A Straw-man Proposal Approach to a PHY Specification

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Needs and Observation

- Need: A complete specification of a PHY
- Observation:
  - We have been working from the ‘short-lead-time’ item (cabling)
  - Cabling presentations present losses based on 802.3ch with frequency extensions
    - ... /Kadry_3cy_02_0820.pdf ; .../DiBiaso_Bergner_Cuesta_3cy_adhoc_01b_10_28_20.pdf ; .../koeppendoerfer_3cy_01_10_28_20.pdf
  - PHY presentations present needs to extend performance to higher rates
    - Specifying IL: .../sedarat_3cy_01_10_14_20.pdf ;
    - Specifying RL: .../jonsson_3cy_01a_10_14_20.pdf
    - Modeling: .../jonsson_3cy_01_10_28_20.pdf ;
  - The two disconnect and are based on different assumptions!
    - PHYs are new designs, cabling is more derivative, results existing in prototype form
- Unlikely to get to a complete PHY specification anytime soon this way

Proposal to Accelerate Progress

- One way to move forward is to begin with a straw-man proposal for a PHY and link segment
  - Then figure what is needed from the channel
  - Adjust to make the two meet
- What exactly do I mean a “strawman proposal” –
  - Wikipedia – “The Internet’s Source of Approximate Truth” (J. D’Ambrosia)
    - “A **straw-man (or straw-dog) proposal** is a brainstormed simple draft proposal intended to generate discussion of its disadvantages and to provoke the generation of new and better proposals.” (https://en.wikipedia.org/wiki/Straw_man_proposal)

What might a Straw-Man Proposal Be?

- 802.3ch is close, and allows frequency scaling
  - 2.5G to 10G – why not to 25G
- PCS blocking, FEC parameters, state diagrams are defined
- Baud rate, Transmit PSD, Jitter, etc. are scaled
- Link segment insertion loss becomes the initial focus for modification
  - Simply extending the IL in frequency isn't going to work.

PHY specifications - bootstrapped

- PAM 4, 7031.25 Nyquist, 14062.5 MBaud
- PCS blocking, scramblers, state diagrams defined
- EEE modes defined
  - Q: Do we need something more for these use cases?
- RS-FEC interleaved block coding, per 802.3ch specification
  - Q: What interleave is needed for 25 Gbps rate?
- PMA electricals defined
  - E.g., 1.3Vpp output, Droop, PSD masks per frequency scaling
- Transmitter test modes defined
  - Receiver test levels need work but after link segment

What about a link segment target

- Frequency extended IL (149.7.1):

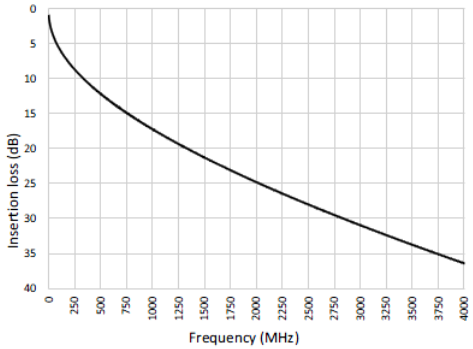


Figure 149–41—Insertion loss calculated using Equation (149–18)

$$Insertion\ loss(f) \le 0.002\,f + 0.68 f^{0.45} \quad \text{(dB)}$$

where

f is the frequency in MHz; $1 \le f \le$ Fmax

- Frequency scaled PSD (149.5.2.4)

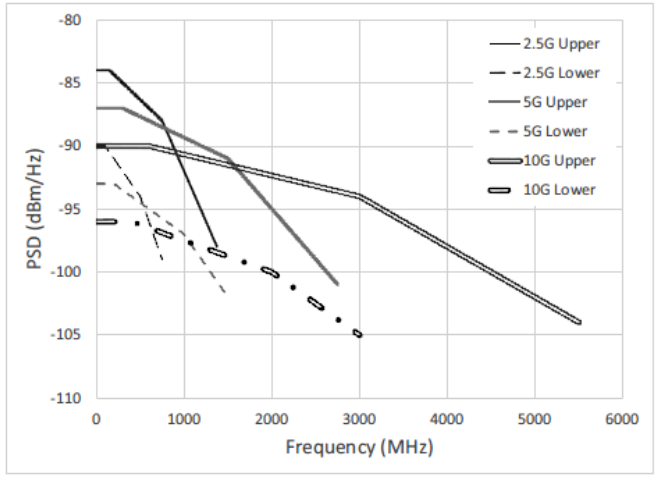


Figure 149–39—Transmitter Power Spectral Density, upper and lower masks

$$LPSD(f) = \begin{cases} -96 - K & \text{dBm/Hz} \quad 5 < f \le 400 \times S \\ -95 - K - \dfrac{f}{400 \times S} & \text{dBm/Hz} \quad 400 \times S < f \le 2000 \times S \\ -90 - K - \dfrac{f}{200 \times S} & \text{dBm/Hz} \quad 2000 \times S < f \le 3000 \times S \end{cases}$$

where

f is the frequency in MHz

$K = 10\log_{10}(S)$

Source: IEEE Std 802.3ch-2020

How does the Receive SNR behave

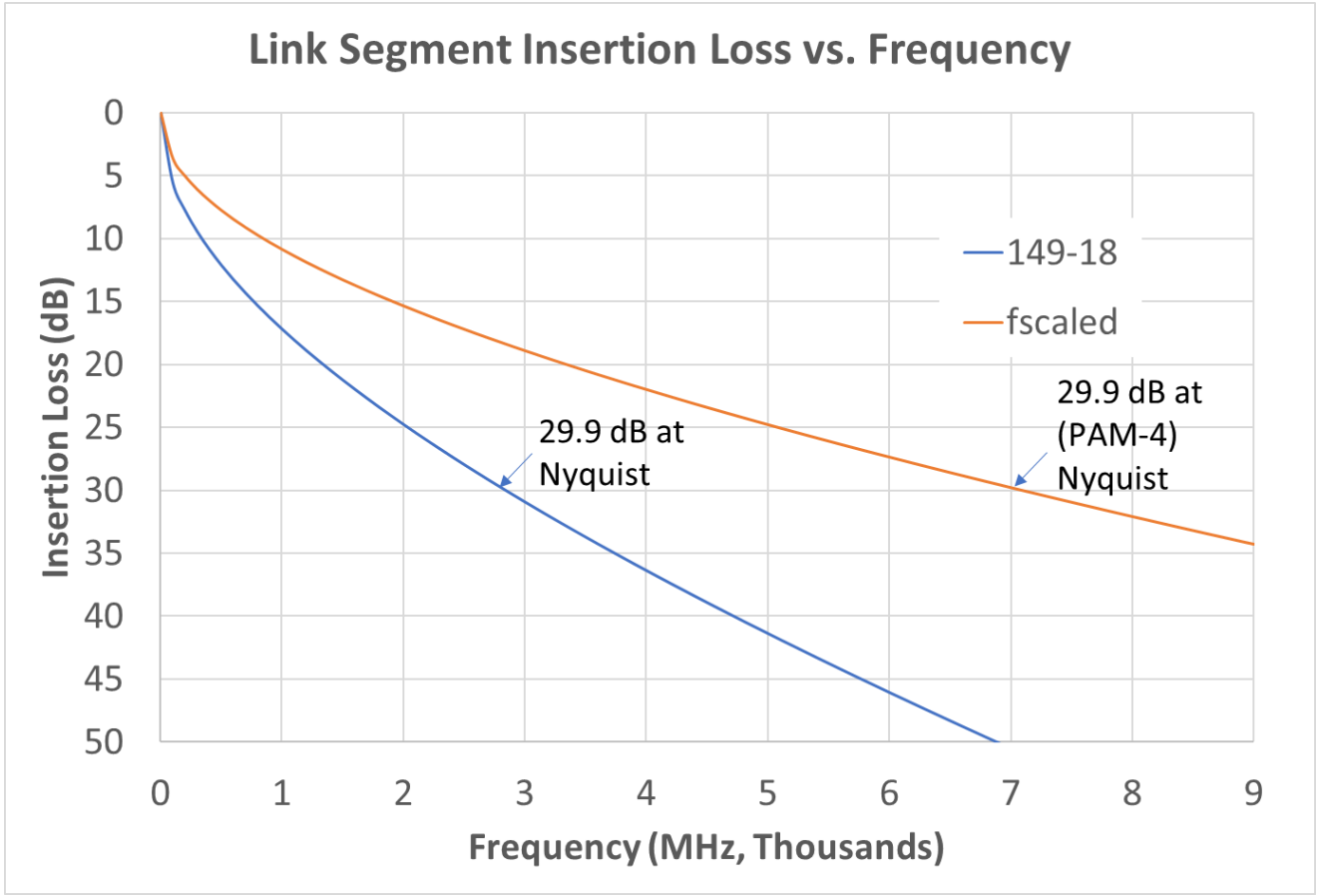
- Salz SNR (BSTJ, Vol 52 No 8 Oct 1973) optimum DFE SNR: $SNR_{Salz} \approx \frac{1}{W}\int_0^W 10\log_{10}\frac{S_i(f)}{N_i(f)}df = \mathrm{Avg}_{0<f<W}[SNR_{dB}(f)]$
- Freq extend: If $W_{new} = 2.5 \times W_{old}$ and new frequencies have significantly lower than $\mathrm{Avg}_{0<f<W_{old}}[SNR_{dB}(f)]$, SNR_{Salz} goes down by up to a factor of 2.5 in dB, e.g., 25dB -> 12.5 dB, a 12.5 dB loss...
- Freq scale: $S(f)$ behaves as TX PSD decreases. For constant TX power of a scaled shape, If $N(f)$ is unchanged, SNR_{Salz} goes down only $10\log_{10}(2.5)$ = 4dB

Frequency Scaled link segment IL

$$IL \leq 0.002\left(\frac{f}{2.5}\right) + 0.68\left(\frac{f}{2.5}\right)^{0.45}$$

This is a starting point

Same IL at Nyquist as .3ch



What does this mean

- Consider adopting the 802.3ch specification as a “TBD” and then comparing new proposals or changes to it with a new “S” factor for 25 Gbps (S = 2.5) and a frequency-stretched link segment

- Gets us started toward a specification
- Gives something solid to compare against
- Gives us clear things to change and a clear metric to evaluate improvements
- Maximizes reuse in silicon design and standards specification

IL Adjustments to consider

- PCB loss is greater
  - 2.7 dB extra loss @ Nyquist per Kadry_3cy_02_0820
  - Suggests IL scaling of ~ 10%
- PHY noise is likely greater at similar power due to bandwidth expansion
  - AFE power proportional to BW * $2^{-N_{AFE}/6.02}$,
    - Noise (N_{AFE}) for the same AFE power ~ 4.0 dB higher
- Suggests possible IL adjustment by 6 dB to 23.9 dB at Nyquist (in line with .../sedarat_3cy_01_10_14_20.pdf)

Proposal

- Consider adopting the 802.3ch specification as a “straw-man proposal”, with a new “S” factor for 25 Gbps (S = 2.5) and a frequency-stretched link segment, as on slide 8.

- Then focus on:
  - How to achieve a reasonable link segment IL
  - What PHY modifications or improvements we may wish to adopt relative to straw-man proposal
  - Close the gap...