Modulation SNR Margin Evaluation and Precoder Proposal for the 25G Automotive PHY

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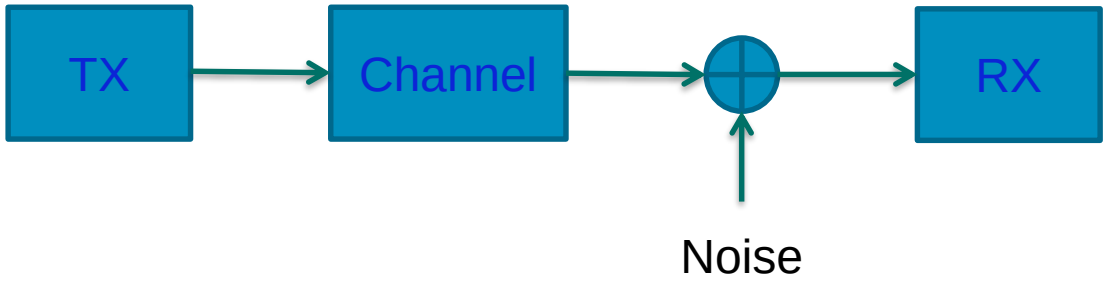
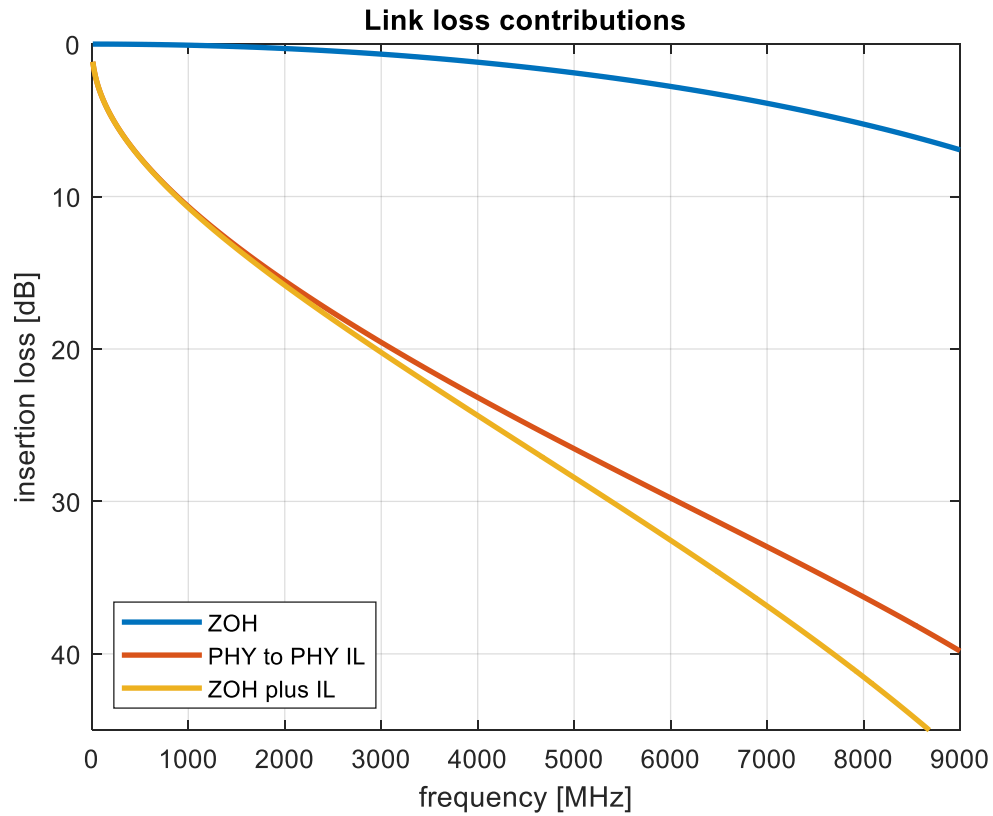
Setup of the SNR margin evaluation:

- 25Gb/s over shielded cable for up to 11m cable reach.
- Framing and FEC overhead the same as 802.3ch:
  - Baud rate scaled by factor of 2.5X.
- TX
  - Signal power: 1Vpp at TP0.
    - Constellation comparison for peak limited TX voltage.
  - Model: zero order hold.
- Link segment and PCB insertion loss:
  - Channel insertion loss specified in diminico_kadry_3cy_01_06_22_21.pdf
  - MDI and PCB insertion loss specified in diminico_3cy_01a_04_27_21.pdf
- 7 constellations considered (1.5 to 3.5 bits per symbol).
  - Previously evaluated for 802.3ch: souvignier_3ch_01c_0518.pdf
- Metric: Allowable input referred noise for BER 1e-6.

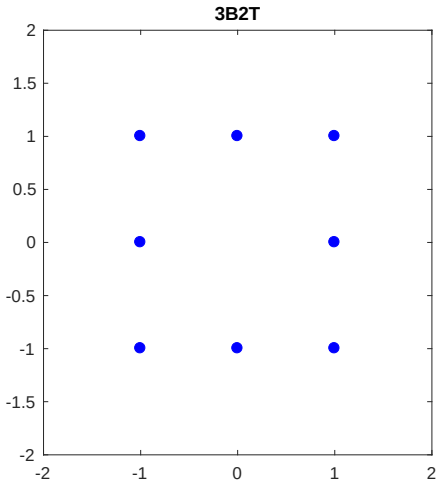
Insertion loss contributions and input referred noise.

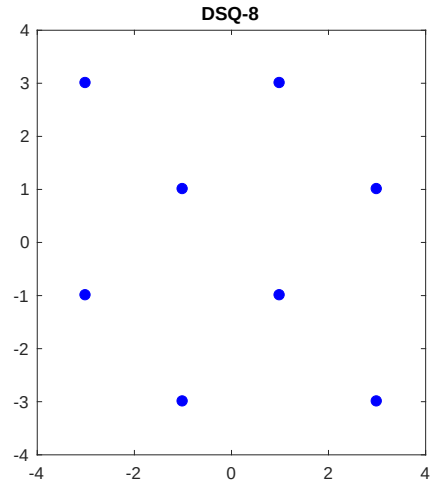


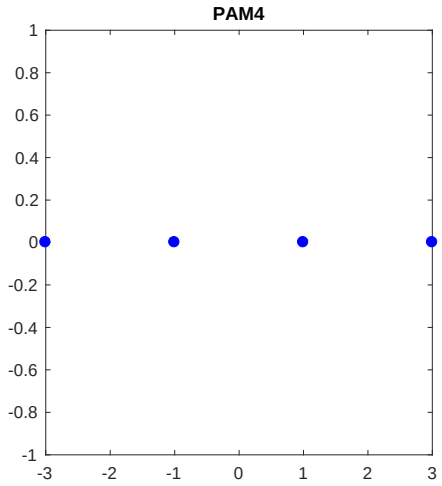
- Peak TX signal voltage: 1Vpp at TP0/TP5.
- TX DAC model: Zero Order Hold.
- Channel: PCB and link segment insertion loss.
- RX input: spectrally flat noise.
- RX using a brick wall filter at Nyquist.
  - Implementation specific HPF, LPF is not considered.

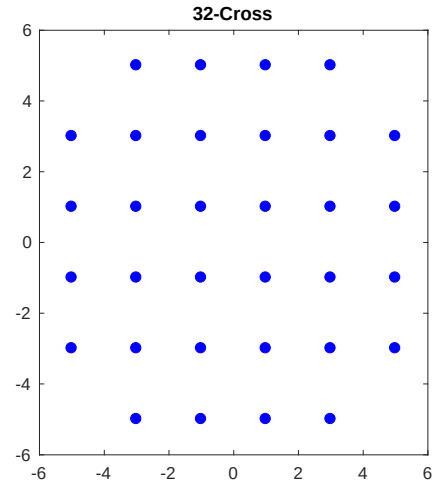


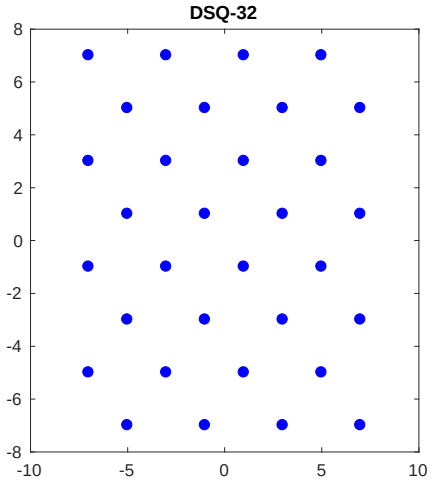
Constellations Considered

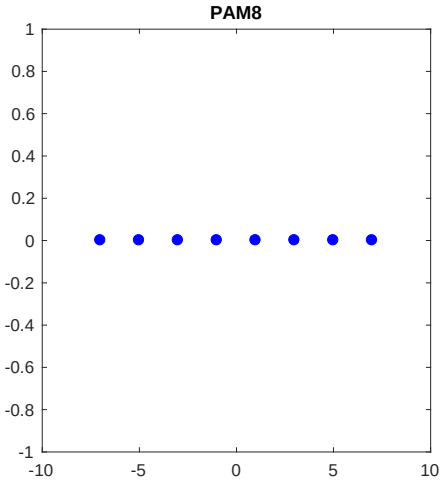


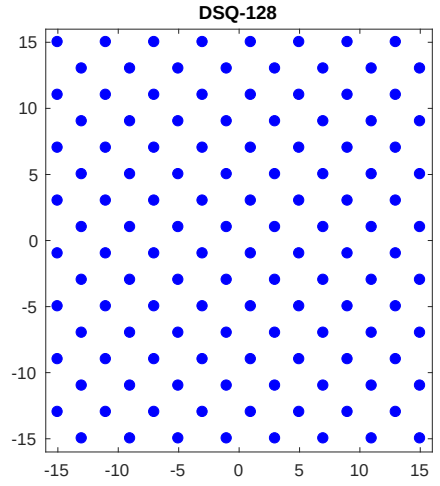












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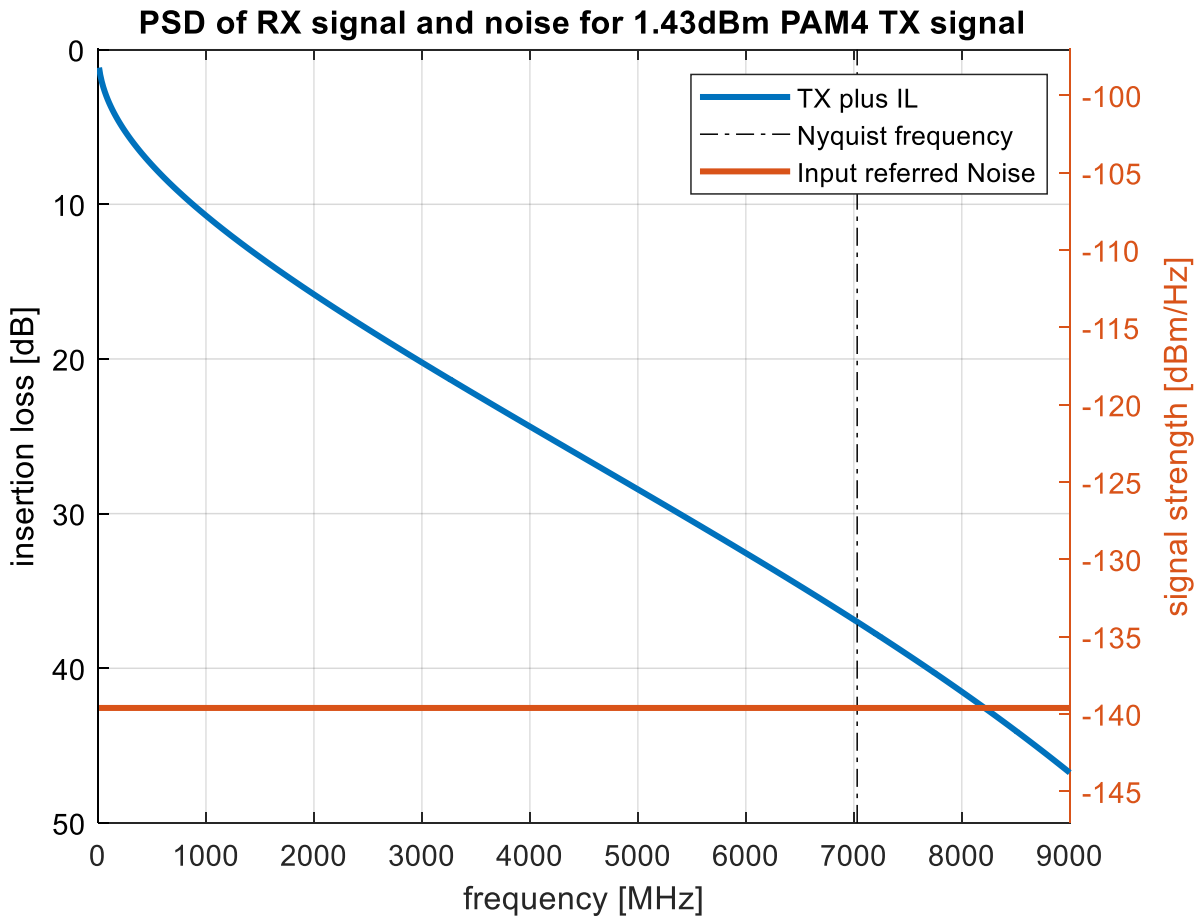
RX PSD and the level of the input referred noise for PAM4

- TX signal: 1Vpp.
- TX signal spread over frequency:
  - -98.5dBm/Hz=-10log10(7.03125GHz)
- Mean of SNR in dBm/Hz
  - -118.9dBm/Hz
- SNR needed for BER=1e-6: 20.7dB.
- Noise level
  - Mean of SNR – SNR needed for BER 1e-6:
  - -139.6dBm/Hz.



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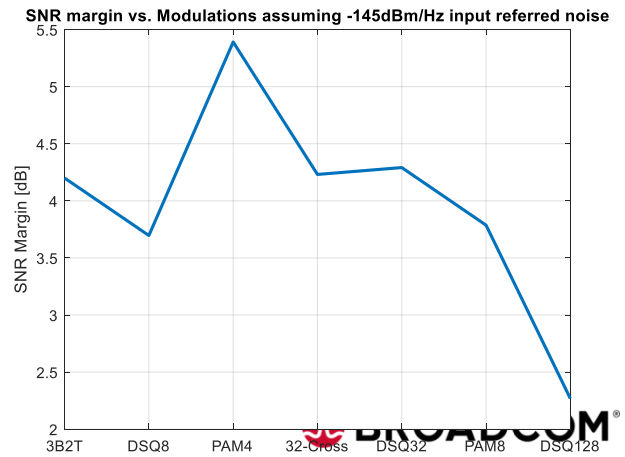
Allowable RX noise for uncoded BER of 1e-6.

Modulation	Bits/ Sym	Symbol Rate (GBaud)	Mean of RX signal (dBm)	Uncoded SNR @1e-6 SER (dB)	Noise (dBm/Hz)	SNR margin (dB) noise at -145dBm/Hz
3B2T	3/2	18.75	-122.2	18.6	-140.8	4.2
DSQ-8	3/2	18.75	-123.5	17.8	-141.3	3.7
PAM-4	2/1	14.0625	-118.9	20.7	-139.6	5.4
32-Cross	5/2	11.25	-115.7	24.0	-140.8	4.2
DSQ-32	5/2	11.25	-116.5	24.2	-140.8	4.3
PAM-8	3/1	9.375	-113.9	27.3	-141.2	4.8
DSQ-128	7/2	8.0357	-112.4	30.3	-142.7	2.3

- -145dBm/Hz noise power assumed for a reasonable overall power consumption of the analog front end.
- Salz SNR = Mean of (Signal) – mean(Noise).
- Metric is the RX input referred noise for a Salz SNR for a BER of 1e-6.
  - Margin: Final adopted RS-FEC should tolerate a BER higher than 1e-6.
- Noise level = Mean of signal – SNR needed for BER 1e-6
- Flat maximum for 2 and 2.5 bits/symbol constellations.



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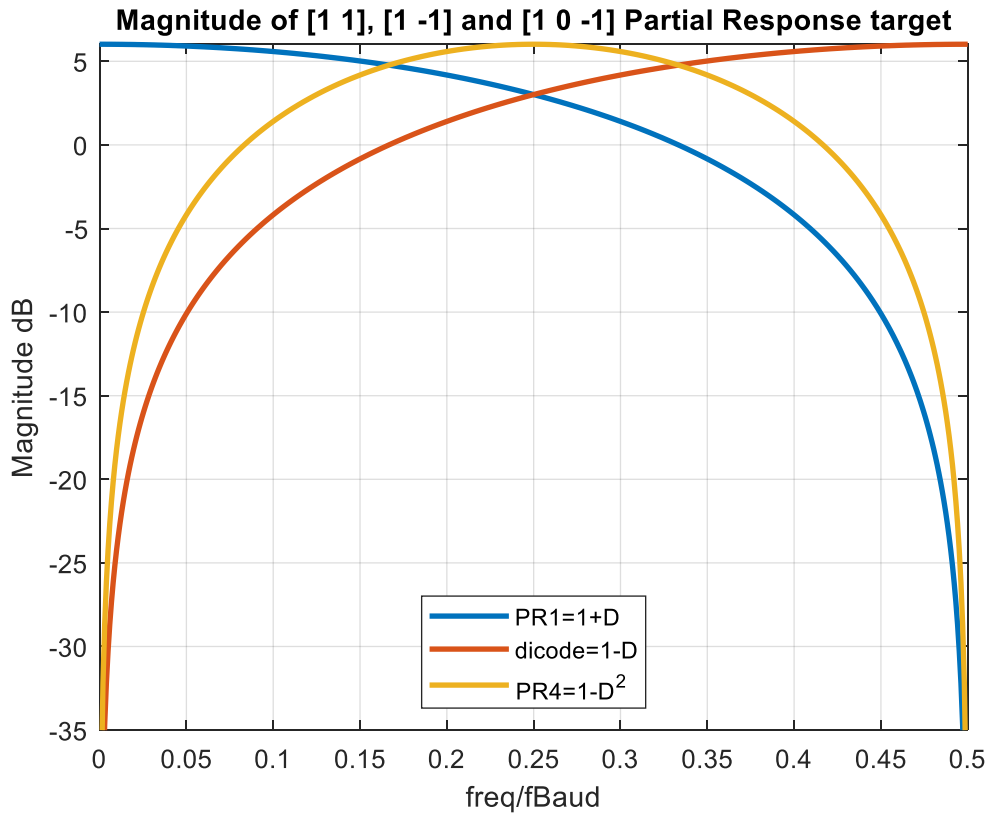
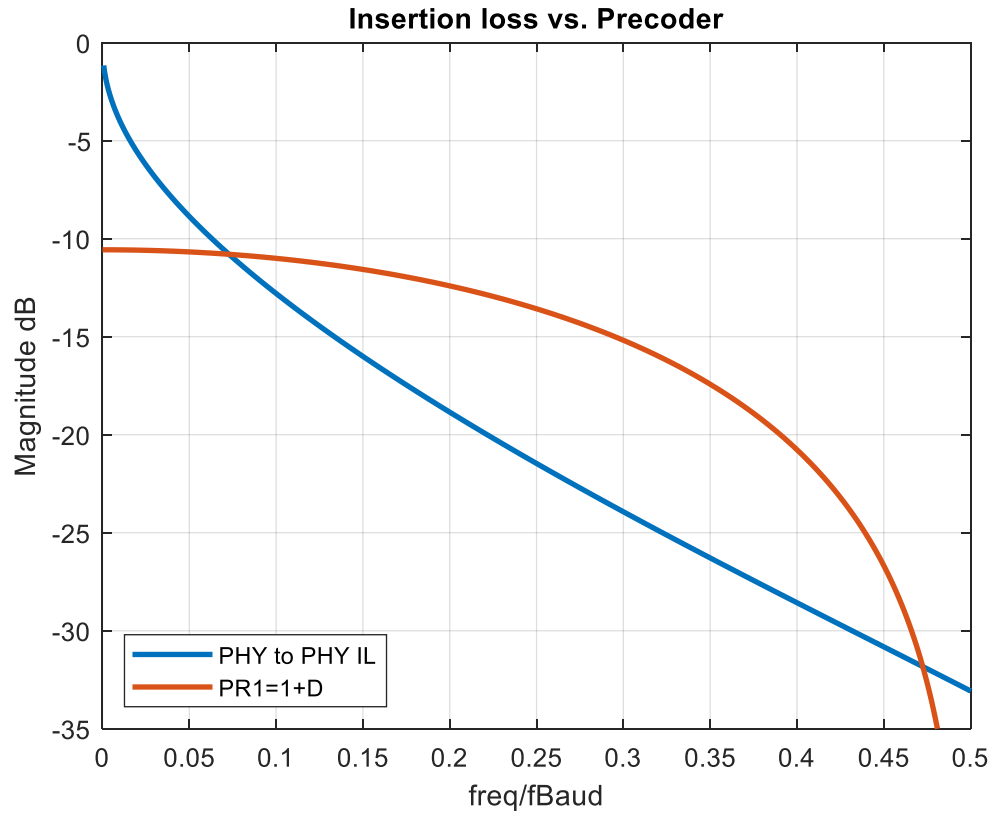
Optional Precoder [1 1], [1 -1] and [1 0 -1]

- Proposed in souvignier_3ch_01_0818.pdf
- PR1=1+D matches low pass behavior of 802.3cy insertion loss.





Conclusion: modulation selection for 25Gb/s over a shielded cable.

- Proposed Modulation for 802.3cy: PAM-4 (2 bits / symbol).
  - Straightforward bit to symbol mapping.
  - Peak limited TX voltage constraint: 1.1dB SNR advantage for PAM4.
  - PAM4 more robust against RFI compared to higher order constellations.

- Include the optional pre-coder [1 1], [1 -1] and [1 0 -1].
  - Most of the signal energy is at the lower frequencies.
  - Good fit for equalization to [1 1].