Effect of Scrambling Choices on 1000BASE-T1 Emission

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Outline

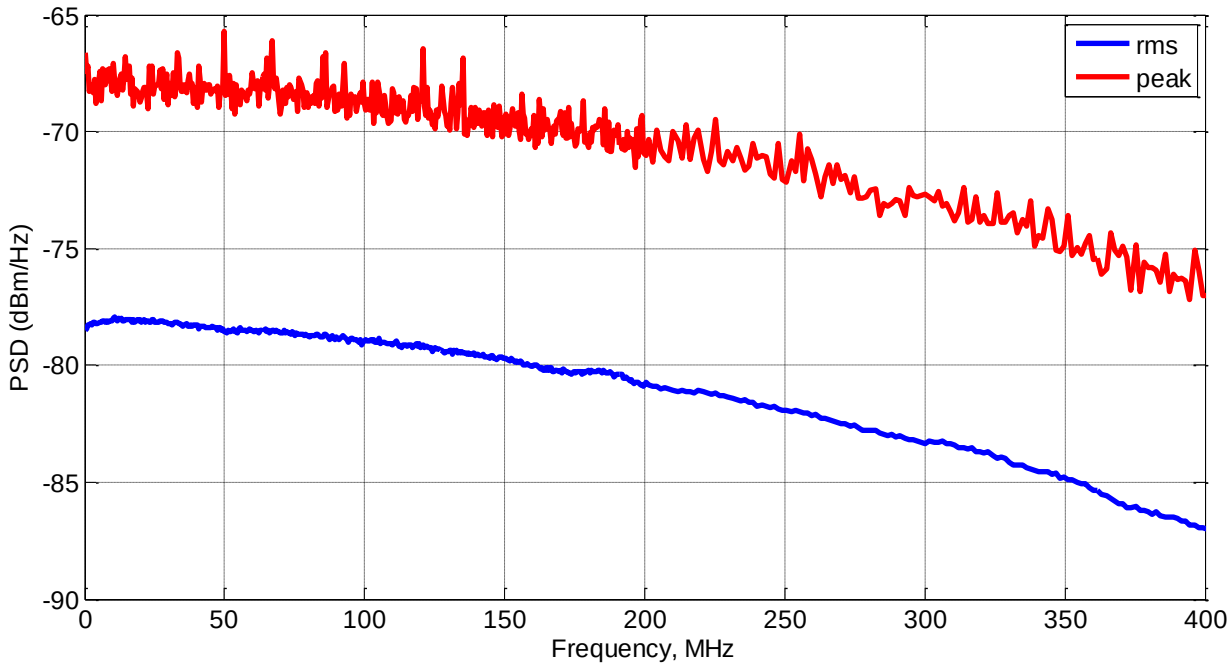
- Automotive emission is measured as peak voltage induced into a filter with 100KHz resolution bandwidth at a given frequency.

- Peak spectrum is compared for various Ethernet technologies from 100BASE-TX to 10GBASE-T in forced Master and some test modes. It is seen that signal sequences generated by longer scramblers may produce larger peak emissions.

- A 15bit and a 18bit scramblers are compared using 1000BASE-T1 parameters and 2D-PAM3 modulation. The shorter scrambler is seen resulting in smaller peak emission.

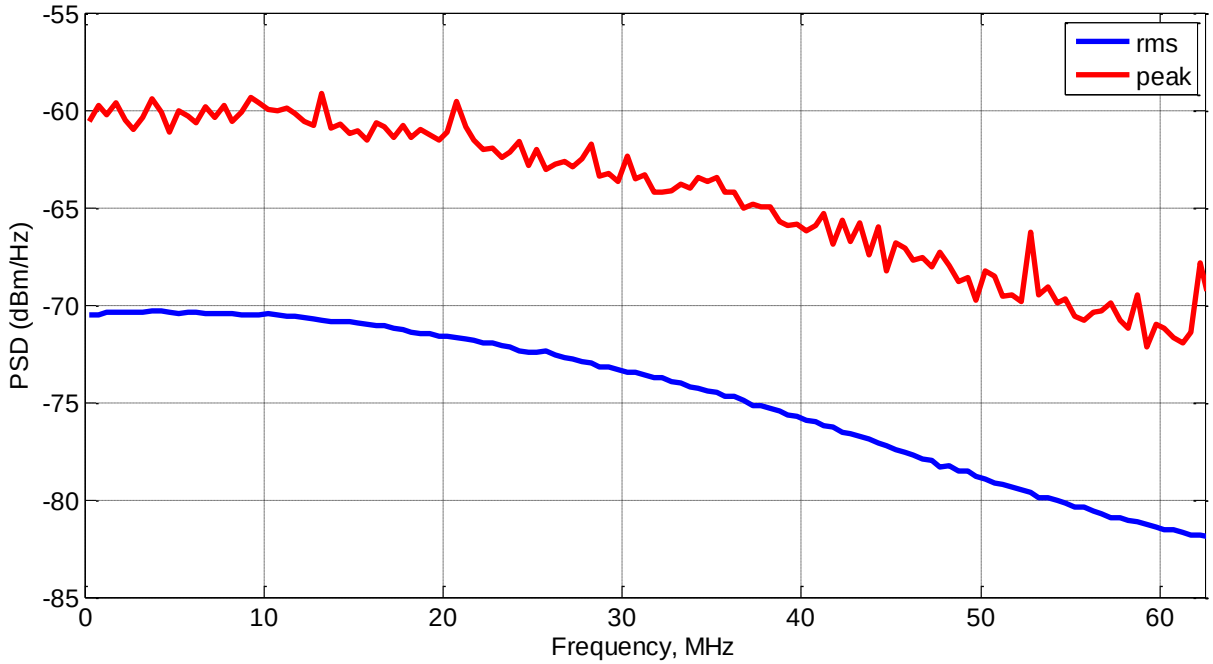
- Scrambler size and format needs to be optimized for emission once FEC and PAM mapping are finalized.

10GBASE-T, Test Mode 1 (PAM2 no THP)



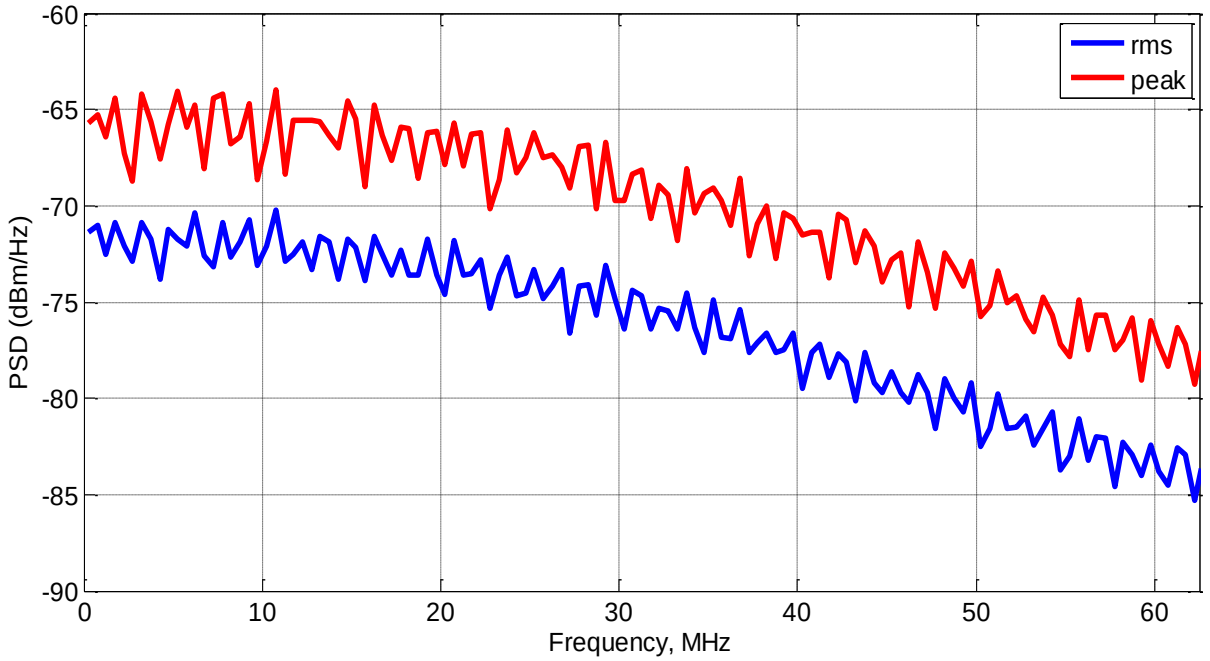
- Peak PSD values measured for 10GBASE-T in test mode 1 (PAM2 with no THP) and on 100KHz RBW are seen larger than rms by more than 10dB. This mode uses PRBS 33 training pattern (33bit scrambler).

1000BASE-T, Forced Master Idle



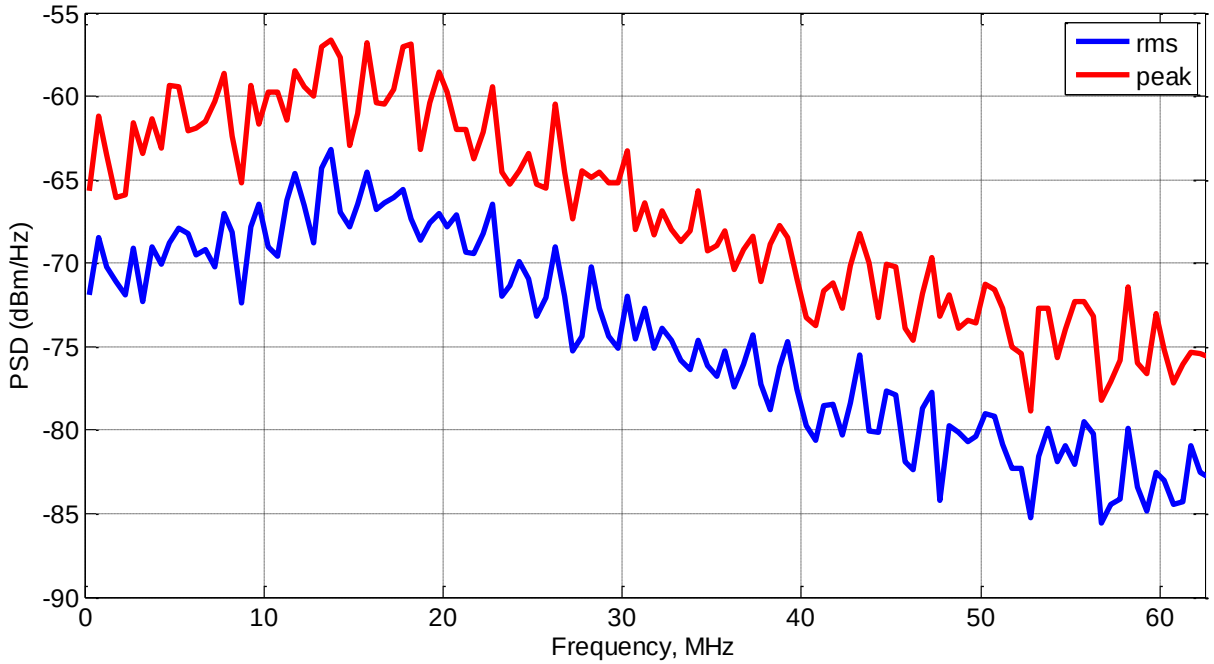
- Peak PSD values measured for 1000BASE-T in forced master mode (PAM3 with 33bit scrambler) on 100KHz RBW are seen larger than rms by more than 10dB.

1000BASE-T, Test Mode 4



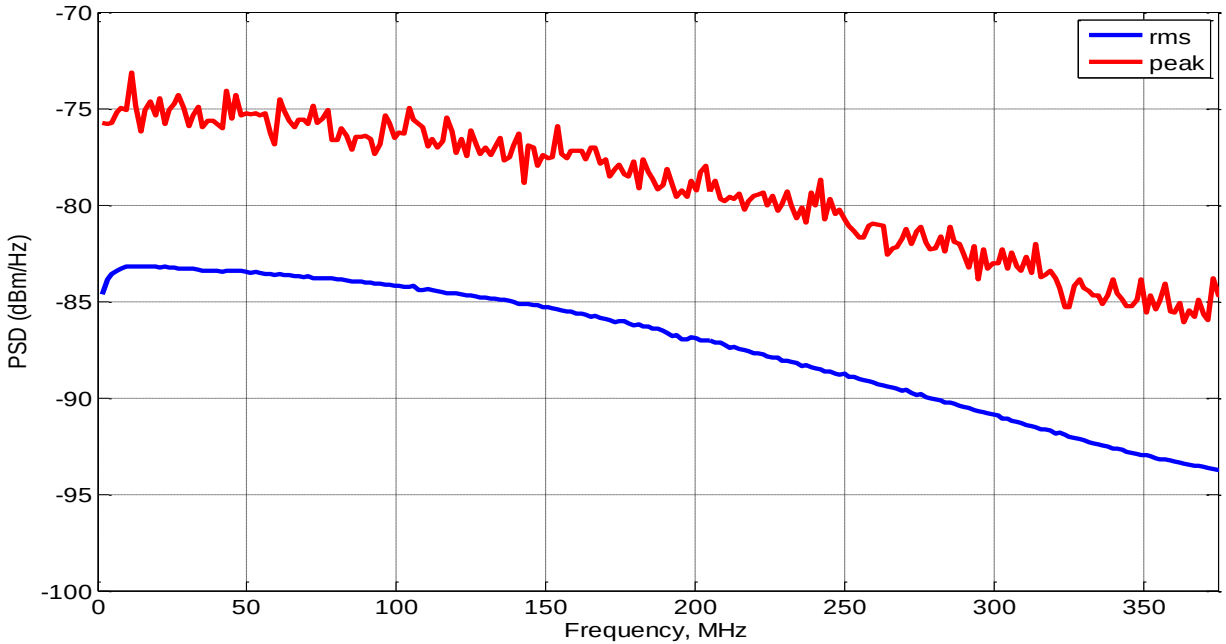
- Peak PSD values measured for 1000BASE-T in test mode 4 (PAM5 with 11bit scrambler) on 100KHz RBW are seen larger than rms by less than 10dB. Sequence period is less than 1/100KHz and therefore the rms curve is not smooth as previous plots.

100BASE-TX



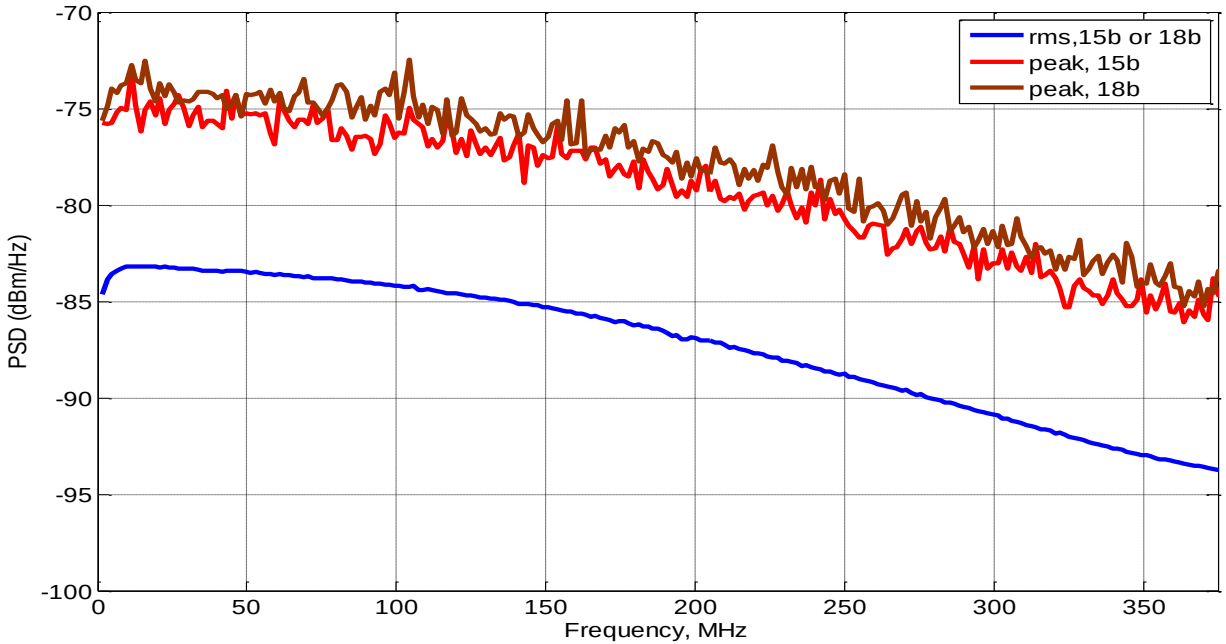
- Peak PSD values measured for 100BASE-TX (MLT-3 with 11bit scrambler) on 100KHz RBW are seen larger than rms by less than 10dB. Sequence period is less than 1/100KHz and therefore the rms curve is not smooth.

Arbitrary Waveform Generator, 15b scrambler



- Peak PSD values measured for a signal generated by AWG with 2D-PAM3 modulation and 15bit scrambler. Symbol rate is 750Msps and $(0.75+0.25Z^{-1})$ PRF is used. Measured peak values on 100KHz RBW are seen larger than rms by about10dB.

Arbitrary Waveform Generator, 18b scrambler



- Peak PSD values measured for a signal generated by AWG with 2D-PAM3 modulation and 18bit scrambler. Symbol rate is 750Msps and $(0.75+0.25Z^{-1})$ PRF is used. Measured peak values on 100KHz RBW are seen larger than those for 15bit scrambler.

Summary

- Scrambler choice is seen making major difference in peak emission.
- Longer scramblers are shown to cause larger peak emission in idle and test modes. This may be related to higher short term correlation for longer sequences.
- In order to test under CISPR 25 set up, the same test mode used for PSD measurement (Test mode 5) is suggested for emission measurement. This should represent normal operation with no traffic (similar to IEEE clause 55.5.2).
- Scrambler length and format needs to be optimized for 1000BASE-T1 once FEC and PAM mapping design are selected. If not optimized, the peak emission may exceed 10dB budget considered for peak to average ratio assumed to derive PSD MASK.