Proposed Asymmetric Low Power Modulation

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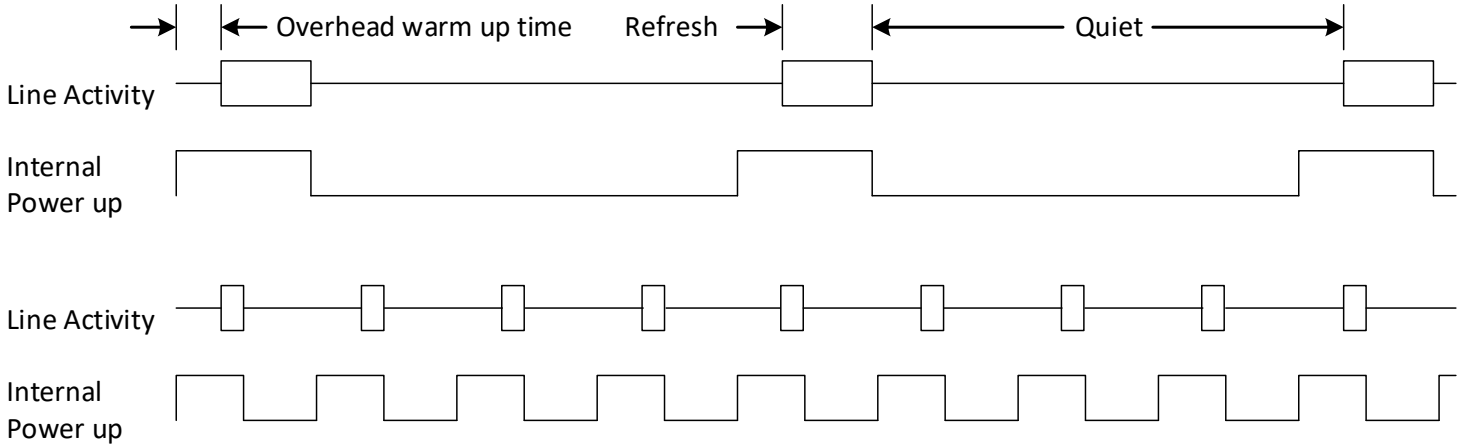
Agenda

- Recap from previous ad-hoc
- Look at EEE power in real products using publicly available data
- Propose low speed modulation scheme
- Compare Energy Consumption

Recap: Higher Baud Rate, Less Efficient Power Savings

- Higher baud rate
  - ➔ Refresh occurs closer together even though duty cycle remains the same
  - ➔ Overhead higher percentage of quiet/refresh cycle
  - ➔ Some circuits cannot shut down at all because of fast turn on time required
  - ➔ Decreased power saving vs theoretical



* Not to scale

Published 1000BASE-T and 10GBASE-T (not T1) EEE numbers

- Unfortunately not much actual EEE power numbers are available without NDA
- 10G nowhere near 95% savings

	Marvell 88E1680M (note 3)	Broadcom 5720 (note 2)	Broadcom 57810S (note 2)
	1000BASE-T	1000BASE-T	10GBASE-T
		2 ports	2 ports
NIC idle without EEE		2.06	12.8
NIC idle with EEE		1.21	9.4
NIC EEE power savings		42%	27%
PHY idle power without EEE (note 1)		1.03	6.4
PHY idle power with EEE (note 1)		0.18	3.0
PHY EEE savings	Over 75%	83%	53%

- Note 1: PHY only number not published. Assume PHY is 50% of NIC power and 100% power savings is from PHY.
- Note 2: https://docs.broadcom.com/docs-and-downloads/collateral/wp/2CSEEE_WP201-R.pdf
- Note 3: https://www.marvell.com/documents/knarnyjewzvogczbbkad/

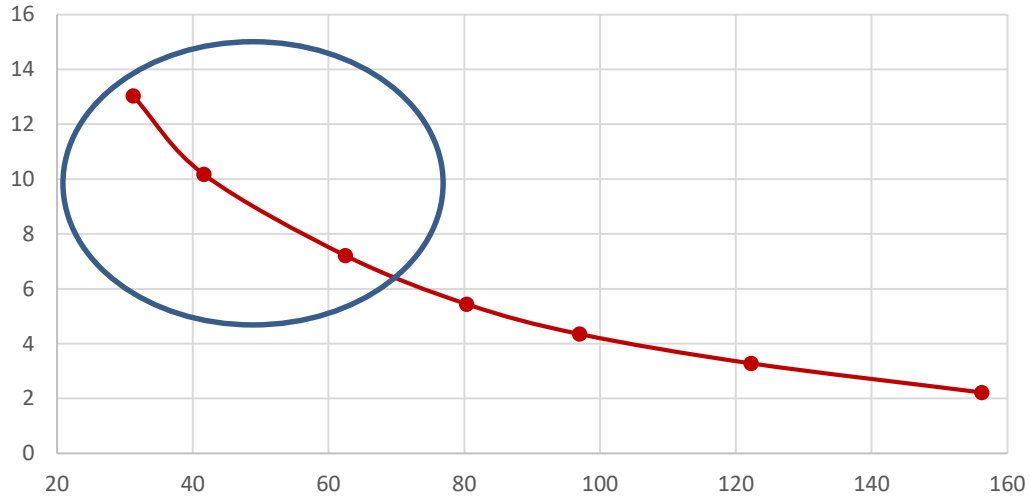
Recap: Alternative ways to save power

- Instead of reducing duty cycle (i.e. EEE bursting)

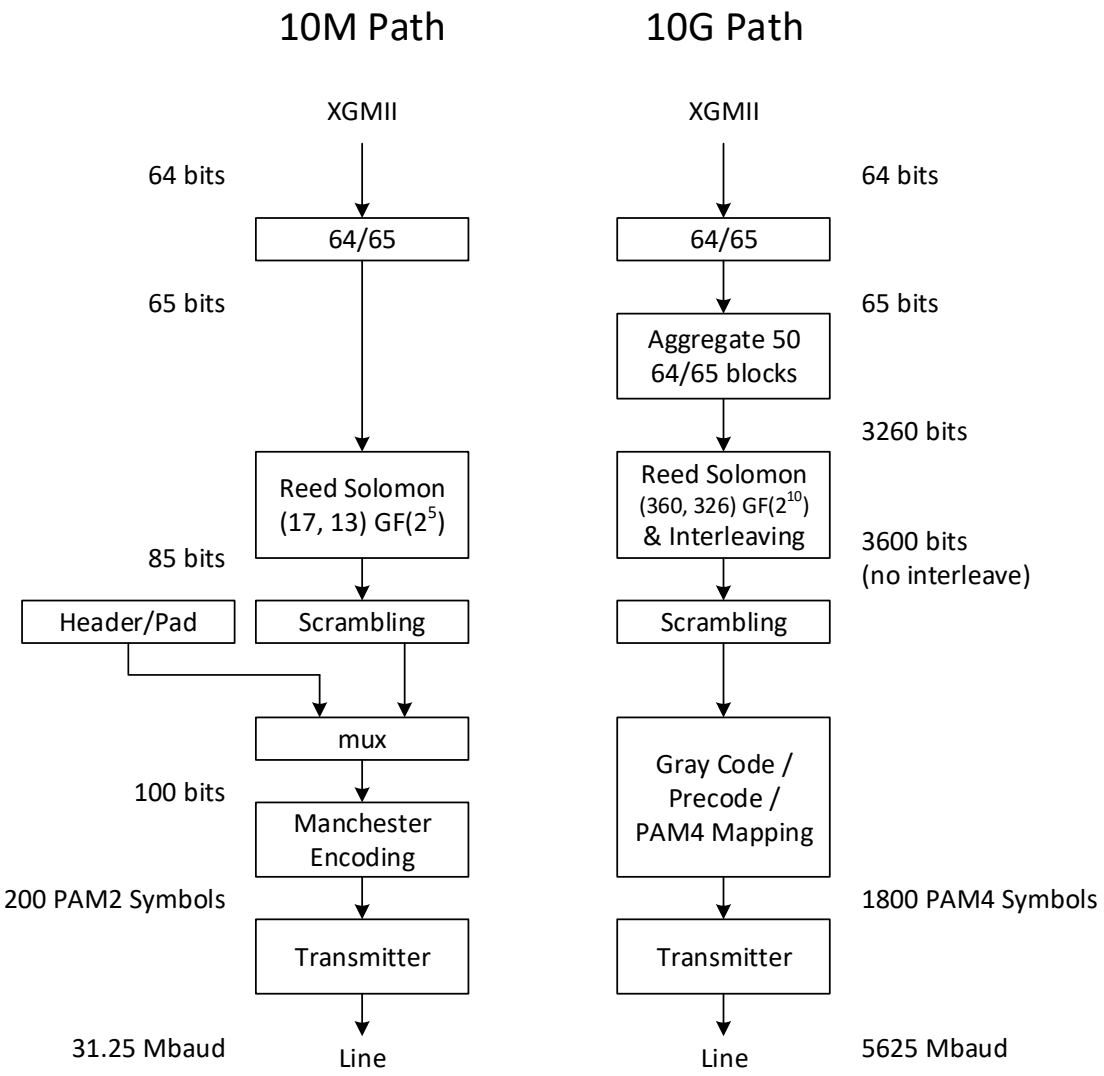
- Slow down clock frequency – Run lower baud rate
- Simplify signal processing – Eliminate high speed echo with filtering, simple slow receiver
- Possible if low speed signal to below 70 Mbaud.

High speed receiver margin (dB)

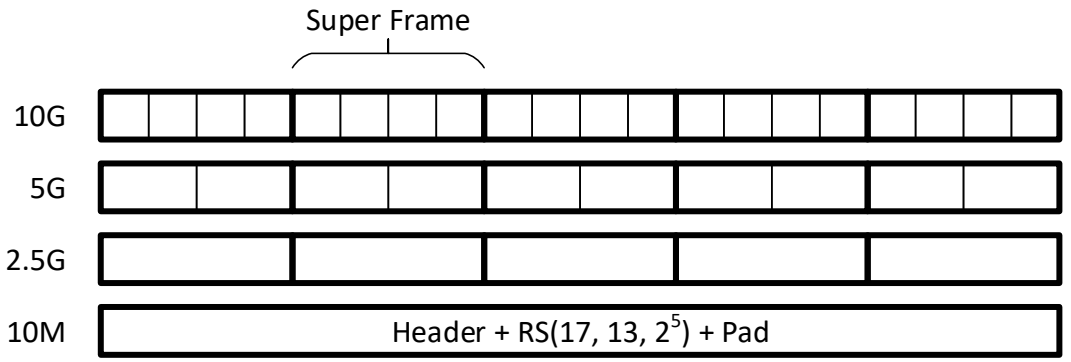
15m cable model



Proposed Low Speed Modulation 10M vs 10G

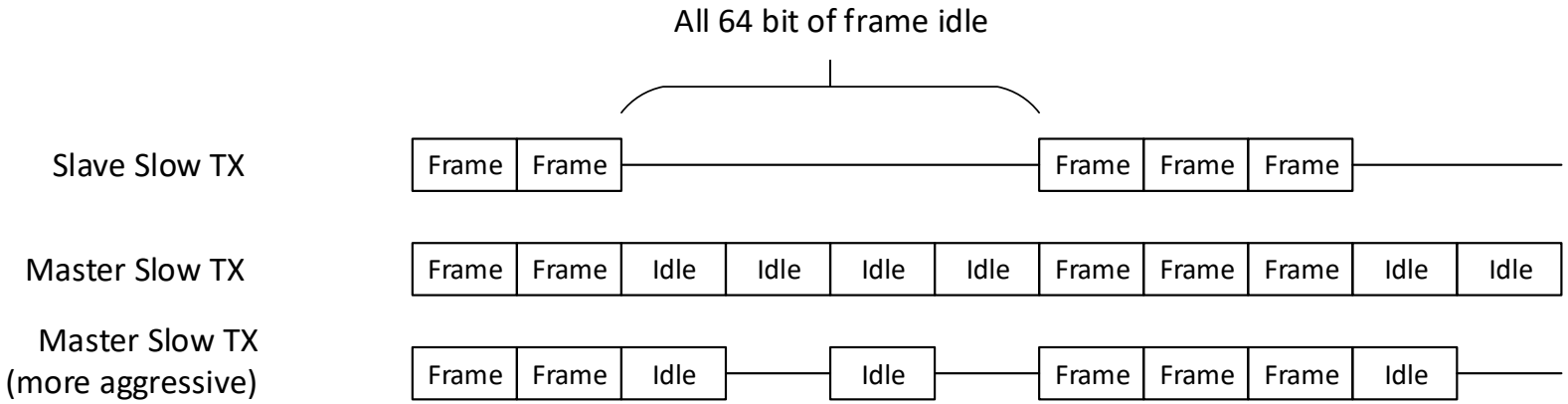


- Reuse 64/65 and scrambler
- Very small Reed Solomon
- Header acts as an alert signal
- Manchester good for clock extraction
- Integer number of super frames



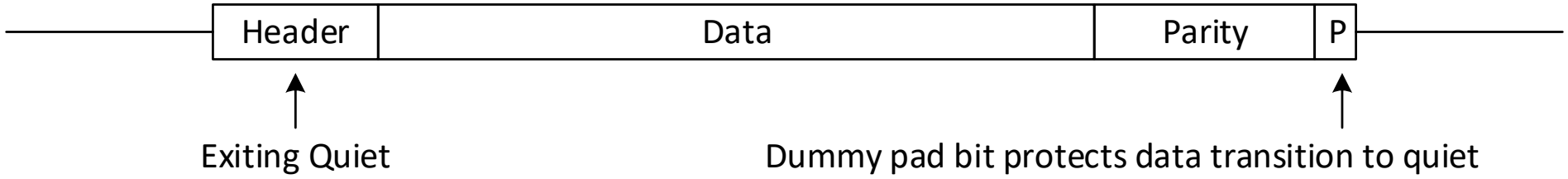
Power Savings Non-Transmission

- Slave transmits only if a RS frame contains non-idle data
- Master transmits continuously to supply clock information to link partner slave
- Alternative master - be more aggressive in transmitting fewer idle frames



Frame Details

- 14 bit header – Acts as alert that data is coming and indicates data type
- 65 bits data
- 20 bits parity – protects at least 320ns and up to 640ns bursts
- 1 bit dummy pad – protects parity bit when transitioning to quiet



Energy comparison – Send 1600 byte burst of data every 1 second, otherwise idle

- EEE Method
  - 32552 refreshes/second x 1800 symbols/refresh + 43200 symbols for (alert, wake, data, sleep)
  - = 58.6M symbols/second with high performance receiver, high speed echo
- Asymmetric Method Slave Transmitter
  - 1600 x 8/64 frames x 200 symbols / frame
  - = 40K symbols/second with simple receiver, no high speed echo
- Asymmetric Method Master Transmitter (Continuous transmission)
  - 31.25M symbols/second with simple receiver, no high speed echo
- Asymmetric Method Master (50% idle transmission)
  - (31.25M – 40K) x 50% + 40K
  - 15.645M symbols/second with simple receiver, no speed power echo

Summary

- EEE power savings becomes more difficult at higher baud rate
- Slow and steady back channel will save more power
  - Reduced signal processing complexity
  - Fewer transmitted symbols
- Proposed modulation a good match for systems that
  - Transmits low amount of data
  - Does not need to quickly switch between slow and fast modes

THANK YOU