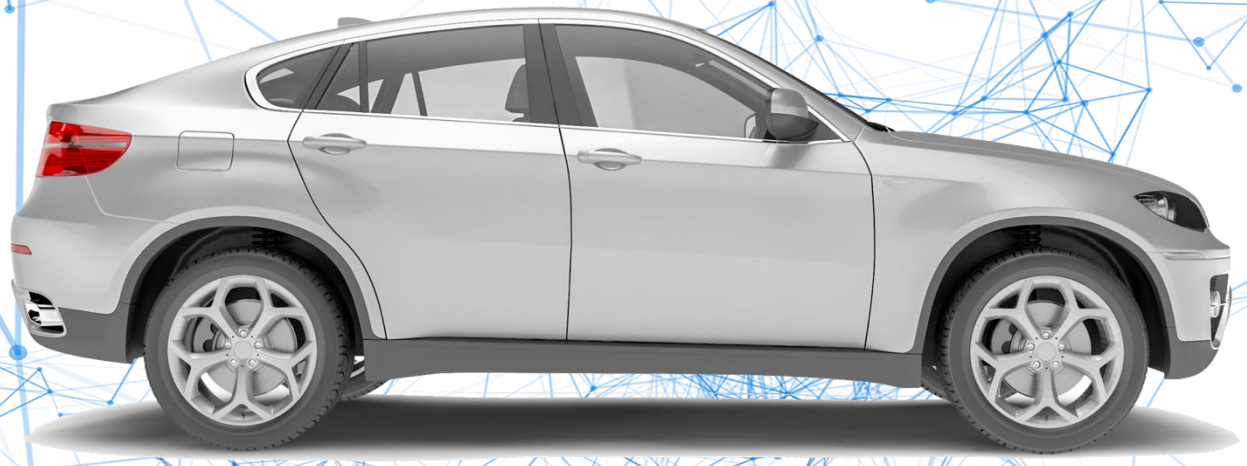


Limiting Factors on Signal-to-Noise Ratio

Hossein Sedarat

December 2020

Overview

- A strawman proposal for insertion loss is derived from 802.3ch limit through frequency-scaling (zimmerman_3cy_01a_1120)
  - 30 dB loss at Nyquist frequency (7 GHz)

- A baseline analysis in jonsson_3cy_01a_12_01_20 indicates positive performance margin with this limit for insertion loss

- This presentation explores the SNR impact of a few limiting factors not considered in the baseline analysis

Outline

- Assumptions in the baseline analysis
- Transmit PSD and its impact on SNR
- PCB insertion loss
- Other contributors to signal loss
- FEC coding gain for Gaussian noise
- EMI considerations
- Other sources of implementation loss

Assumption in Capacity Analysis

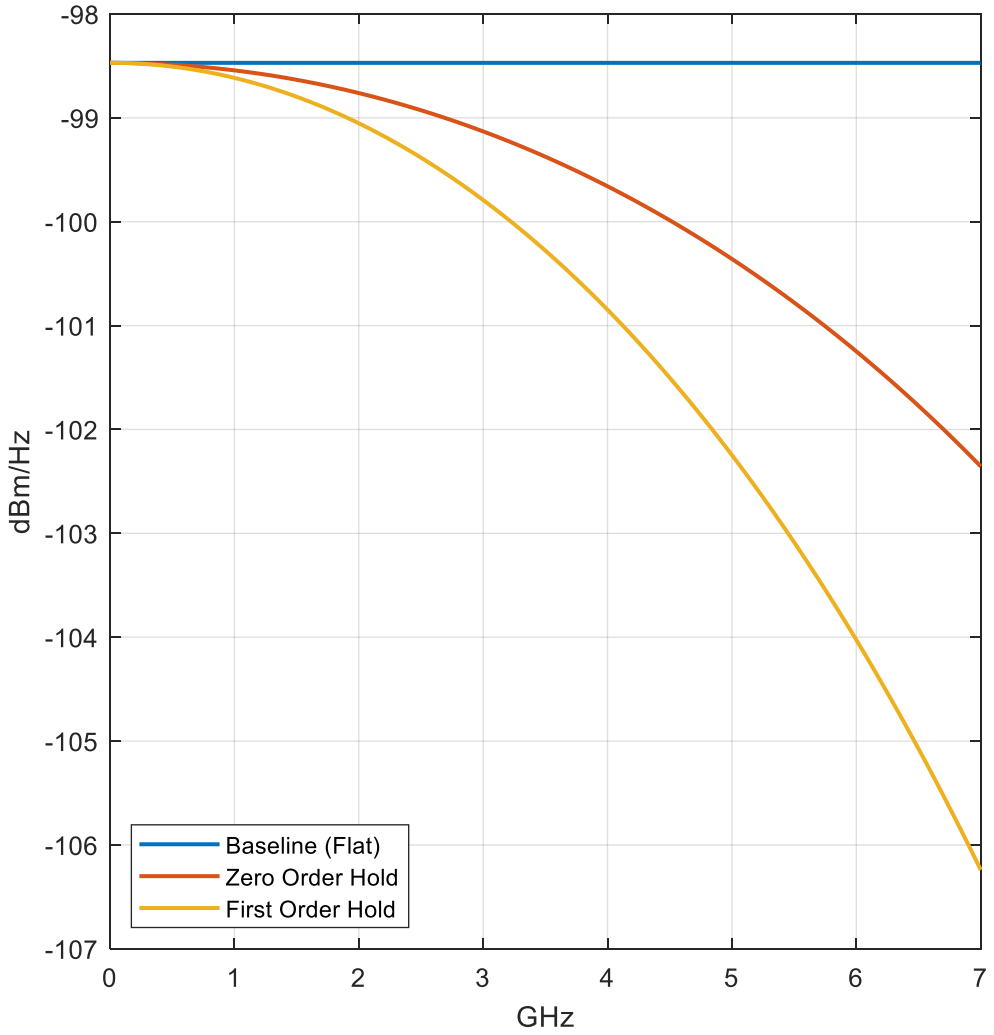
- The baseline analysis indicates roughly 2.5 dB of PHY operating margin with an insertion loss according to the strawman proposal

- Some of the assumptions in that analysis
  - Flat transmit PSD
  - No other source of signal loss besides the cable
  - Generous allocation of FEC coding gain to Gaussian noise
  - No allocated budget for EMI
  - Limited allocation for implementation loss

Transmit PSD

- A flat transmit PSD is not realistic
- At the minimum, we should consider zero order hold
- Assuming the same peak voltage, zero order hold results in 4 dB loss at Nyquist
- A higher order hold, with higher loss, may be more desirable for emission considerations

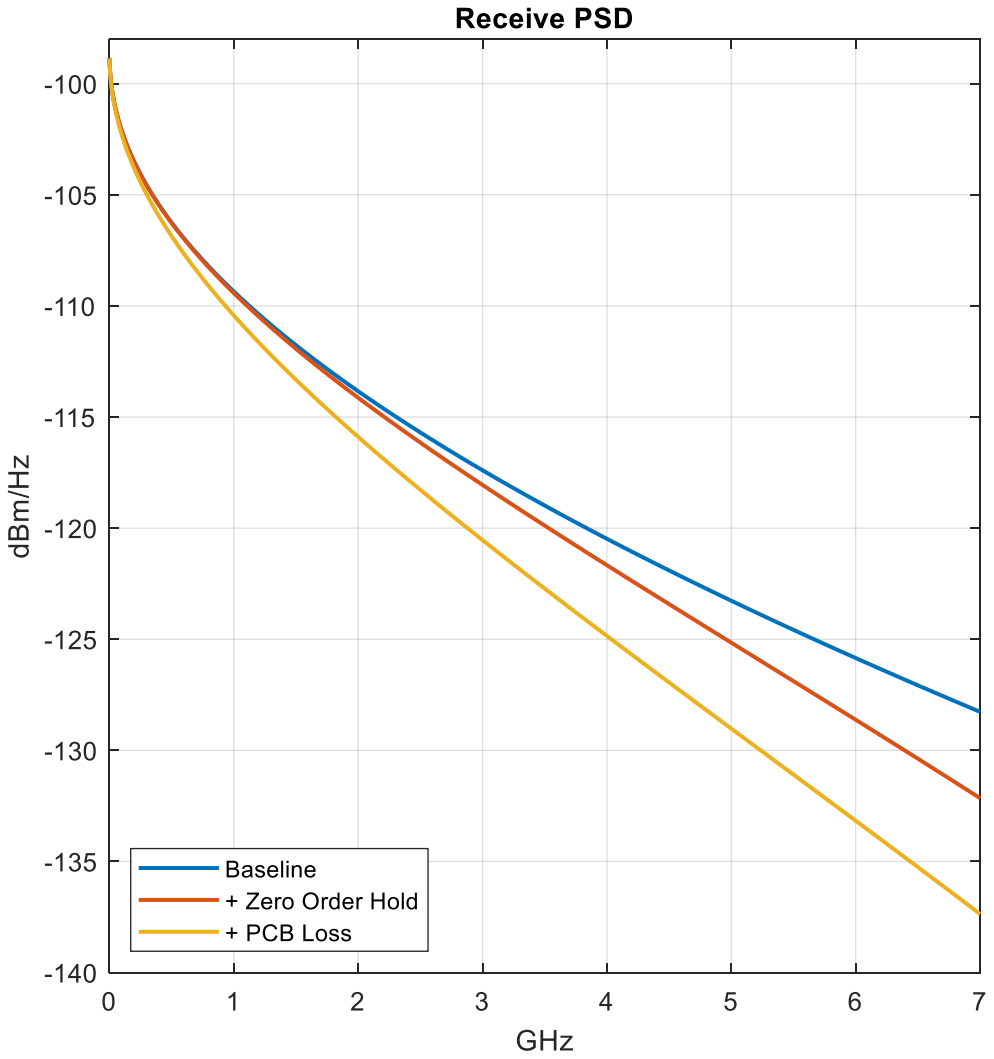
➔ **SNR loss due to ZOH = 1.2 dB**



PCB Insertion Loss

- The baseline analysis assume no insertion loss for PCB
- Considering kadry_3cy_02_0820 with the suggested loss of more than 5 dB at Nyquist

➔ **Incremental SNR loss = 2.6 dB**

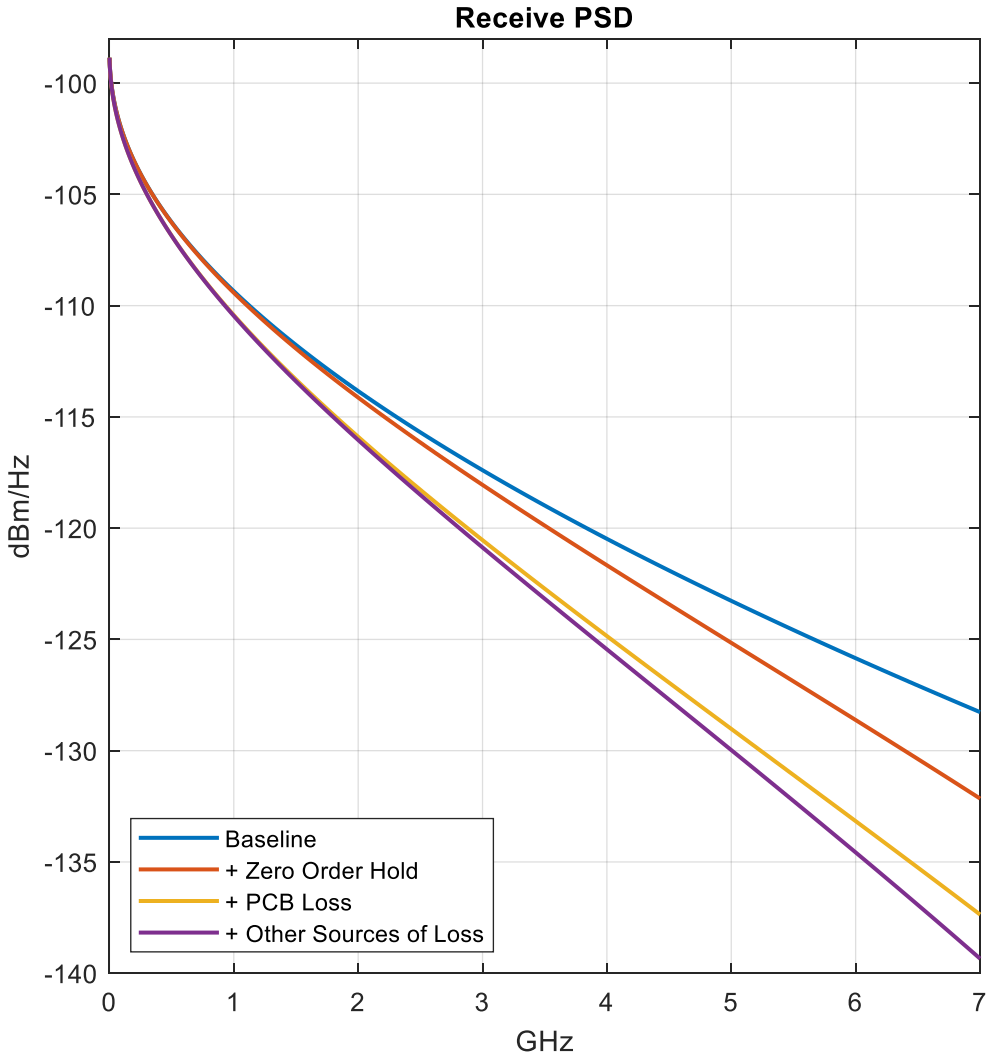


Other Sources of Signal Loss

- Partial list of additional sources of signal loss:
  - Inline connectors
  - Common-mode choke
  - ESD protection
  - PoDL and AC coupling
- The loss at Nyquist can easily grow to a few dBs at each end of the link

With an optimistic signal loss of only 1 dB at each end:

➔ **Incremental SNR loss = 0.6 dB**



FEC and Impulse Noise

- FEC is the primary mechanism to protect against impulse noise
- Impulse noise is a burst of high-power disturbance
- The impulse burst may cover many words of an FEC frame (even with interleaving)
- Comparing to the frame size, the impulse burst covers 2.5 times more words than 802.3ch

→ Impulse noise is not uniformly spaced in time and it should not be treated as such in coding gain calculation

FEC Coding Gain

- FEC error correction capability has to be partitioned between impulse noise and Gaussian noise
  - Favoring Gaussian noise: consider uniform impulse rate resulting almost all of FEC coding gain (6 dB) allocated to Gaussian noise
  - Favoring impulse noise: dedicate the entire FEC capability for impulse noise correction with no coding gain for Gaussian noise
  - Fair partitioning: FEC should correct errors due to long burst of impulse noise and Gaussian noise simultaneously resulting in lower coding gain for Gaussian noise

With fair allocation:

➔ **Reduction in coding gain = 1.6 dB**

RF Noise Immunity

- RF interference is an important noise source that has to be taken into account in overall noise budget

- A wider signaling bandwidth increases the susceptibility to RF noise
  - Wider frequency range and exposure to RF sources
  - Poor coupling/shielding attenuation of cable at high frequencies
  - Worse mode-conversion and imbalance at higher frequencies

In order to tolerate 5 mv of EMI (sedarat_3cy_01_1120):

➔ **EMI margin allocation = 3.0 dB**

Implementation Loss

- There are other sources of implementation loss besides AFE noise and partial echo cancellation
- Some of these sources are
  - Finite resolution in digital signal processing
  - Finite length of filters
  - Additional equalization constraints due to challenges of very high sampling rate
  - Sampling phase, PLL phase noise and clock jitter

While 3 dB allocation is very reasonable, consider a minimal value:

➔ **Implementation loss = 1.0 dB**

Summary and Conclusion

- The strawman proposal for insertion loss shows 30 dB of loss at Nyquist
- A baseline analysis showed a positive operating margin for PHY with this limit
- Considering a few real limiting factors, the SNR margin is reduced by as much as 10 dB deep into negative values

➔ The strawman proposal for insertion loss is a very challenging limit line

	SNR Margin (dB)
Baseline	+2.5
+ Zero order hold	-1.2
+ PCB loss	-2.6
+ Other sources of loss	-0.6
+ FEC gain correction	-1.6
+ EMI margin allocation	-3.0
+ Implementation loss	-1.0
Final SNR Margin	**-7.5**

THANK YOU

ETHERNOVIA | hossein.sedarat@ethernovia.com