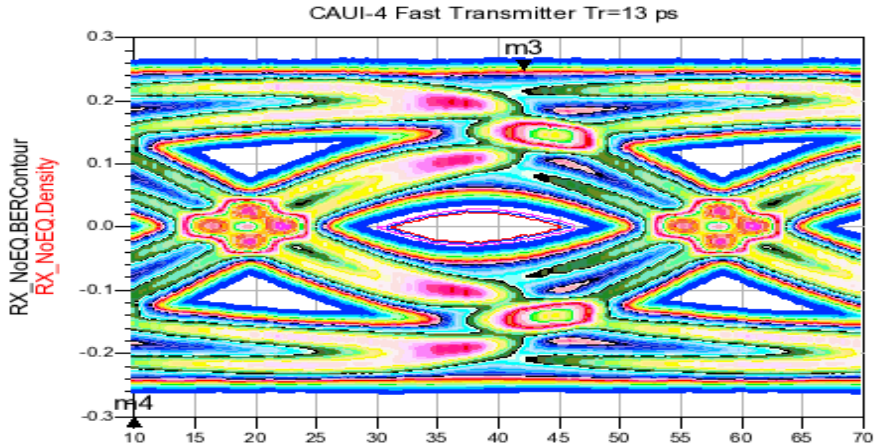

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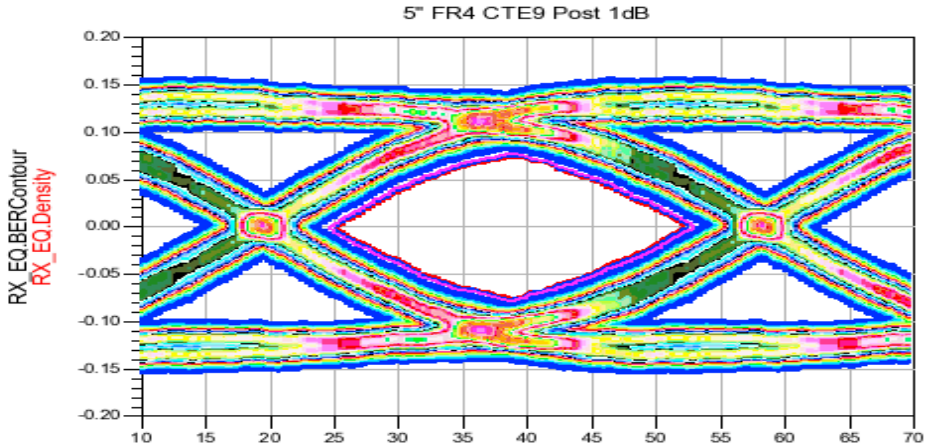

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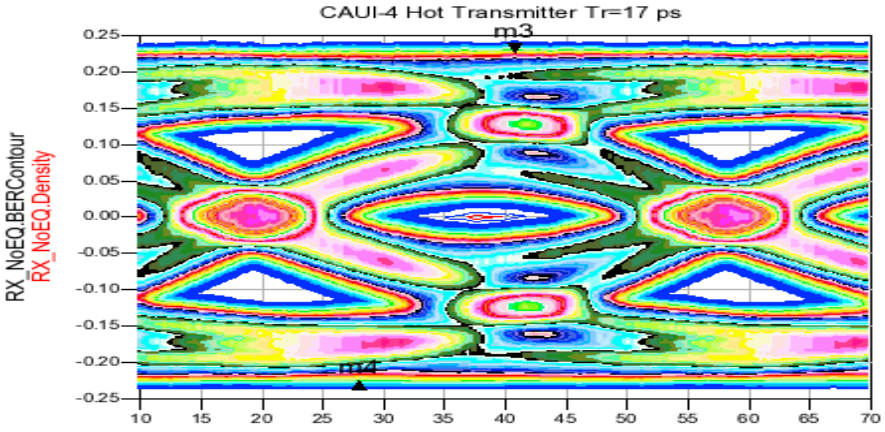
13 dB FR4 Channel with Hot and Fast Transmitter

- Optimum TX de-emphasis 4 dB for hot and 3 dB for fast TX



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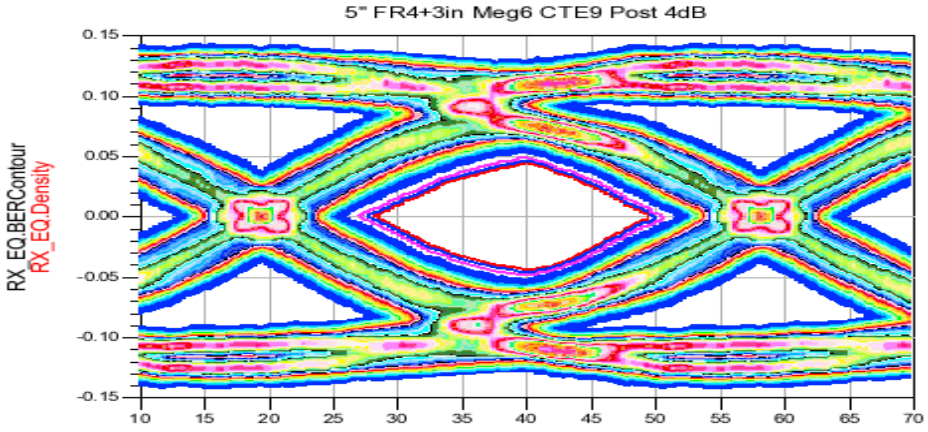

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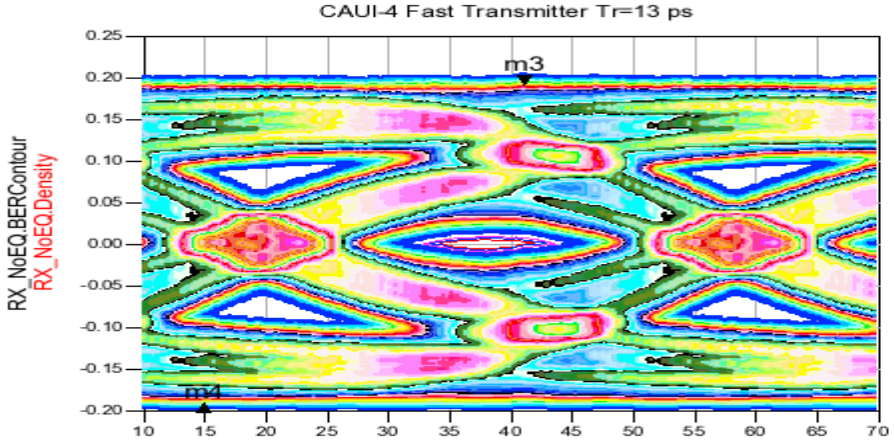

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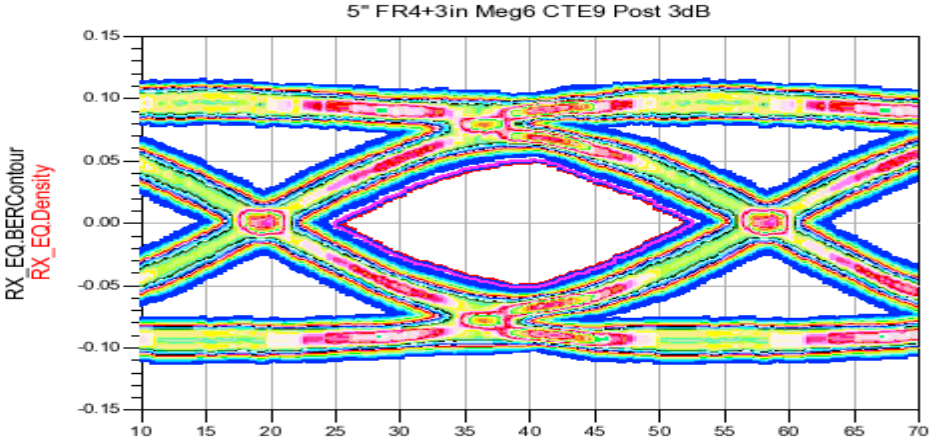

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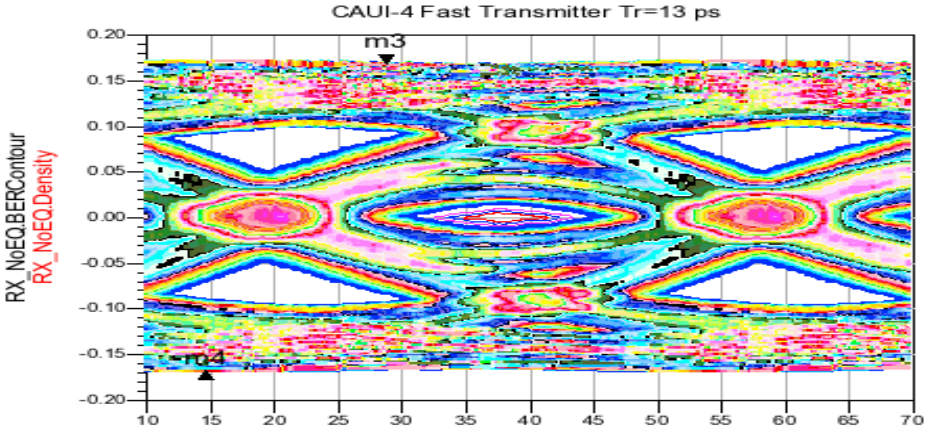
15 dB FR4 Channel with Hot and Fast Transmitter

- Optimum TX de-emphasis 6 dB for hot and 6 dB for fast TX



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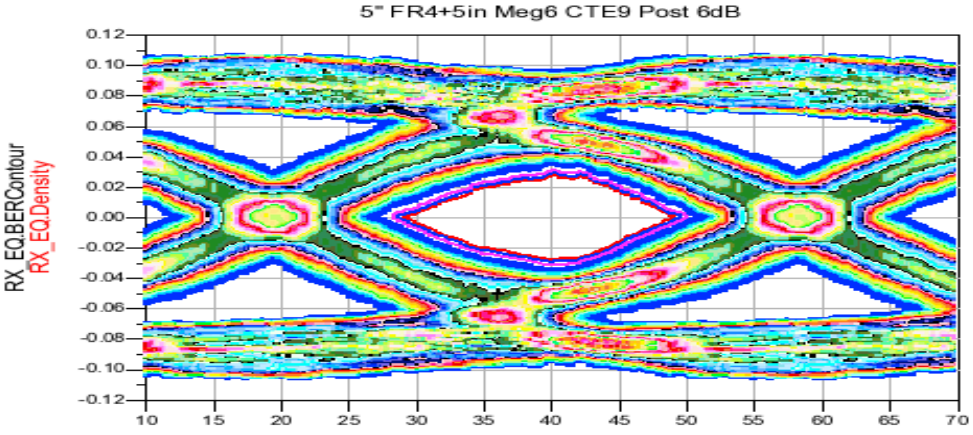

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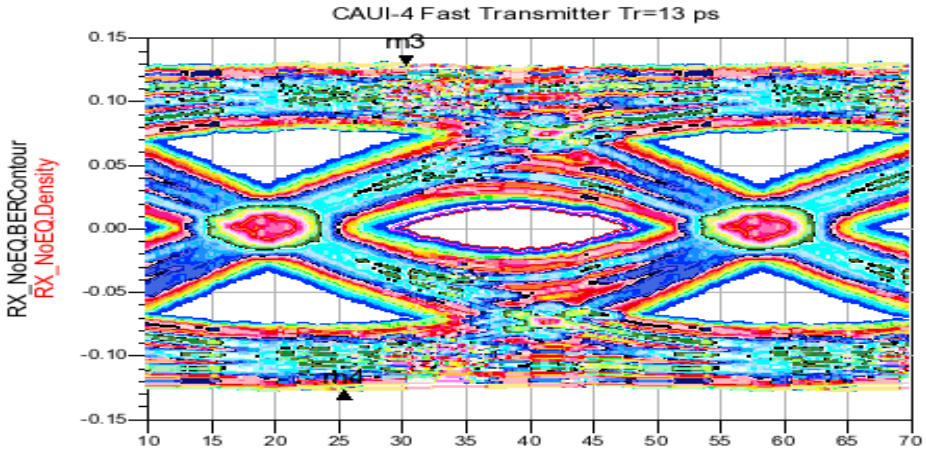

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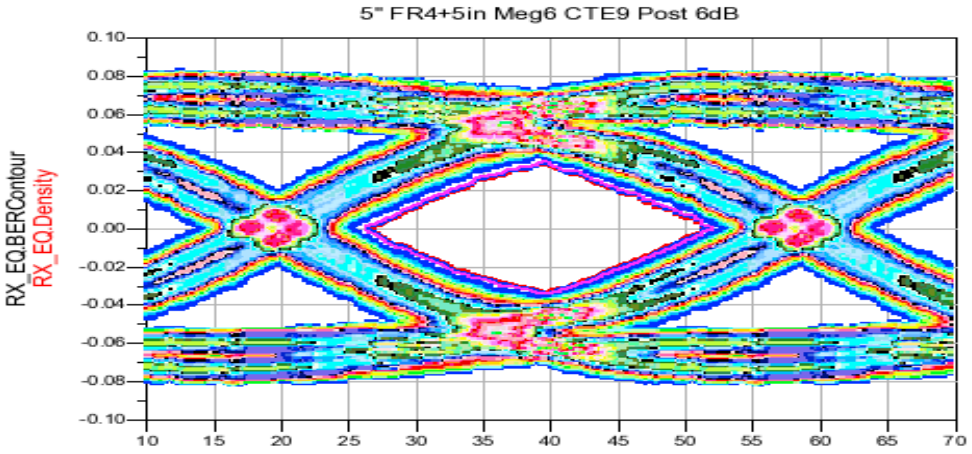

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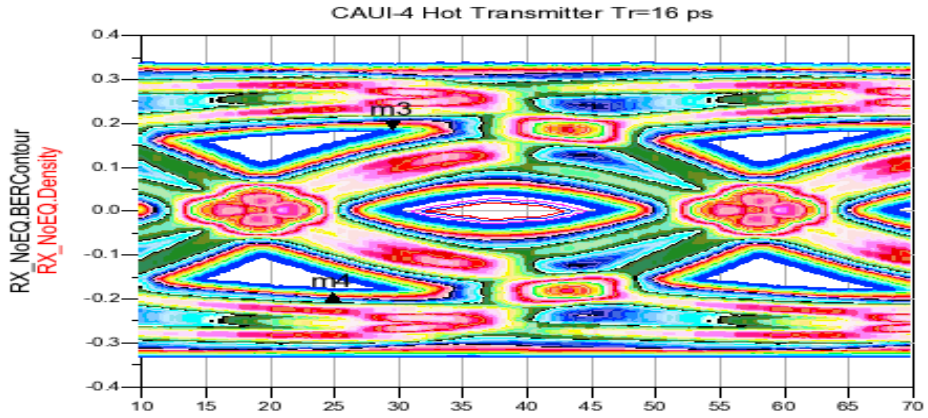
8.25” TE Quadra Channel with Hot and Fast Transmitter

- Optimum TX de-emphasis 6 dB for hot and 6 dB for fast TX



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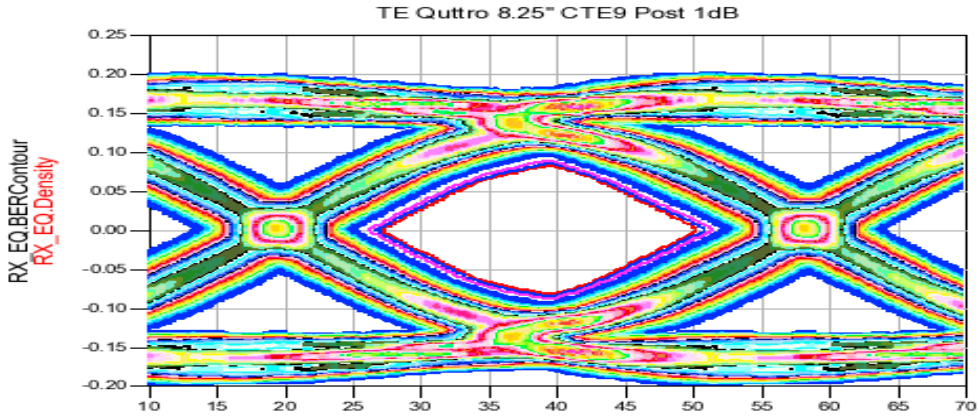

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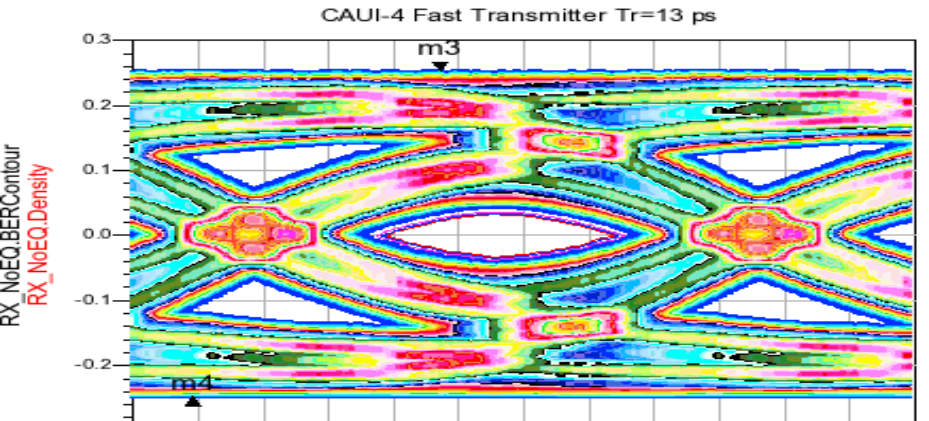

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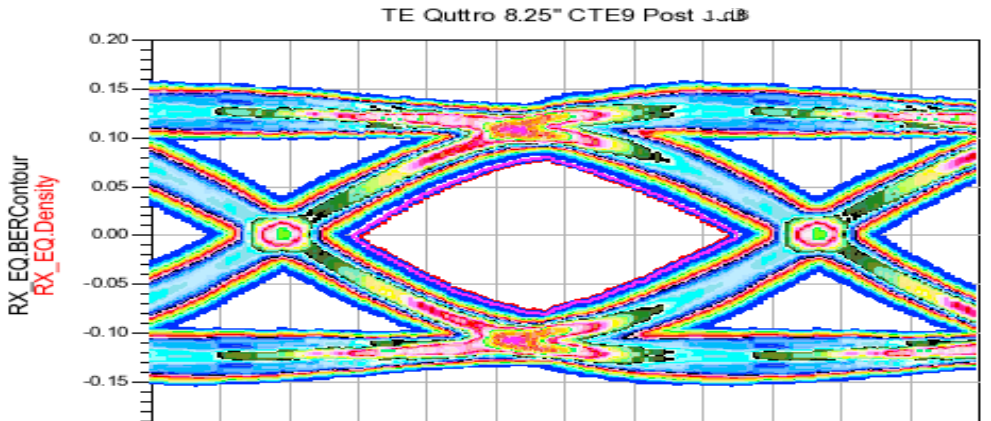

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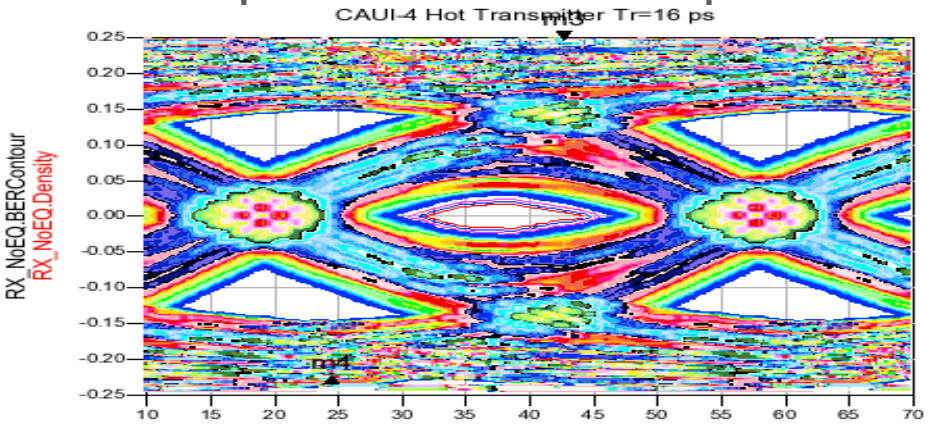
8.25” TE Quadra Channel + 2dB with Hot and Fast Transmitter

- Optimum TX de-emphasis 6 dB for hot and 6 dB for fast TX



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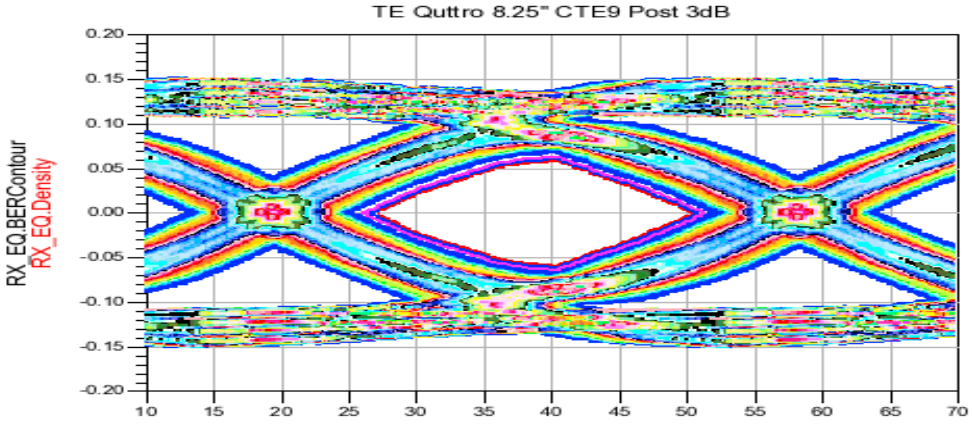

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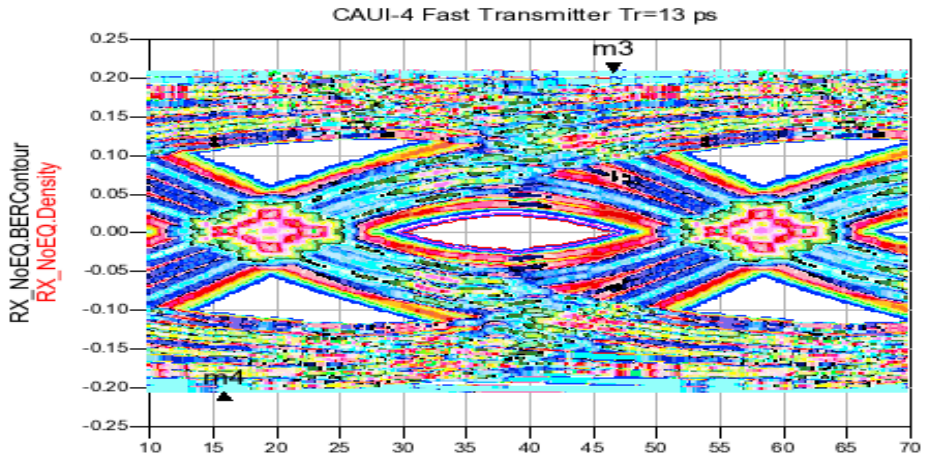

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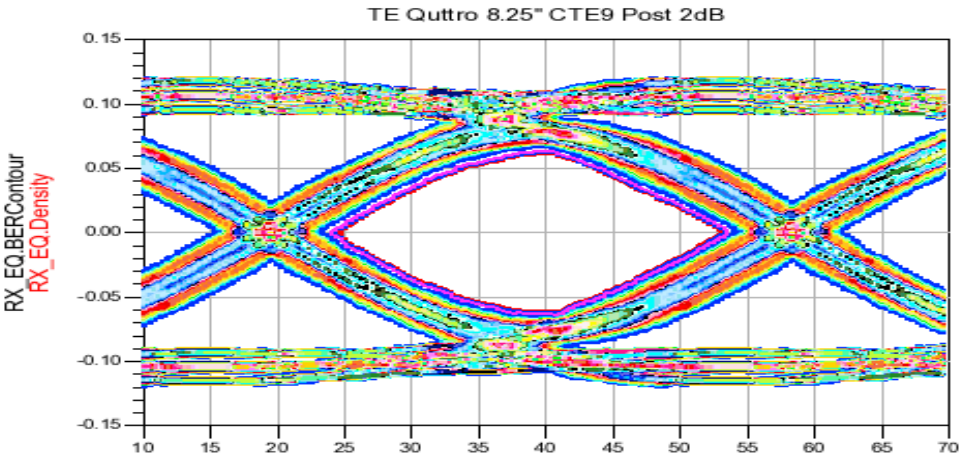

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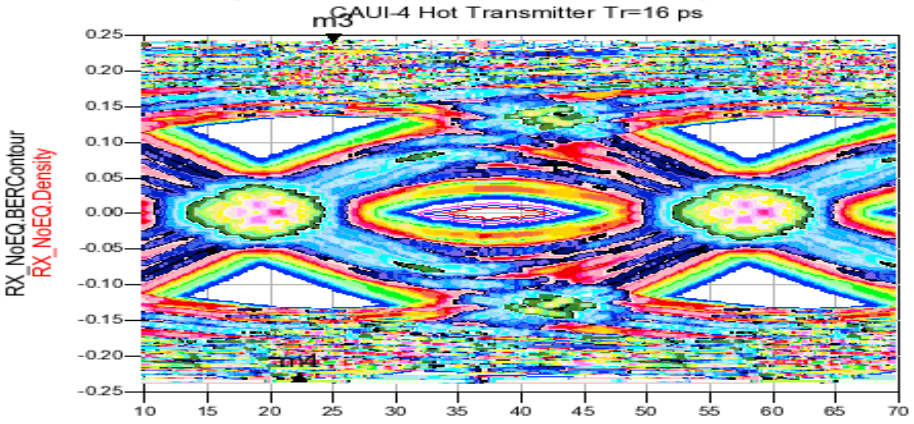
8.25” TE Quadra Channel + 3dB with Hot and Fast Transmitter

- Optimum TX de-emphasis 6 dB for hot and 6 dB for fast TX



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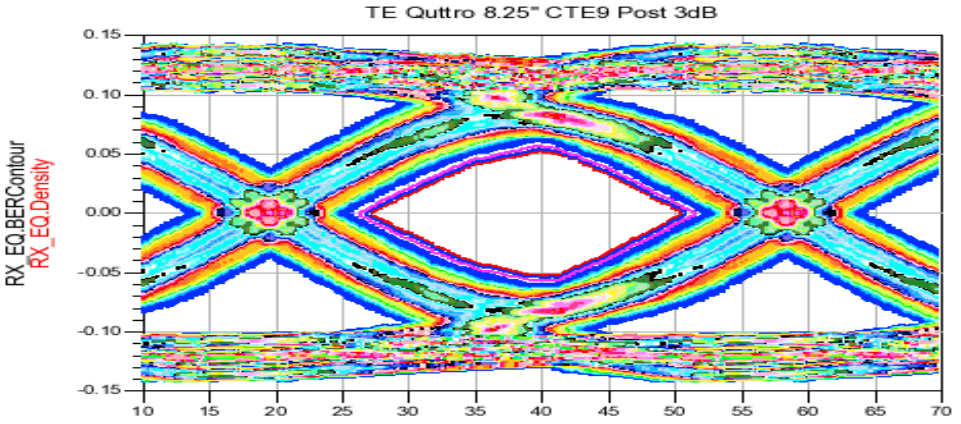

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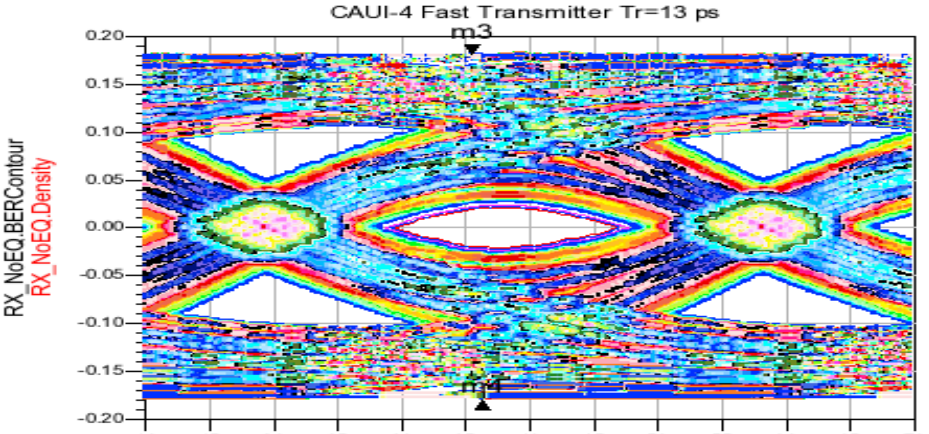

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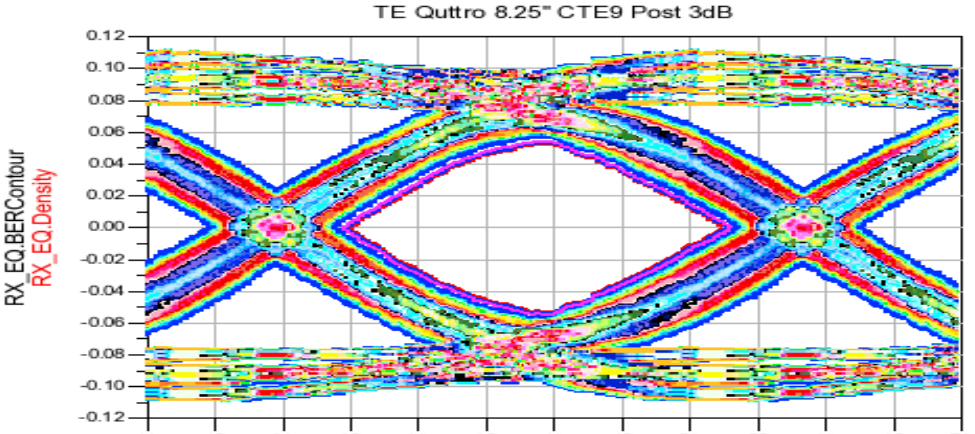

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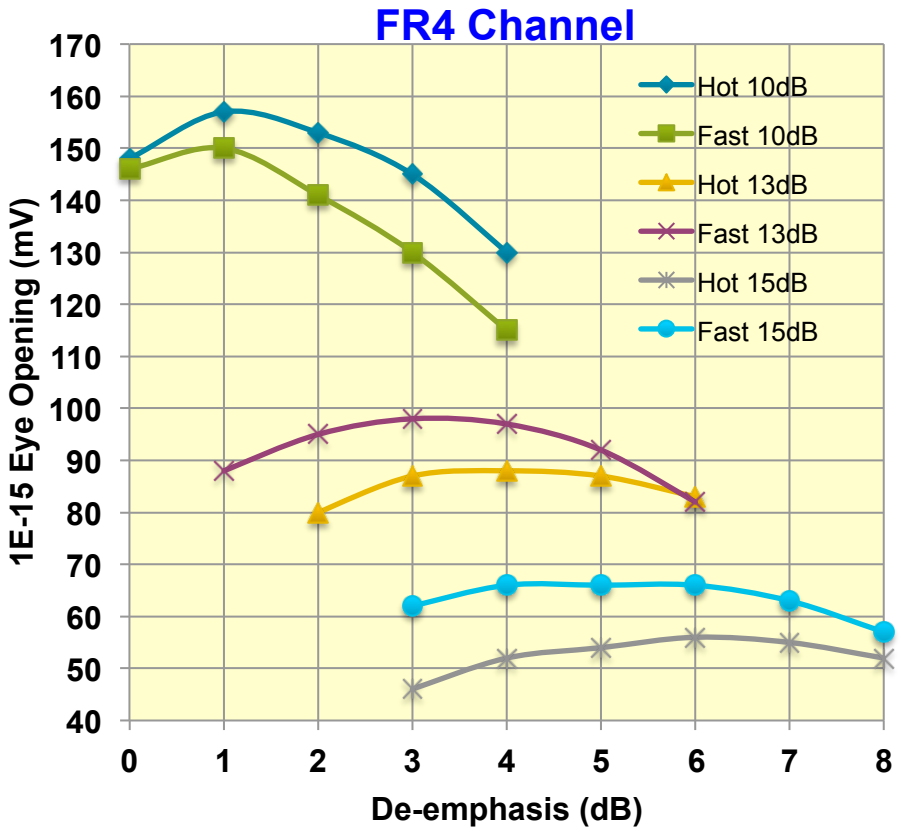
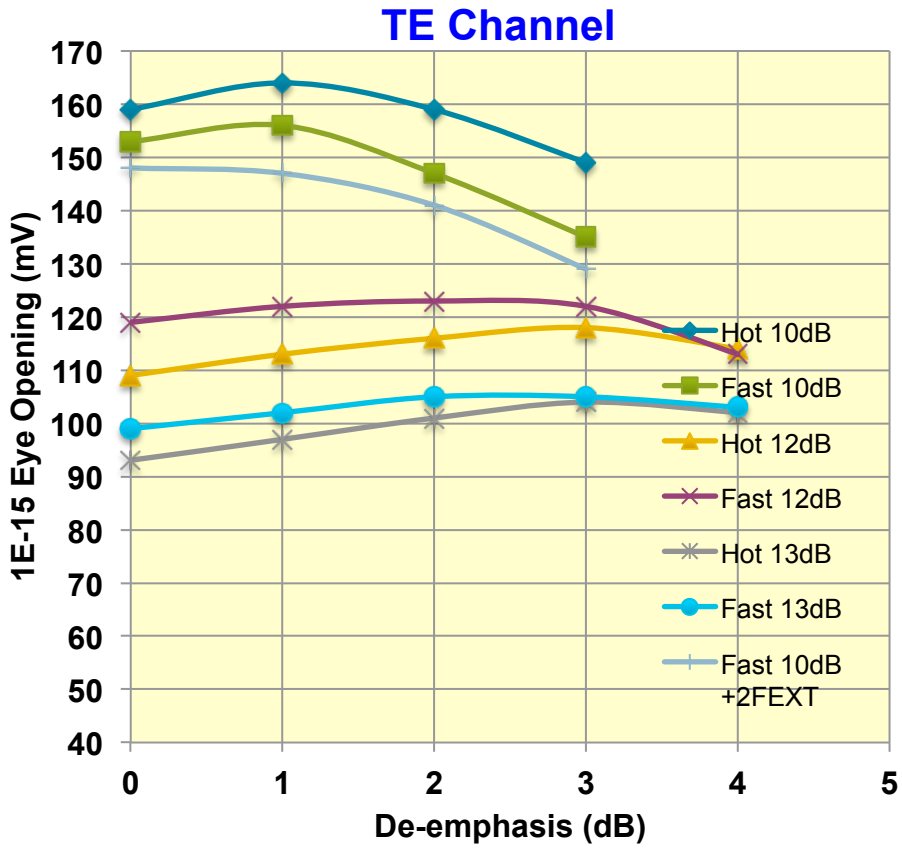
0.000	2.773E-11	0.105

Summary of Eye Opening

- Hot driver and fast driver have nearly similar far end performance!
- TE Quadra 10 dB channel has slightly better performance compare to channel with two long vias (~80 mils) and two short stub (~12 mils)
- Considering only 2 FEXT TE 10 dB channel ~ 6% VEC penalty





Summary

- For CAUI-4 chip to chip two channels were investigated
  - FR4 channel with deep vias and short stubs
  - TE Quadra based channel
- Result shown here is far end eye excluding DC block and receiver package and parasitic as observed on the scope with reference CTLE with gain of 9 dB
  - The equalized eye opening at the actual slicer typically ~25% less due to the RX package, ESD, and DC blocks
  - Hot transmitter has comparable performance to fast transmitter having 25% less amplitude
  - As the channel loss increases >12 dB fast TX start performing better
  - Trading off transmitter rise time/jitter with amplitude is a good trade off
- CAUI-4 chip to chip could support up to 15 dB assuming TX FFE and RX CTLE having fast/low jitter or 800 mV driver and require improving receiver sensitivity
  - Current CAUI-4 chip to module TP1a limit is 100 mV
  - To support 13 dB channel TP5 eye opening will be ~ 90 mV
  - To support 15 dB channel TP5 eye opening will be ~ 60 mV.

Thank You