Scrambler Options for Multi-Gig PHYs

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Motivation

- Choosing a right scrambler is a key
  - Whiten the spectrum by avoiding undesired spurs
  - Randomize the data stream
  - Receiver less complex
- Compare the performance of differnet scramblers that are currently being discussed in tu_3ch_03_1018.pdf

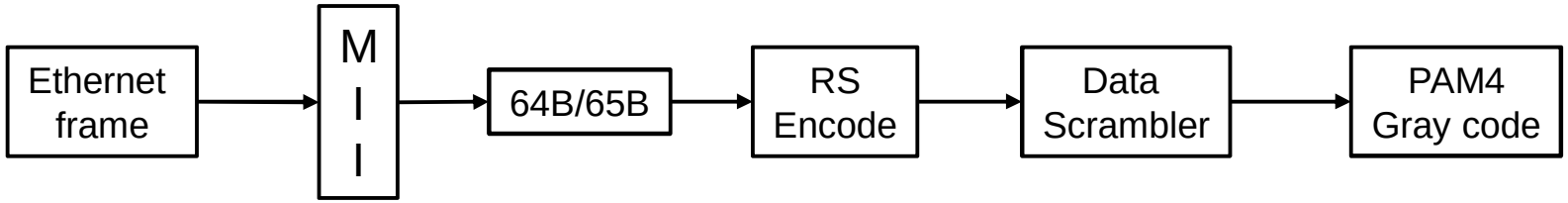
Data Scrambler Choices

- 10GBASE-T
  - Master: $1+X^{39}+X^{58}$
  - Slave: $1+X^{19}+X^{58}$
- 1000BASE-T1
  - Master: $1+X^{4}+X^{15}$
  - Salve: $1+X^{11}+X^{15}$
- 1000BASE-T
  - Master: $1+X^{13}+X^{33}$
  - Salve: $1+X^{20}+X^{33}$

Theory: Scrambler Evaluation

- Transmit Power Spectrum Density (TX-PSD)
  - Expected to be smooth and w/o any spurs
  - No emission issue
- DC Balance
  - Ideally #1's and #0's should be equal
  - Avoid long sequence of 1's and 0's
  - No need of complex receiver
- Transition density
  - Good timing recovery
  - Low signal processing effort at receiver

Simulation Setup

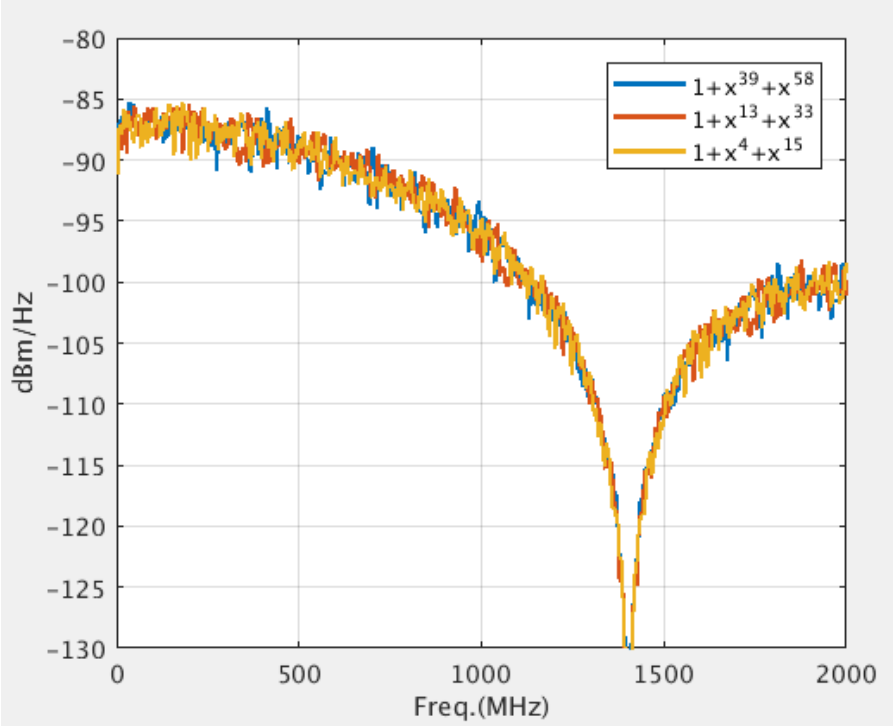


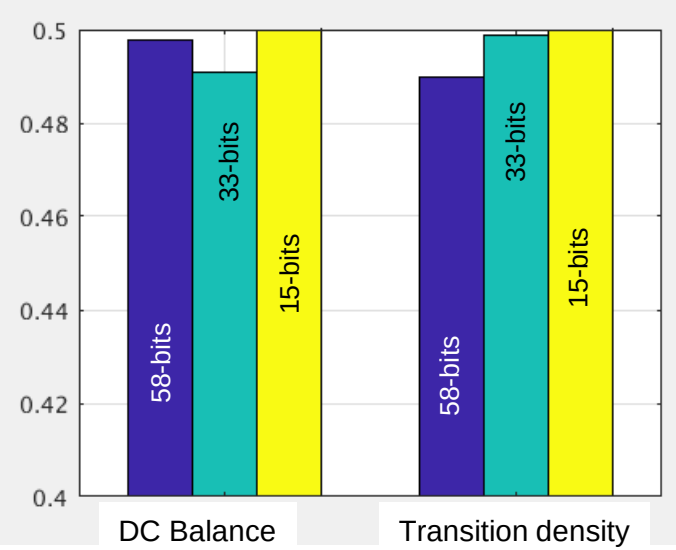
- 1530 Bytes Ethernet Frame and repeated multiple times
  - Ethernet data capture using Wireshark
  - Contiguous block of 1’s
  - Contiguous block of 0’s
  - Contiguous 736 Bytes block of 1’s and 0’s
  - Contiguous 3 Bytes block of 1’s and 0’s
  - Contiguous 5 bits block of 1’s and 0’s

Wireshark Data

- 1 → total no. of 1's in scrambled frame
- 2 → transition density in scrambled frame

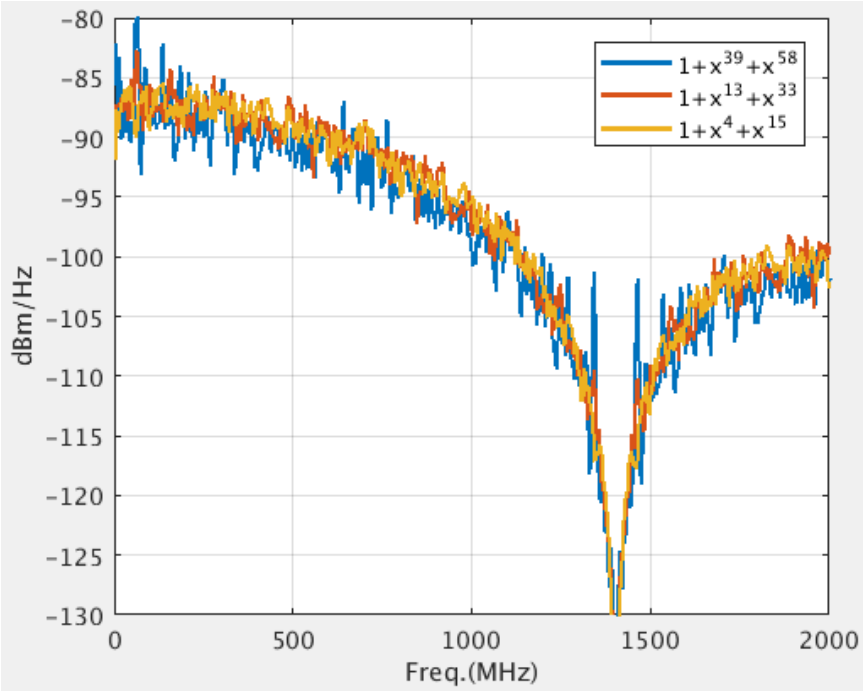
- Yellow → 15 bits scrambler (1000BASE-T1)
- Green → 33 bits scrambler (1000BASE-T)
- Blue → 58 bits scrambler (10GBASE-T)

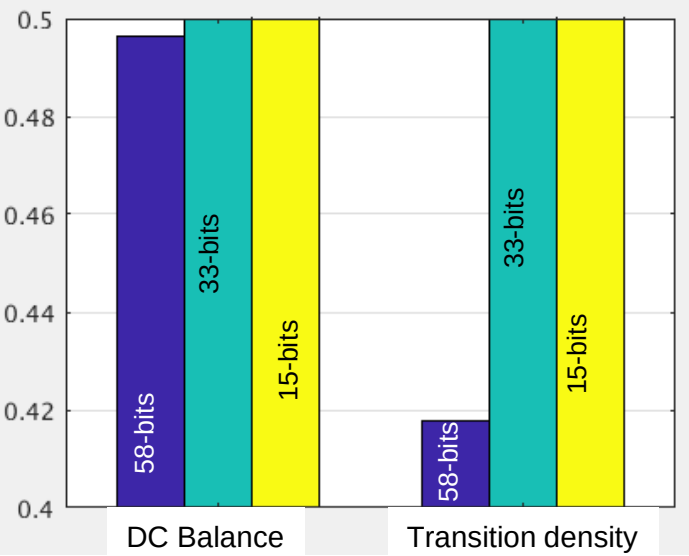




3 Bytes of 1's and 0's Making 1530 Bytes Frame

- 1 → total no. of 1's in scrambled frame
- 2 → transition density in scrambled frame
- Yellow → 15 bits scrambler (1000BASE-T1)
- Green → 33 bits scrambler (1000BASE-T)
- Blue → 58 bits scrambler (10GBASE-T)

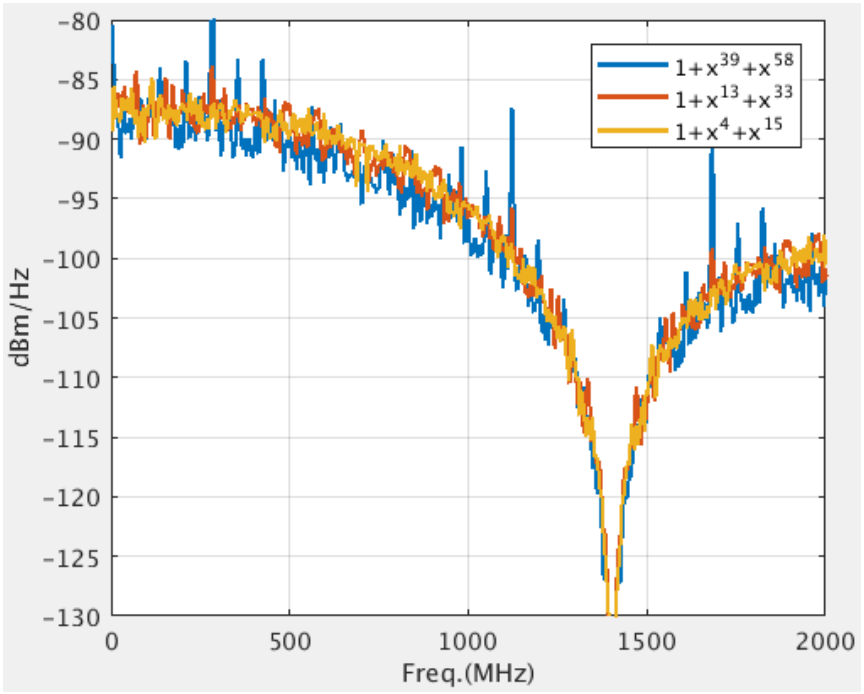


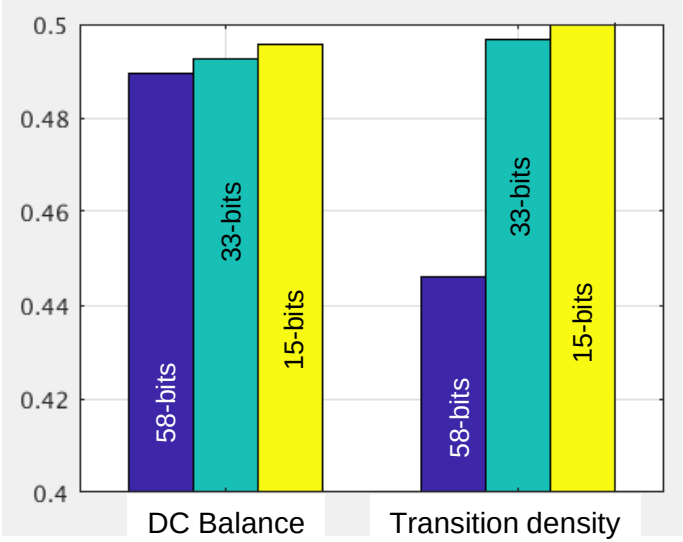


5 Bits of 1's and 0's Making 1530 Bytes Frame

- 1 → total no. of 1's in scrambled frame
- 2 → transition density in scrambled frame

- Yellow → 15 bits scrambler (1000BASE-T1)
- Green → 33 bits scrambler (1000BASE-T)
- Blue → 58 bits scrambler (10GBASE-T)





Scrambler Survey

- 1530 bytes Ethernet frame

IEEE Standards	Scrambler size	Baud Rate	Scrambler cycle
100BASE-TX	11-bits	125MBaud	16.3us
100BASE-T1	33-bits	66MBaud	130.1s
1000BASE-T1	15-bits	750MBaud	43.6us
1000BASE-T	33-bits	125MBaud	68.7s
10GBASE-T	58-bits	800MBaud	11.4 Years

Conclusions

- All three candidates 15, 33, and 58-bits scramblers do not pose any treat to emission violation for best case scenario → Wireshark captured data which is sufficiently randomized
- Few specific input data patterns such as consecutive burst of 1's and 0's do pose treat to emission violation using 58-bits scrambler
- Performance of 15-bits and 33-bits scramblers are comparable w.r.t emission, DC balance, and transition density. However, 15-bit scrambler shows the best performance
- Recommendation: Do not adopt 58-bits scrambler for Multi-Gig

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