802.3bz 2.5G/5GBASE-T TF

PCS/PMA Proposal

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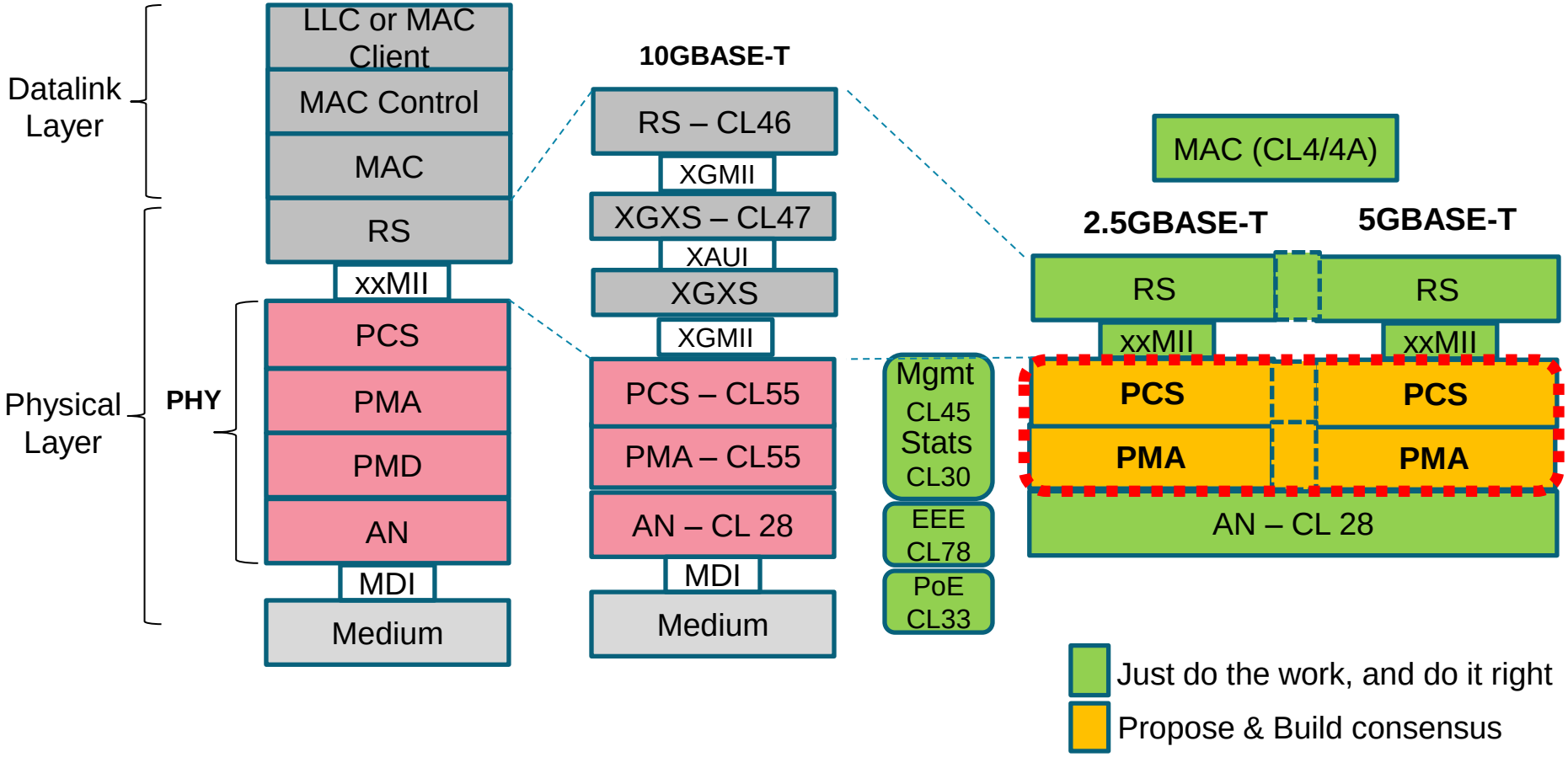
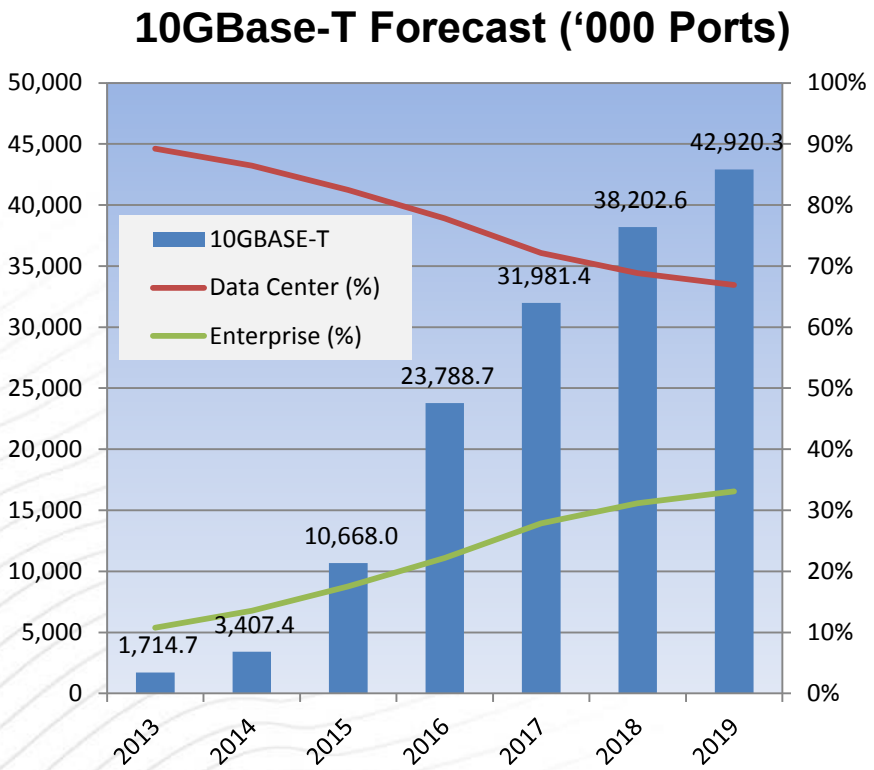
PCS/PMA Layering

2.5G and 5G BASE-T Layering considerations



10GBASE-T Market – Significant Growth

- 10GBase-T market doubled in 2014 (from 2013)
- Expected to grow to >40M by 2019
- 1/3 of all ports will be shipped for the enterprise by 2019



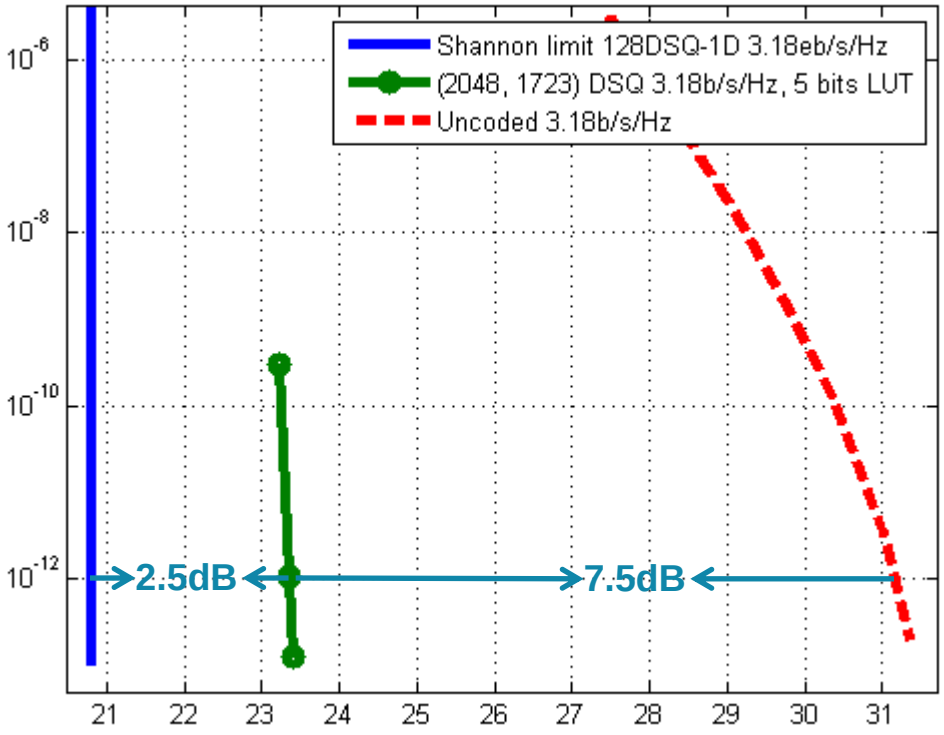
Source: Dell'Oro Feb'15

10GBASE-T Standard

- Hockey stick growth in Enterprise & Data Center environments
- 10GBASE-T operates successfully in Enterprise & Data Center environments
- Use and knowledge of 10GBASE-T is widely disseminated:
  - 10GBASE-T standard was approved in June 2006.
  - Three generations in the field: 65nm, 40nm and 28nm.
  - Multi-vendor interoperability well established.
- Due to 10GBASE-T's success, an amendment to IEEE Std 802.3 (802.3bq) is under way for:
  - 25G
  - 40G
- Scaling the 10GBASE-T standard is a fast and sure path to a 2.5/5GBASE-T standard.

10GBASE-T Modulation and Coding

- DSQ-128 and (2048,1723) LDPC
  - 10GBASE-T is a performance optimized transmission standard less than 2.5dB from Shannon capacity



Frequency-scaled 10GBASE-T Full Duplex Baseband Transmission

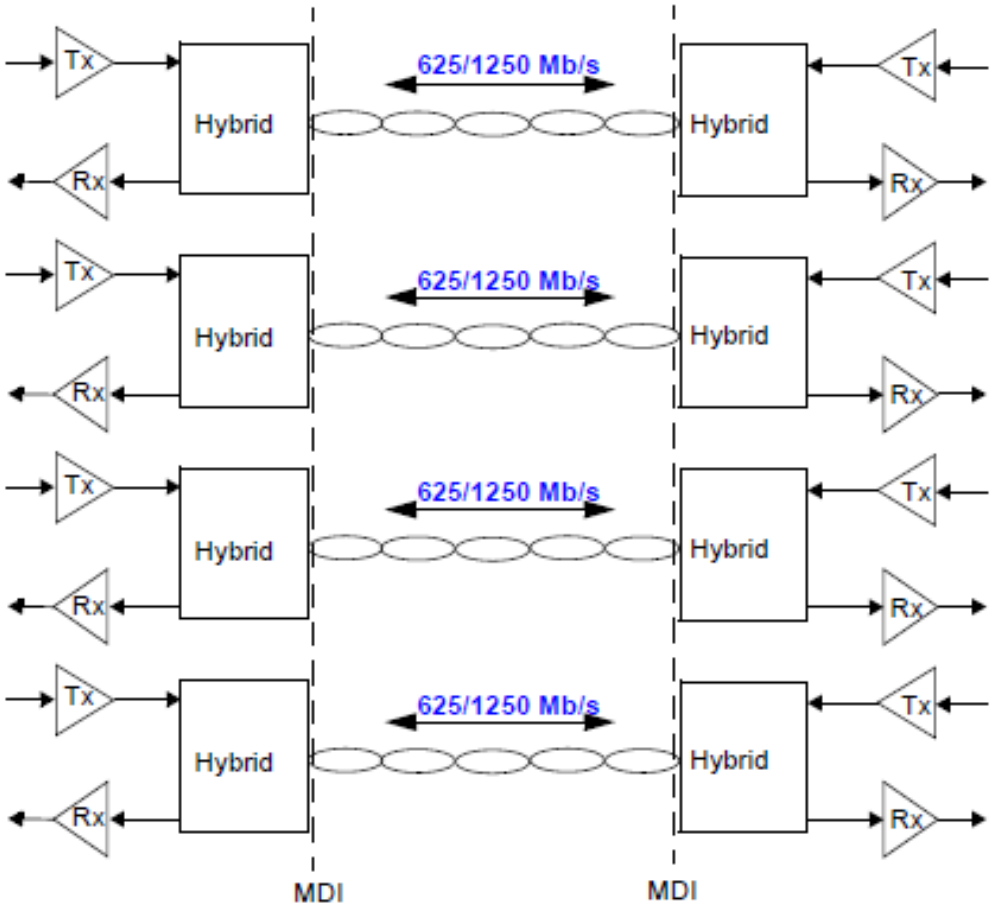
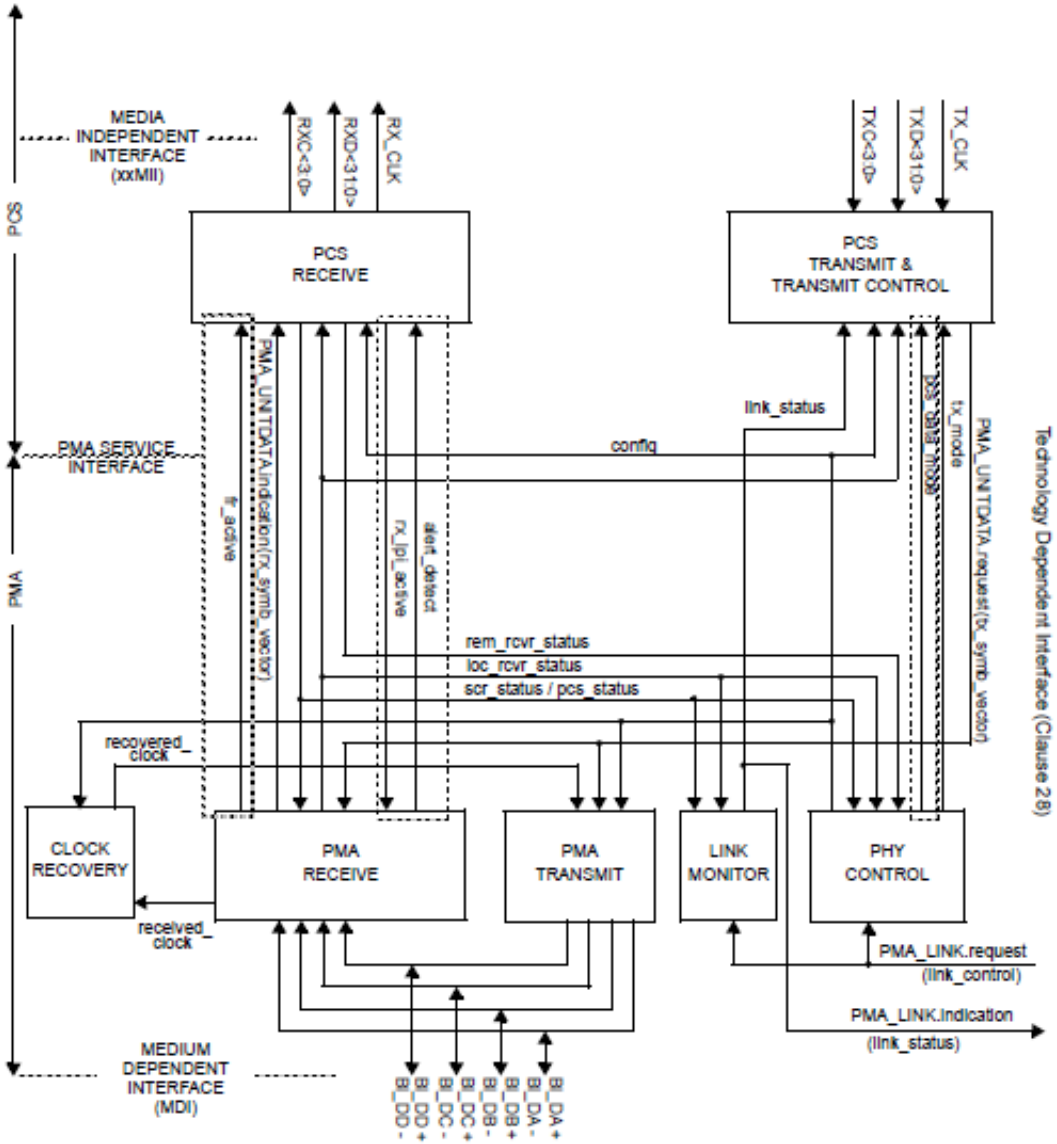


Figure xx-2--2.5/5GBASE-T topology

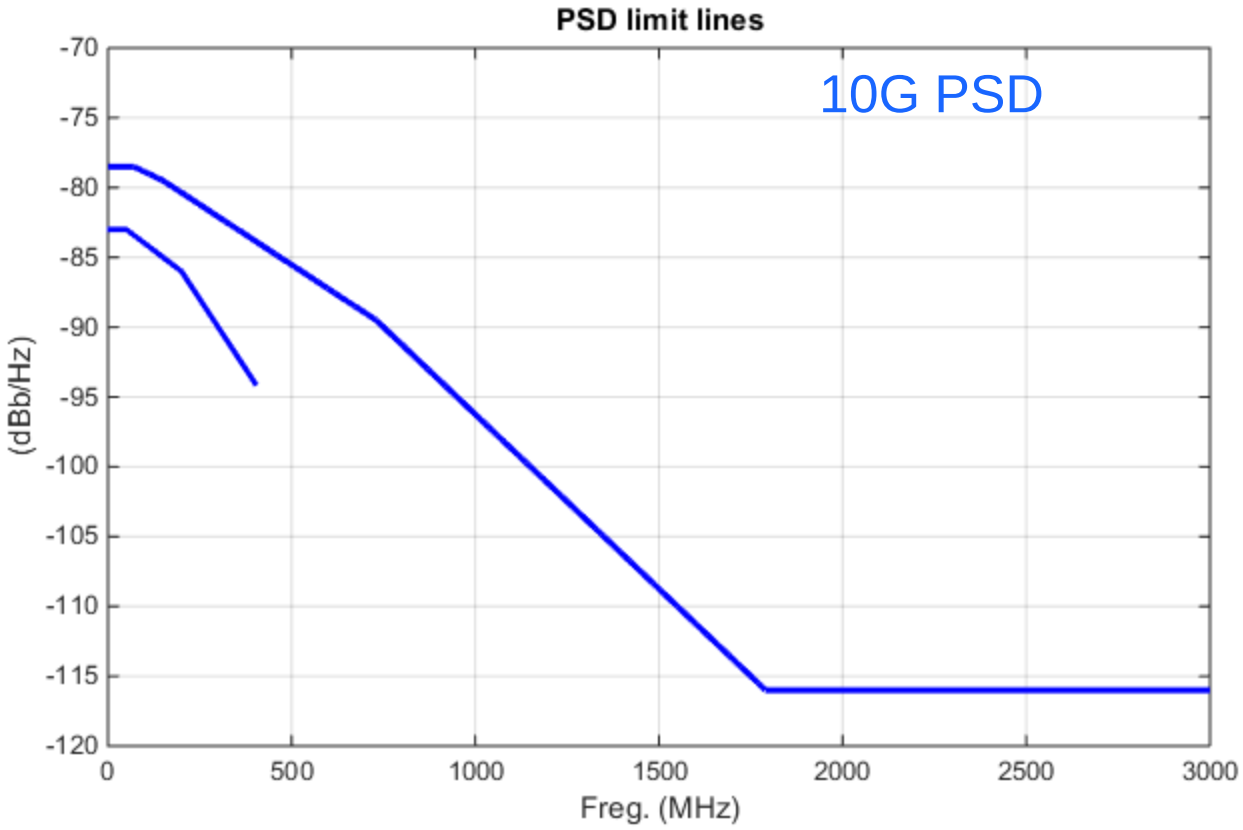
Frequency-scaled 10GBASE-T Full Duplex Baseband Transmission



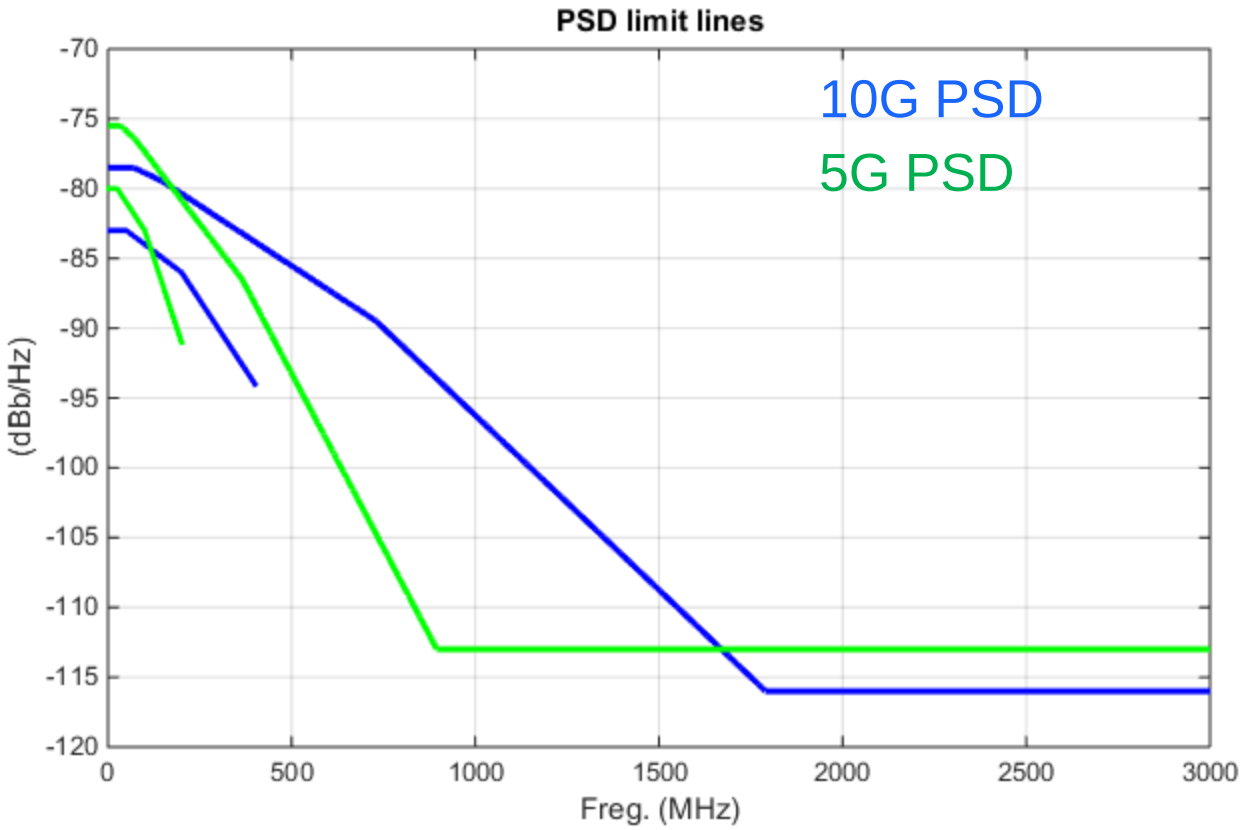
Proposed 2.5/5GBASE-T Technical Approach (1)

- Scale frequencies:
  - ½ for 5G
  - ¼ for 2.5G
- Use industry-wide 10GBASE-T compatible start-up sequence.
- Preserve industry accepted implementation delay.
- Reuse TX specifications with 3dB (5G) and 6dB (2.5G) higher TX-PSD:
  - Additional protection against cross-talk
  - Maintains EMC characteristics

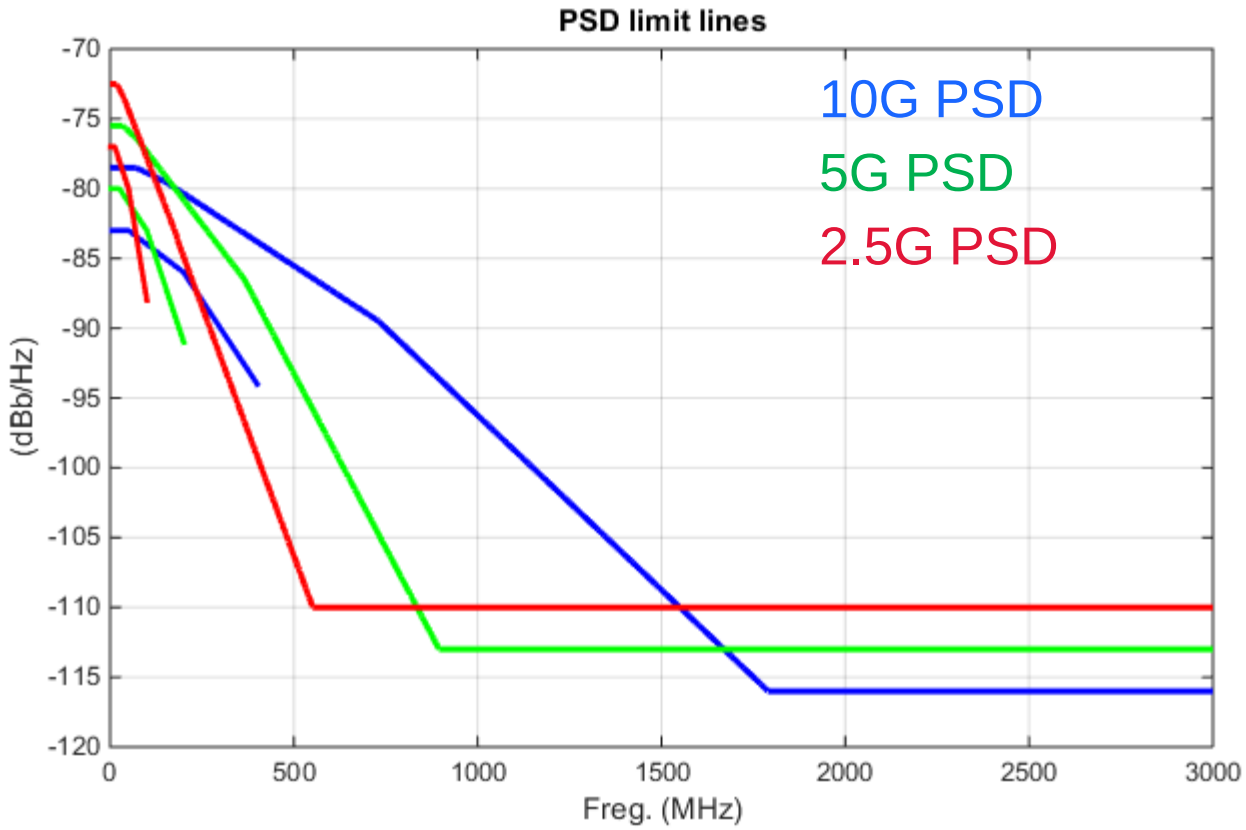
10Gb/s TX PSD Limit Lines



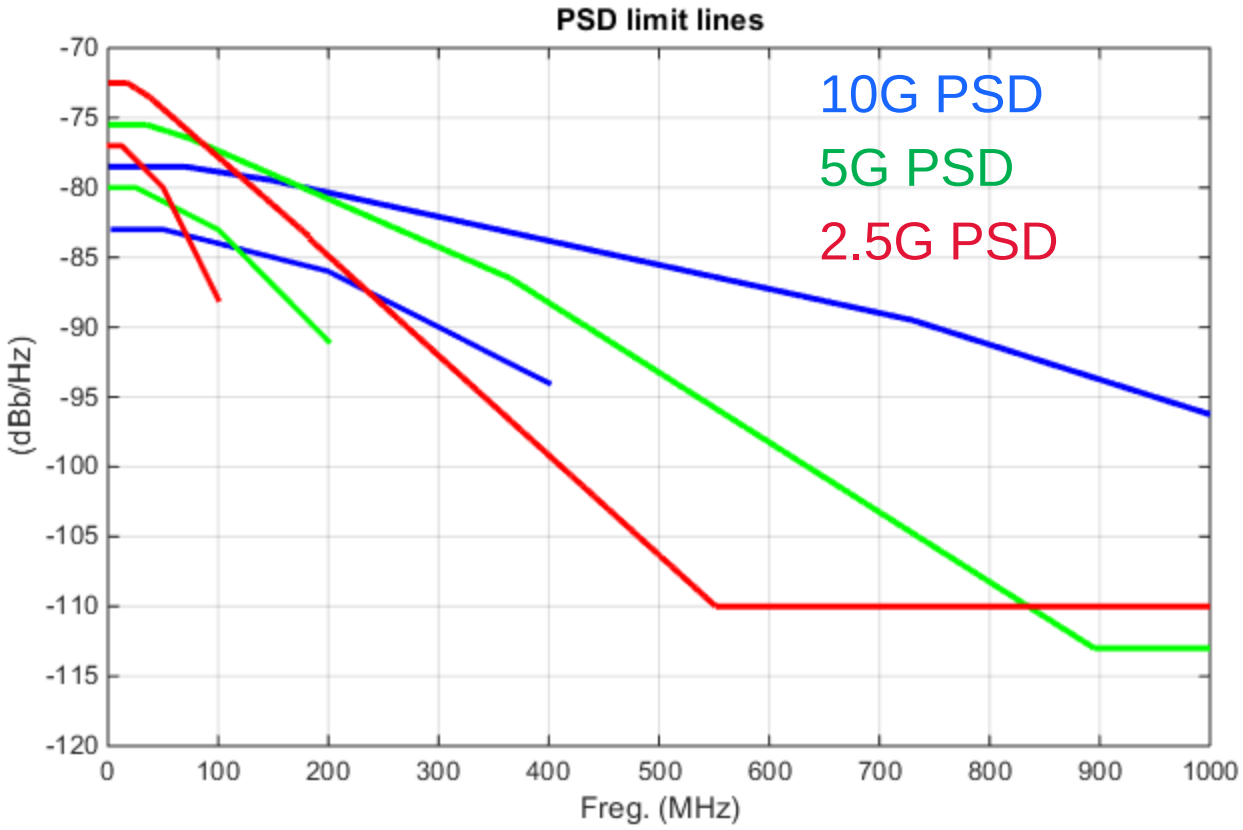
10G and 5G TX PSD Limit Lines



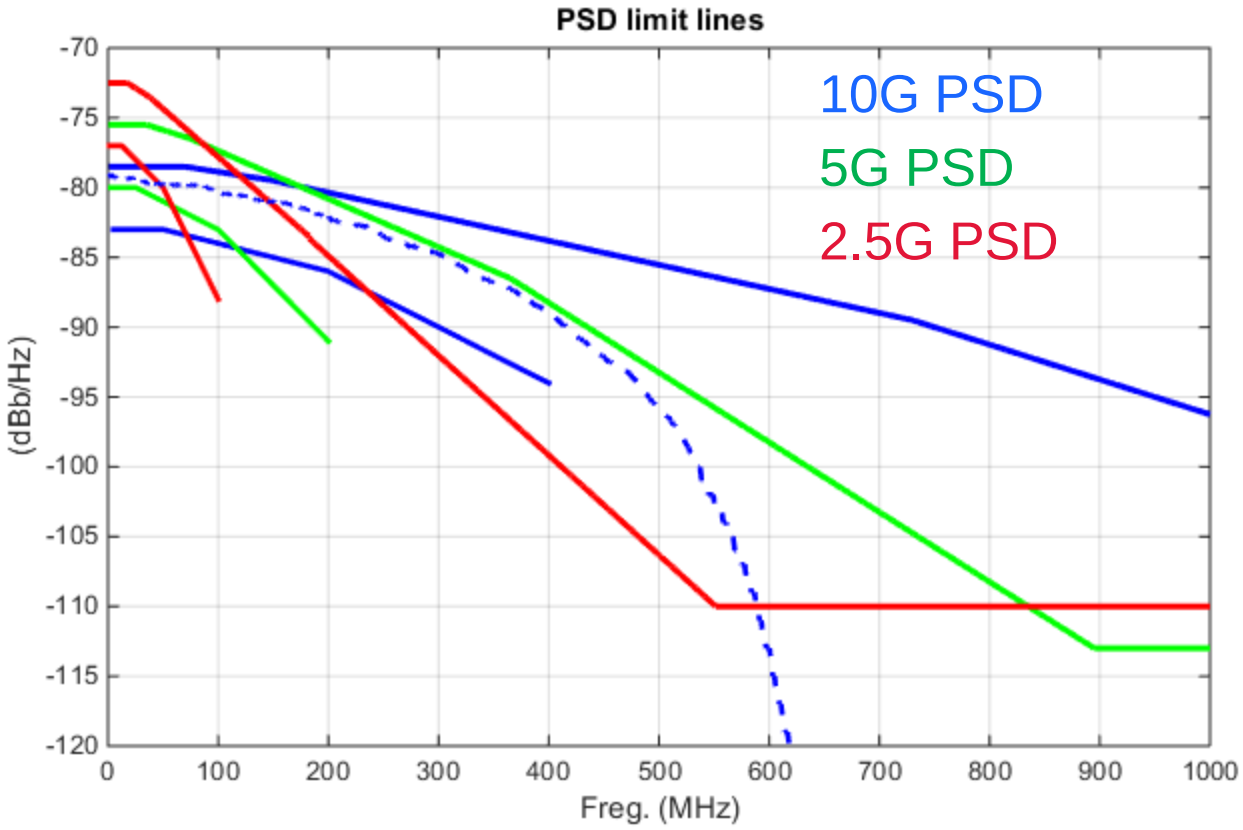
10G, 5G and 2.5G TX PSD Limit Lines



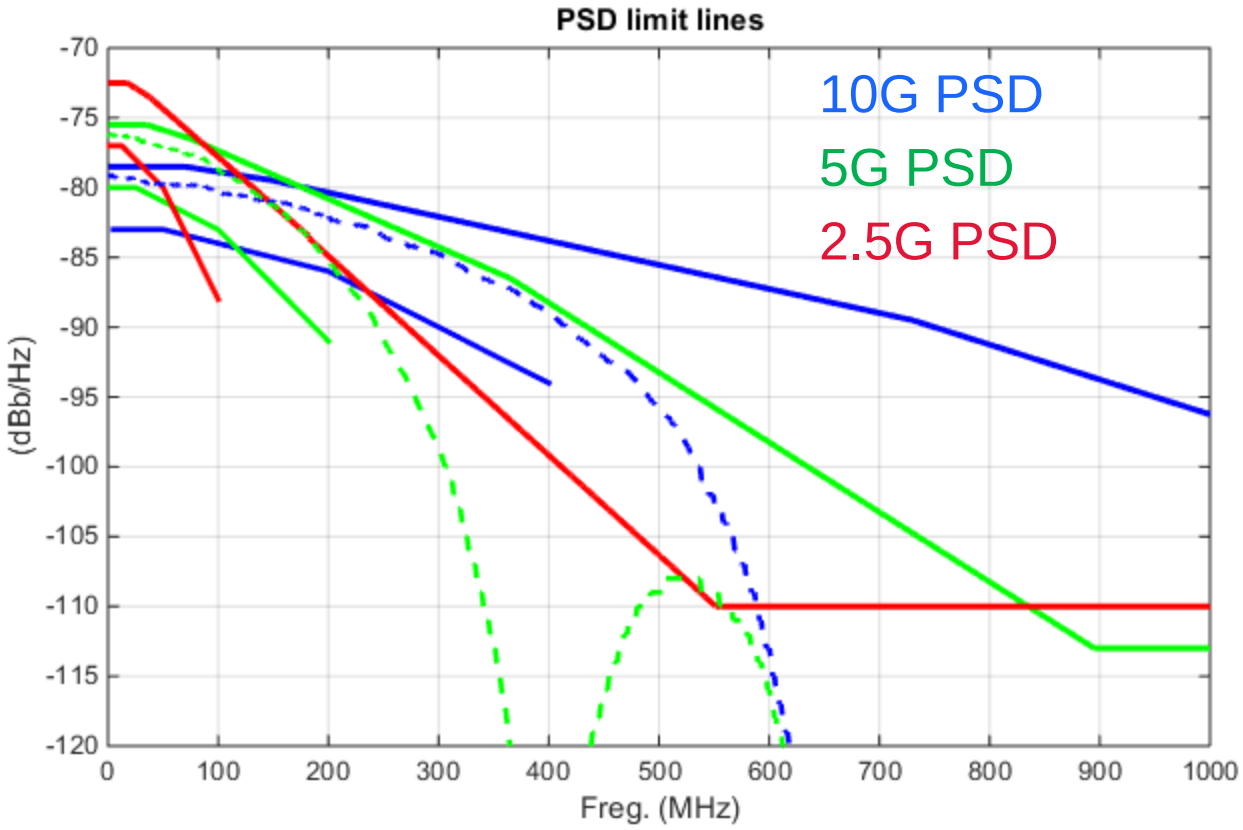
Limit lines frequency limited to 1GHz



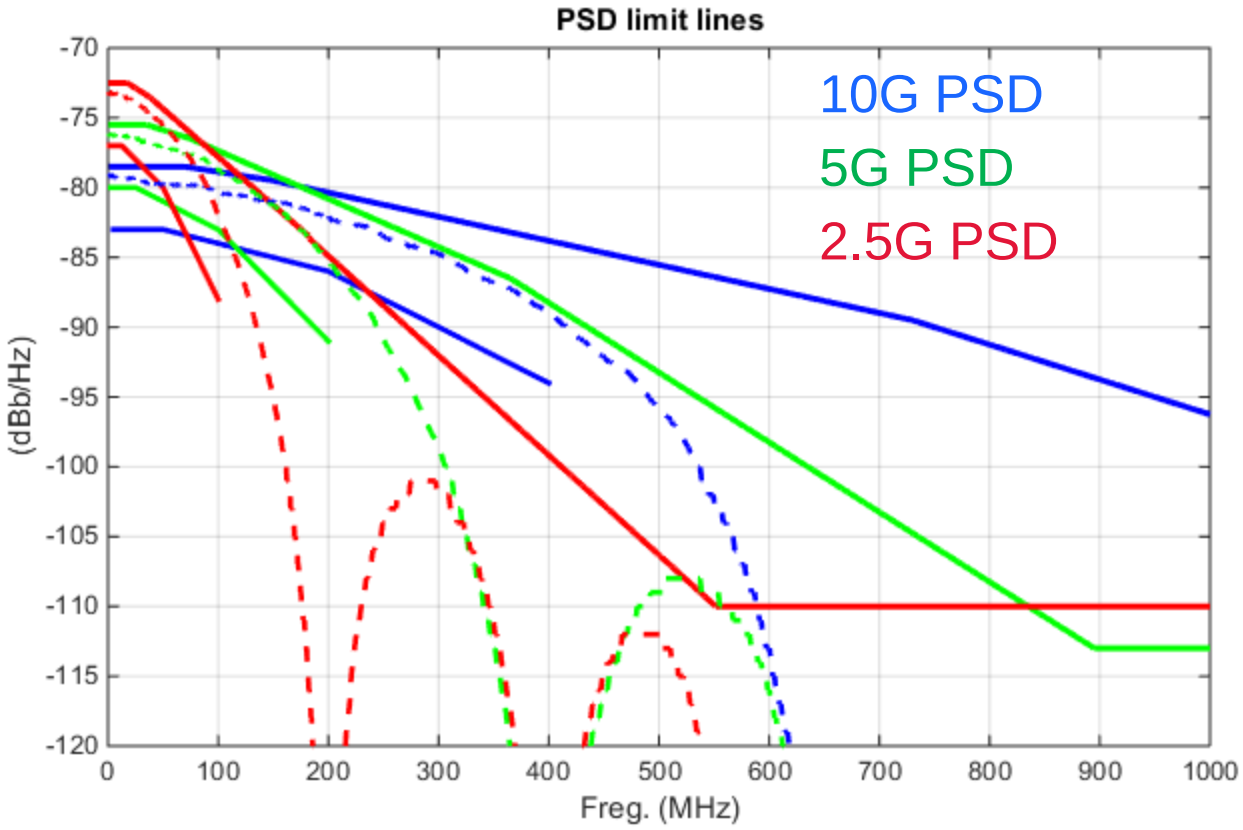
Measured 10Gb/s TX PSD



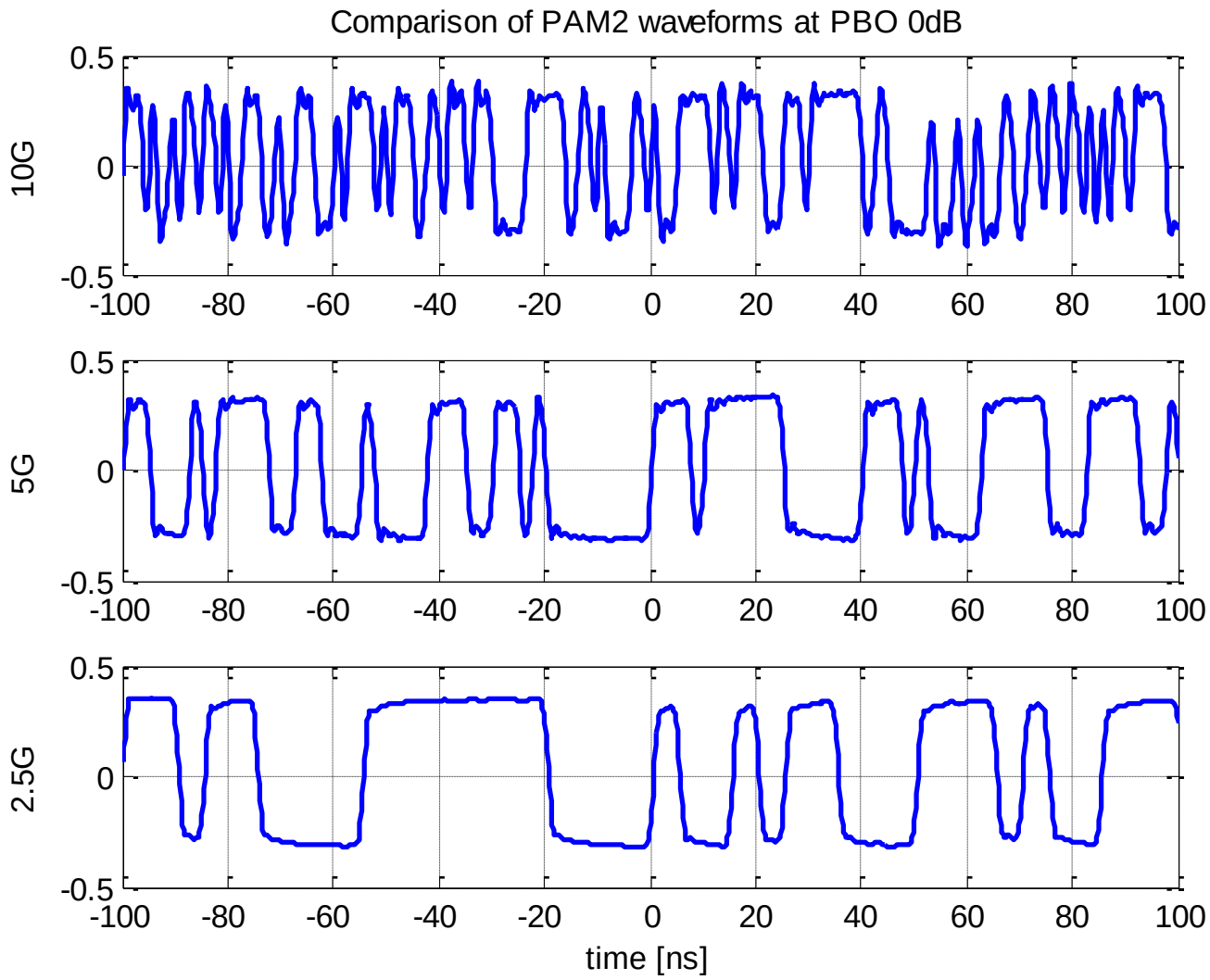
Measured 10G and 5G TX PSD



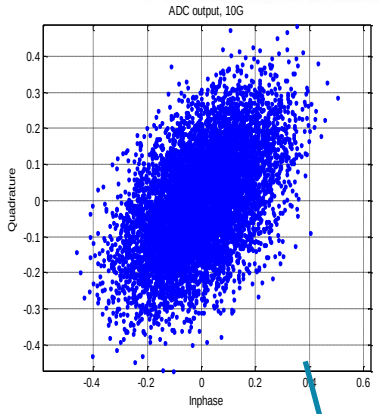
Measured 10G, 5G and 2.5G TX PSD

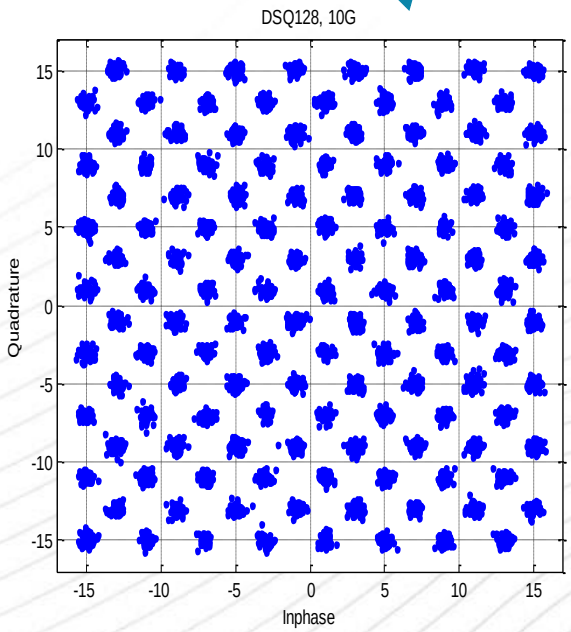


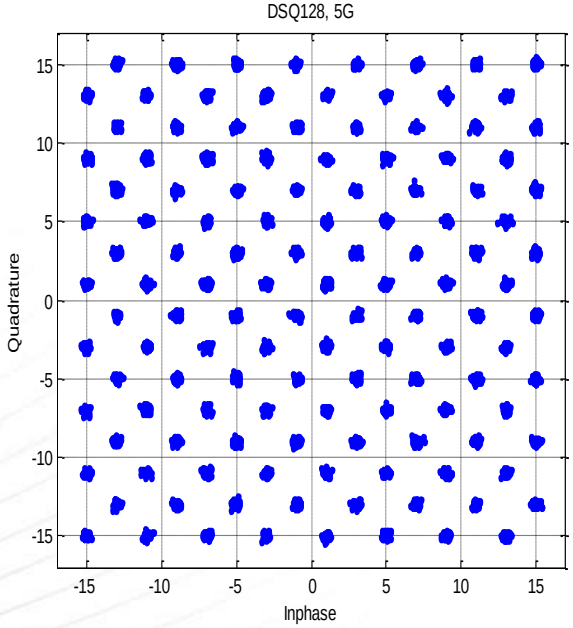
0dB PBO PAM2 time-domain TX waveforms

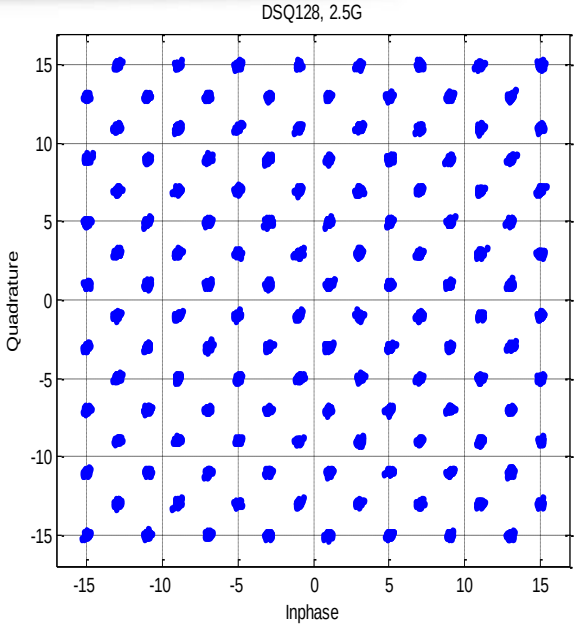


Equalized RX Constellation









- **Echo and NEXT cancellation**
- **FEXT cancellation and equalization**

Proposed 2.5/5GBASE-T Technical Approach (2)

- DSQ-128 signaling on four twisted pairs.
  - 3.125bits per symbol needed for
    - 200MBd for 2.5G
    - 400MBd for 5G
  - 3.5bits per symbol
  - Guarantees sufficient SNR for the timing loop by avoiding false decisions
  - Efficient 12dB constellation partitioning
- Near Shannon capacity (2048/1723) LDPC code
- For 10GBASE-T, this approach was extensively analyzed in the 802.3 standards committee and found to provide the best performance, compared to all other alternative proposals.
- All bits are protected
  - Some bits protected by LDPC code
  - Remaining bits protected by Euclidean Distance

2.5/5GBASE-T PCS/PMA Proposal Summary

- **Leverage proven 10GBASE-T Technology**
  - Robust DSQ-128 Modulation
  - High-performance LDPC coding
- **Provide excellent performance**
  - Error-free operation over 100m of Cat5e & Cat6 at 2.5Gb/s & 5Gb/s
  - Robust against alien noise sources (24/7 problem)
  - Robust against impulsive noise sources (infrequent)
- **Straightforward implementation**
  - Re-use of 10GBASE-T blocks accelerates multi-vendor implementation
  - Minimal hardware changes
- **Support fast-track standardization**
  - Leverage successful 10GBASE-T standardization
  - Enable direct path to IEEE standardization

Thank you!