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Output Voltage Proposal for PAM-4 Transmitter

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Introduction

- PAM-4 PHY is expected to equalize channel insertion losses of around (-50)db at 12.5 GHz.
- At 1v peak-to-peak differential output voltage (Vpp), FEC with at least 7dB of coding gain may be required for 10^{-12} BER[1].
- Part of this FEC coding gain (1dB – 2dB) can de distributed to:
  - Transmitter only (Higher Vpp)
    - Increased power, noise, and jitter
    - Process limitations
  - Transmitter and receiver (Trellis/MLSD[2])
    - Increased latency and complexity
- This presentation will investigate the gain obtained from higher Tx Vpp in the presence of higher receiver noise and transmit jitter.

[1]: http://www.ieee802.org/3/bj/public/sep11/hatab_01_0911.pdf
[2]: http://www.ieee802.org/3/bj/public/sep11/dabiri_01_0911.pdf

Simulations Parameters

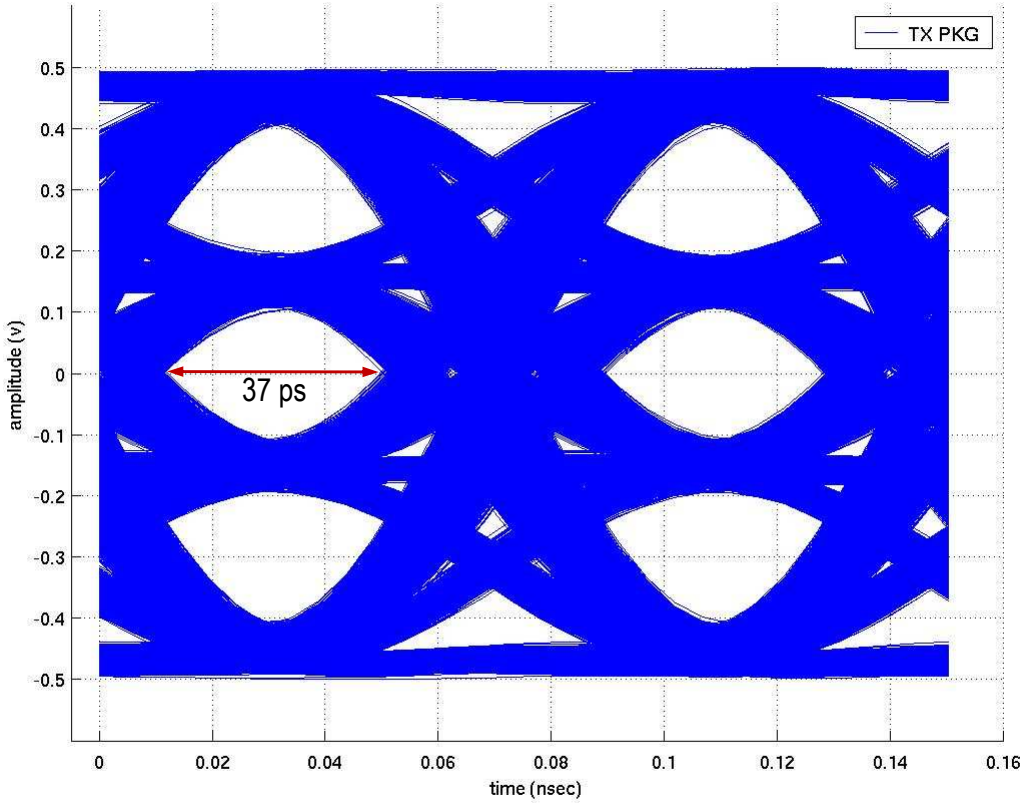
Channel	Channel
Transmitter	Receiver
Device Package: Pkg35mm_T21mm115ohm LoXtalk_BGALoXtalk.s8p	**Device Package:** Pkg35mm_T21mm115ohm LoXtalk_BGALoXtalk.s8p
Device Package Crosstalk: NA	**Device Package Crosstalk:** NA
R_1: 50 ohm	**R_2:** 50 ohm
C_1 : 0 F	**C_2:** 0 F
Channels: TEC_Whisper42p8in_Nelco6_THRU_C8C9.s4p	
Near-End Crosstalk: 6 aggressors Asynchronous Victim Tx replicated	
Far-End Crosstalk: 2 aggressors Asynchronous Victim Tx replicated	

Link
Bit Rate: 25 Gb/s
Modulation: PAM-4
Signaling Rate: 12.890625 GHz
Number of symbols simulated: 50000
Target symbol error ratio: 10^{-12}

Transmitter
Test Pattern: PRBS31
Bit Encoding: 64B/66B
Vpp: 0.8 v → 1.2 v
Equalizer: NA
Deterministic Jitter: 0.05 UI (peak-to-peak) Sinusoidal at 5 MHz
DCD: 0.02 UI (peak-to-peak)
Random Jitter: 0.6 ps (RMS)
Total Jitter: 0.21 UI (peak-to-peak)

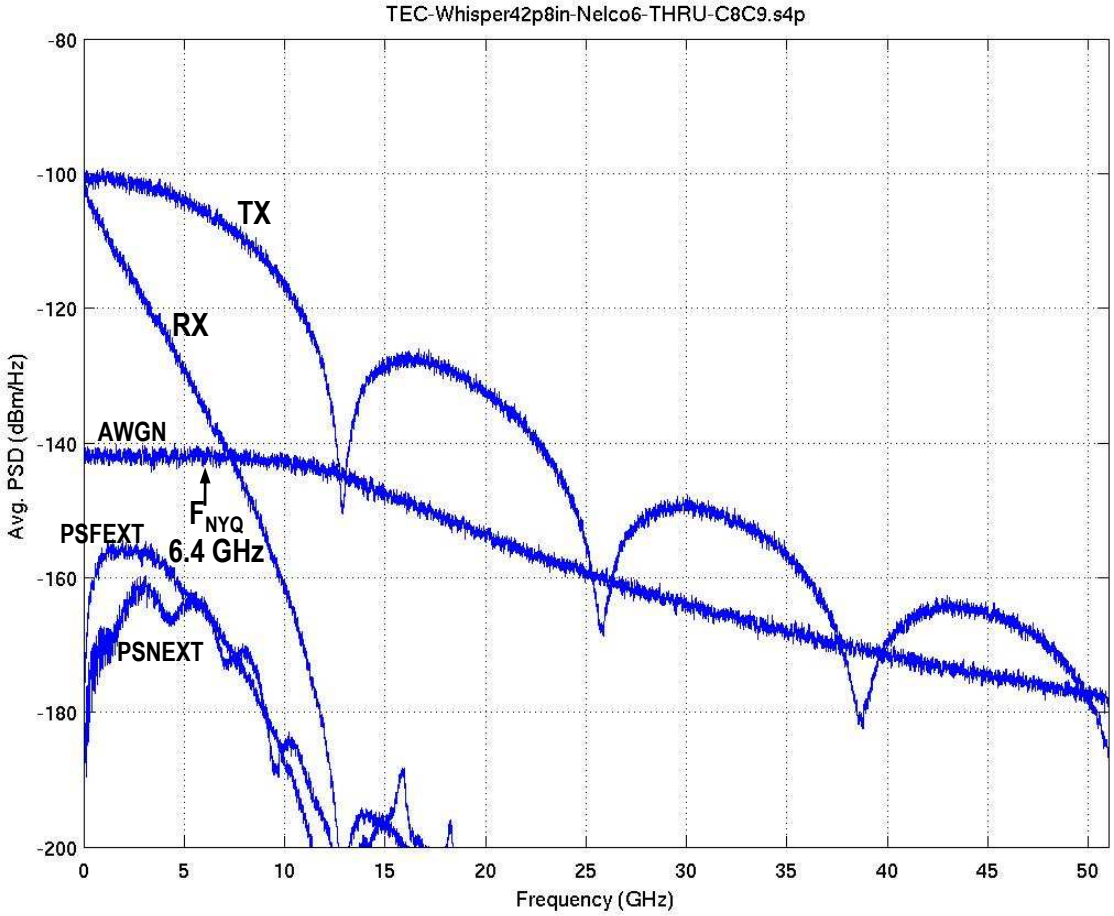
Receiver
Random Noise: -144 dBm/Hz → -142 dBm/Hz (4.5 mv → 5.5 mv RMS)
Deterministic Jitter: NA
Random Jitter: NA
CT Filter: NA
Equalizer Structure: DFE: 12 FFE: 8 (T-Spaced) LMS
CDR: Ideal
Performance Metrics: SNR (dB)

PAM-4 Eye Opening at Transmitter with Package

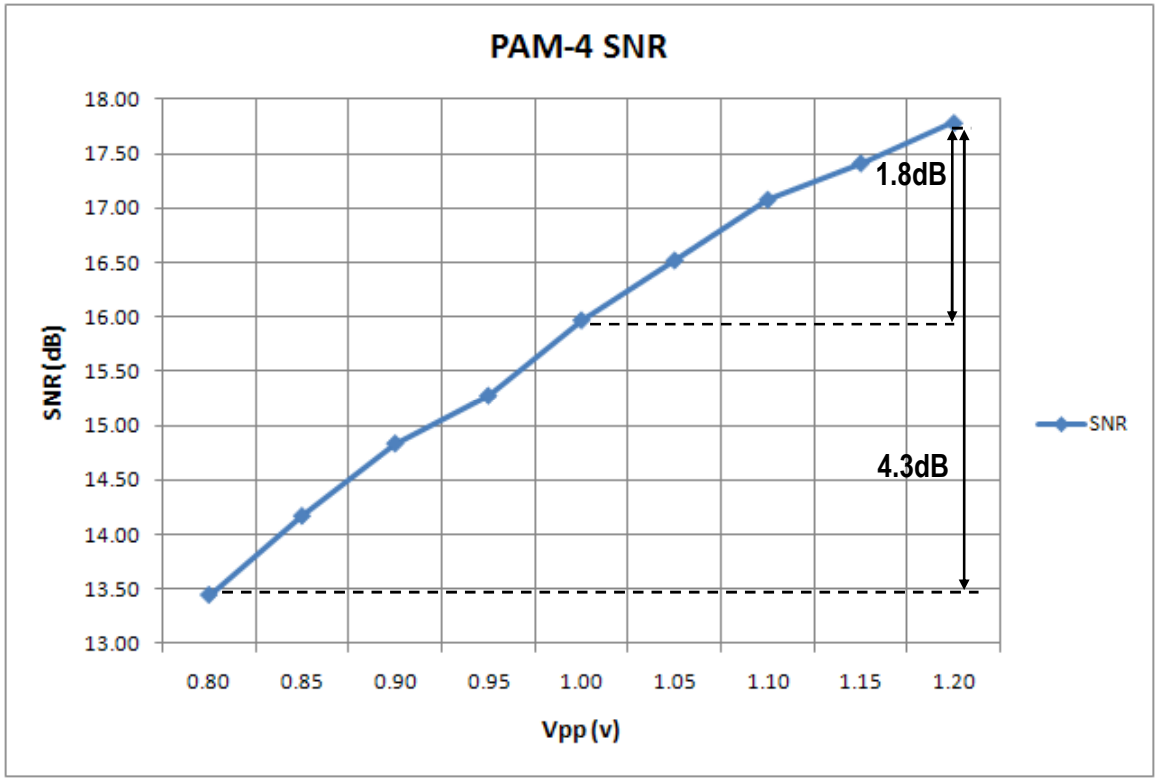


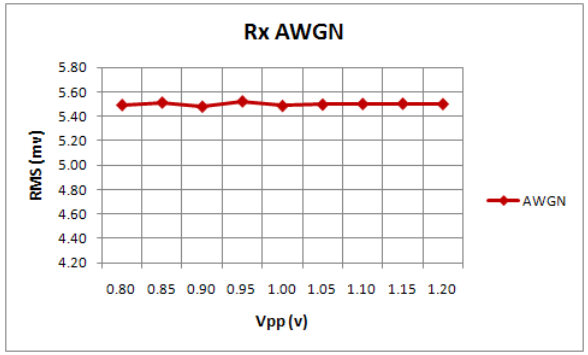
- Total Tx Jitter ≈ 1UI - 0.47UI – 0.33UI = 0.2UI

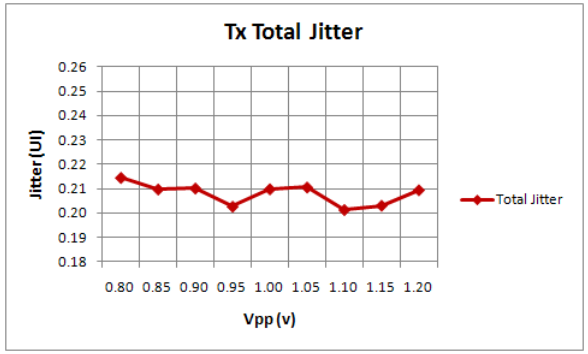
Power Spectral Densities



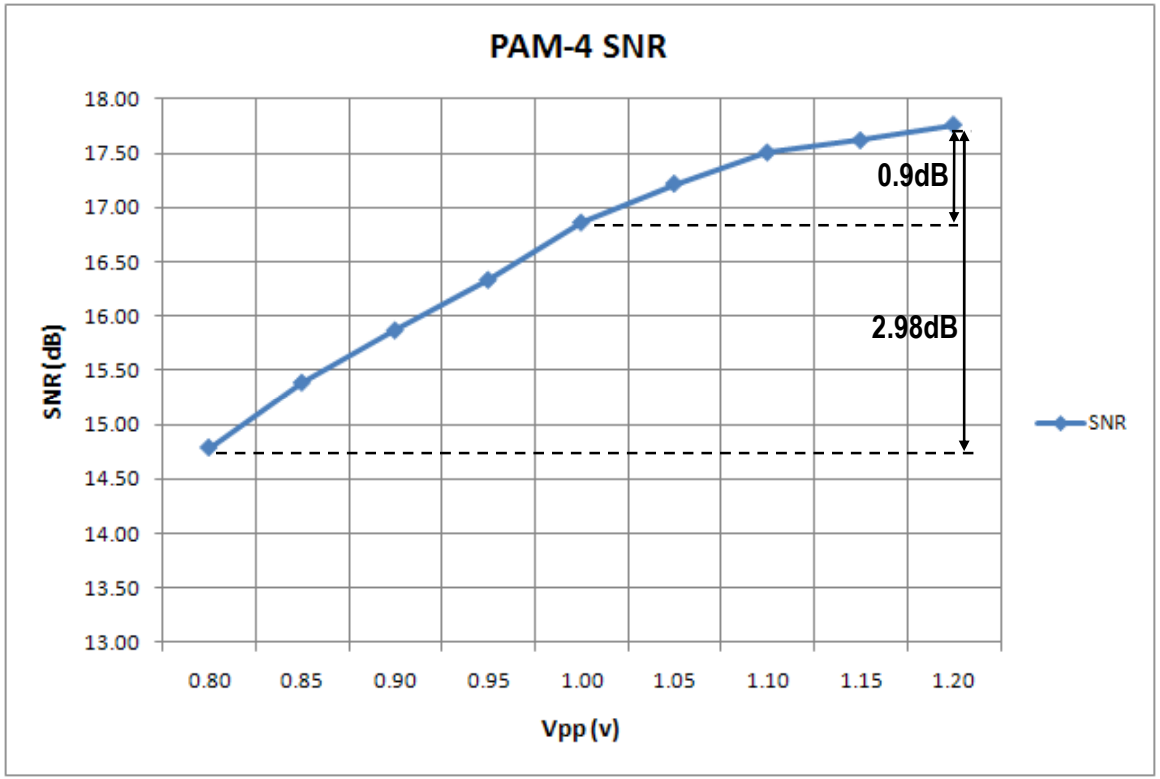
System SNR vs. Vpp with Constant AWGN

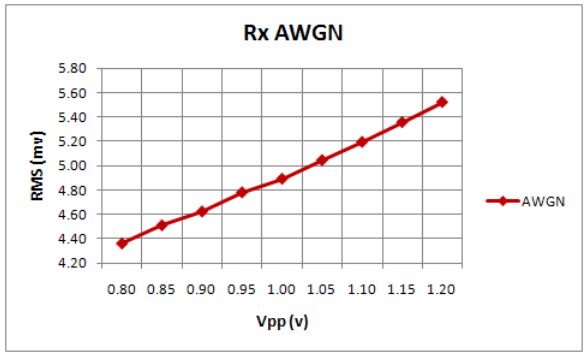


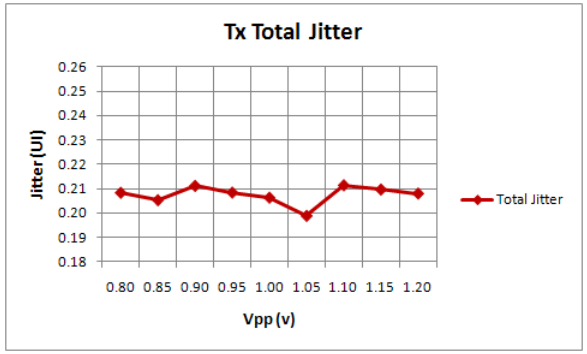




System SNR vs. Vpp with Higher AWGN







Conclusion

- Investigated PAM-4 output peak-to-peak differential voltage values:
  - Vpp was varied from 0.8v to 1.2v
    - With no additional Rx noise and Tx jitter
    - With additional Rx noise (AWGN up to -142 dBm/Hz):
      - AWGN is dominant noise source. Other sources can be considered:
        - Additional Tx jitter
        - Non-linear distortions
- Increasing Vpp from 1.0v to 1.2v :
  - With constant AWGN levels (5.5 mv RMS) there is about 2dB improvement in SNR margin.
  - With increasing AWGN levels (4.5mv to 5.5mv RMS) there is about 1dB improvement in SNR margin.
- Propose to adopt 1.2v output peak-to-peak differential voltage for PAM-4 PHY.