2.5G and 10G PHYs Modulation Scheme Proposal

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Supporters

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Problem Statement

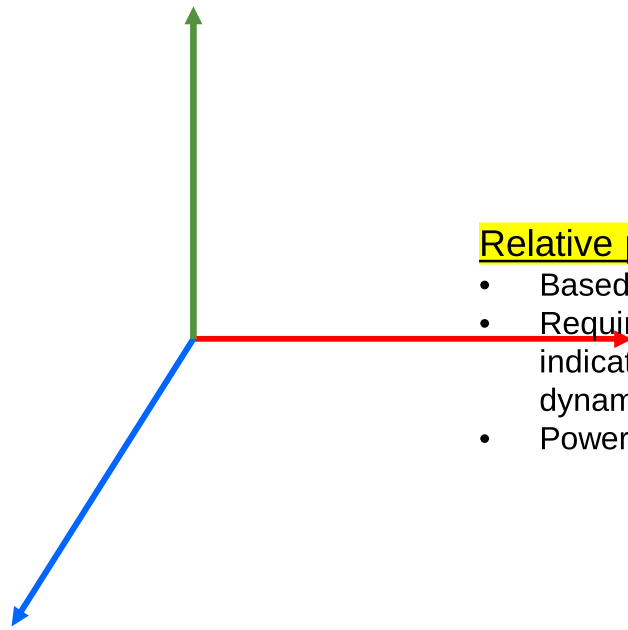
- Choosing PHY modulation scheme is a complex optimization problem with multiple constraints
- Optimum Bandwidth
  - Optimal bandwidth that gives the max. SNR
- Power consumption
- Interference tolerance
  - Narrow band interference
- EMC
  - Emission and Immunity
- Transient noise (e.g., ISO Pulses)

Analysis

- Thermal noise: -140dBm/Hz
- Baseline Insertion and Return losses as adopted in Geneva
- 1Vpp transmit voltage (TX-PSD from Pandey_3ch_01_1117.pdf)
- Channel length: 15m
- Channel code overhead: ~12%
- Parameters
  - Ideal SNR margin to capacity(dB)
  - Require echo cancellation (dB)
    - Echo cancellation needed at receiver to achieve the capacity
  - Relative power
  - Noise tolerance

Optimum bandwidth

- Frequency domain analysis
- Based on infinite length DFE SNR calculation



Relative power

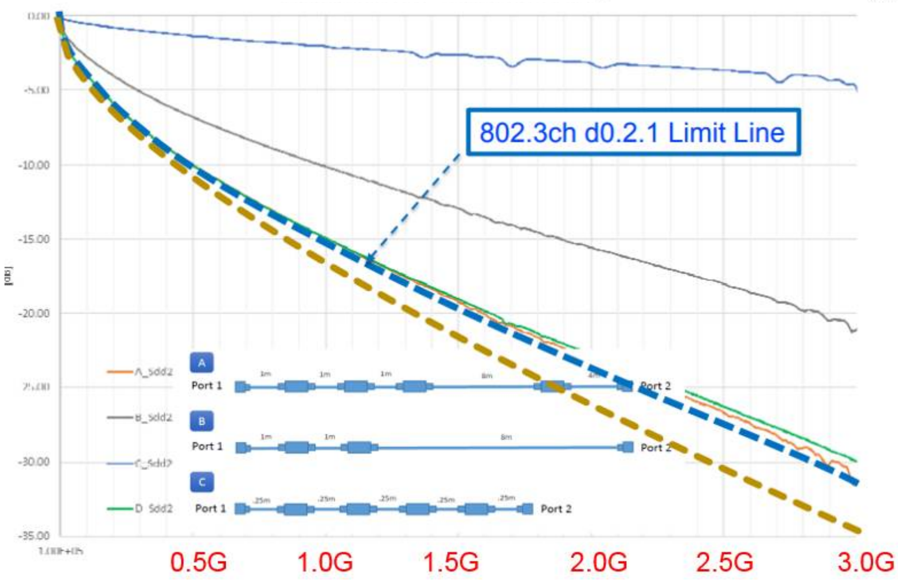
- Based on ADC power FOM
- Require SNR → ENOB that indicates the require dynamic range of ADC
- Power = F_{nyq}* 2.^(ENOB)

Noise tolerance

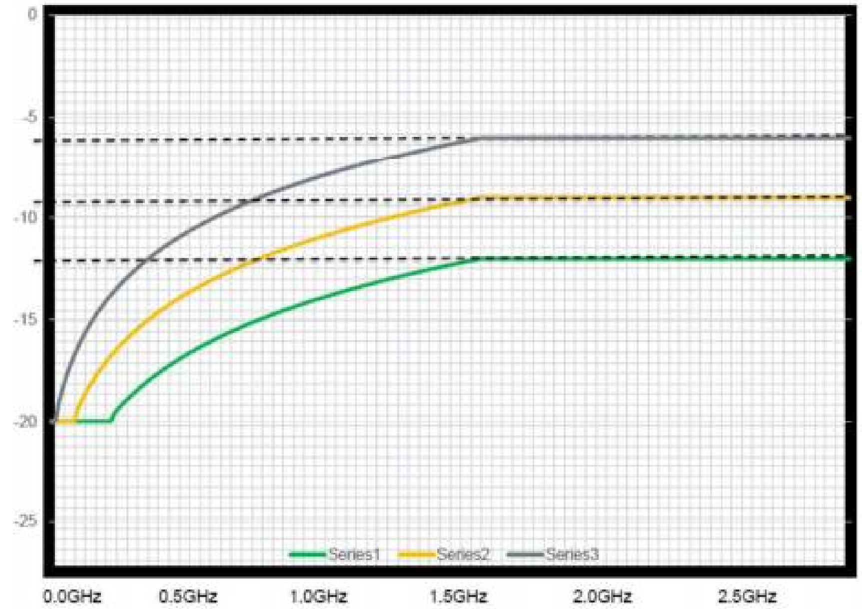
- Time domain anaysis
- Eye opening at slicer using realistic finite length DFE
- Checking the margin w.r.t BCI and ISO Pulse noises

Channel

Insertion loss



Return loss



- $IL_{3GHz} > 20dB$ → N=0
- $10dB < IL_{3GHz} < 20dB$ → N=1
- $IL_{3GHz} < 10dB$ → N=2

$$\text{Return.Loss(dB)} \le \begin{cases} 20\text{dB} & 5 \le f < 500/2^N \\ 12-3N - 10\log(f/3000) & 500/2^N \le f < 3000 \\ 12-3N & 3000 \le f < 5500 \end{cases}$$

(*f in MHz*)

10G PHY: Salz SNR Analysis – 15m Cable

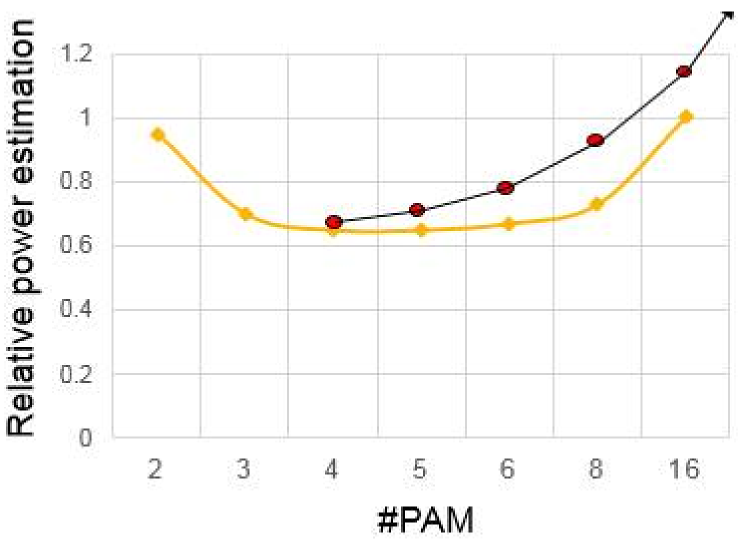
15m Cable	PAM2	PAM3	PAM4	PAM5	PAM6	PAM8	PAM16
Baud Rate (GBaud)	11.2	7.0	5.6	4.8	4.3	3.7	2.8
Nyquist Freq. (GHz)	5.6	3.5	2.8	2.4	2.1	1.8	1.4
IL@Nyquist (dB)	48.0	34.5	30.0	27.0	24.5	22.5	19.3
RL@Nyquist (dB)	12.0	12.0	12.5	13.0	13.5	14.2	15.3
Ideal SNR Margin (dB)	14.3	18.5	**19.3**	**19.1**	18.6	17.5	13.7
Echo cancellation (dB)	17.0	24.3	26.9	28.2	28.8	29.5	30.0

2.5G PHY: Salz SNR Analysis – 15m Cable

15m	PAM2	PAM3	PAM4	PAM5	PAM6	PAM8	PAM16
Baud Rate (MBaud)	2800	1766	1400	1204	1082	932	700
Nyquist Freq. (MHz)	1400	883	700	602	541	466	350
IL@Nyquist (dB)	19.2	14.5	12.7	11.6	11.0	10.0	8.5
RL@Nyquist (dB)	15.0	17.5	18.2	19.0	19.5	20.0	20.0
Ideal SNR Margin (dB)	32.2	**35.0**	34.3	33.3	32.2	30.2	25.0
Echo cancellation (dB)	29.3	33.3	34.1	34.4	34.5	34.5	34.5

Relative Power Estimation

- Assumption ~12% FEC overhead for all modulations!
- Relative power estimation is based on FOM of data convertors
- Relative power = BW * $2^{(ENOB)}$
- ENOB = design_margin –SNR (dB)
- Higher level of PAM (>PAM4) needs more overhead for tolerate the NBI interference
- Relative power will increase for higher level of PAM



Interference Tolerance

- FFE as an all pass filter
- Finite length DFE with reasonable number of taps
- Eye opening is w/o considering noise sources
    - Thermal noise, residual echo/ISI, clock jitter, interferences (BCI/ISO pulses), residual baseline wander etc.
- Noise interferences (BCI and ISO Pulses) amplitude greater or equal to (Eye Opening/2) will result BER for a moderate coding overhead ~12%

10G	PAM2	PAM3	PAM4	PAM5	PAM6	PAM8	PAM16
Eye Opening	734mV	390mV	267mV	204mV	165mV	119mV	57mV

In absence of noise and interferences PAM16 can tolerate BCI or ISO pulse < 28.5mV with no margin at all!

2.5G	PAM2	PAM3	PAM4	PAM5	PAM6	PAM8	PAM16
Eye Opening	863mV	449mV	305mV	231mV	186mV	134mV	62mV

In absence of noise and interferences PAM16 can tolerate BCI or ISO pulse < 31mV with no margin at all!

Putting-All-Together

- 2.5G PHY
  - Optimal SNR: PAM3
  - Relative power: PAM3 and PAM4
  - Noise tolerance: PAM3
- 10G PHY
  - Optimal SNR: PAM4 and PAM5
  - Relative power: PAM4 and PAM5
  - Noise tolerance: PAM4
- Both (2.5G and 10G) need <3GHz bandwidth

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