Multi-level PAM Study for M-Gig Automotive PHYs-II

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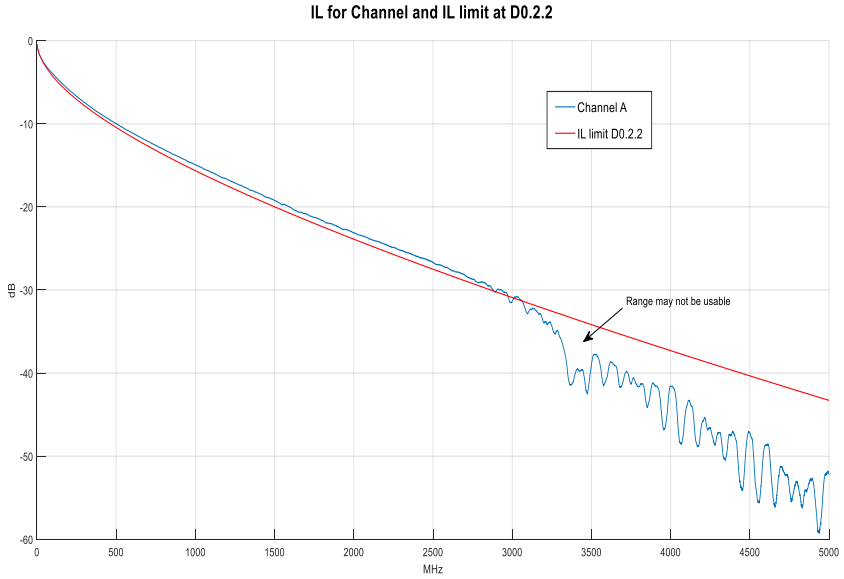
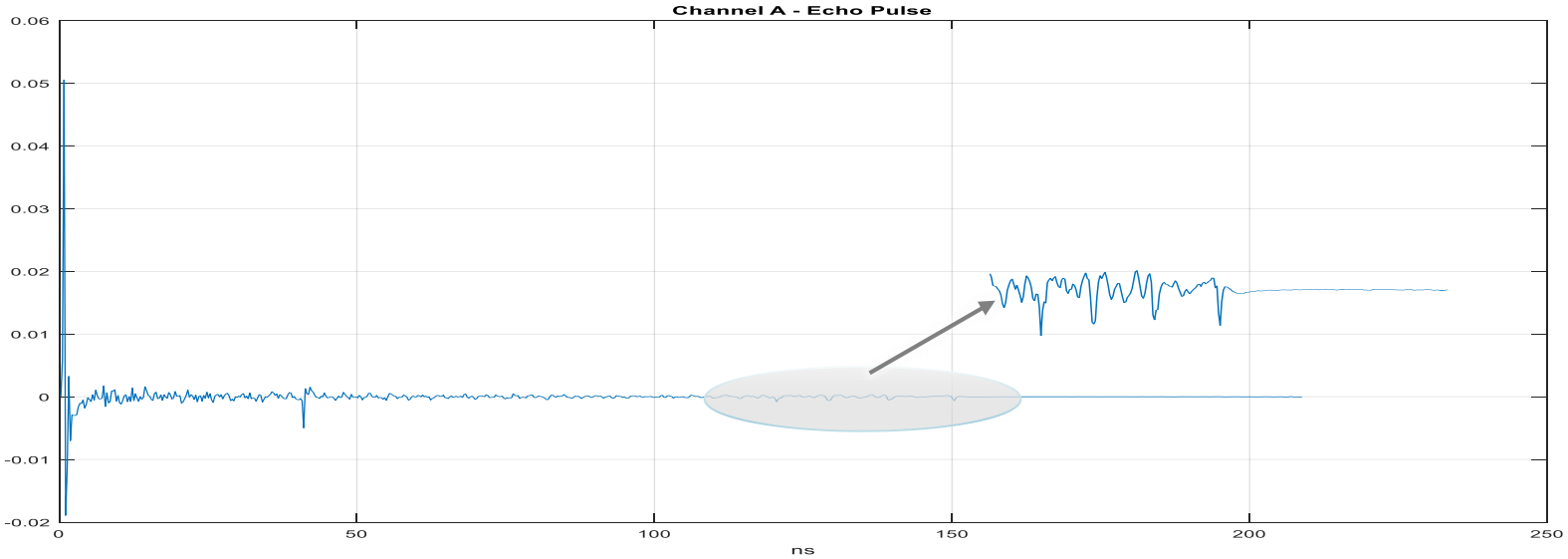
PAM level study for MGBASE-T1

- Extended Analysis on EMC performances over PAM-M schemes 2.5/5/10G speeds
  - http://www.ieee802.org/3/ch/public/sep17/wu_3ch_01_0917.pdf
- Analysis Setup
  - Sample Channel A which was presented – scaled to IL limit line at D0.22
    - http://www.ieee802.org/3/ch/public/sep17/DiBiaso_3ch_01a_0917.pdf
  - Added differential EMI tone (NBI) at MDI
  - FEC: RS(450, 406, 2^9), coding gain 6~ 7dB
  - TX transmit Vppd = 2V and 1V (Vppd = 1Volt at 1000BASE-T1 spec)
  - Other noises
- Case Study PAM5/6/8/12/14/16
  - Baud rate ~ 937.5 MHz at PAM8, for all other cases are simply scaled
    - 12.5% percent overhead for bit mapping and coding
    - m/n ratio of 25Mhz reference (m= 75, n = 2)

Sample Channel – Observations



Freq (MHz)	IL(dB)	Limit
350	8.15	8.60
600	11.08	11.5
938	14.37	15.07
1200	16.70	17.45
2400	25.96	26.80

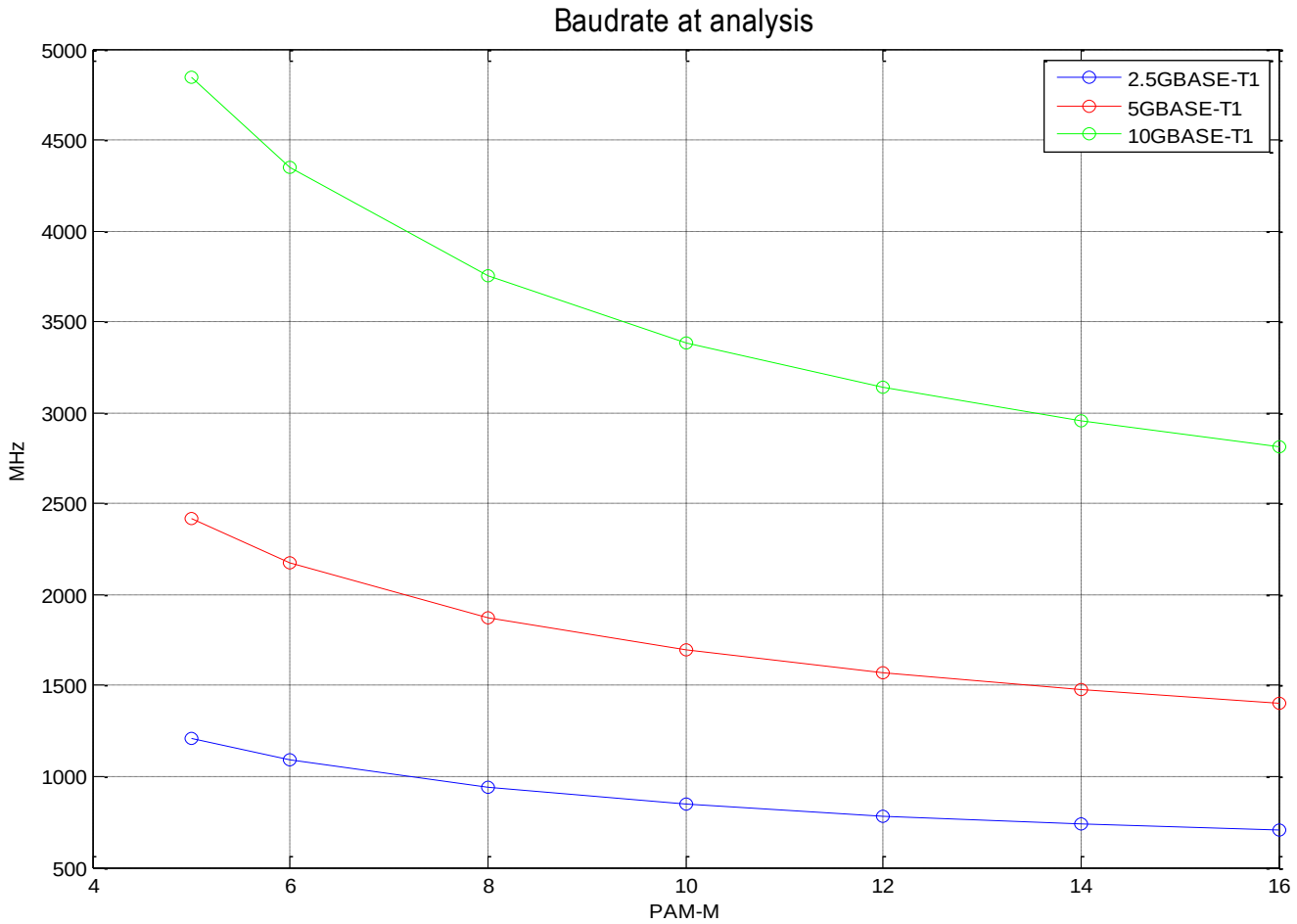


PAM scheme with EMI noise at MDI

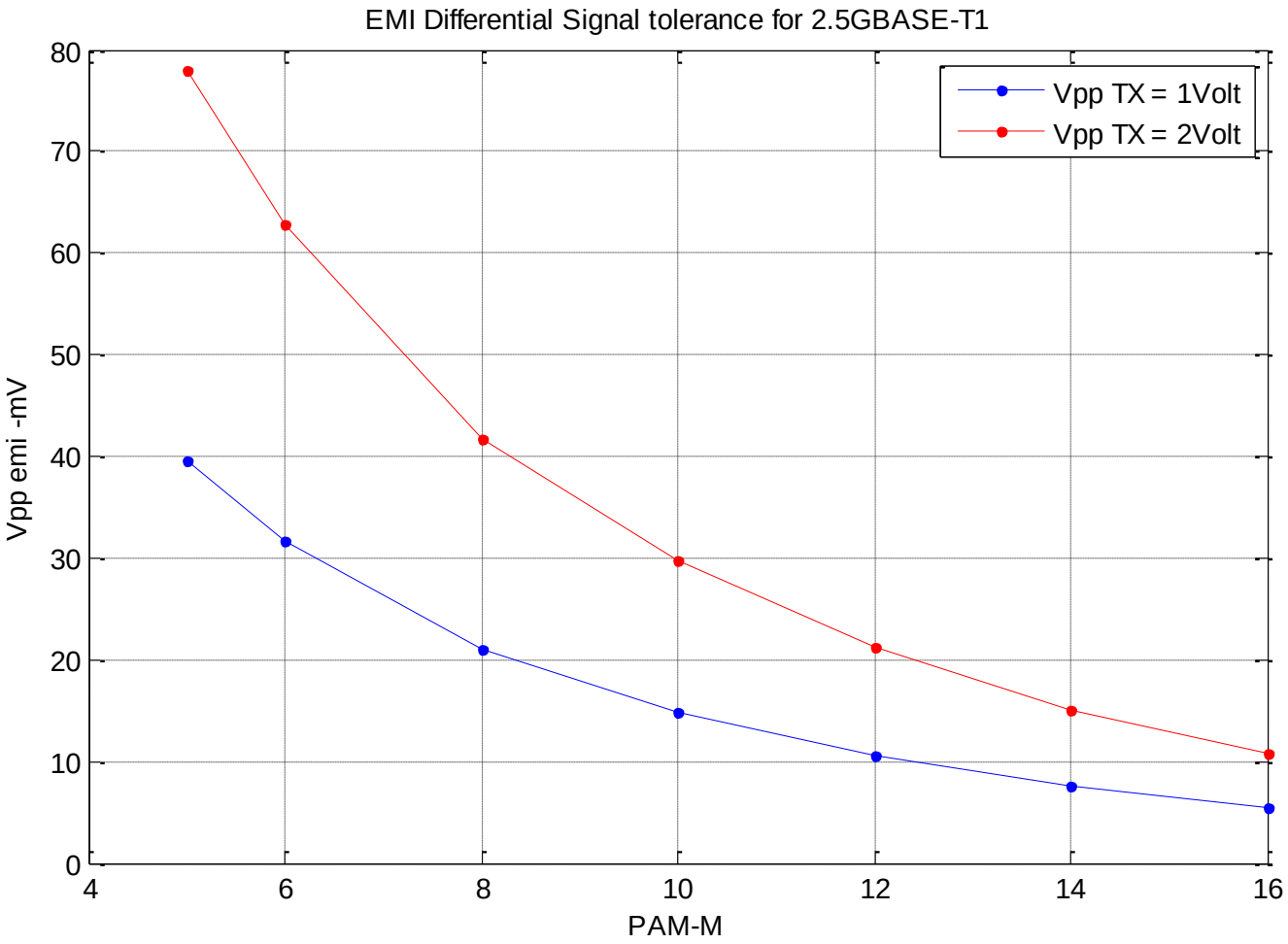
- EMI noise shown at Slicer
  - EMI noise at MDI
  - Insertion Loss of total channel
- The Symbol error rate of PAM-M can be estimated at worst case.
  - $\boldsymbol{V_{emi}}$ is the V_{pp} of EMI noise shown at Slicer, it is related to EMI noise level at MDI, channel Insertion loss, and detailed receiver design
  - M is PAM level
  - V is the peak level of Transmit signal
  - $\boldsymbol{\sigma}$ is the noise variance, deducted from SNR without EMI noise

$$P_e \approx Q\left(\frac{\frac{2V}{M-1} - V_{emi}}{2\sigma}\right)$$

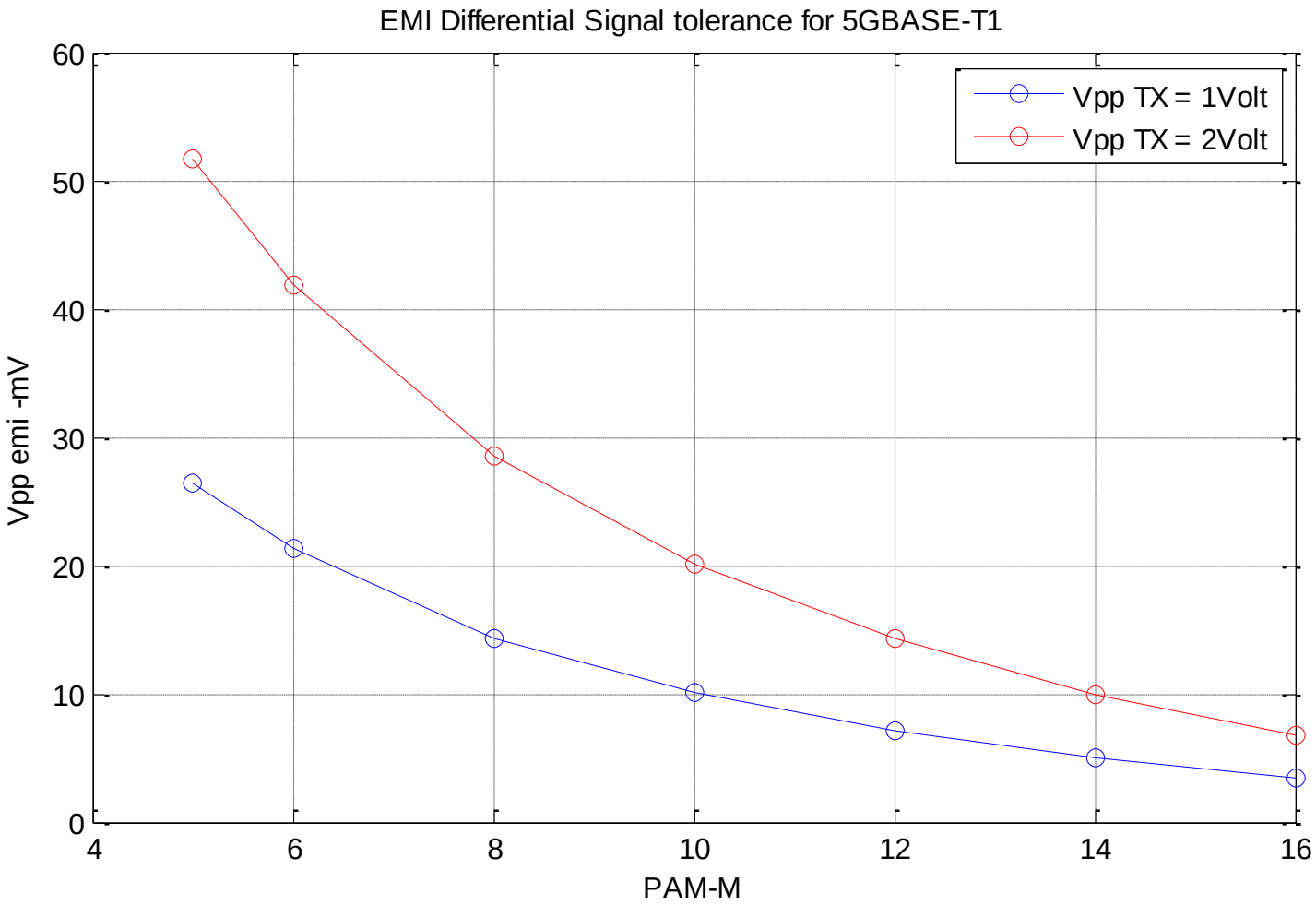
Estimated Working frequency range



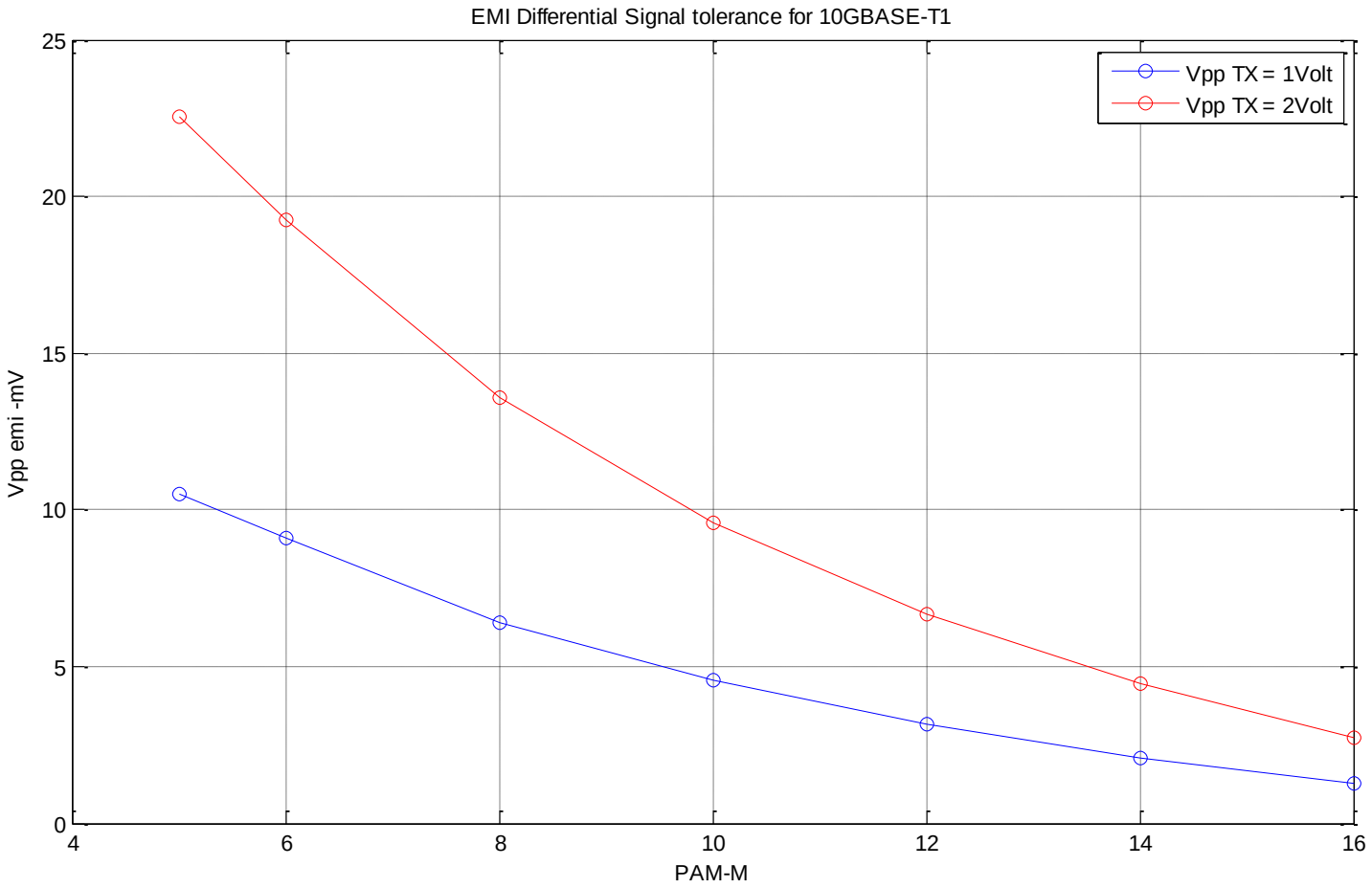
EMI Differential Signal tolerance for 2.5GBASE-T1



EMI Differential Signal tolerance for 5GBASE-T1

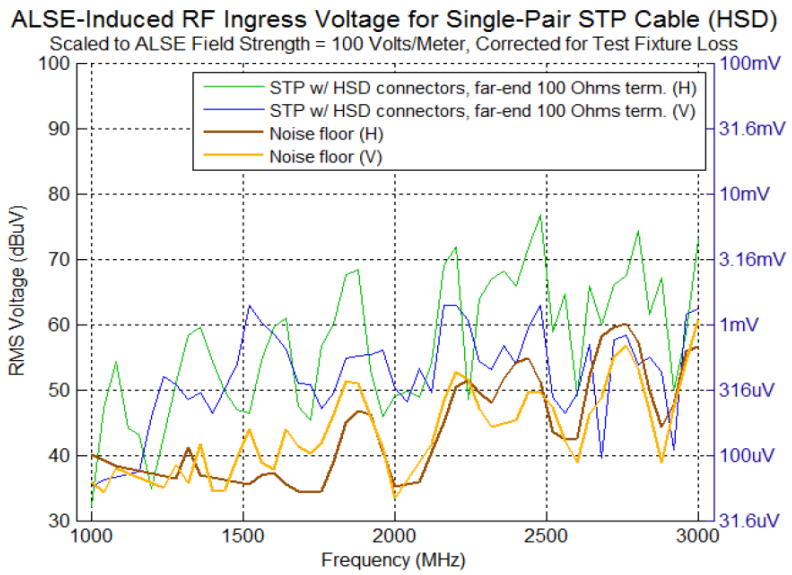


EMI Differential Signal tolerance for 10GBASE-T1

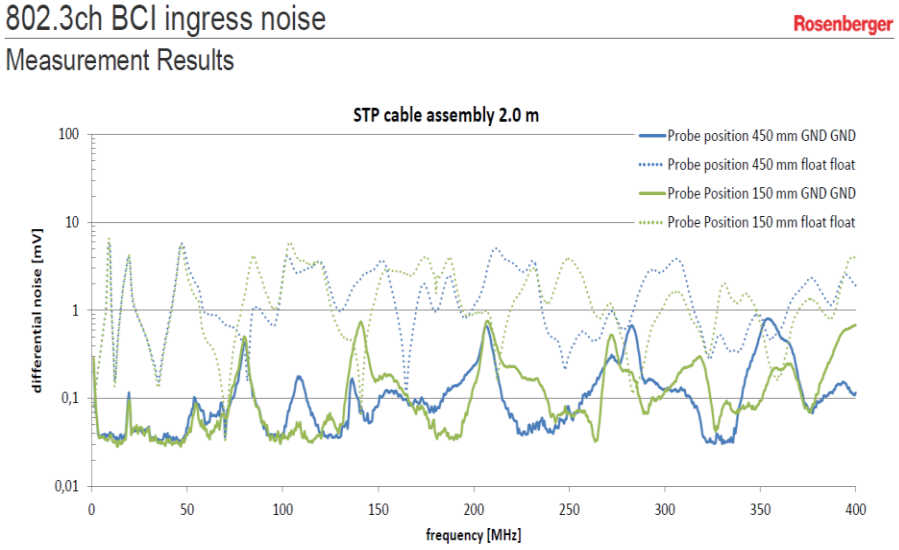


BCI test ingress noise reported on 802.3ch

- BCI Ingress noise at chip pad will be vary over shielding effective of cable, performance of CMC and balance of components on boards, probe position and resonance etc.
- Larry Cohen: http://www.ieee802.org/3/ch/public/nov17/Cohen_Shirani_3ch_01_1108.pdf-Page 10
- Thomas Muller-http://www.ieee802.org/3/ch/public/nov17/mueller_3ch_01_1117.pdf- page 13



Depending on the connectors, the measured at 80Mhz-3GHz, range up to 5 mV - 6 mV rms for scaled to 100v/m Field strength



Depending on the grounding, the measured values range from 1 mV up to 8 mV.

Conclusions:

- For the sample channel A studied, the useful band is up to 3.0GHz, and meets bandwidth needed for PAM 5 for 10G speed considering 15-20% excess BW.
- Higher PAM level needs Higher TX signal level
- With FEC, the immunity tolerance (Vpp) at MDI, TX-Vpp = 2Volts
  - ✓ 10GBASE-T1: PAM8 – about 10mV, PAM 16 – about 4 mv
  - ✓ 5G BASE-T1: PAM8 – about 25 mV, PAM 16 – about 7mv
  - ✓ 2.5G BASE-T1: PAM8 – about 40 mV, PAM 16 – about 10mv
  - ✓ BCI ingress noise tests needed, previous reports show ~20mVpp level
- PAM8 is the choice for 2.5GBASE-T1 with some margin
  - ✓ Lower level PAM schemes need much wider bandwidth than that used at 802.3bp
  - ✓ BCI ingress differential noise at higher frequency over 600Mhz rarely reported
  - ✓ At 2.5G mode, big Salz SNR margin exists, main concern is EMI ingress.
  - ✓ Higher requirements on components, shielding and etc. on board
- Emission estimations over STP channel needed to decide on TX level