Transmit Power in ACT/GMSLE

Hossein Sedarat (Ethernovia)
Jay Cordaro (ADI)

ETHERNOVIA®

Overview

- Proposing transmit power numbers for ACT/GMSLE
  - Multi-Gbps and 100 Mbps
  - STP and coax
- These power numbers are shown to support a trivial structure for upstream 100 Mbps receiver
- These power numbers are shown to be compatible with emission requirements

Transmit Power Proposal

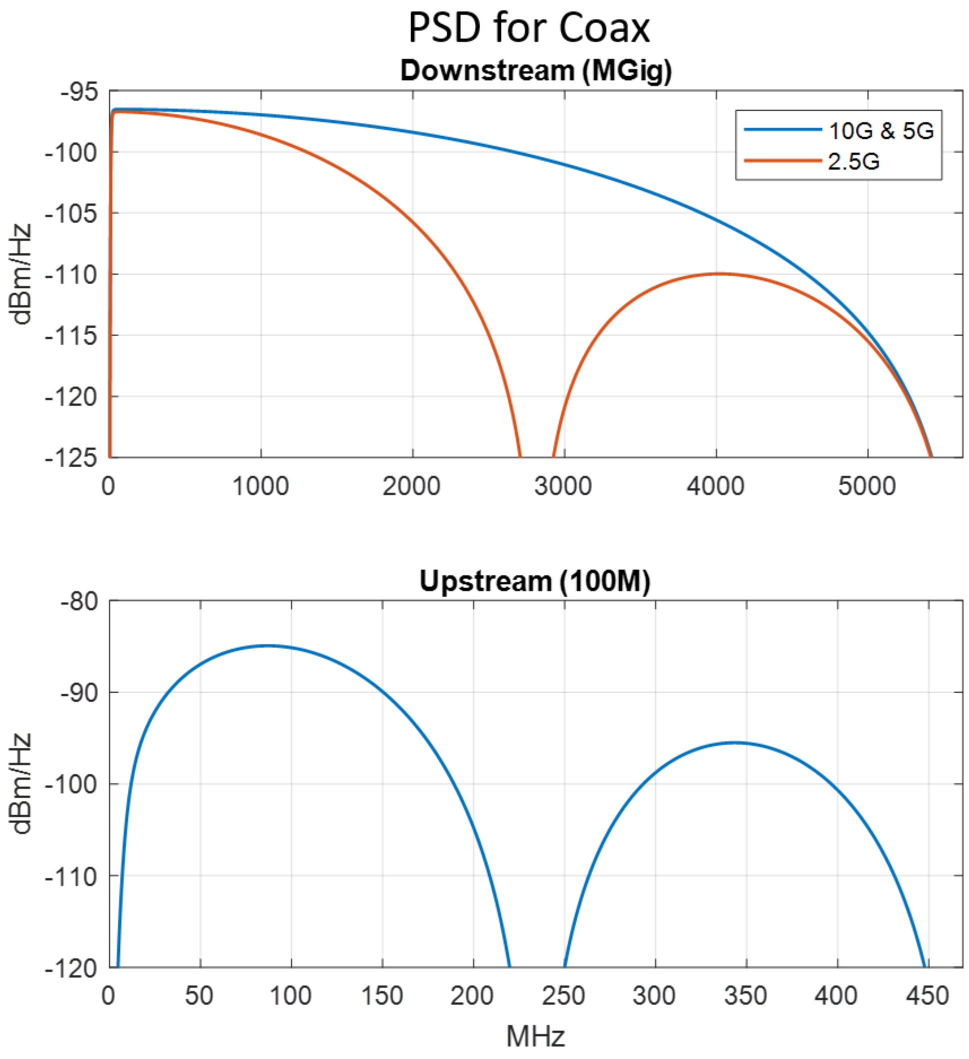
- Transmit power for STP
  - 10G (PAM4): adopted from 802.3ch
  - 5G (PAM2): same as 10G and 802.3ch, resulting in ~2.5 dB lower voltage swing
  - 2.5G (PAM2): 3 dB lower than 10G and 802.3ch, resulting in ~5.5 dB lower swing
  - 100M (DME): Maximum power complies with emission requirements with margin
- Power for coax is 3 dB lower than STP

Transmit Power (dBm)

	Coax		STP	
	Min	Max	Min	Max
10G	-4	-1	-1	2
5G	-4	-1	-1	2
2.5G	-7	-4	-4	-1
100M	-6	-3	-3	0

Power Spectral Density

- Plot shows PSDs at mid-range of transmit power for Coax
- PSD for STP is 3 dB higher
- Echo into upstream 100M receiver is independent of downstream data rate



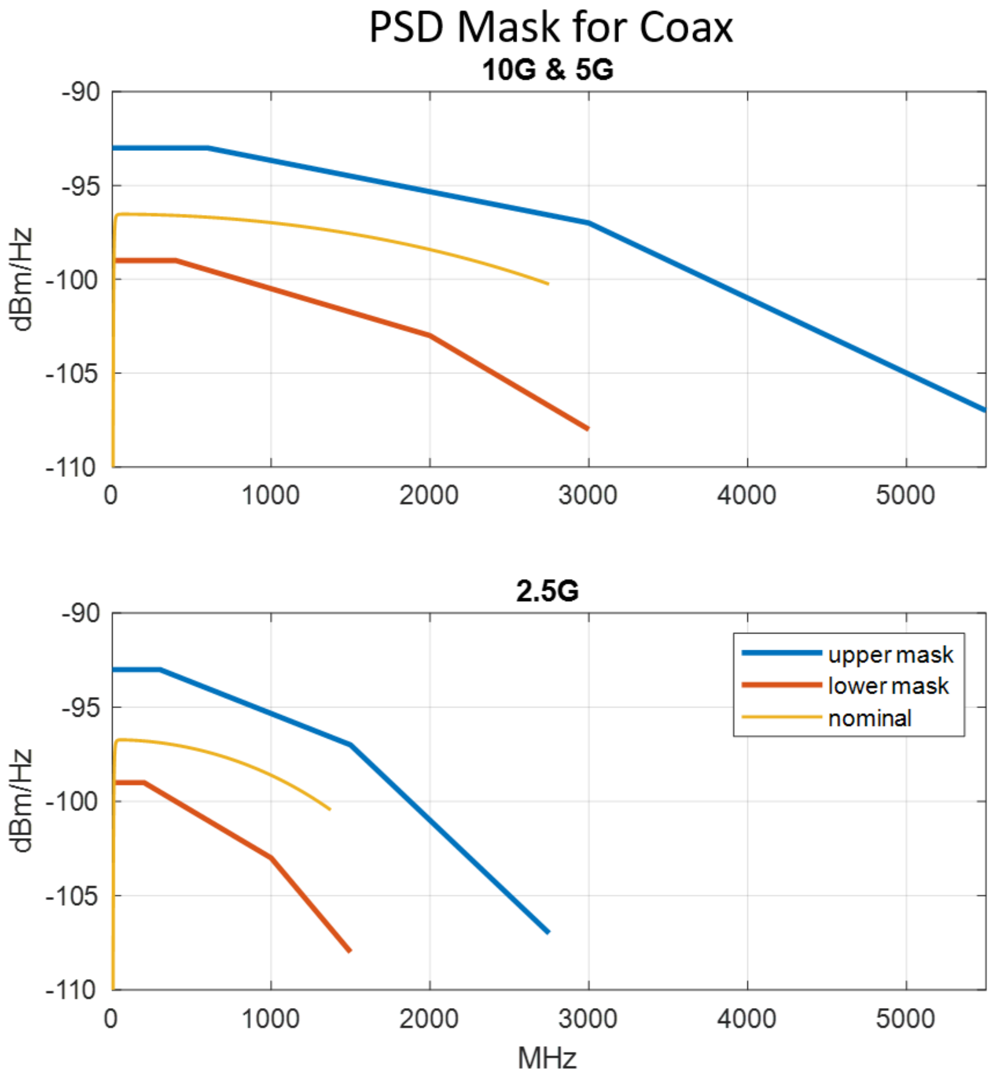
ETHERNOVIA®

PSD Mask - Downstream

$$UPSD(f) = \begin{cases} P_0 & 0 < f \leq 600 \times S \\ P_0 + 1 - \dfrac{f}{600 \times S} & 600 \times S < f \leq 3000 \times S \\ P_0 + 8 - \dfrac{f}{250 \times S} & 3000 \times S < f \leq 5500 \times S \end{cases}$$

$$LPSD(f) = \begin{cases} P_0 - 6 & 5 < f \leq 400 \times S \\ P_0 - 5 - \dfrac{f}{400 \times S} & 400 \times S < f \leq 2000 \times S \\ P_0 - \dfrac{f}{200 \times S} & 2000 \times S < f \leq 3000 \times S \end{cases}$$

- P_0 is -93 dBm/Hz for coax, and -90 dBm/Hz for STP
- S is 1 for 10G and 5G, and 0.5 for 2.5G
- f is frequency in MHz

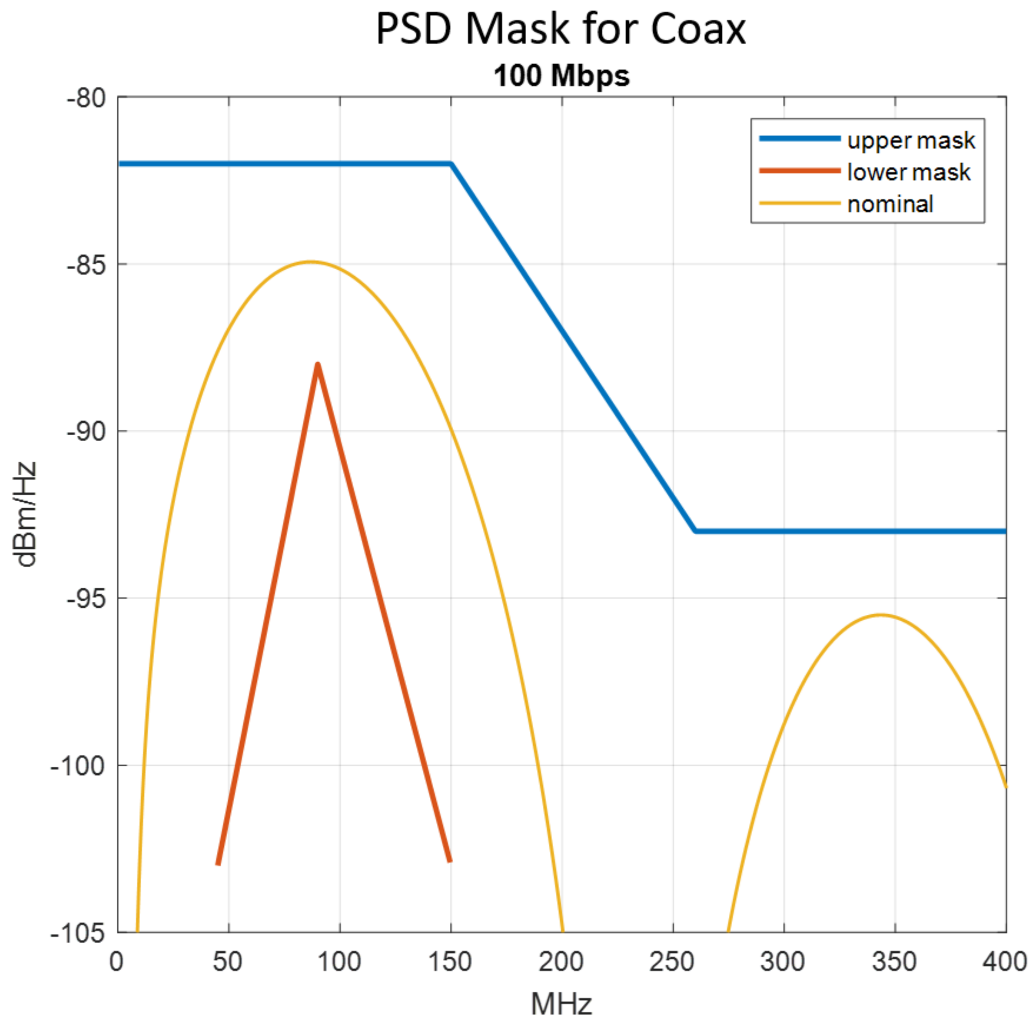


PSD Mask - Upstream

$$UPSD(f) = \begin{cases} P_0 & 0 < f \le 150 \\ P_0 + 15 - \dfrac{f}{10} & 150 < f \le 260 \\ P_0 - 11 & 260 < f \le 400 \end{cases}$$

$$LPSD(f) = \begin{cases} P_0 - 6 - \left(\dfrac{90 - f}{3}\right) & 45 < f \le 90 \\ P_0 - 6 - \left(\dfrac{f - 90}{4}\right) & 90 < f \le 150 \end{cases}$$

- P_0 is -82 dBm/Hz for coax, and -79 dBm/Hz for STP
- f is frequency in MHz



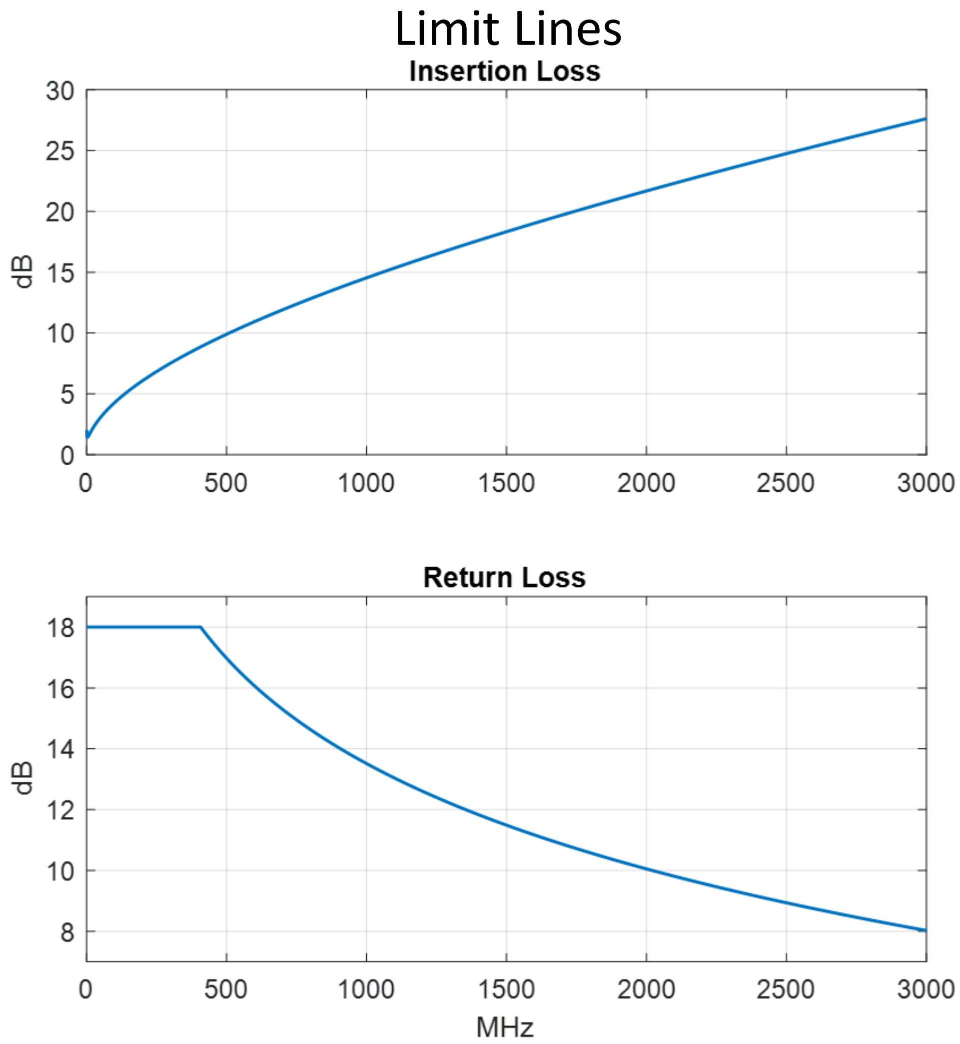
ETHERNOVIA®

100M Receiver Complexity

Channel Response

- Assuming cable limit lines based on the update version of [Boyer_2412]
  - ~23.5 dB loss at 2.8125 MHz

- Assuming another 3 dB of PCB loss

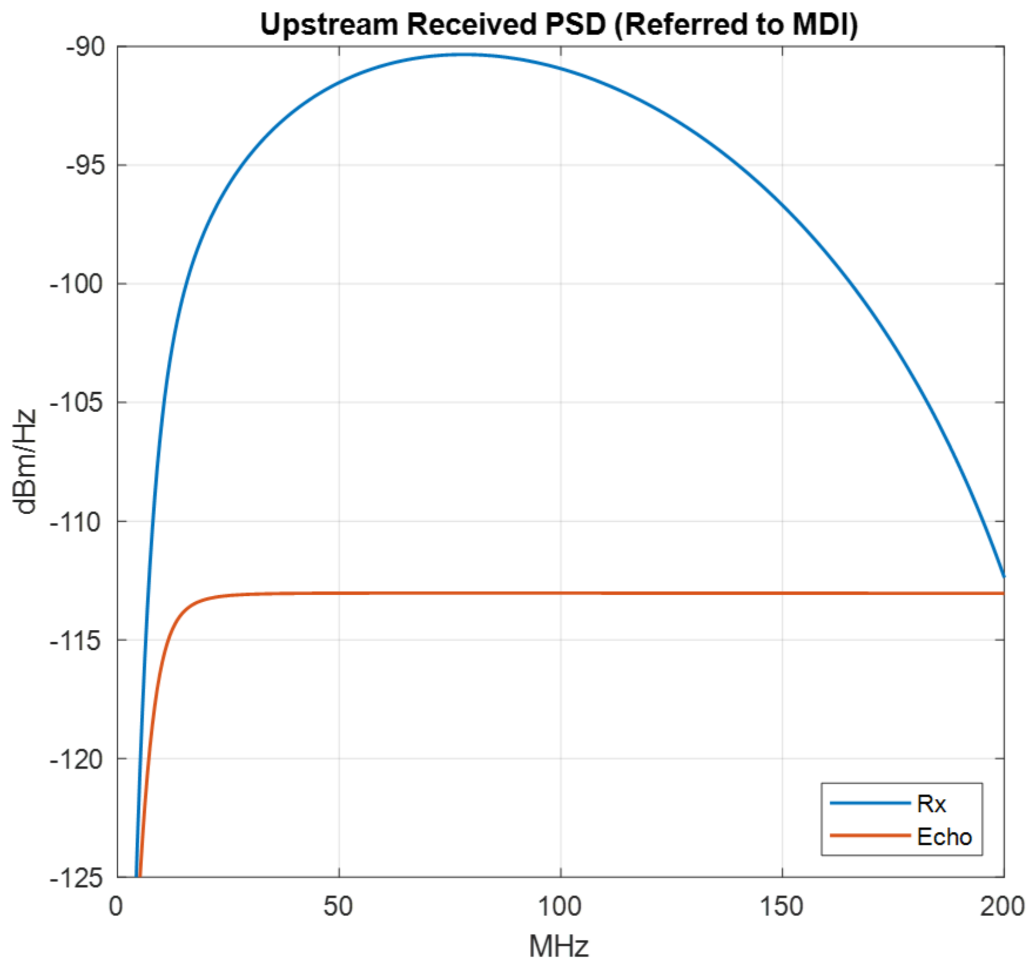


ETHERNOVIA®

PSD - Upstream Received Signal

Assuming worst imbalance in transmit power for echo:

- Minimum upstream power
- Maximum downstream power

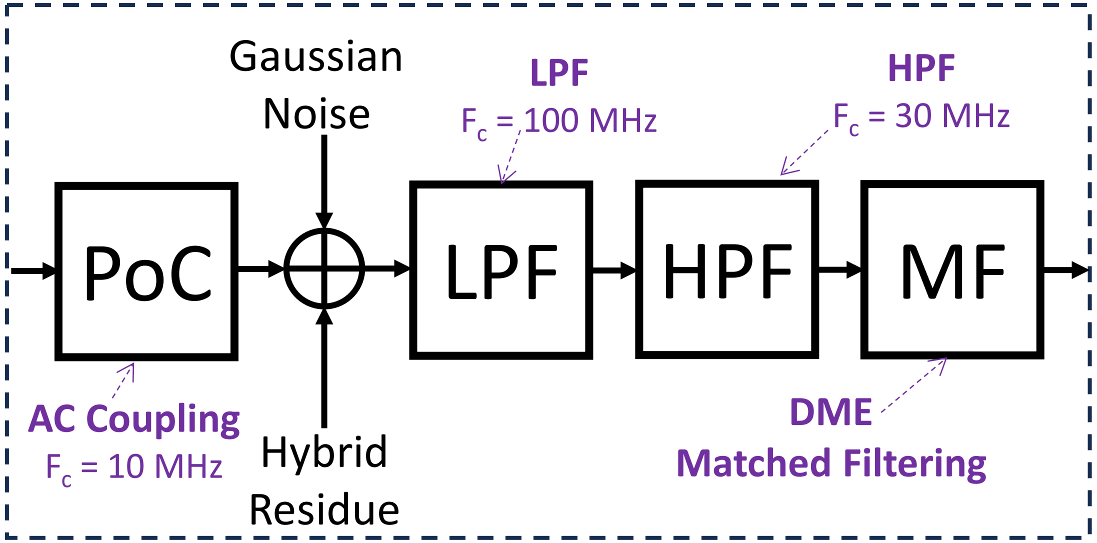


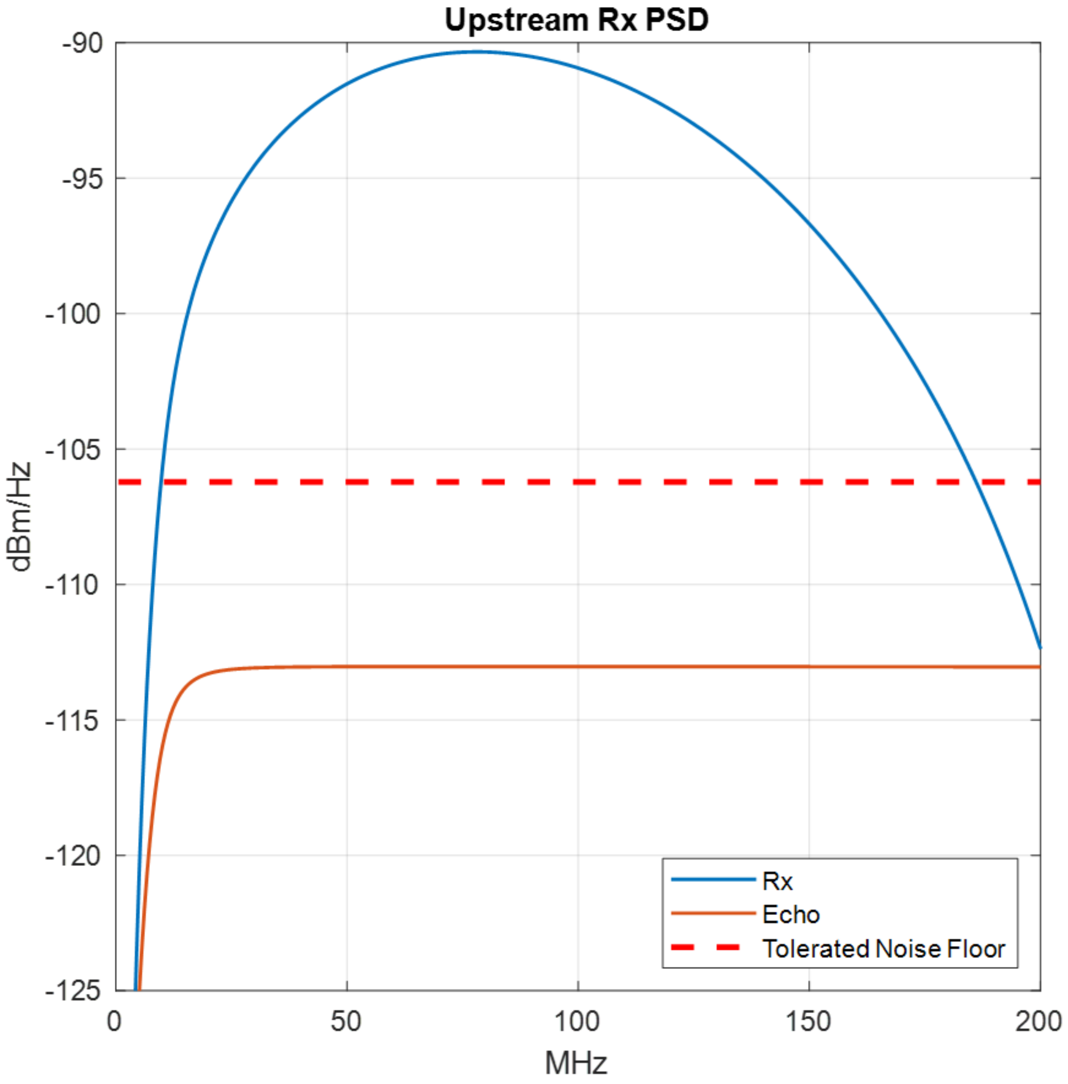
ETHERNOVIA®

PSD – Tolerated Noise

Following the modelling and analysis presented in sedarat_2503, echo remains well below tolerated noise floor in upstream receiver

Receiver Model





ETHERNOVIA®

Upstream Receiver Complexity

- No need for echo cancellation
- Simple (or no) equalization
- No baseline-wander effect for HPF as high as 30 MHz
- Small dynamic range
- Narrow exposure band to EMI sources, limited to very low frequency
- Not sensitive to MDI return loss and double-reflections
- Tolerant of imperfect hybrid cancellation

802.3dm Sensor Integration Process Scaling

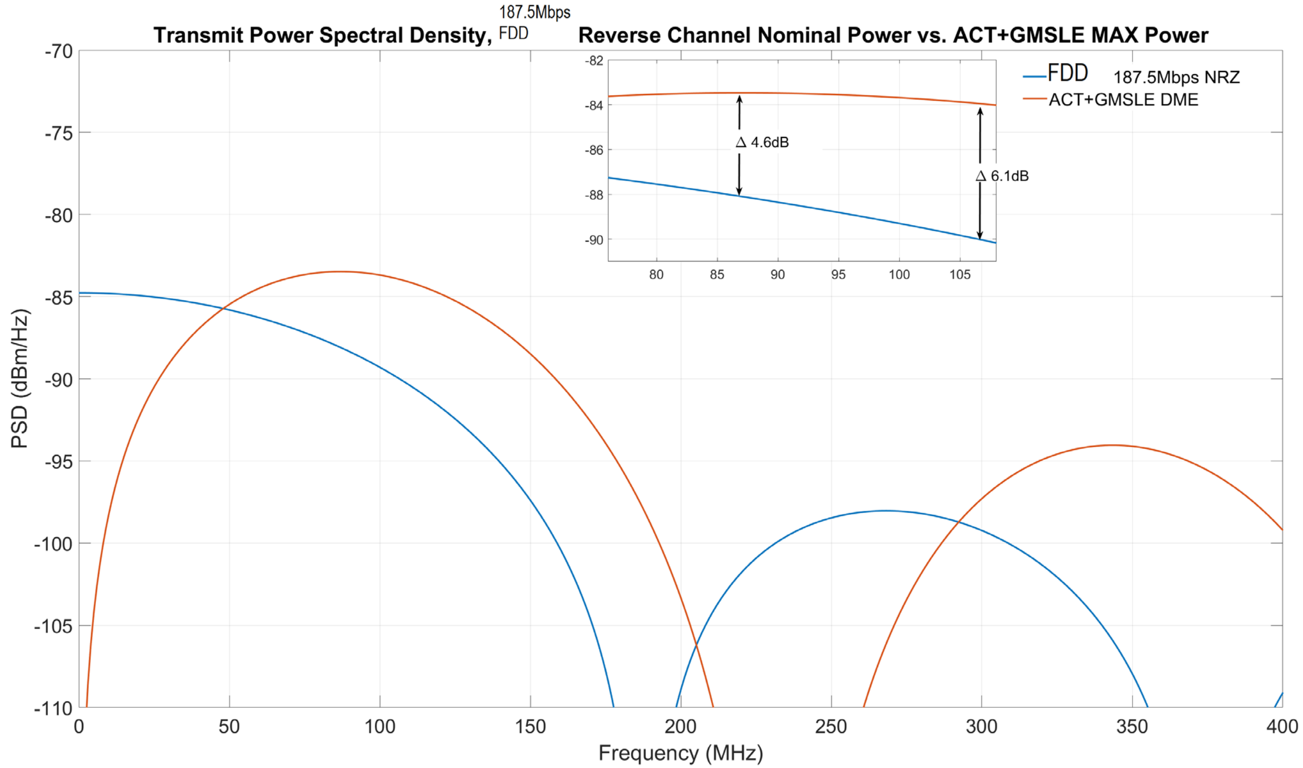
- TDD and GMSLE camera serializers were estimated and presented previously
  - Both estimated in 55nm, comparing relevant blocks ONLY
  - ACT+GMSLE very similar to GMSLE (slightly less complex FEC decoder for Upstream)
    - FOM: Analog area, digital area, ring area to provide total area + relative silicon complexity
- TDD implements a full speed adaptive receiver on both sides of the link
- 16nm TDD Camera PHY vs a 55nm ACT+GMSLE Camera PHY
  - TDD Camera PHY in 16nm estimated at 1.4x the area of a 55nm ACT+GMSLE PHY
    - Note that 16nm is more complex than 55nm, so relative complexity is ~3x a 55nm FDD PHY
- Integration:
  - In the future, 802.3dm sensor PHYs will be integrated into the sensor
    - Cameras will remain in 22nm and 40nm for foreseeable future
    - MMICs will remain at 22FDX/28nm SOI
    - TDD has similar extra area (2-2.3x) compared to FDD in same geometry (40/28/22nm)
- Increased TDD complexity versus ACT+GMSLE at the sensor
  - Larger die area or more complex silicon process, Time Division Duplexing has more complexity

100M Emission

FM Band Emissions

- FM band Emissions are a critical concern for Automotive PHYs
- With Coax link segment, compare one-sided PSD of DME modulated ACT+GMSLE 100Mbps Upstream at host versus PSD of an existing FDD SerDes implementation with 187.5Mbps reverse channel at host
  - Focus on FM Band (76-108MHz)
  - An existing FDD SerDes at typical power (-5dBm)
  - ACT+GMSLE at MAX power (-3dBm)
- Examine an existing FDD SerDes implementation Radiated Emissions in FM Band
- Demonstrate ACT+GMSLE emissions margin in FM band using existing FDD PSD and emissions

Upstream PSD Comparison
FDD SerDes vs ACT+GMSLE

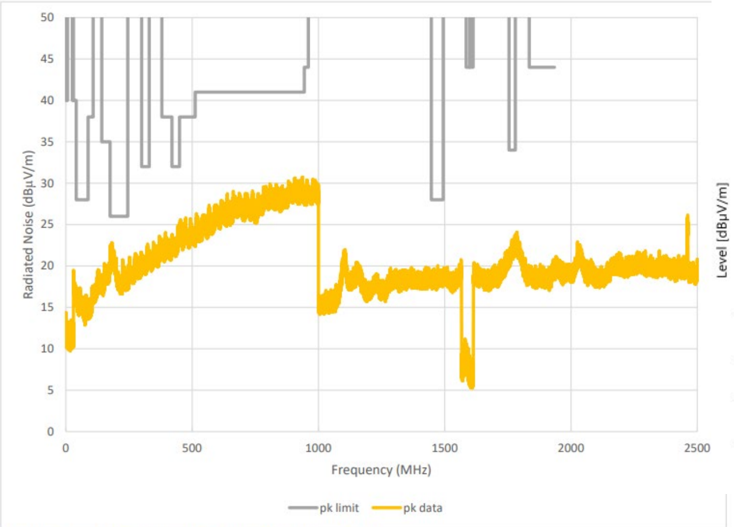


- ACT+GMSLE Upstream at -3dBm transmit power has PSD +4.6dB to +6.1dB higher in FM Band than nominal
- Even max transmit power is not an issue as the next slide will show

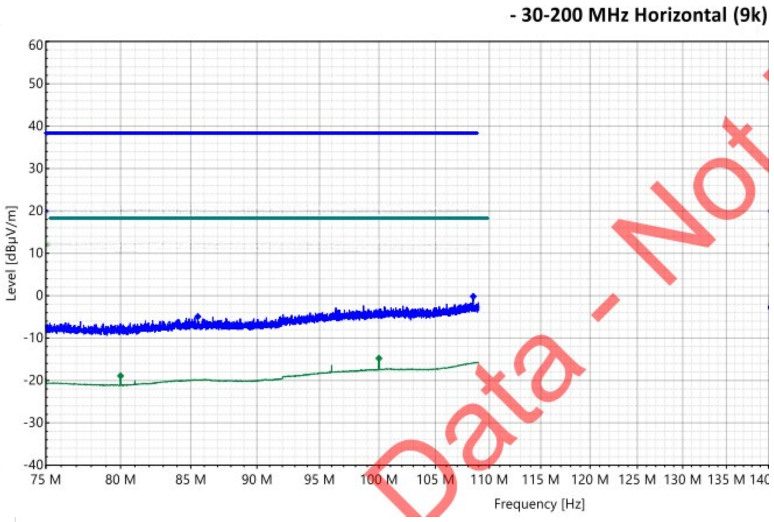
ETHERNOVIA®

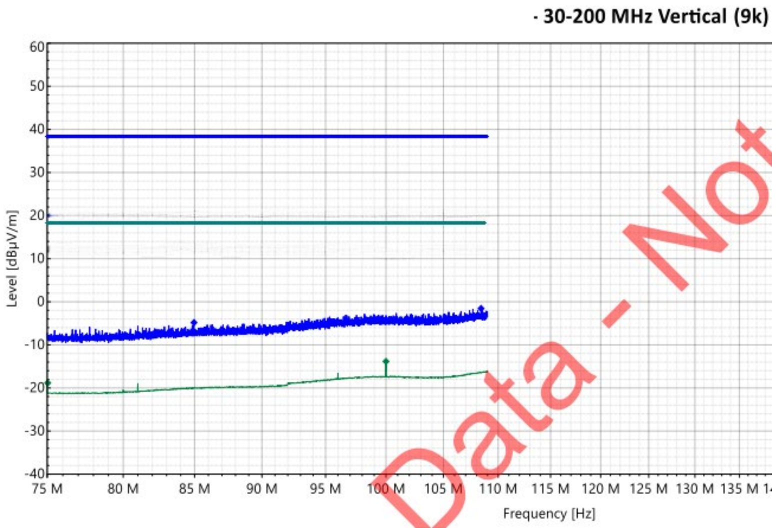
FDD SerDes Emissions

- An existing FDD SerDes implementation EMC report is available on the web
- Figures below show:
  - Broadband peak emissions 0-2.5GHz emissions from that report
  - 75MHz-108MHz peak and average scans at 9kHz RBW captured at a 3rd party certified laboratory
- Emissions in the FM band are not an issue for ACT+GMSLE with DME
  - For CISPR25 Class 5 as well as OEM test limits
  - Even with maximum transmit power, ACT+GMSLE offers robust margin to emissions limits



Plot 2. Radiated Emissions Detailed Test Data – Peak





ETHERNOVIA®

Summary

- Proposed transmit power levels and PSD masks for ACT/GMSLE
- With these power levels, the upstream receiver remains trivial with healthy link margin with no echo cancellation
- A comparison with radiated emission data from an existing FDD SerDes implementation with that of ACT+GMSLE shows that the emission from ACT+GMSLE upstream transmitters can pass emissions requirements with a healthy margin

ETHERNOVIA®

Thank You