Analysis of PAM modulation to meet EMC/EMI requirements

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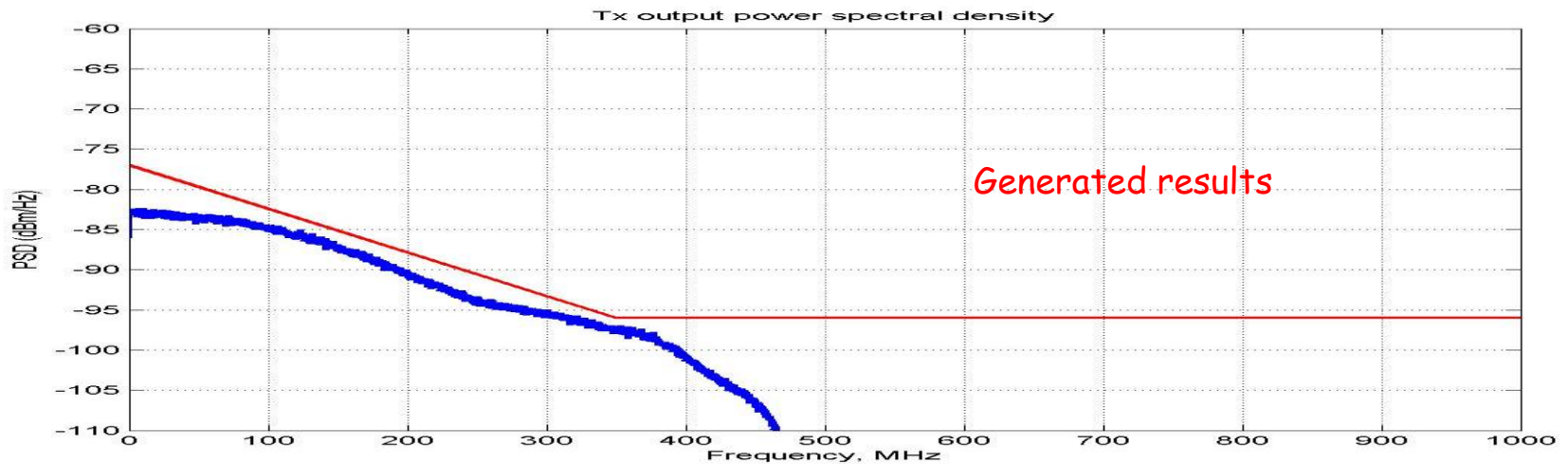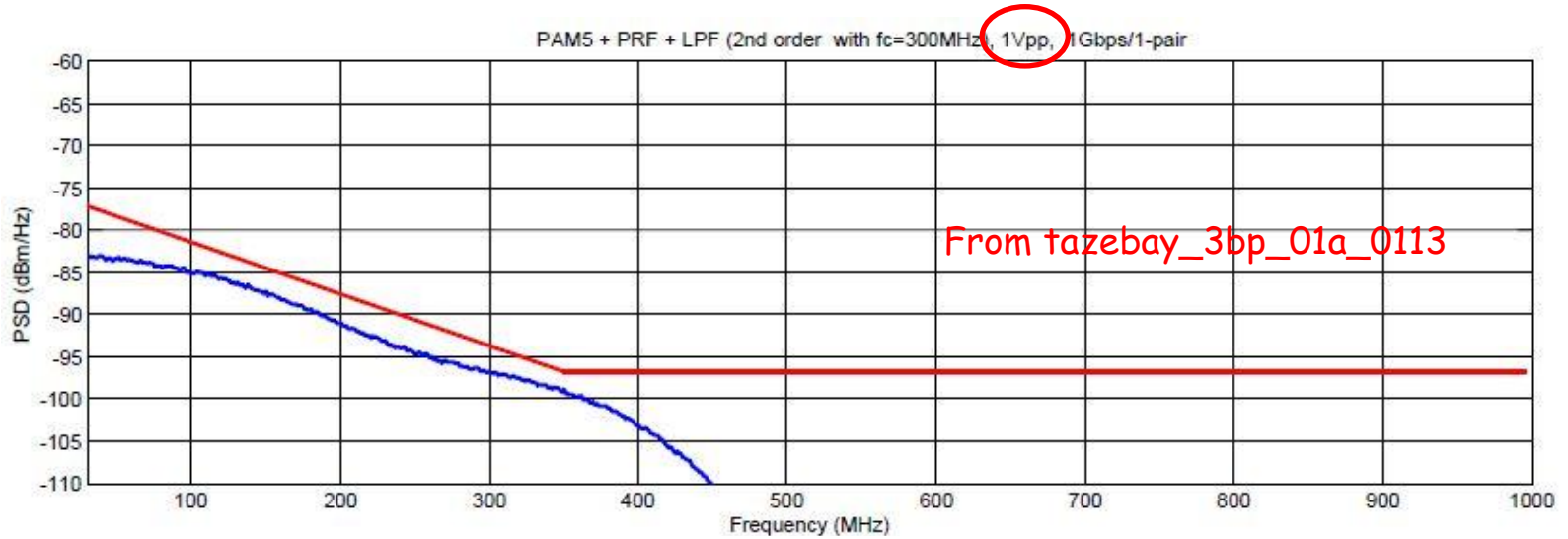
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Abstract

- In this presentation we look at the tradeoff analysis of the different PAM modulations to meet the EMC and EMI requirements defined in the channel model ad-hoc group to achieve the throughput rate in RTPGE

Tx PSD for PAM-5

- Verification of PSD estimation methodology by replicating results in "tazebay_3bp_01a_0113"

- Conditions
  - Modulation: PAM-5 @ 500MHz symbol rate (1.16Gbps with overhead)
  - Tx swing: 1Vppd
  - Tx PRF: ¾ + ¼ z^-1
  - Tx Analog LPF @ 300MHz (2nd order butterworth)

Verification of PSD script

PAM5 + PRF + LPF (2nd order with fc=300MHz, 1Vpp, 1Gbps/1-pair)

From tazebay_3bp_01a_0113

Tx output power spectral density

Generated results

EMC Compliance & EMI Tolerance

- PAM-5 with filtering designed to just meet the EMC PSD limit (~1.4Vppd) does not meet the EMI requirements "bliss_3bp_0313"
  - 1.4Vppd estimated from "tazebay_3bp_01_0113" that shows the psd for 1Vppd

- Further this does not allow for increased EMC due to higher "peak" voltage on the line from full duplex operation
  - In reality, Tx swing would need to be reduced further to meet EMC requirements

- Lower order modulations PAM-3, NRZ should be considered seriously as
  - they operate at lower tx swing and could result in lower EMC
 - they have higher tolerance to sin wave interference as pointed out in "bliss_3bp_0313"

Tx PSD Comparison for NRZ, PAM-3 and PAM-5

- PAM-5
  - 500MHz symbol rate
  - Tx swing: 1.4Vppd
  - Tx PRF: $0.75 + 0.25*z^{-1}$
  - Tx Analog LPF @ 300MHz

- PAM-3
  - 732MHz symbol rate (500*log2(5)/log2(3))
  - Tx swing*: 0.96Vppd
  - Tx PRF: $0.68 + 0.32*z^{-1}$ (2.74dB more attn)
  - Tx Analog LPF @ 439MHz (3/5 * baudRate)

- NRZ
  - 1161MHz symbol rate (500*log2(5)/log2(2))
  - Tx swing*: 0.77Vppd
  - Tx PRF: $0.61 + 0.39*z^{-1}$ (6.83dB more attn)
  - Tx Analog LPF @ 697MHz (3/5 * baudRate)
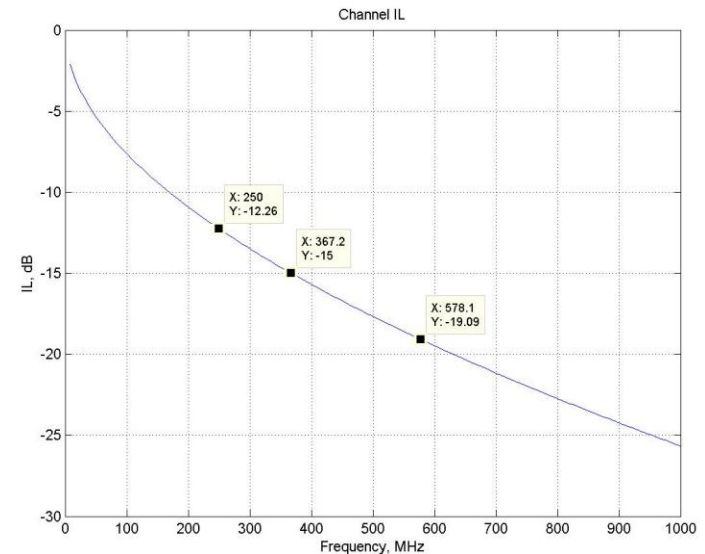
*Tx swing scaled to have same EMI tolerance ie, same dmin at Rx

Channel IL

Tx PSD Comparison
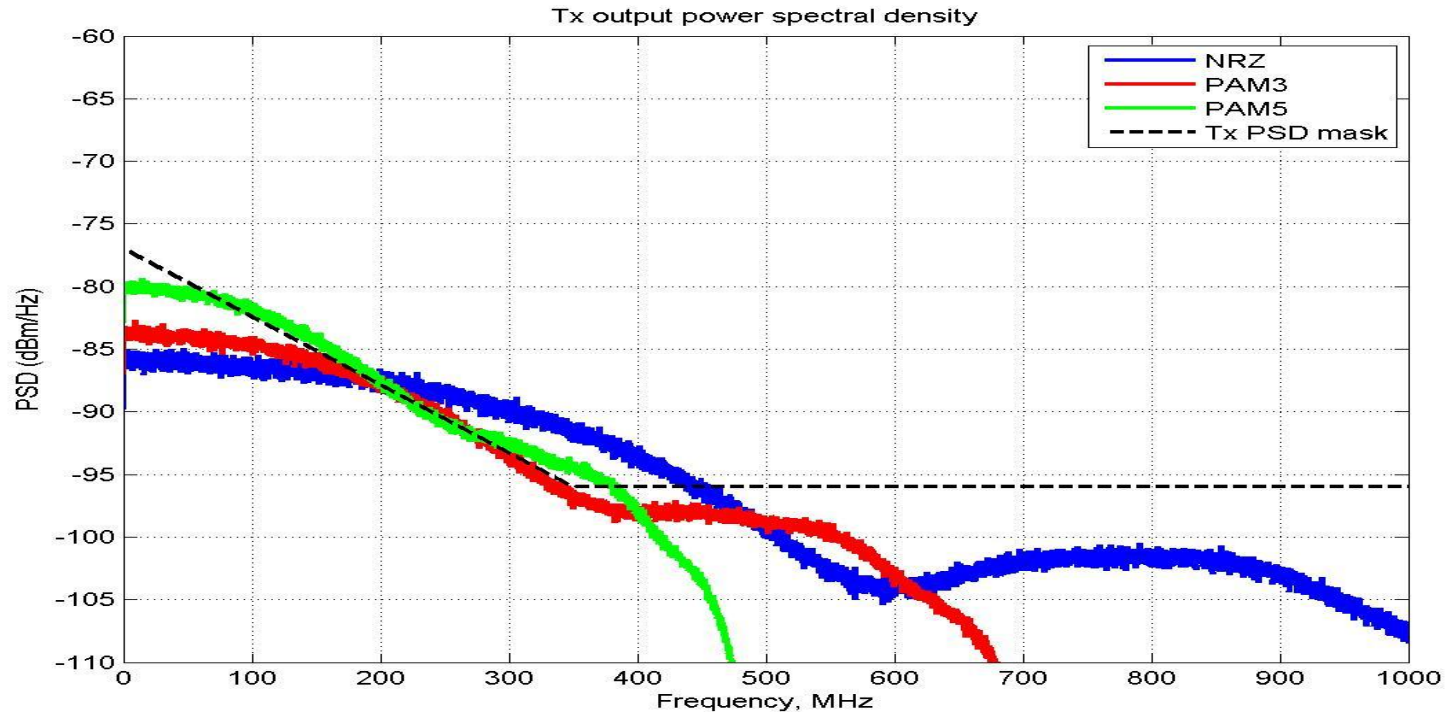
⇒ Lower order modulations **NRZ, PAM3** help reduce the energy in the low frequency region

Summary

- Lower order modulations **NRZ, PAM3** reduce energy in the low frequency region

- To meet PSD mask at high freq
  - additional Tx filtering/shaping can be used
  - symbol rate can be reduced at the cost of FEC overhead