Training & EEE Baseline Proposal

IEEE 802.3bp - Interim Meeting - September 2014

William Lo, Zhenyu Liu, Marvell

What Is Baselined So Far

- PAM3
- 750 Mbaud/s
- 3B2T mapping
- 8N / (8N + 1) Encoding
  - N = 10 implied based on 3B2T mapping selection
- Need to choose FEC to allow us to complete the training and EEE protocol definition

Baseline Proposal #1

- Use RS(450, 406, 2^9) code for the FEC
- $p(x) = x^9 + x^4 + 1$
- $g(x) = (x - a^0)(x - a^1)\ldots(x - a^{43})$
- RS encoder/decoder implementation complexity is dominated by multiplier complexity
  - MUL complexity proportional to number of terms in field generator polynomial p(x)
  - Choose the generator polynomial with least terms
- The first 405 9-bit symbols are data from 45 complete 80/81 encoder blocks
- The 406th 9-bit symbol is reserved for future use
  - Use for OAM?
  - Set as a constant value for now

Baseline Proposal #2

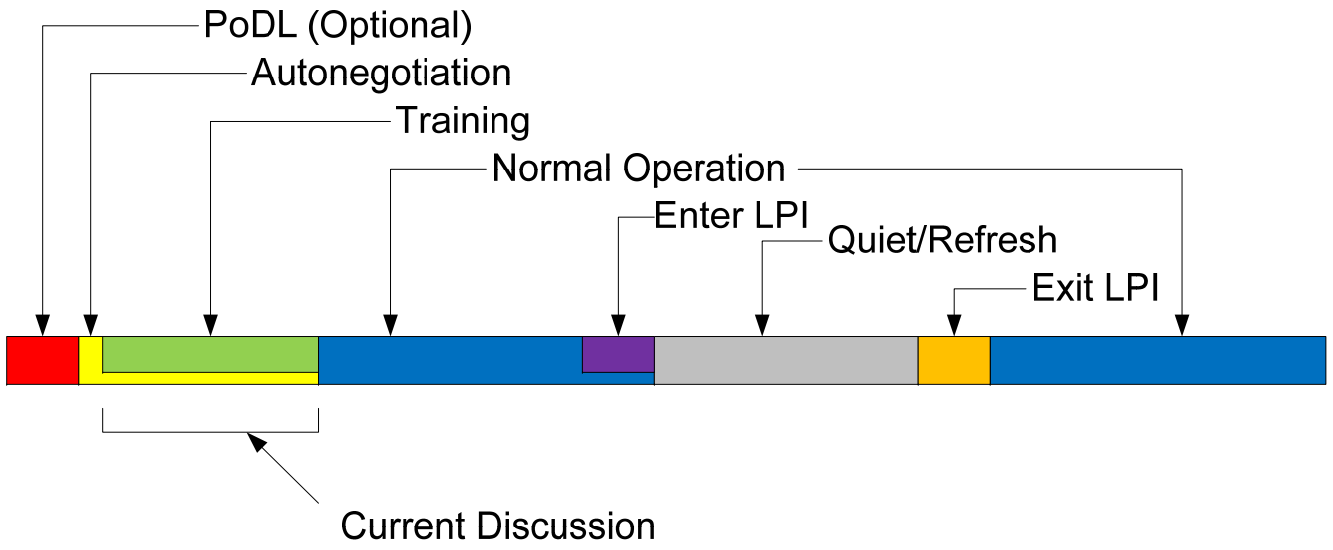
- Adopt training and EEE framework in this presentation as baseline
- Based on Lo_3bp_03_0714.pdf and Graba_3bp_01a.pdf with additional modifications

Proposed Parameters (Changes based on RS FEC)

- **Optimized to work with RS(450, 406, 2^9), PAM3, 750MBaud/s**

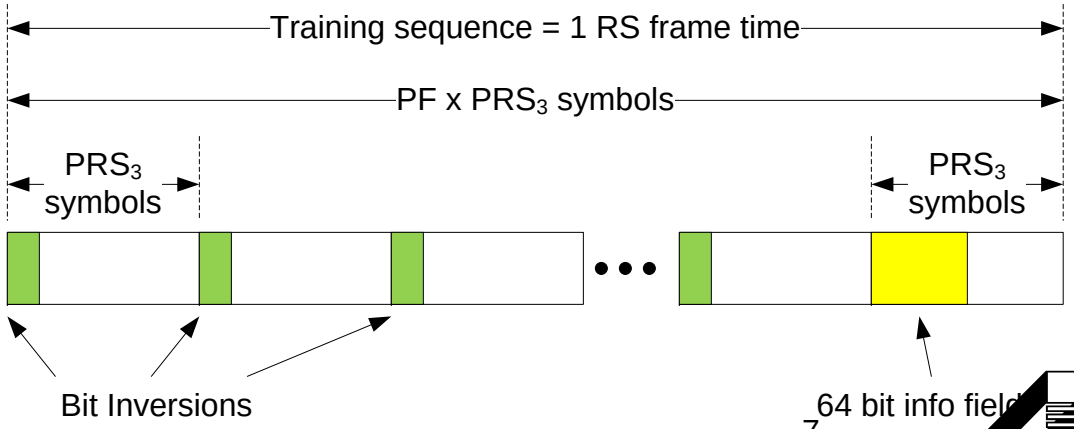
Symbol	Definition	New
RS3	# PAM3 symbols per RS frame	2700
RST	Duration of RS frame (ns)	3600
PRS3	# PAM3 symbols per partial RS frame	180
PRST	Duration of partial RS frame (ns)	240
PF	# partial frames per RS frame	15
QRF	# RS frame per quiet refresh cycle	24
QRT	Duration of quiet refresh cycle (ns)	86400
AF	# partial RS frames separating alert	15
AlertGranularityT	Alert Granularity (ns)	3600
Refresh_LPI	# partial RS frames for refresh	6
Refrest_T	Duration for refresh (ns)	1440
QR Ratio	Quite/Refresh Ratio	60
Enter_LPI_RS	# RS frames with all LPI to enter LPI	1
Alert_LPI	# alert sequences to exit LPI	Slide 16
Alert_T	Alert window (ns)	720
Exit_LPI_RS	# RS frames with all idles upon exit LPI	Slide 16
Alert_sym	# symbols in alert sequence	Slide 16

PHY TRAINING



1000BASE-T1 Training (Same as Lo_3bp_03_0714.pdf except new RS)

- Use same PAM2 LFSR sequence from 10GBASE-T for training
- Issue – 1 RS frame a lot longer than 1 LDPC frame
  - RS(450, 406, 2^9) = 3600 ns
- Want bit inversion and info field to occur more frequently given nosier environment
- Solution – Introduce partial RS frame
  - Divide RS frame time into PF number of PRS_3 symbol groups
  - Info field occurs once per RS frame time. Indicated by XORed 0xBBA7 pattern
  - Info field first 64 bits of PRS_3 symbol group to avoid offset calculations.



Info Field (Same as Lo_3bp_03_0714.pdf)

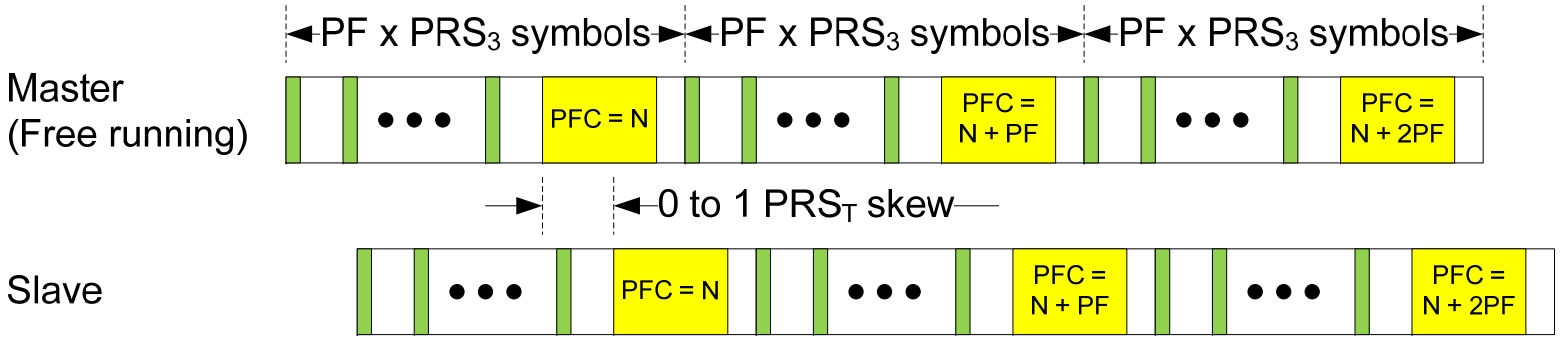
- **Simplify to 64 bits.**
  - **No need for PBO and THP**
- **No transition counter needed**
  - **No PBO or THP so no need to count down to readapt DSP to new TX settings**
  - **Significantly speeds up training**
- **Partial RS Frame Count (PFC) used to establish time synchronization for EEE**
  - **Simpler mechanism than using transition counter to zero LDPC frame count on entering PCS_Test training state in 10GBASE-T**
  - **Free running on 1000BASE-T1 master**
  - **Slave must match partial frame count (PFC) to within +0/-1 partial RS frame measured at the receiver input**

1000BASE-T1
0xBB
0xA7
0x00
Message
Partial frame count mod (QRF x PF)
CRC16
CRC16

10GBASE-T
0xBB
0xA7
0x00
0x00
TX Setting
TX Setting
TX Setting
Message
SNR (format dependent) Transition counter THP Coefficient Vendor specific
CRC16
CRC16

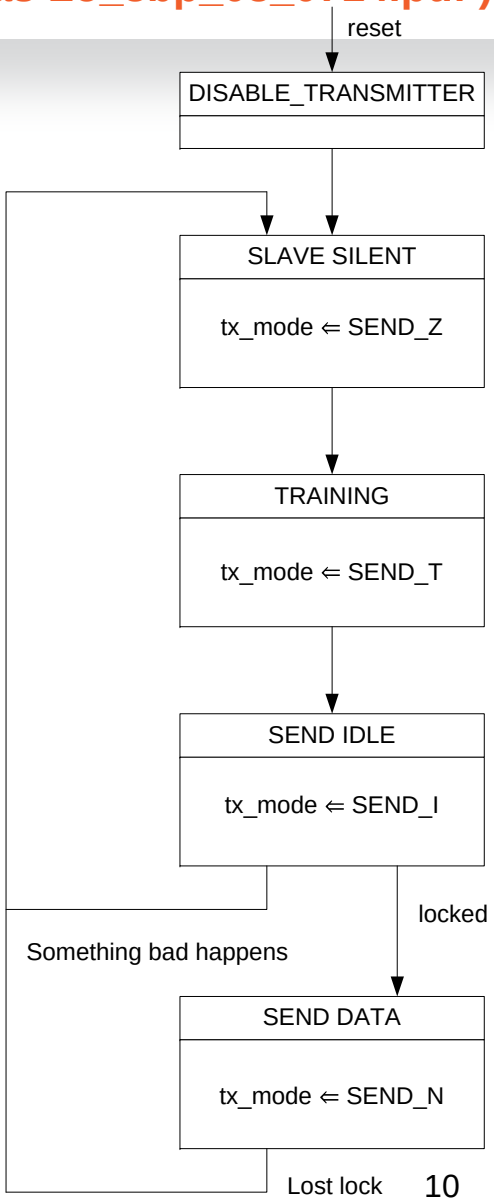
Example of slave partial RS frame count matching
(Simplified from Lo_3bp_03_0714.pdf)

- **PF x PRS_3 symbols per training sequence**
- **Master free runs and increments PFC by PF every training sequence**
  - **mod (QRF x PF) implied in diagram**
- **Slave locks to within +0/-1**
  - **Slave accepts master PFC only if CRC16 is good.**
  - **Robust to noise since not every info field needs to be processed to recover master PFC**

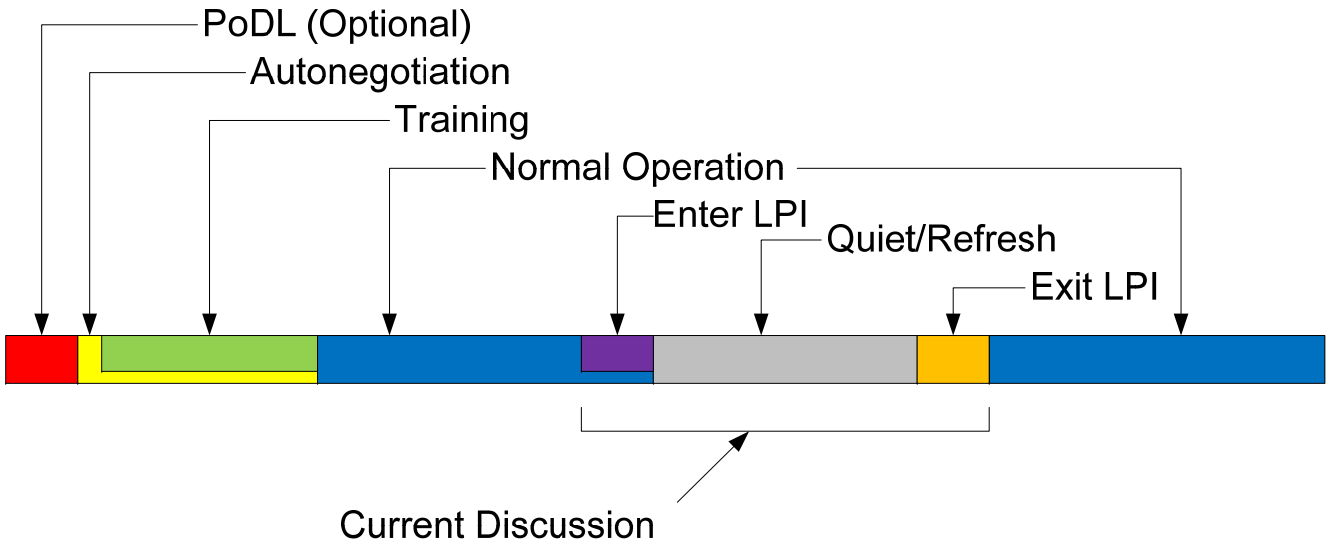


PHY Control State Machine (Same as Lo_3bp_03_0714.pdf)

- Greatly simplified since no PBO or THP coeff exchanged
- Sketch of state machine
  - Master transmits PAM 2 and slave silent
  - Both transmit PAM2 in Training
  - Message exchanged in info field indicating ready to move to PAM 3
  - Send PAM3 idles for some time
  - Link up and send data
- Details of state transition TBD



ENERGY EFFICIENT ETHERNET

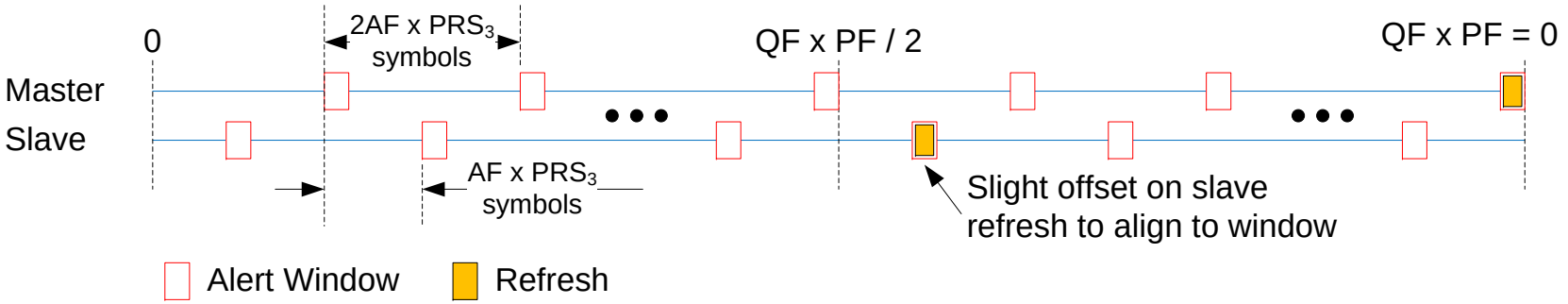


EEE - Entering LPI (Same as Lo_3bp_03_0714.pdf)

- **If LPI seen on GMII fill remaining bytes in RS frame with LPI symbol. Then send LPI_RS number of RS frame with nothing but LPI symbols.**

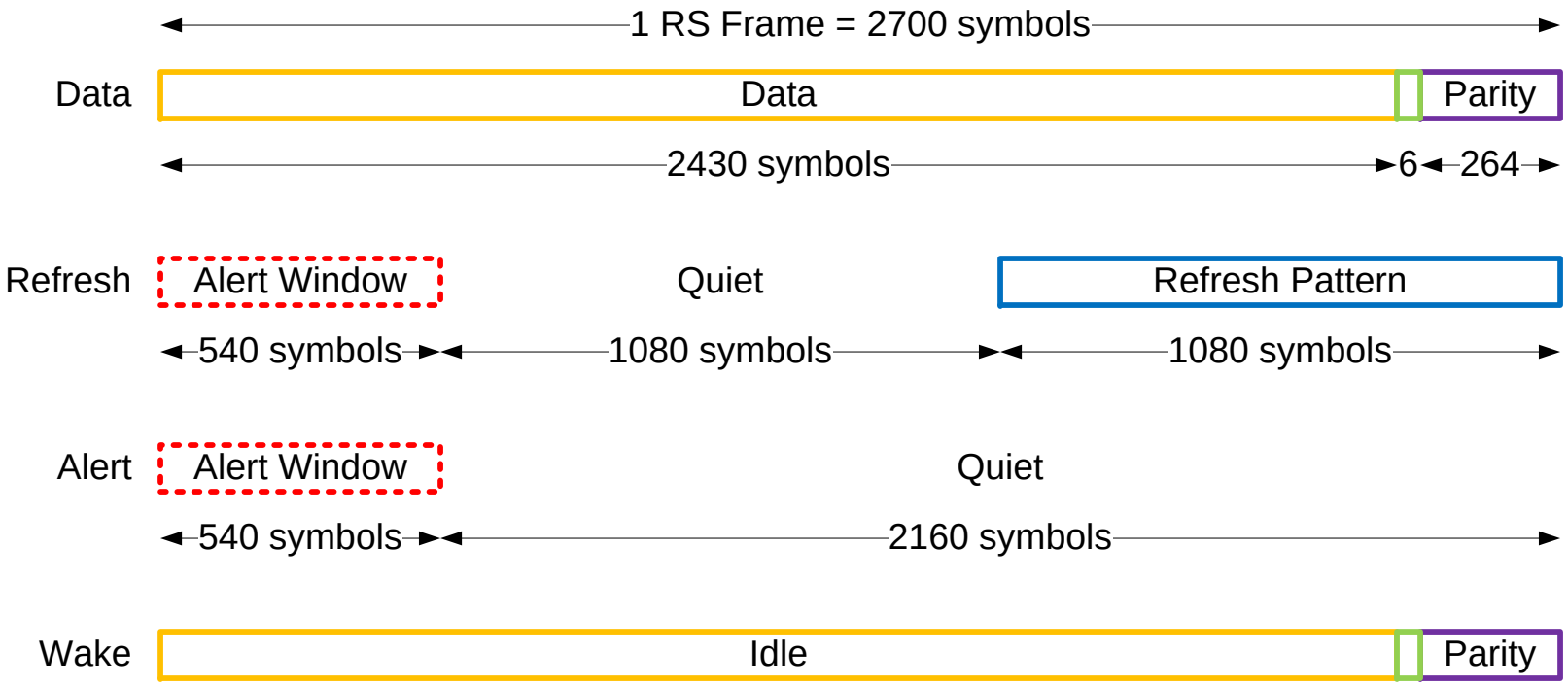
EEE – Quiet/Refresh and Alert (Same as Lo_3bp_03_0714.pdf and similar to Graba_3bp_01a.pdf)

- **Master and Slave Refresh Staggered as shown**
- **Use 1000BASE-T wake time of 16.5us instead of 4.48us of 10GBASE-T to allow more power savings**
- **Allow alert signal to be sent only during certain windows**
  - **Allows receiver to power down outside window**
  - **Stagger windows between master and slave so alert signal never overlap**
  - **Will increase worst case wake time waiting for window**
  - **Align refresh with alert window**
  - **Space alert windows 2 x AF x PRS_3 symbols apart and stagger master and slave windows by AF x PRS_3**



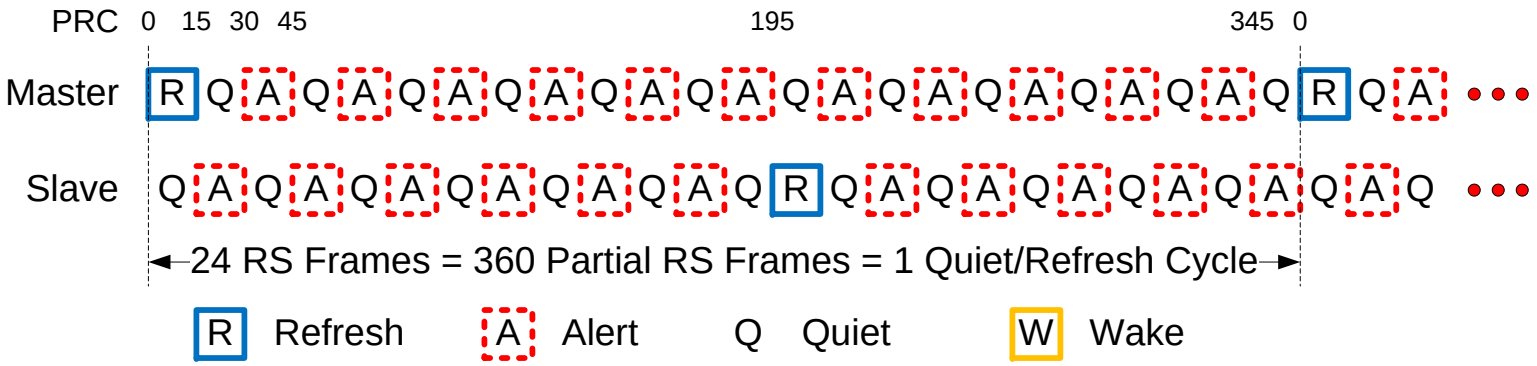
Quiet / Refresh / Alert – With actual numbers

- **Every 2700 symbol can have 1 of 5 activities**
  - **Data – Regular RS frame**
  - **Refresh – an alert window followed by refresh pattern**
  - **Alert – an alert window only**
  - **Quiet – pure quiet period.**
  - **Wake – wake pattern – simply a data frame with all idles**



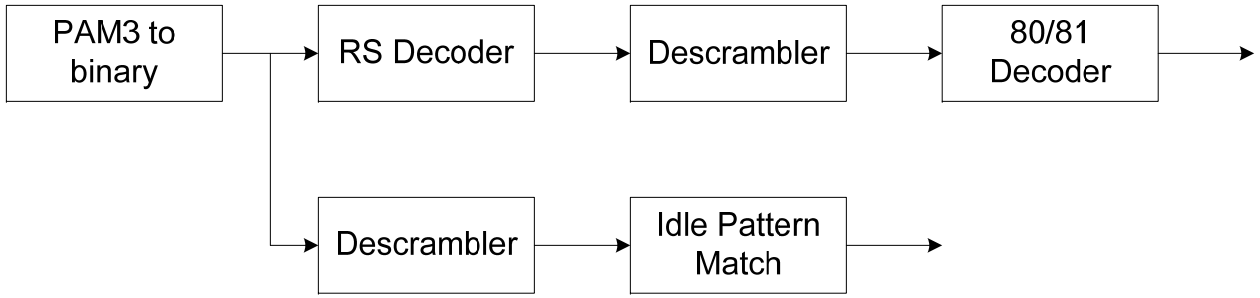
Quite Refresh Cycle – With actual numbers

- Every quiet/refresh cycle consists of 24 RS Frame times
- Same as 360 80/81 encoder transfers
- Same as 360 Partial RS Frame times
- Quiet and Alert are offset between master and slave
- Wake can only be sent during PHYs Quiet time



EEE – Exit LPI Procedure (New)

- **Send RS frame with all bytes idles**
  - **This is the wake pattern. Alert pattern not needed.**
- **Lets the main data path warm up**
  - **No need to send another RS frame to sync up descrambler**
  - **Worst case wakeup time 2 x RS_T + latency = 2 x 3.6us + approx 5us = 12.2us**
- **Optional parallel path for early detection of sufficient number of idles bytes in pattern match to exit LPI**
  - **Data is not corrected by RS**
  - **May want to apply less stringent criteria in case sufficient errors corrupts the wake pattern**



Refresh Pattern (New)

- Use PAM3 to keep output power constant.
- Use LFSR to generate random sequence.
  - Advances 1620 bits per 24 RS frame time
  - Maps to 1080 PAM3 symbols
  - Use the same LFSR as the one in training
- LFSR start at the same seed upon entering LPI.
  - Known sequence at the receiver

THANK YOU