Simulations and Methodology Addressing CAUI-4 C2C

IEEE 802.3 bm

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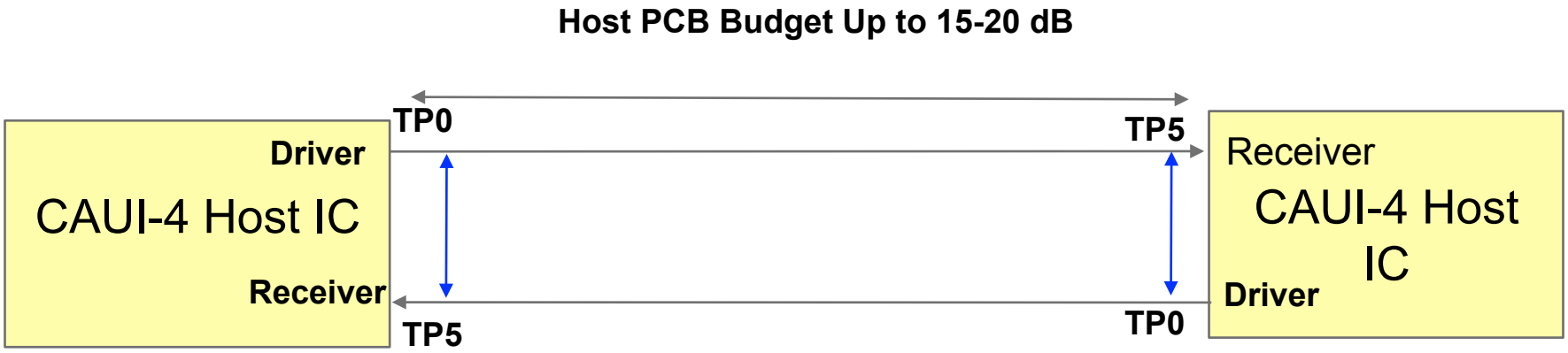
Overview

- A CAUI-4 chip to chip adhoc has been investigating channel with 15-20 dB assuming TX FIR with RX CTLE
  - Results presented in Orlando showed feasibility of 15 dB channel http://www.ieee802.org/3/bm/public/mar13/ghiasi_01_0313_optx.pdf
  - There is strong preference on the user side to push the channel loss to 20 dB
  - Need to balance what end user want with what is feasible
  - A code such as 802.3bj COM code be utilized to verify if 20 dB channel can be supported and in some cases based on the construction the BER objective may not be met
  - How do we define chip to chip loss budget if COM is normative
- Results presented in Orlando also showed far end eye opening is function of transmitter amplitude, rise/fall time, and jitter
  - Two transmitters were investigated
    - Hot transmitter with 800 mV diff Amp, TJ=0.28 UI, and Tr/Tf=17 ps
    - Fast transmitter with 600 mV p-p diff Amp, TJ=0.18 UI, Tr/Tf=12 ps
  - Hot transmitter delivered greater far end eye opening up to about 11-12 dB channel loss but as the channel loss increases fast transmitter with less amplitude delivered better far end eye
  - Transmitter tradeoffs provide flexibility and improves signal correlation at the far end.

CAUI-4 Architecture and Reference Points

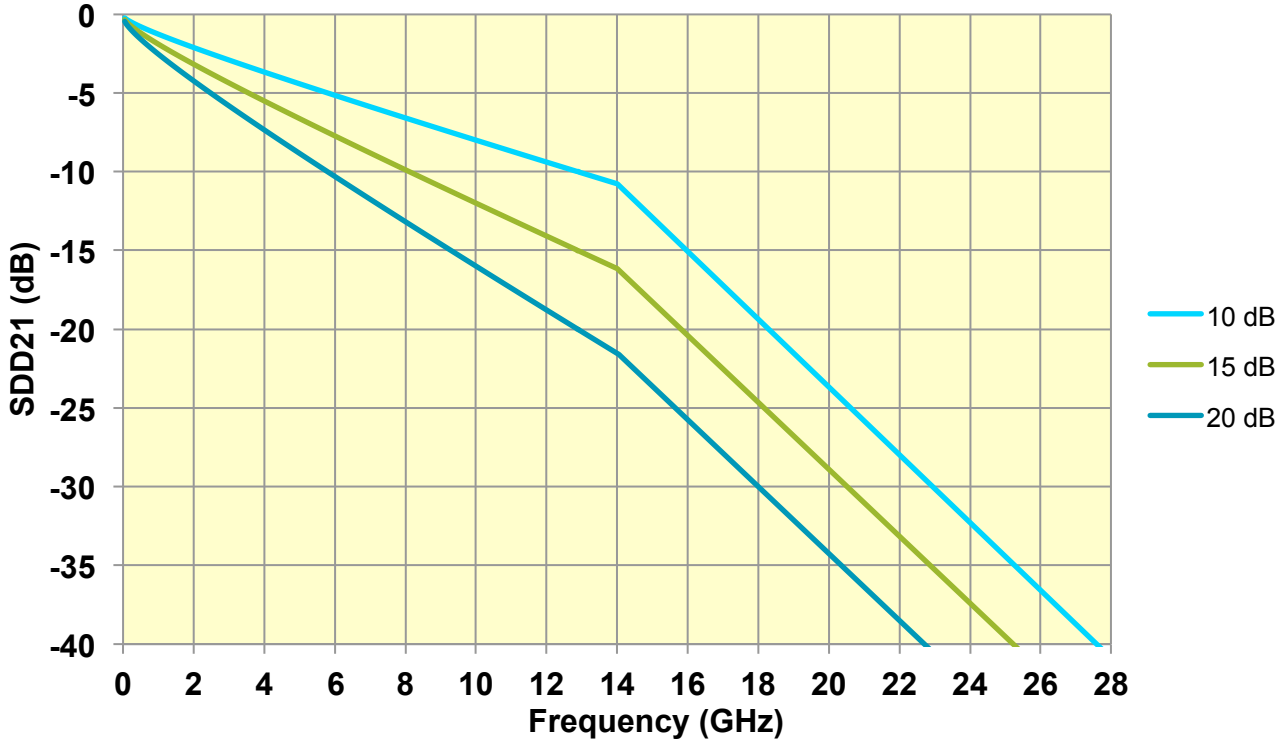
- Pushing 3 tap TX FFE with RX CTLE to 15 dB is very feasible
- There is strong user preference to push the channel loss to 20 dB something that require end to end simulation or BJ like COM code
  - We need to consider the user preference but ultimately we need to deliver a robust specification that can be built and meets the BER objective



CAUI-4 Chip to Chip Informative Channel

- We could define an informative lower / upper bound for the channel loss but use COM for normative compliance

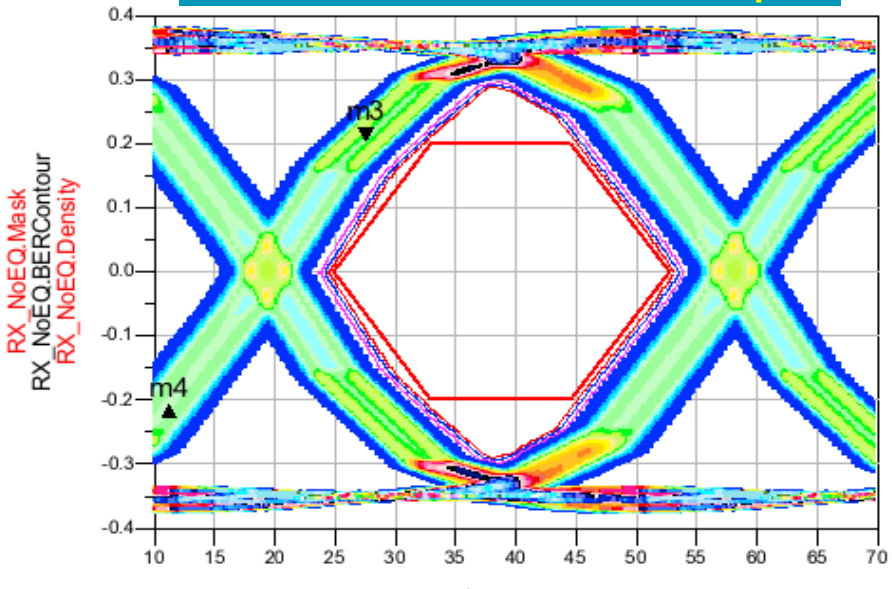
$$SDD21(15dB) = -0.121 - 0.867 * \sqrt{f} - 0.914 * f \quad from\ 0.05 - 14\ GHz$$
$$= 19.368 - 2.152 * f \quad from\ 14 - 25\ GHz$$
$$SDD21(20dB) = -0.161 - 1.156 * \sqrt{f} - 1.218 * f \quad from\ 0.05 - 14\ GHz$$
$$= 13.368 - 2.152 * f \quad from\ 14 - 25\ GHz$$



Example of Big and Little Chip CAUI-4 Transmitter

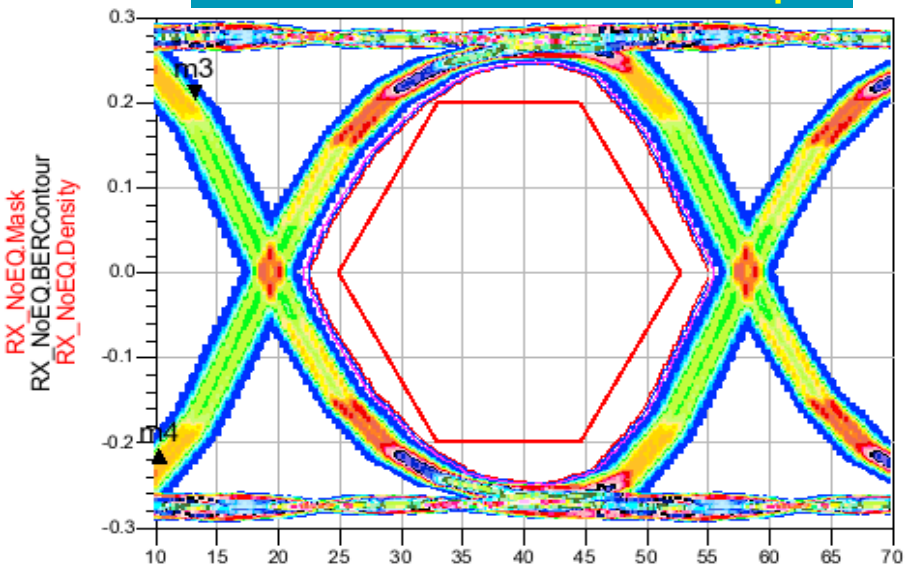
- Define Hot driver with standard jitter but 800 mV output
  - Tr ~ 17 ps TJ=0.28 UI@1E-15 (de-emphasis 1 dB)
- Define Fast-low jitter with 600 mV output
  - Tr ~ 12 ps TJ=0.18 UI@1E-15 (de-emphasis 0.5 dB)
- Eye mask at TP0a provide flexibility to trade off Tr/Tf, amplitude, and jitter
  - Mask coordinates (0.14,0), (0.35,±0.2), (0.65,±0.2), (0.86,0)

CAUI-4 Hot Transmitter Tr=17 ps



index	..._NoEQ.WidthAtBER)	...NoEQ.HeightAtBER)
0.000	2.890E-11	0.579

CAUI-4 Fast Transmitter Tr=12 ps



index	..._NoEQ.WidthAtBER)	...NoEQ.HeightAtBER)
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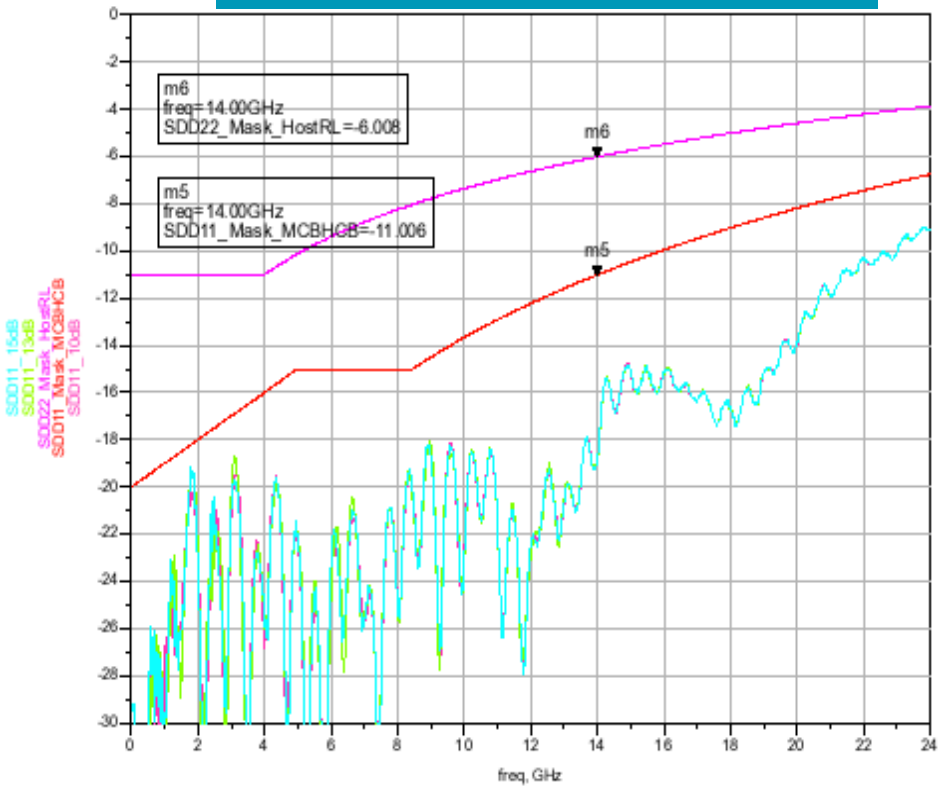
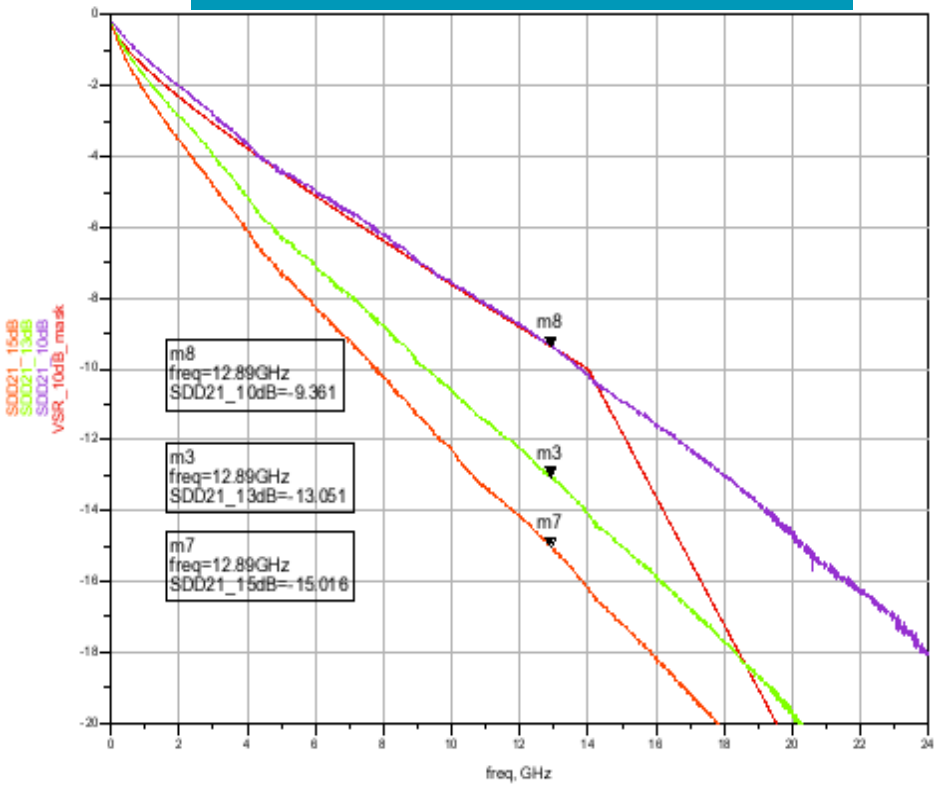
FR4 Channel Response

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

FR4 Host Channel



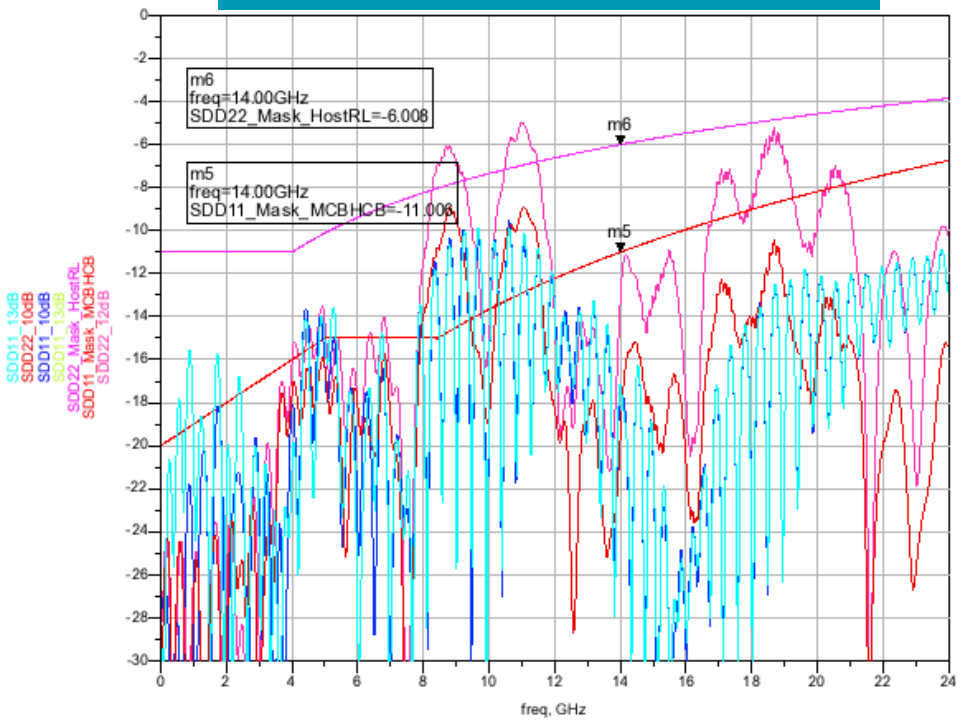
FR4 Host Channel



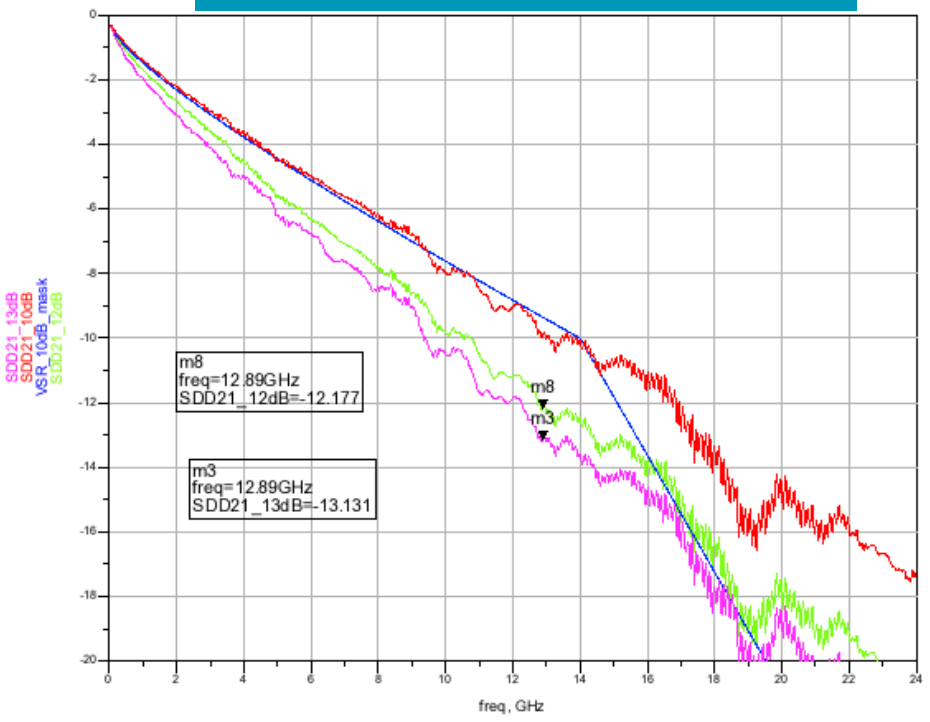
TE 7” Quadra Channel Response

- 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

TE Host Channel



TE Host Channel

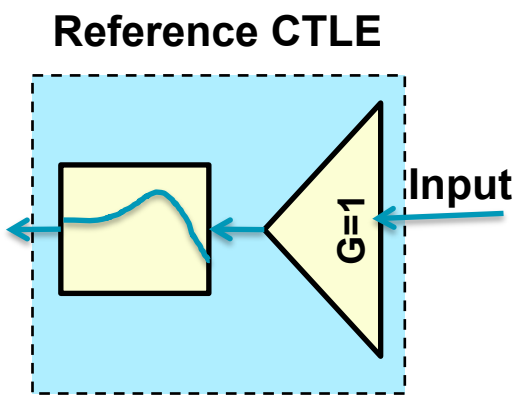


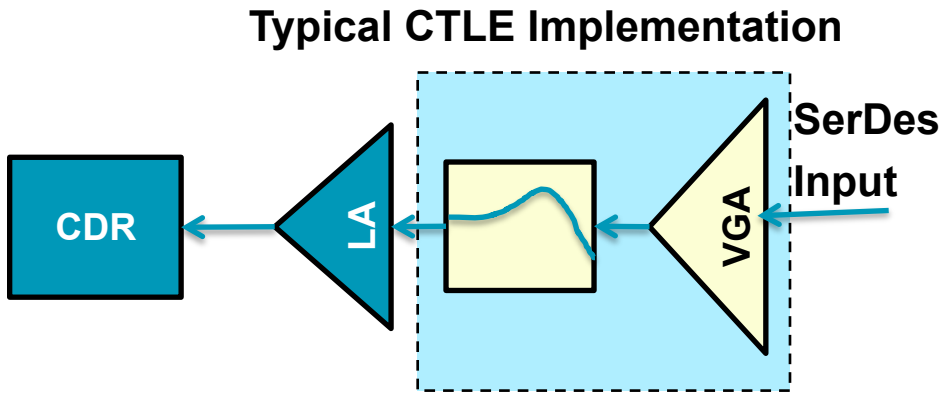
OIF 28G VSR/CAUI-4 Chip to Module CTLE Definition

- Based on most common implementation of CTLE with single pole with 2 zeros

$$Gain = G\frac{P1 \bullet P2}{Z}\frac{(Z - j*\omega)}{(P1 - j*\omega)(P2 - j*\omega)}$$

  - For reference comparison the CTLE should have no AC gain
  - Actual implementation will have VGA as well as limiting AMP with AC gain
  - Scopes software CTLE implementation is based on the reference CTLE for TP5 compliance

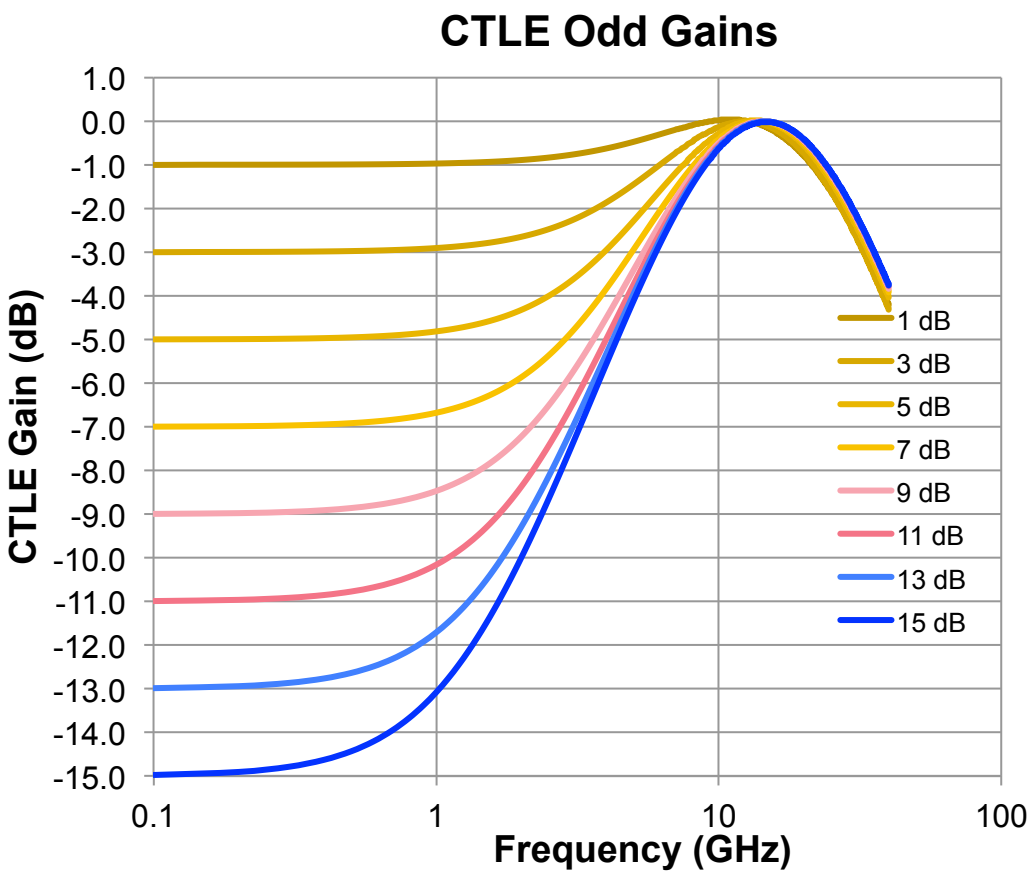




Expanded CTLE Response

- OIF 28G-VSR and CAUI-4 chip to module define CTLE response from 1-9 dB
  - Additional CTLE filter 10-15 are provided for purpose of CAUI-4 C2C study

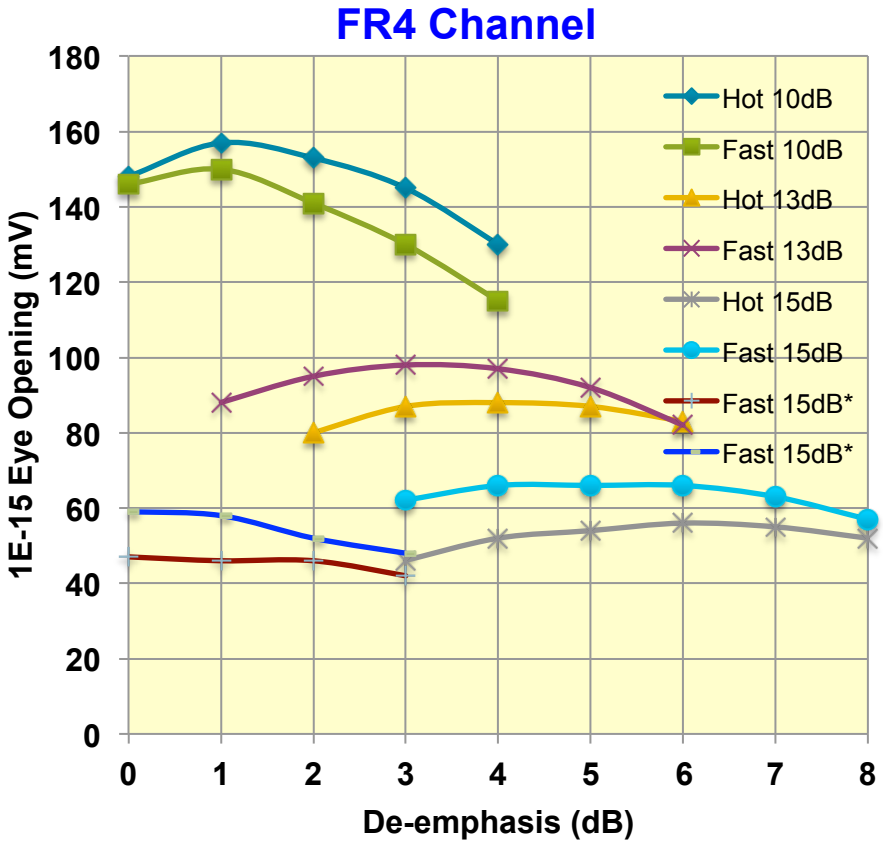
http://www.ieee802.org/3/bm/public/tools/index.html

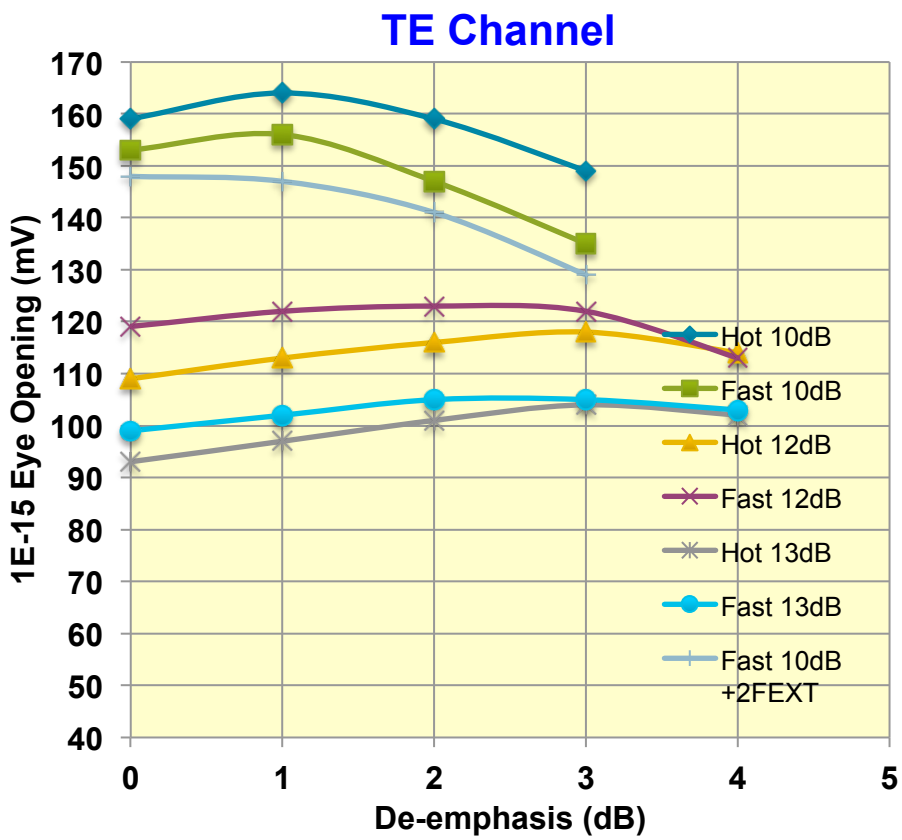


Gain (dB)	G (Linear)	Z (GHz)	P1 (GHz)	P2 (GHz)
1	0.89	7.1e9	1.86e10	1.41e10
2	0.795	7.1e9	1.86e10	1.41e10
3	0.795	7.1e9	1.56e10	1.41e10
4	0.633	4.98e9	1.56e10	1.41e10
5	0.563	4.35e9	1.56e10	1.41e10
6	0.5	3.82e9	1.56e10	1.41e10
7	0.446	3.4e9	1.56e10	1.41e10
8	0.398	3e9	1.56e10	1.41e10
9	0.3548	2.672e9	1.56e10	1.41e10
10	0.316	2.372e9	1.56e10	1.41e10
11	0.2818	2.11e9	1.56e10	1.41e10
12	0.2512	1.874e9	1.56e10	1.41e10
13	0.2239	1.67e9	1.56e10	1.41e10
14	0.1995	1.484e9	1.56e10	1.41e10
15	0.1778	1.325e9	1.56e10	1.41e10

Summary of Eye Opening

- Fast driver performs better for higher loss channel
  - For full simulation details please see http://www.ieee802.org/3/bm/public/mar13/ghiasi_01_0313_optx.pdf
  - All results are with 9 dB CTLE with exception of result with * based on 14 dB CTLE
  - Increasing CTLE filter peaking did not improve far end eye opening just reduced TX FFE setting





How to deal with compliance

- Transmitter Normative
  - CAUI-4 test method at TP1a can be applied to TP0a
  - Apply statistical eye mask for compliance either at 1e-12 or 1E-15
  - Statistical eye mask allow trading off transmitter Tr/Tf, jitter, and amplitude for improved correlation at TP5
    - COM does not provide trading off transmitter property for equal far end eye
    - BJ output waveform does capture amplitude aspect, indirectly the Tr/Tf, but jitter effect drop off due to average waveform
- Receiver Normative
  - Use CAUI-4 TP1a test method with software CTLE to determine hardware compliance as well as calibration of stress generator for TP5
  - Use the above software CTLE to calibrate stress generator to test the host
- Channel compliance
  - Can provide an informative upper and lower bound channel loss
  - Retrofit COM to be the normative compliance tool for guaranteed channel compliance.

Summary

- Pushing the channel loss to 20 dB is risky unless the channel is verified with an end to end simulation like ADS, SiSoft, or COM
  - There is strong user support to increase channel loss budget to 20 dB but our 1st responsibility is to define robust specification that can be built
  - For CAUI-4 C2C to support even 15 dB assuming TX FFE and RX CTLE, the TP5 sensitivity need to be 50 mV a factor 2 improvement from current CUAI-4 chip to module specification
- Transmitter tradeoff can be added as part of TP0a statistical eye mask test to allow flexibility in the transmitter and improve the correlation to TP5
  - It may require to add 2nd transmitter to the COM code a hot transmitter with 800 mV and a fast transmitter with 600 mV.

Thank You !