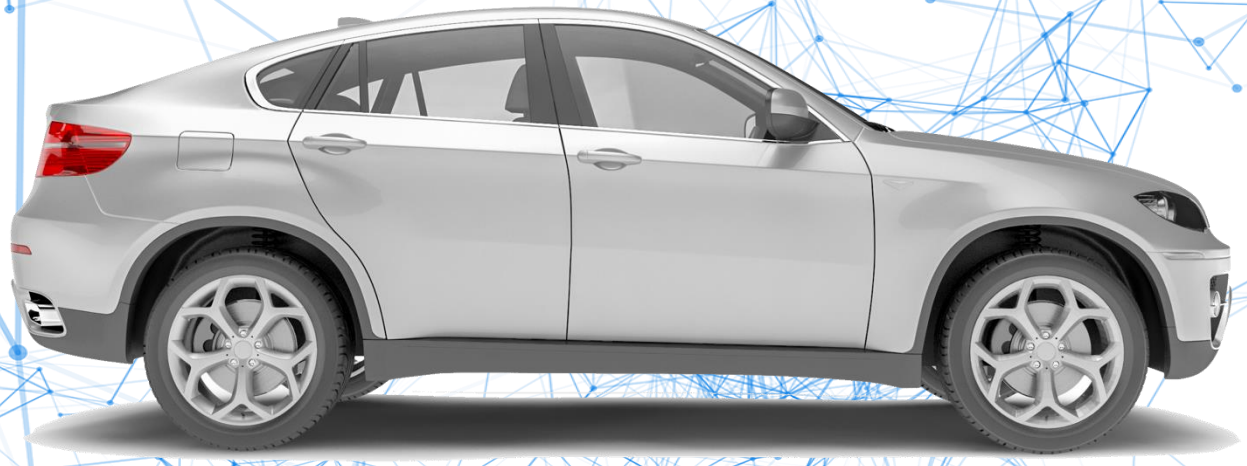

Choice of Modulation

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IEEE 802.3cy August 2021

Overview

- Task force recently adopted the limit lines for insertion loss and return loss
- This presentation revisits modulation options given these newly adopted limit lines
- The analysis presented here follows closely that of a previous contribution (sedarat_3cy_1120)

Baud Rate, Bandwidth and SNR

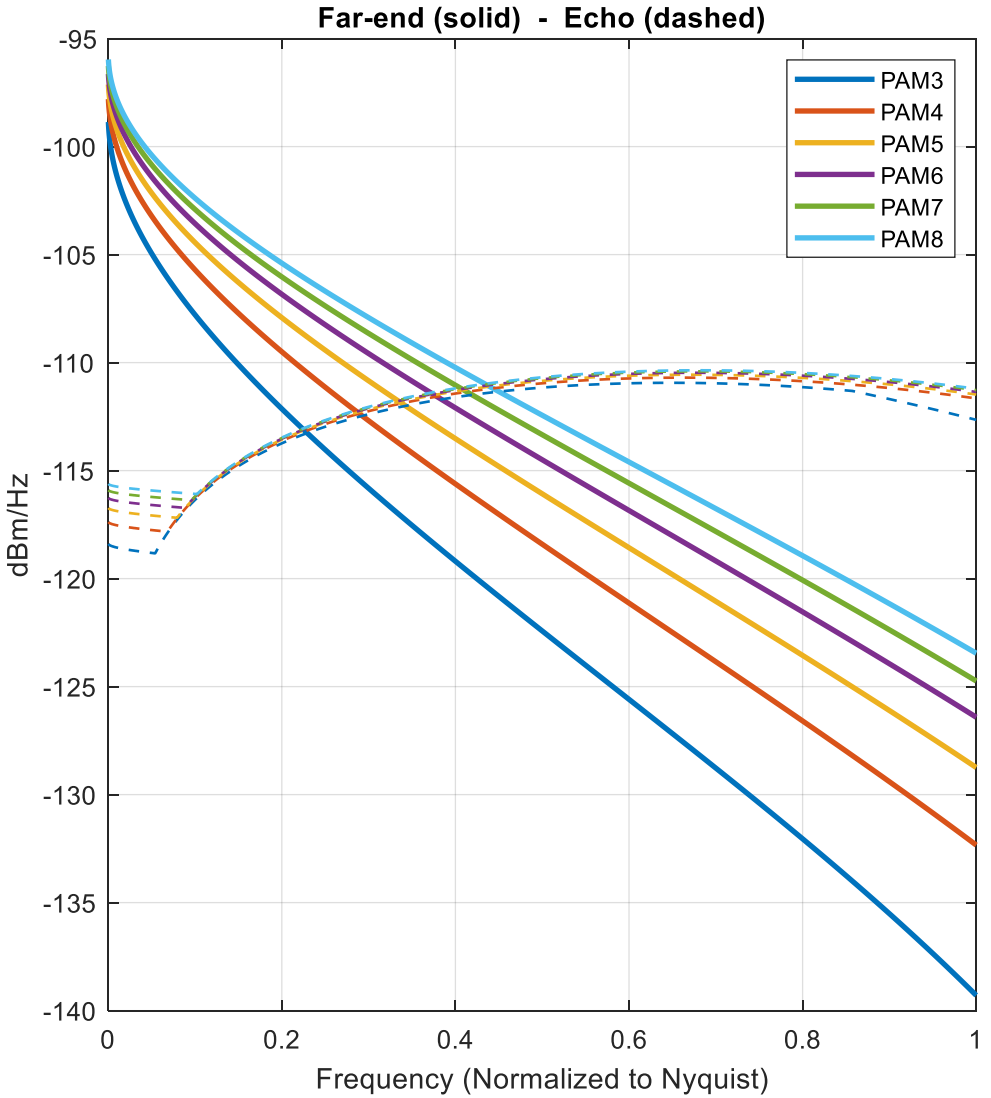
- Assuming FEC redundancy and other overheads to be the same as 802.3ch
- Target error rate: 10^{-12}
- Assuming FEC coding gain covers implementation loss and design margin

Modulation	PAM3	PAM4	PAM5	PAM6	PAM7	PAM8
Baud Rate (GHz)	**17.7**	**14.1**	**12.1**	**10.9**	**10.0**	**9.4**
Nyquist (GHz)	**8.9**	**7.0**	**6.1**	**5.4**	**5.0**	**4.7**
Required Slicer SNR (dB)	**21.3**	**24.0**	**26.1**	**27.7**	**29.1**	**30.3**

PSD: Received Signal and Echo

- Transmit PSD: zero order hold
- Transmit power: 0 dBm
- Insertion and return loss at limit line
- PCB/MDI loss as in [diminico_0521]

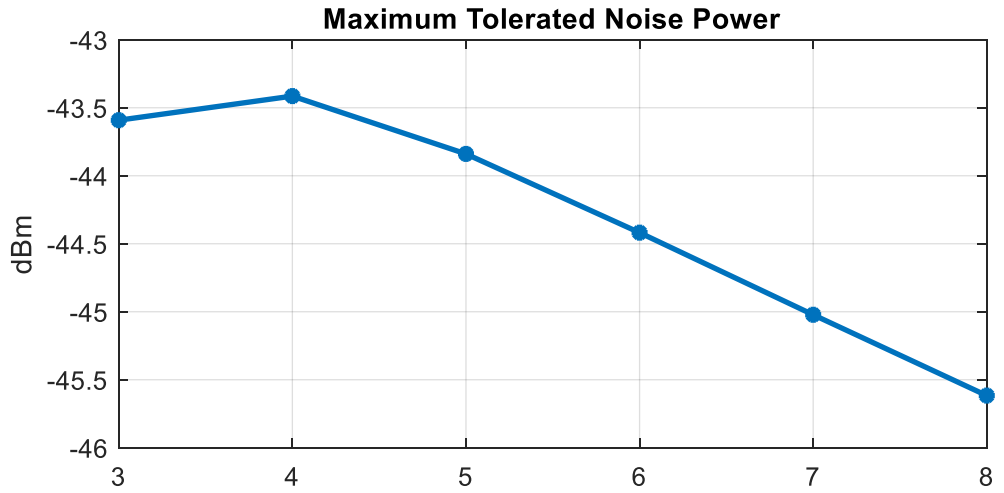
Constellation	PAM3	PAM4	PAM5	PAM6	PAM7	PAM8
Signal Power (dBm)	**-12.9**	**-12.0**	**-11.4**	**-10.9**	**-10.6**	**-10.4**
Signal-to-Echo Ratio (dB)	**-0.2**	**1.4**	**2.5**	**3.4**	**4.0**	**4.4**

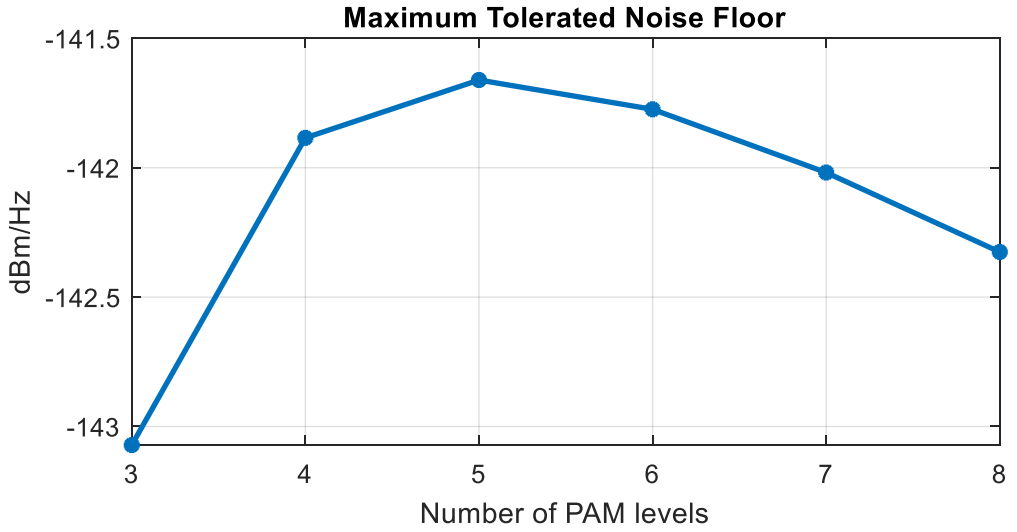


Tolerated Noise

Constellation	PAM3	PAM4	PAM5	PAM6	PAM7	PAM8
Required Slicer SNR (dB)	**21.3**	**24.0**	**26.1**	**27.7**	**29.1**	**30.3**
Required Input SNR (dB)	**30.7**	**31.5**	**32.4**	**33.5**	**34.4**	**35.3**
Equalization Loss (dB)	**9.4**	**7.5**	**6.3**	**5.8**	**5.3**	**5.0**

- Equalization loss is lower for denser constellations
- Received signal power is higher for denser constellation
  - ➔Maximum tolerated noise power and noise floor have limited variations across different constellations
  - ➔ Both PAM4 and PAM5 are close to the sweet spot





PAM4 vs PAM5

- PAM4 advantages:
  - Lower SNR requirements reduces the complexity and power consumption
  - More tolerant of constant power noise sources
  - More immunity to RF interference
- PAM5 advantages:
  - More tolerant to stronger white noise sources
  - Lower baud rate:
    - PHY complexity and power consumption is generally reduced with lower baud rate
    - The power and time span of echo response is reduced with baud rate
    - Equalization is easier with lower insertion loss in a narrower bandwidth
    - RF interference is generally weaker at lower frequencies
    - Emission is easier to control at lower frequencies
    - Less sensitivity to timing error and jitter at lower bandwidth
    - Shielding, isolation and balance is easier to control in lower frequencies

Summary and Conclusions

- PAM4 and PAM5 are both reasonable choices offering similar levels of noise tolerance
  - PAM4 tolerates lower SNR and higher noise power (by less than a dB)
  - PAM5 tolerates stronger noise floor (by less than a dB)

- PAM5 operates at lower baud rate and bandwidth (6 GHz vs 7 GHz), offering advantages in many aspects
  - This makes PAM5 a strong candidate to consider

THANK YOU

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