

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

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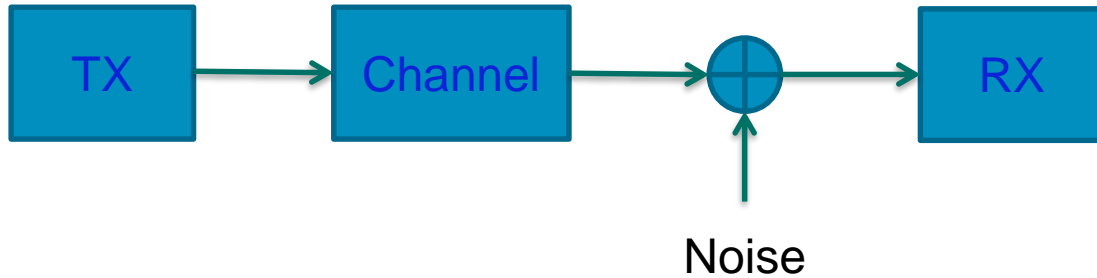
Contributors

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- Tooraj Esmailian

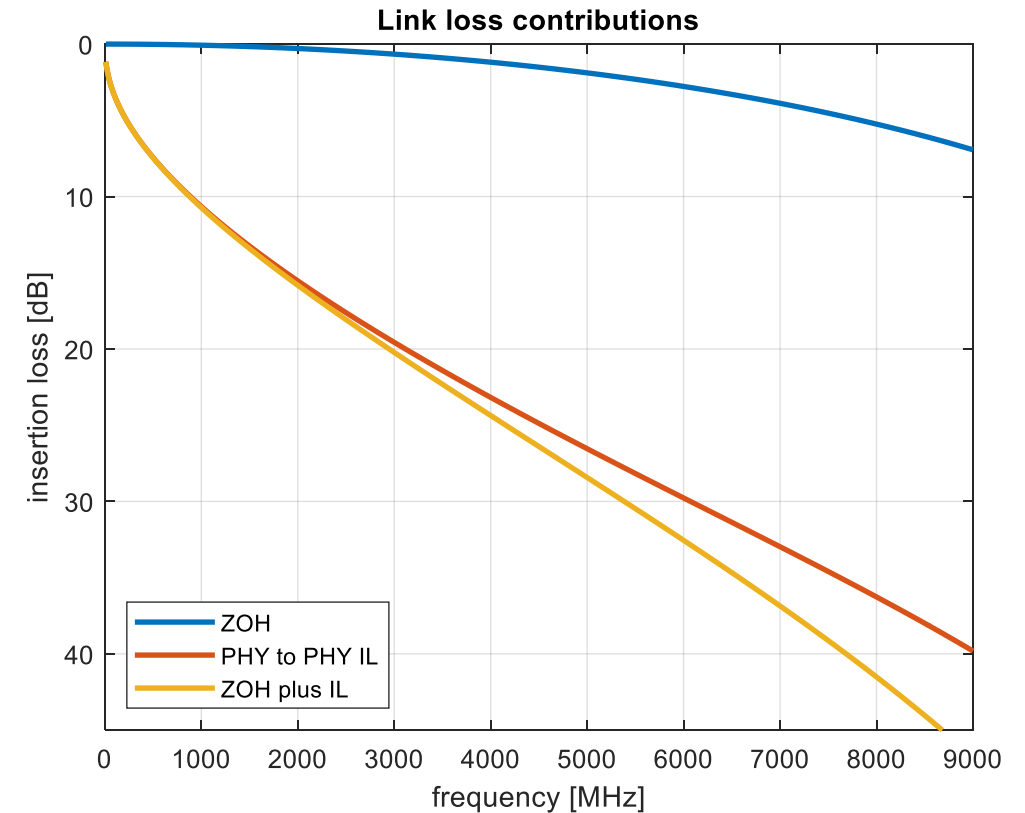
Setup of the SNR margin evaluation:

- 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: 1.43dBm nominal at TP0.
 - Constellation comparison for same TX power.
 - 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.

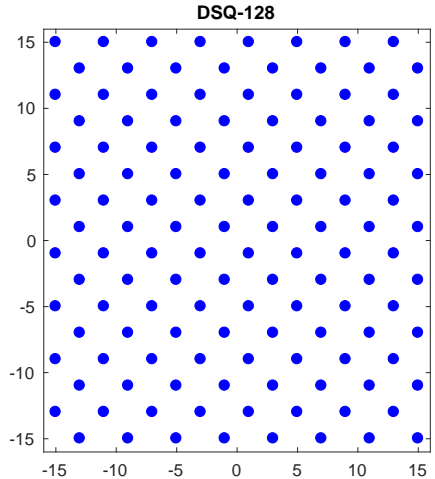
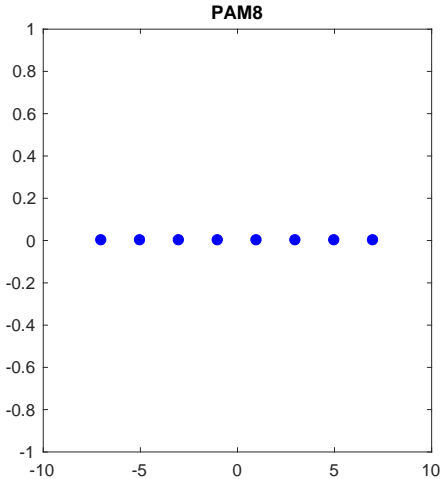
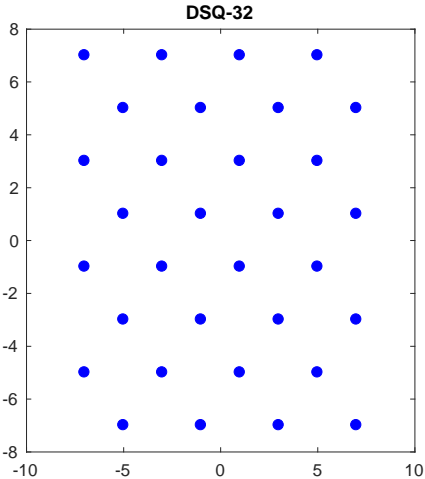
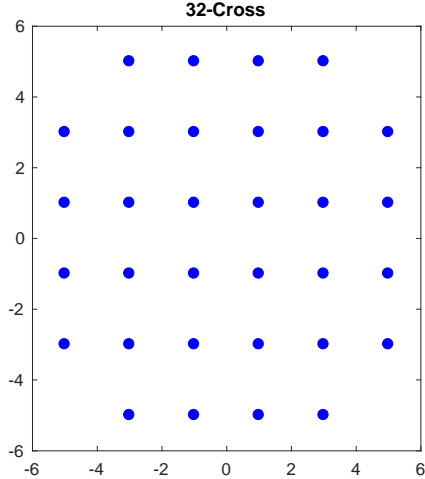
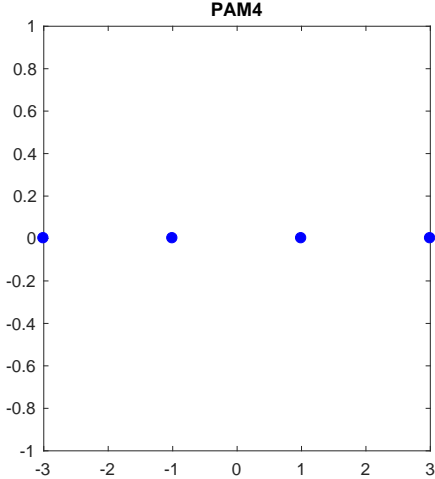
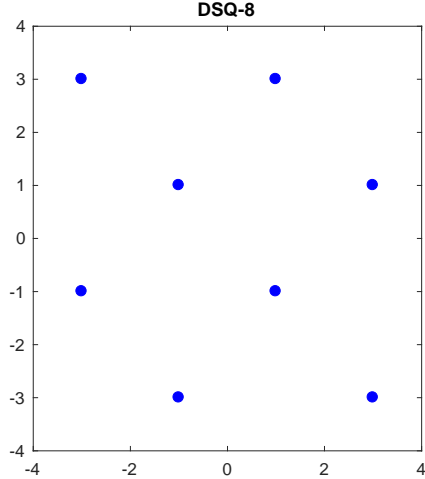
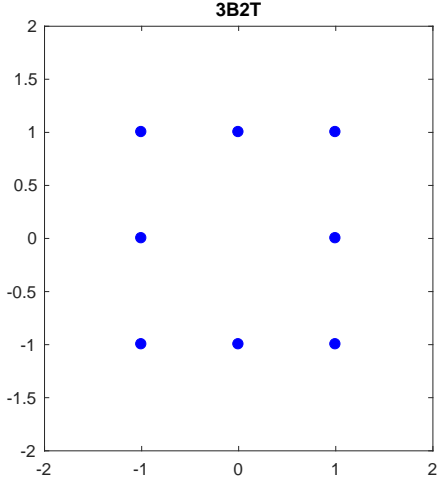
Insertion loss contributions and input referred noise.



- TX signal power: 1.43dBm 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.

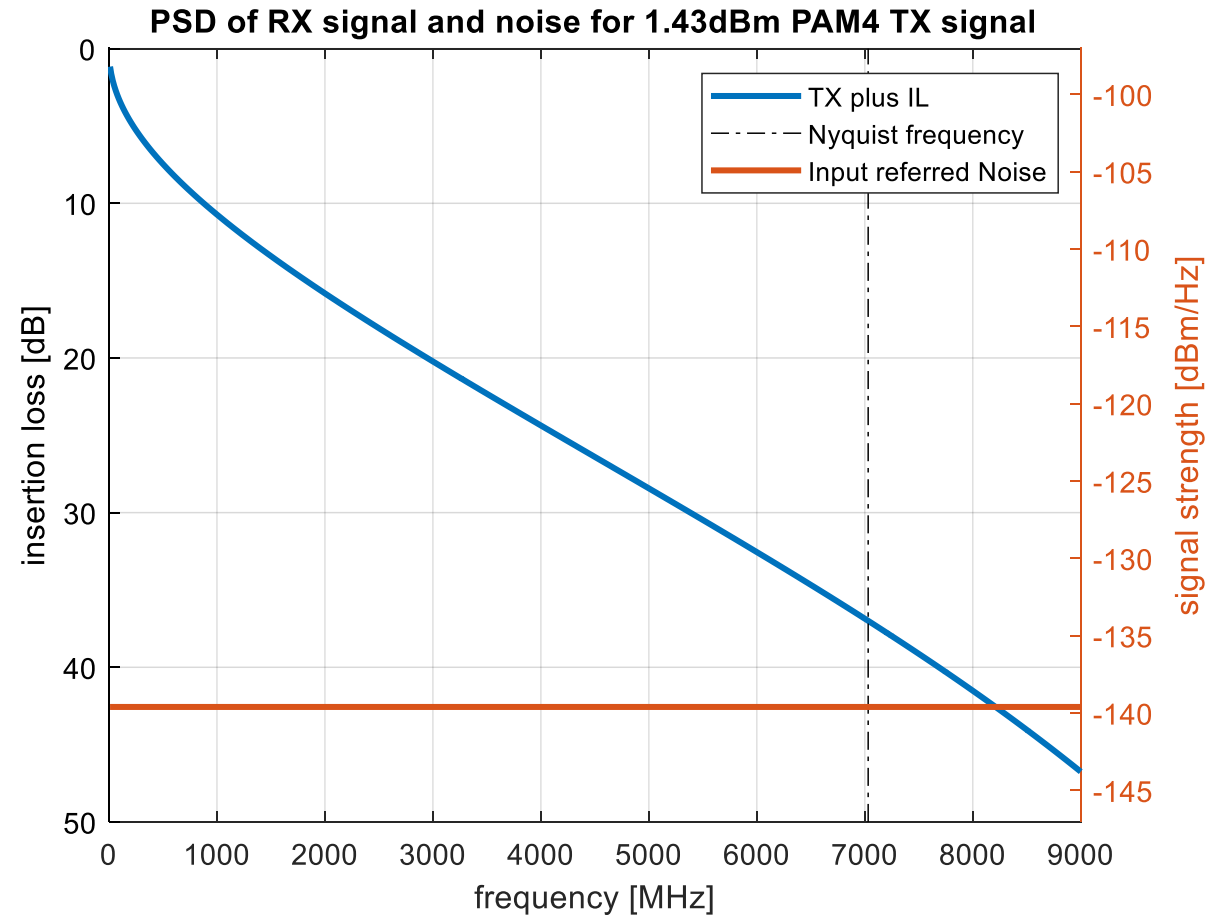


Constellations Considered



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

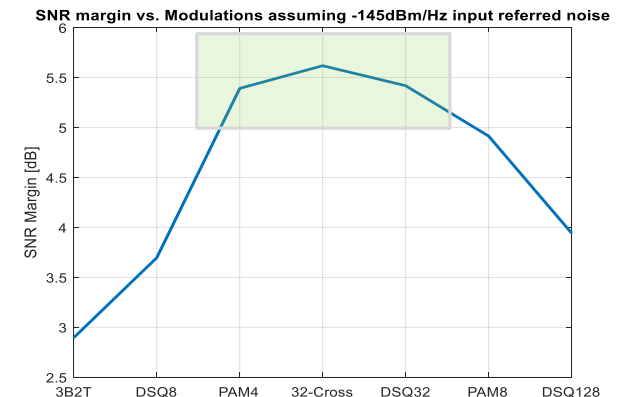
- TX signal: 1.43dBm
- TX signal spread over frequency:
 - $-98.5\text{dBm/Hz} = -10\log_{10}(7.03125\text{GHz})$
- Mean of SNR in dBm/Hz
 - -118.9dBm/Hz
- SNR needed for BER=1e-6: 20.7dB.
- Noise level
 - Mean of SNR – SNR needed for BER 1e-6:
 - -139.6dBm/Hz .



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

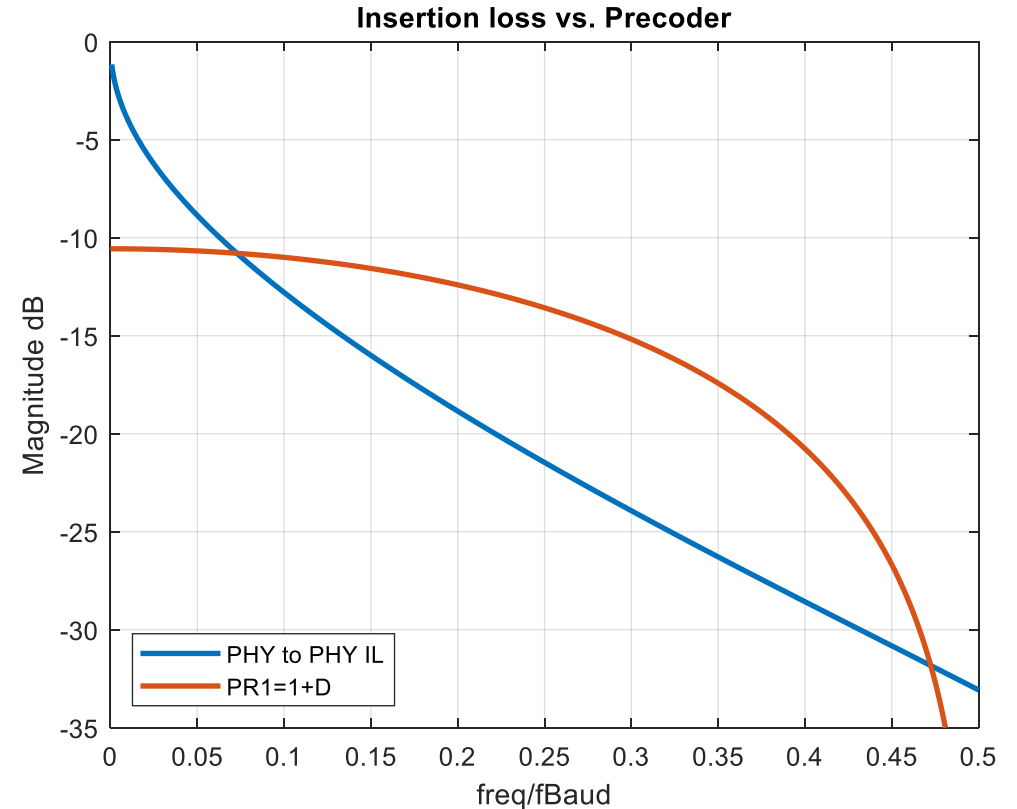
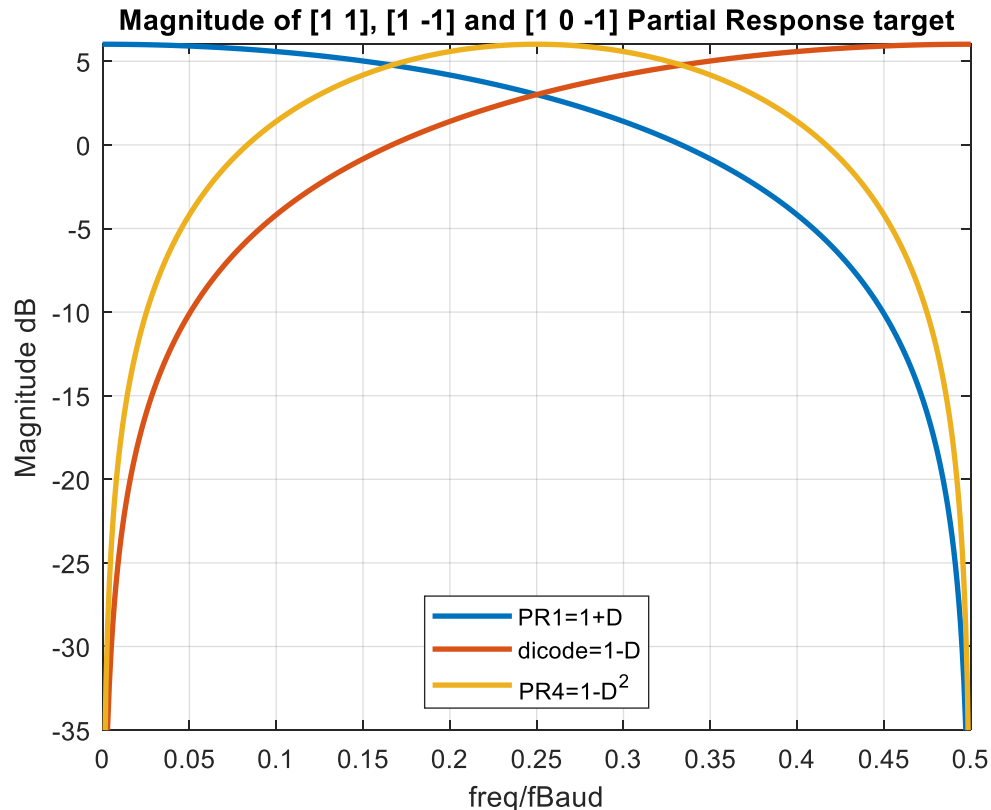
Modulation	Bits/Sym	Symbol Rate (GBaud)	Mean of RX signal (dBm)	Uncoded SNR @1e-6 SER (dB)	Noise (dBm/Hz)	SNR margin (dB) noise at -145dBm/Hz
3B2T	3/2	18.75	-123.5	18.6	-142.1	2.9
DSQ-8	3/2	18.75	-123.5	17.8	-141.3	3.7
PAM-4	2/1	14.0625	-118.9	20.7	-139.6	5.4
32-Cross	5/2	11.25	-115.4	24.0	-139.4	5.6
DSQ-32	5/2	11.25	-115.4	24.2	-139.6	5.4
PAM-8	3/1	9.375	-112.8	27.3	-140.1	4.9
DSQ-128	7/2	8.0357	-110.8	30.3	-141.1	3.9

- 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.



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

- 25Gb/s over shielded cable was considered.
- Preferred Modulation: PAM-4 (2 bits / symbol)
 - Allowable input referred noise is within 0.2dB of the optimum of the examined modulations.
 - Lower signal constellation is more robust against interference.
- Most of the signal energy is at the lower frequencies:
 - Good fit for equalization to $[1 \ 1]$.
 - Optional pre-coder $[1 \ 1]$, $[1 \ -1]$ and $[1 \ 0 \ -1]$ should be included.