802.3bz 2.5G/5GBASE-T TF

PCS/PMA Proposal

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2.5G and 5G BASE-T Layering considerations

PCS/PMA Layering

Datalink Layer
- LLC or MAC Client
- MAC Control
- MAC
- RS
- xxMII

PHY
- PCS
- PMA
- PMD
- AN
- MDI
- Medium

10GBASE-T
- RS – CL46
- XGMII
- XGXS – CL47
- XAUI
- XGMII

2.5GBASE-T
- RS
- xxMII
- XGMII

5GBASE-T
- RS
- xxMII
- XGMII

MAC (CL4/4A)

Mgmt
- CL45
- Stats
- CL30

EEE
- CL78

PoE
- CL33

Medium
- AN – CL 28

Just do the work, and do it right
Propose & Build consensus
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
Frequency-scaled 10GBASE-T Full Duplex Baseband Transmission
Proposed 2.5/5GBASE-T Technical Approach (1)

- Scale frequencies:
  - \( \frac{1}{2} \) for 5G
  - \( \frac{1}{4} \) 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

PSD limit lines

10G PSD

(dB/Hz)

Freg. (MHz)
10G and 5G TX PSD Limit Lines

PSD limit lines

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

PSD limit lines

10G PSD
5G PSD
2.5G PSD

(dBc/Hz)

Freg. (MHz)
Limit lines frequency limited to 1GHz
Measured 10Gb/s TX PSD

PSD limit lines

-70
-75
-80
-85
-90
-95
-100
-105
-110
-115
-120
0 100 200 300 400 500 600 700 800 900 1000
Freg. (MHz)

10G PSD
5G PSD
2.5G PSD
Measured 10G and 5G TX PSD

![PSD limit lines graph](image)

- 10G PSD
- 5G PSD
- 2.5G PSD
Measured 10G, 5G and 2.5G TX PSD
Comparison of PAM2 waveforms at PBO 0dB

- 10G
- 5G
- 2.5G

time [ns]
Equalized RX Constellation

- Echo and NEXT cancellation
- FEXT cancellation and equalization
• DSQ-128 signaling on four twisted pairs.
  • 3.125 bits per symbol needed for
    – 200MBd for 2.5G
    – 400MBd for 5G
  • 3.5 bits 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!