# EEE Proposal for 1000BASE-T1

**San Diego, CA**

**July 16, 2014**

**Jim Graba**

**jgraba@broadcom.com**

# Contributors

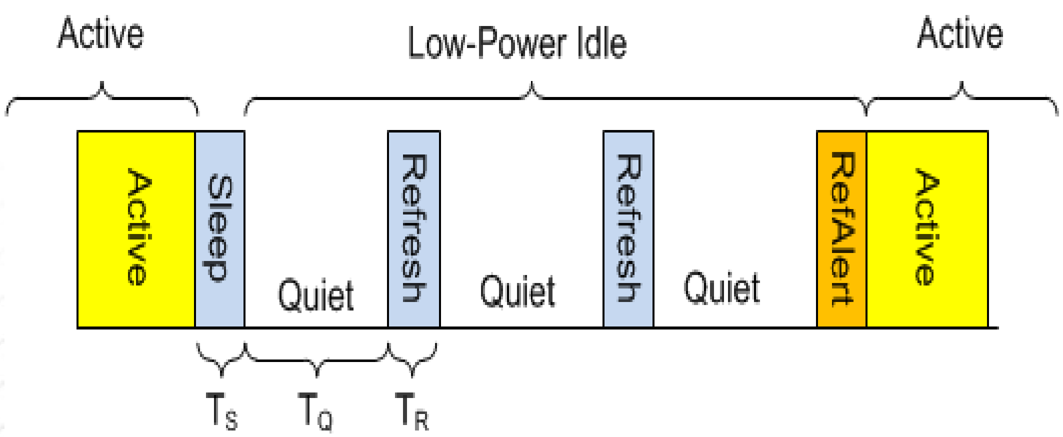
- Ahmad Chini
- German Feyh
- Mehmet Tazebay
- Mike Tu
- Peiqing Wang

# Overview

- **General 1000BASE-T1 EEE Format**
- **EEE Tradeoffs**
- **Use Similar 10G LPI Timing?**
- **Alert & Refresh**
- **LPI Exit – Case Analysis**
- **LPI Parameter Choices**
- **Conclusions**

# General 1000BASE-T1 EEE Format

- **10G EEE provides a baseline**
  - Use Refresh segments to allow adaptation while dissipating little power
  - Leave LPI mode without incurring a large latency
  - Allow asymmetrical LPI mode (1000BASE-T EEE did not)




- **1000BASE-T1 EEE differences with 10G EEE**
  - One twisted pair
  - Refresh can use the same modulation as Normal data – opportunity for simplification
  - Reed Solomon frame is larger than 10G's LDPC frame

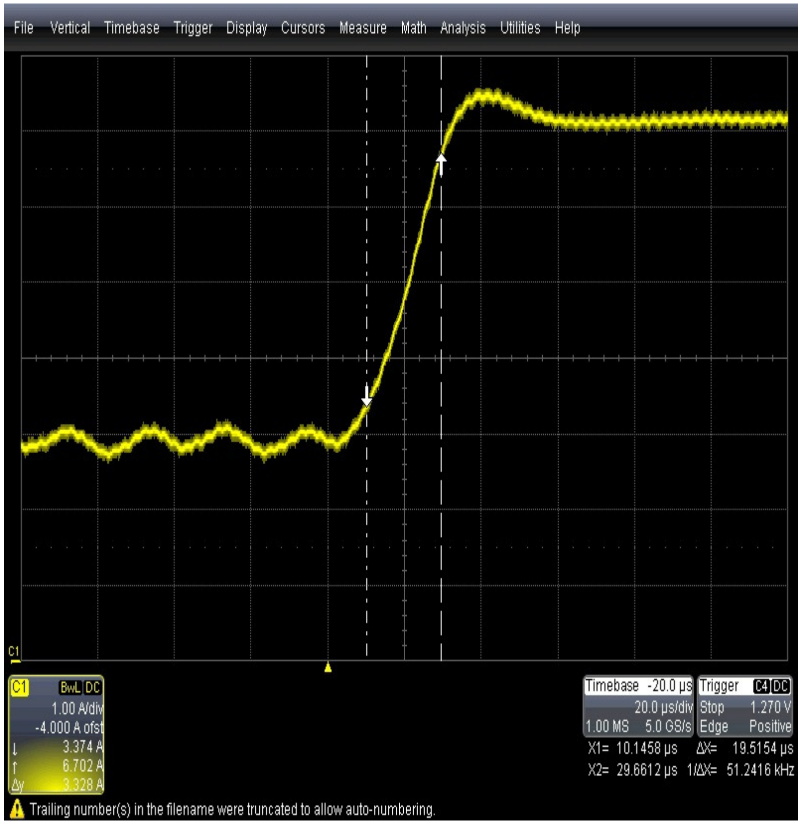
# EEE Tradeoffs

- **Adaptation**
  - Updates are decimated by RefreshLen / QRPeriod
  - Loop BW decrease during LPI is roughly proportional to the decimation
  - Sampling phase can drift during last Quiet before exiting LPI mode

- **Better power savings => more latency**
  - Analog circuits take time to obtain full capability when leaving a low power state
  - Regulator circuits take time to settle LPI mode

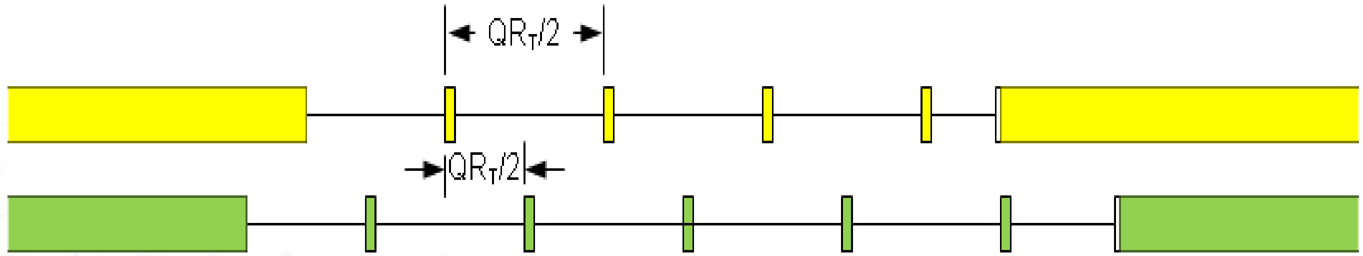
- **1000BASE-T1 EEE vs 10G EEE**
  - Less current swing between power states
  - PAM3 is less sensitive to phase offset compared to 10G's DSQ
  - Only 1 twisted pair to deal with => less Refresh congestion
  - ECC blocks are much bigger

Power supply current at LPI exit



# Use similar 10G LPI timing?

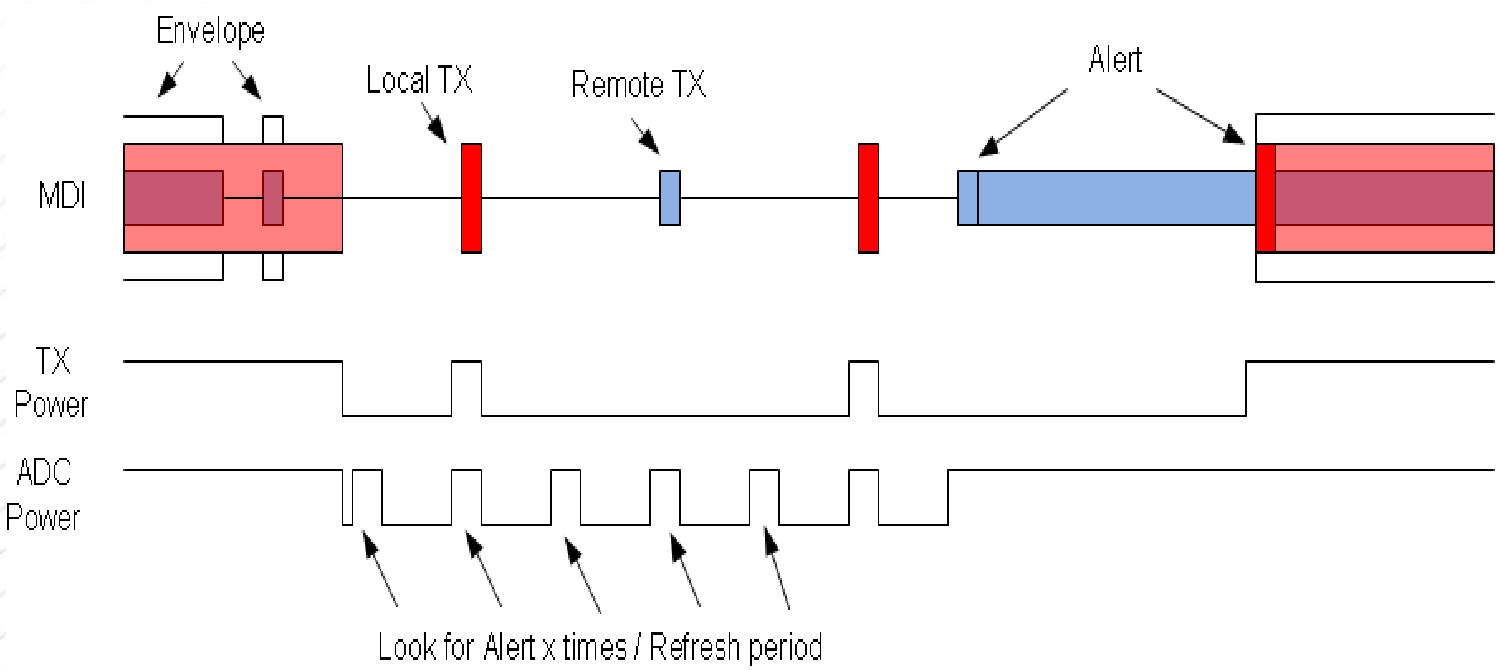
- **On a single twisted pair the Quiet/Refresh period is ~163us**
  - Adaptation decimation = 512/4 = 128 => LPI adaptation rate = Normal/128
  - 10G time between any TX or RX Refresh was ~20us
  - Now that time ($QR_T/2$) would be 80us. Should we reduce it to 20us for 1000BASE-T1 EEE?




- **If we reduce $QR_T$ too much we lose the capability to put the RX AFE in a low power state**
  - See next page
- **Need to align Slave RX and TX Refreshes during Training akin to 10G LPI**

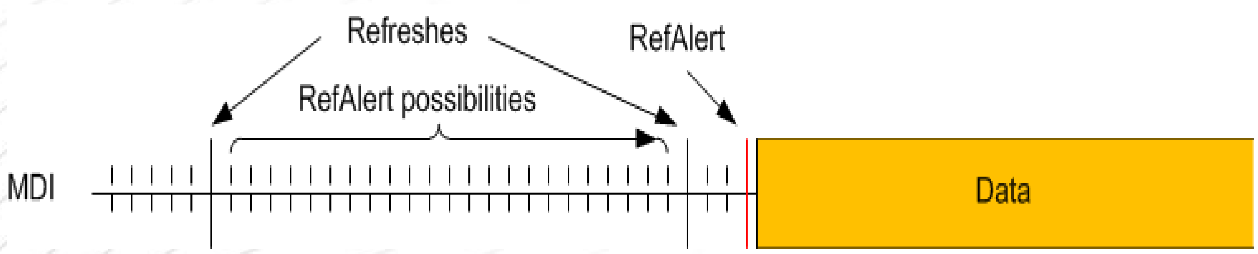
# Alert

- **10G EEE Alert could start at any 0.32us interval => the Alert twisted pair channel must be powered on continually**
  – Following this blindly means the ADC cannot power down
- **Solution: allow the Alert to only appear at discrete times**
  – Now the ADC can be powered on at those times only to check for Alert
  – Need enough time between Alert possibilities to power down => long Quiet time



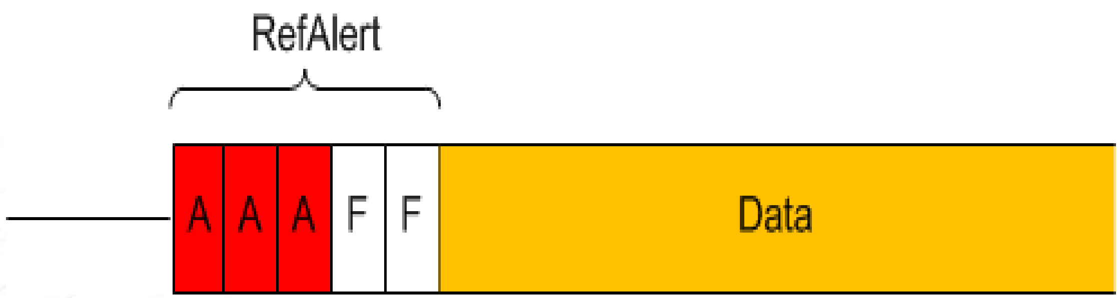
# Embed Alert into Refresh

- **During LPI mode Refreshes consist of zeros scrambled and converted to PAM3 symbols**
- **To leave LPI mode transmit a Refresh with a scrambled pattern instead of zeros - RefAlert**



# RefAlert composition

- **Length**
  - Long enough to reliably detect the embedded Alert pattern
  - Enough time after pattern detection to account for detection latency
  - 3xPRS* of Alert + 2xPRS filled with scrambled zeros
  - ~ 0.7us <= ½ Refresh length

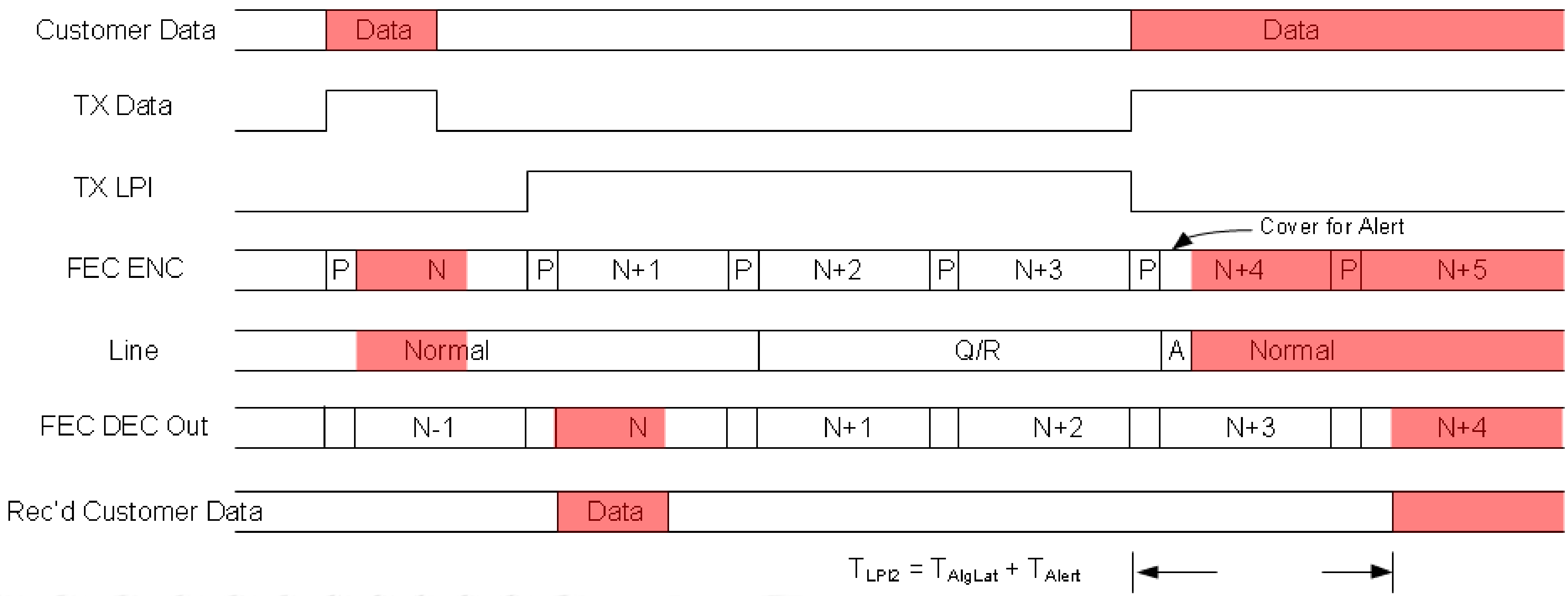



- **Benefits**
  - Can be detected using normal data DSP => 10G Alert needs to be detected pre-DSP
  - Don't have to deal with non-random echo => 10G is a fixed pattern
  - Power on time for possible RefAlert = 1/3 Refresh length

# Leaving LPI – Case 2 (Table 78-4)

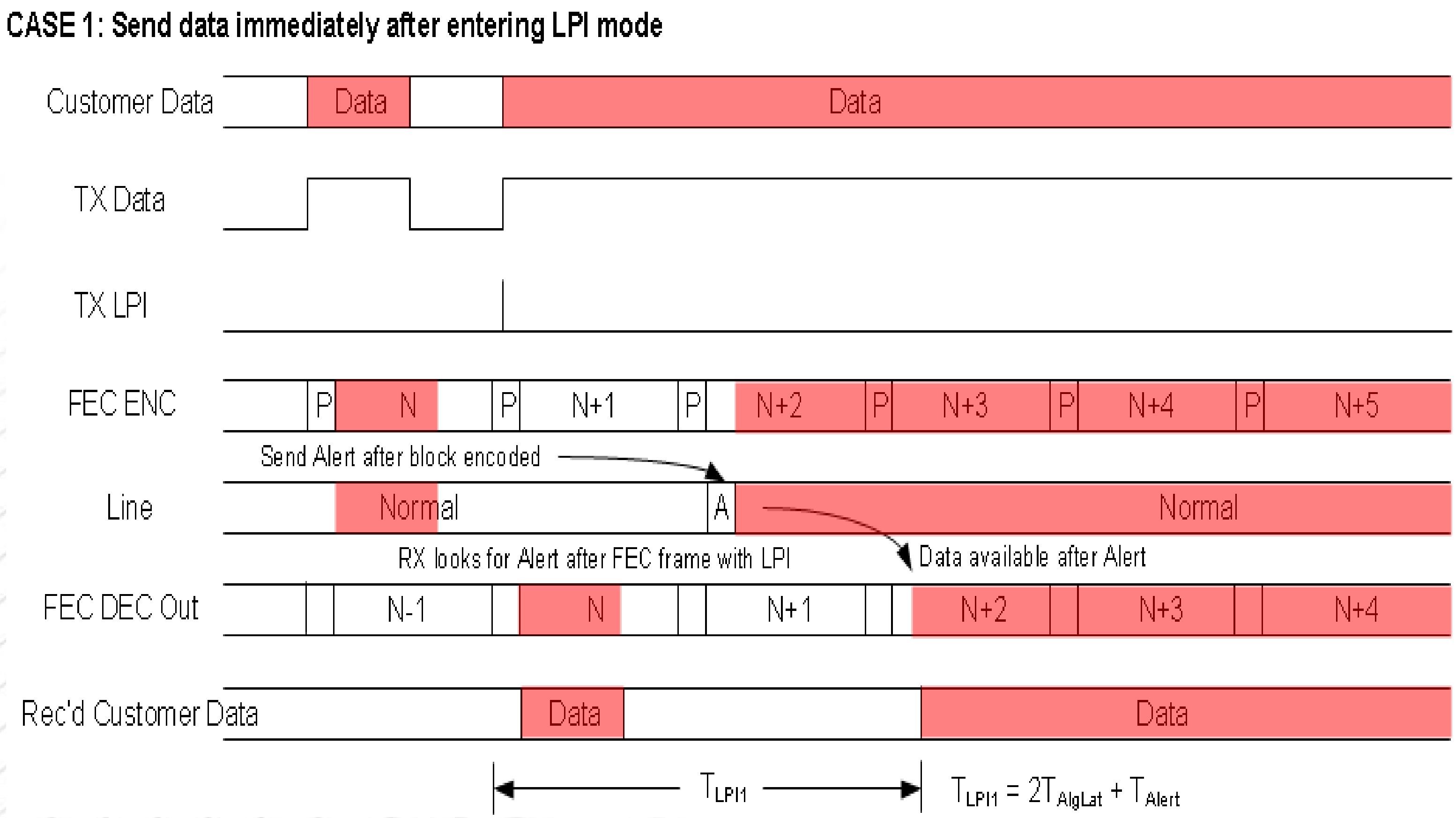
- **Most likely**
- **Keep RS frame cadence constant**
  - Use partially filled RS frames

**CASE 2: Send data while in LPI mode**



# Leaving LPI – Case 1

- **Send data immediately after signaling intention to enter LPI**
  - Worst latency
  - Well within 16.5us
- **Corner case**



# LPI parameters choices

- **1000BASE-T1 RS frames are much larger than 10G LDPC frames**
  - **These are too large to use to place Refreshes**
  - **Use partial RS frames (proposed by William Lo)**
  - **Use Broadcom's 3B2T RS(450, 406) scheme**

| Parameter | 10G EEE | 1000BASE-T1 EEE | units |
|---|---|---|---|
| $RS_T$ | 0.32 | 3.6 | us |
| $PRS_T$ | N/A | 144 | ns |
| $QR_T$ | 163.84 | 108 | us |
| $Refresh_T$ | 1.28 | 1.44 | us |
| $QR_{Ratio}$ | 128 | 75 | $Refresh_T/QR_T$ |
| $Alert_T$ | 1.28 | 0.72 | us |
| $AlertGranularity_T$ | 0.32 | 4.03 | us |

# Conclusion

- **Propose we use 10G EEE type LPI**
- **Propose we embed Alert into Refresh**
- **Propose we keep the RS framing phase constant throughout the LPI process**
- **Need to determine parameters**
- **Need to specify LPI alignment during training**