

PAM4 Modulation on a 28G-VSR Channel

For IEEE 802.3bs

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Purpose

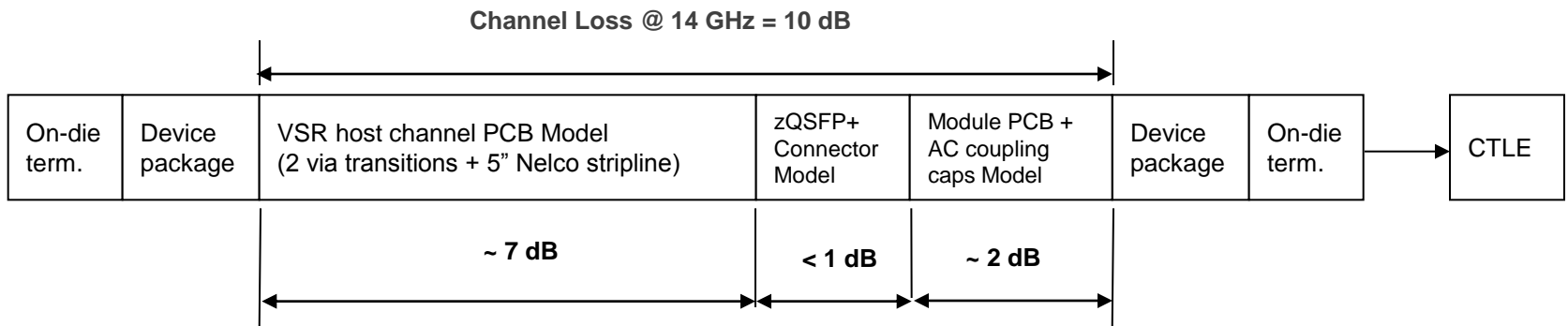
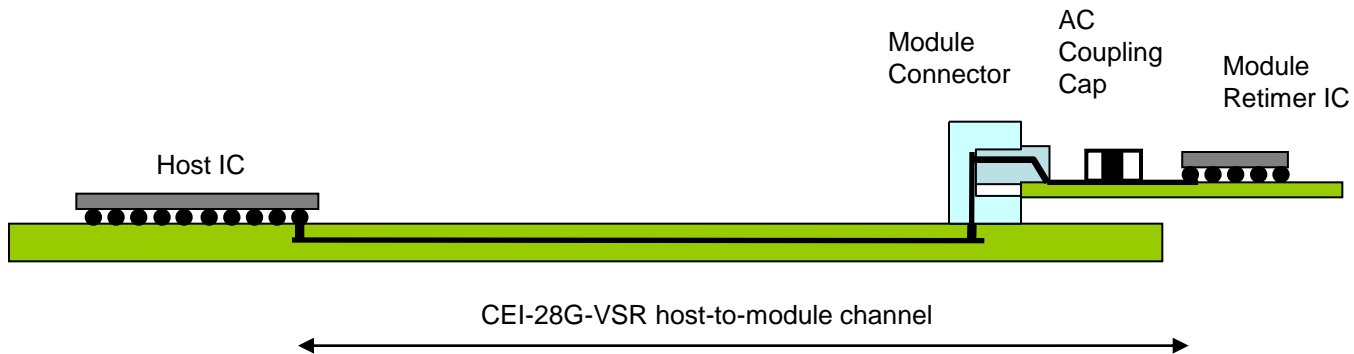
- Summarize PAM4 simulation results on a 28G-VSR channel, addressing C2M CDAUI-8 BTI:

Big Ticket Items – C2M CDAUI-8

- proposals
 - NRZ: palkert_3bs_01_0115.pdf
 - PAM4: brown_3bs_01a_0115.pdf
- Actions:
 - Evaluate Coupling between electrical and optical interfaces
 - Refine proposal ILD/xtalk
 - Test data from industry products, when available
 - Power
 - Simulations on adopted channel
 - Industry channel data for simulation purposes
 - Package effects
 - Test procedures and reference receivers with channel simulations

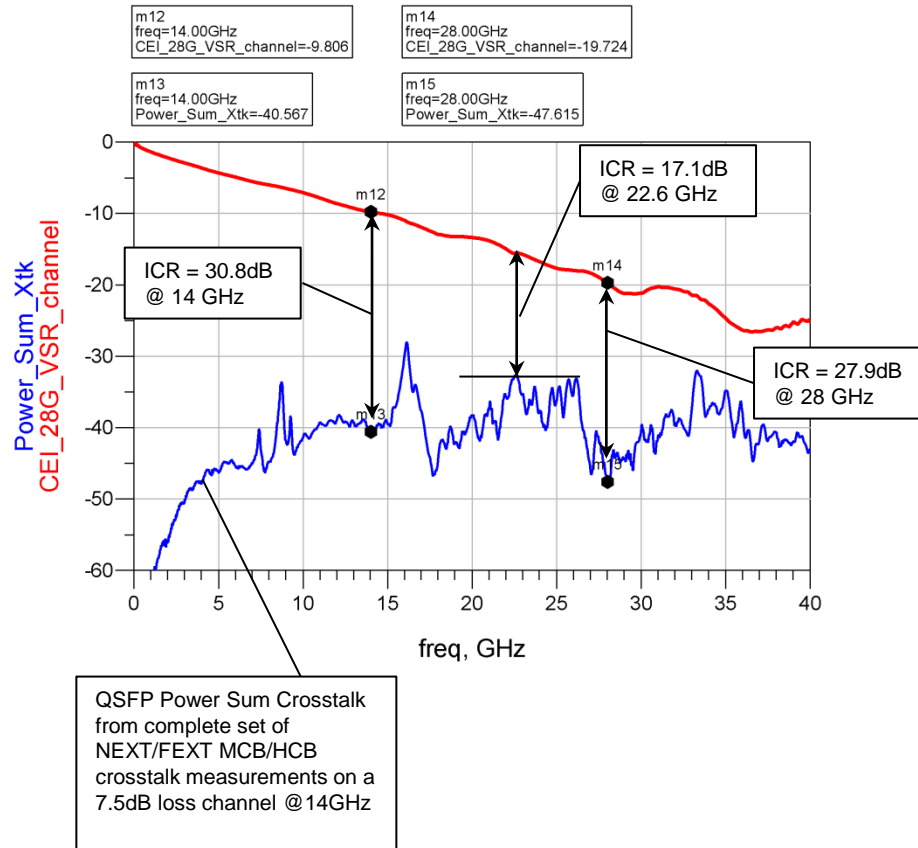
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CEI-56G-VSR channel



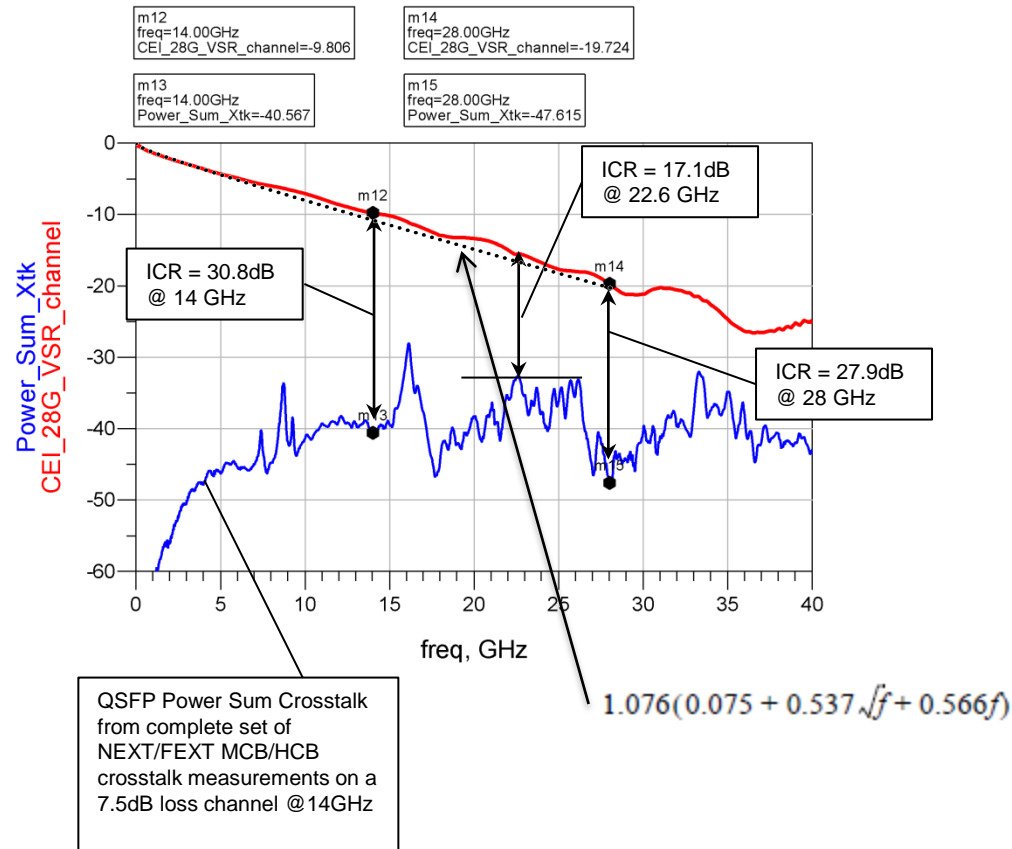
CEI-56G-VSR channel

Previously presented as oif.2014.035.00 (Semtech contribution)

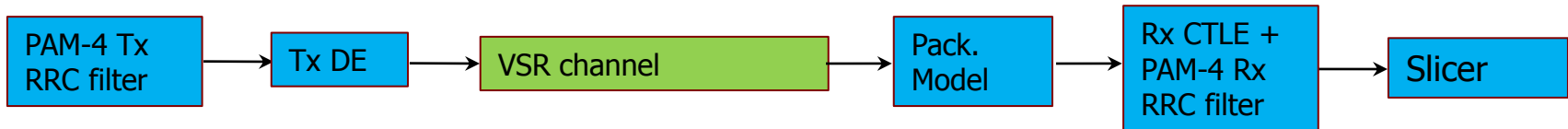


CEI-56G-VSR channel

Channel IL meets adopted CDAUI-8 c2m max IL curve



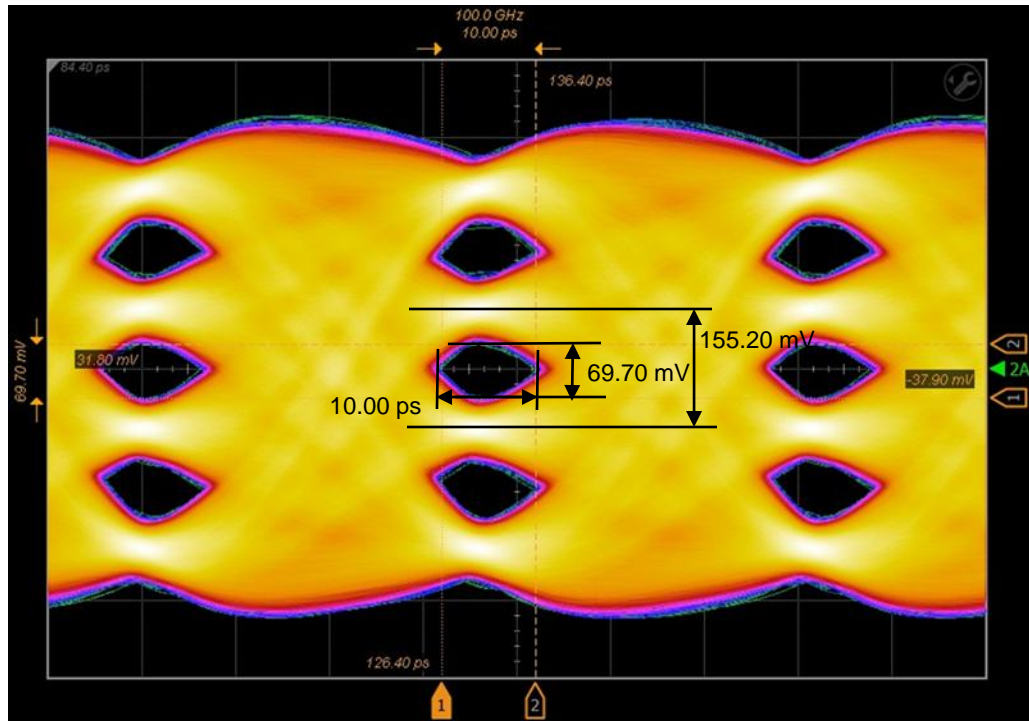
Simulated PAM-4 Channel



- Tx parameters
 - PRBS23 data pattern
 - Root raised cosine filter having $\alpha=1.0$ with $x/\sin x$ compensation
 - Nominal output swing of 800mVpp differential
 - 0.005 UI of clock Random Jitter
- Channel
 - CEI-28G-VSR 10dB loss channel + Rx package model
- Rx parameters
 - Enhanced CTLE transfer function with mid-band shaping

56 Gb/s PAM-4 results

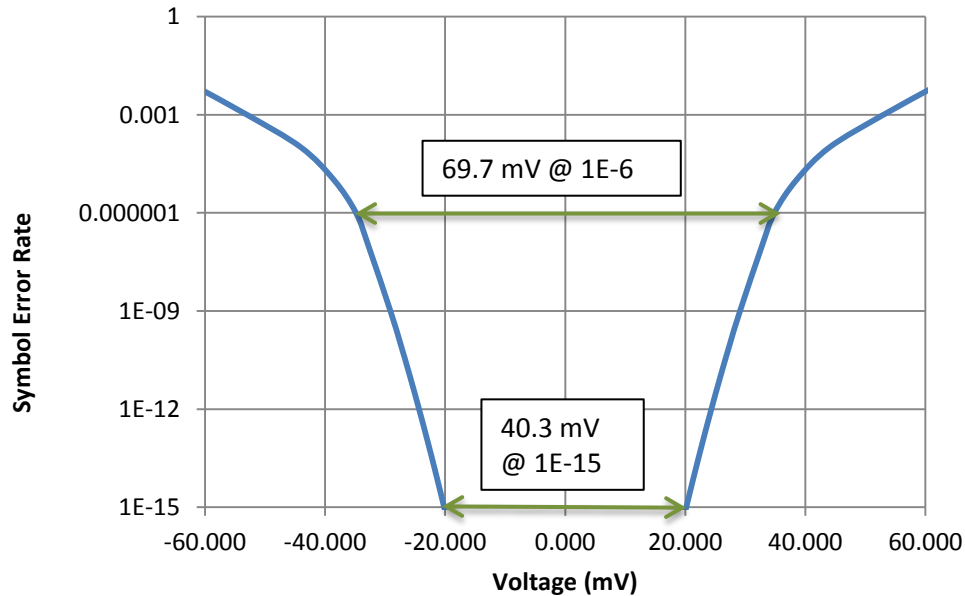
- **SER = 1E-6 eye diagram**



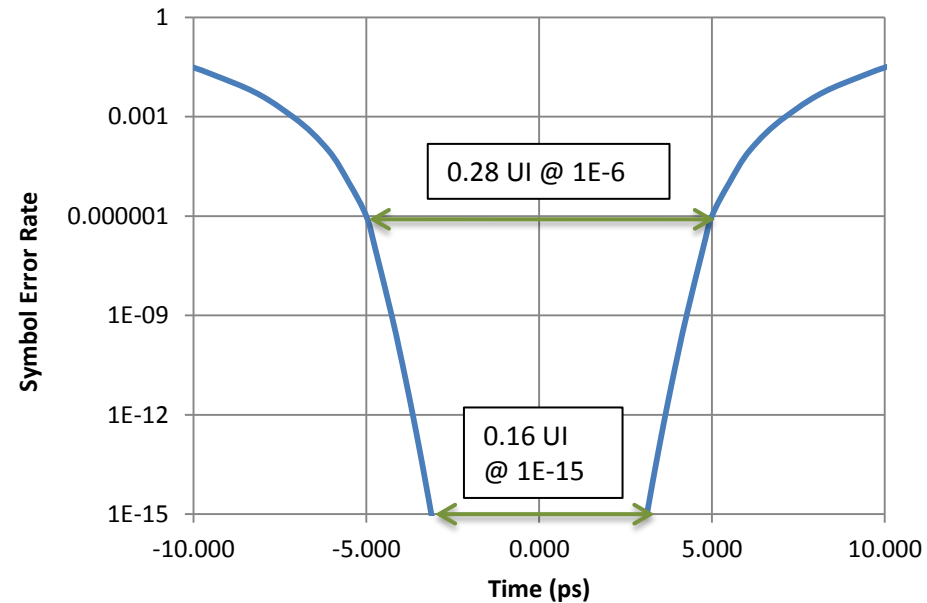
- Tx DE set to 2.5dB pre-cursor de-emphasis
- Rx CTLE set to 8.02 dB peaking at Nyquist freq

56 Gb/s Bathtub Curves

Voltage Bathtub

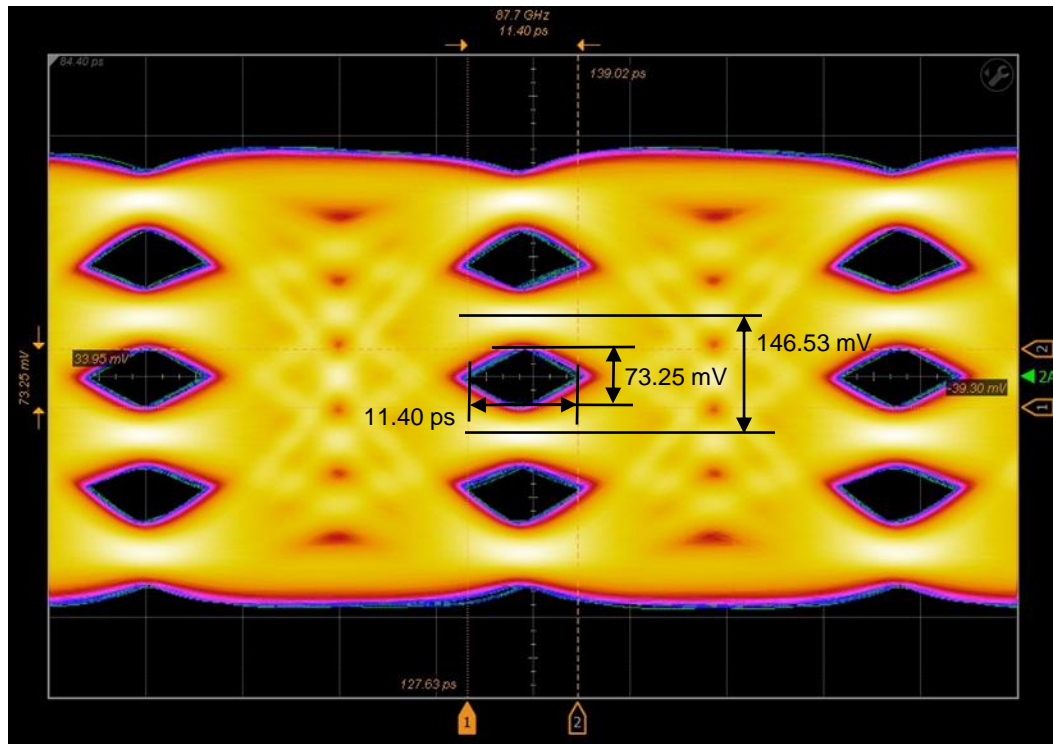


Timing Bathtub



51.56 Gb/s PAM-4 results

- **SER = 1E-6 eye diagram**



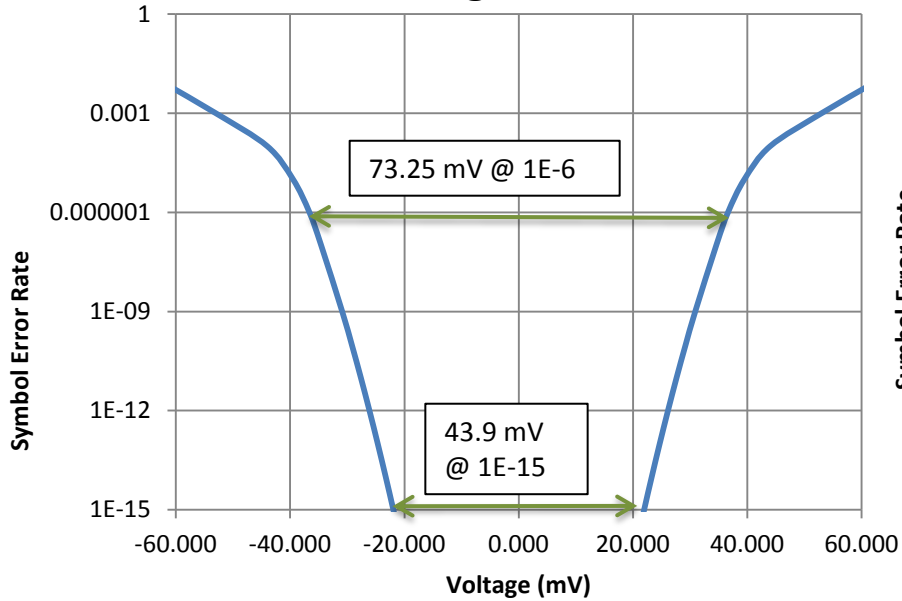
Veye = 73.25 mV
(VEC = 6.02 dB)

Heye = 0.294 UI

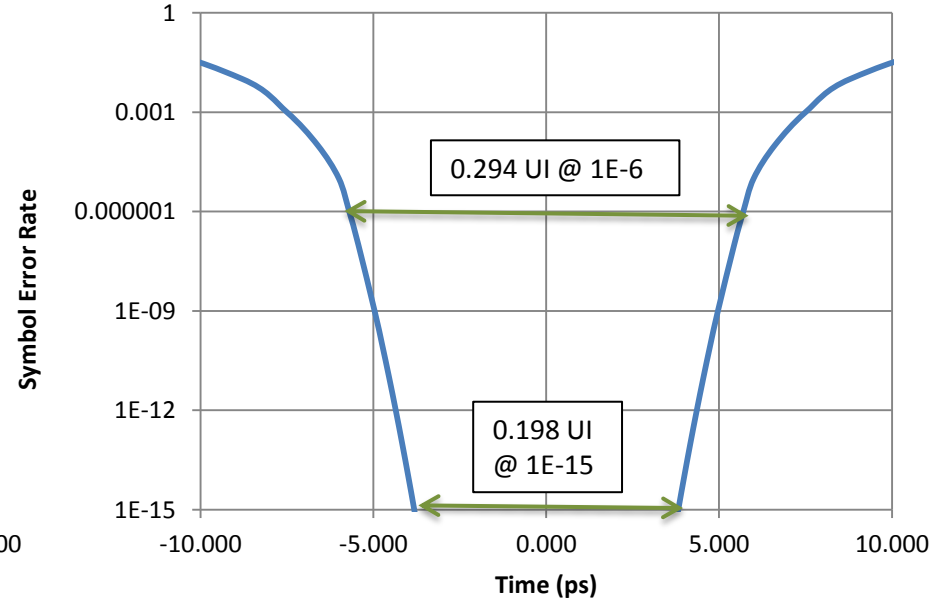
- Tx DE set to 2.0dB pre-cursor de-emphasis
- Rx CTLE set to 6.5 dB peaking at Nyquist freq

51.56 Gb/s Bathtub Curves

Voltage Bathtub



Timing Bathtub



Simulation Summary

| Case | SER=1E-6 Veye (mVpp) | SER=1E-6 Heye (UIpp) | SER=1E-15 Veye (mVpp) | SER=1E-15 Heye (UIpp) |
|---------------------|-------------------------|-------------------------|--------------------------|--------------------------|
| 51.6 Gbps System | 73.3 | 0.294 | 43.9 | 0.198 |
| 56 Gbps System | 69.7 | 0.280 | 40.3 | 0.160 |

Conclusions

- Summarized PAM4 system simulations used to derive the CEI-56G-VSR and CDAUI-8 c2m PAM4 baseline specs
- Next steps:
 - Investigate performance over a wider range of conditions and channels, including legacy CAUI-4 c2m channels
 - Need host ASIC package and via models