Enhancements to Initialization Procedure

Sept ’05 Presentation to Ethernet over Backplane working group
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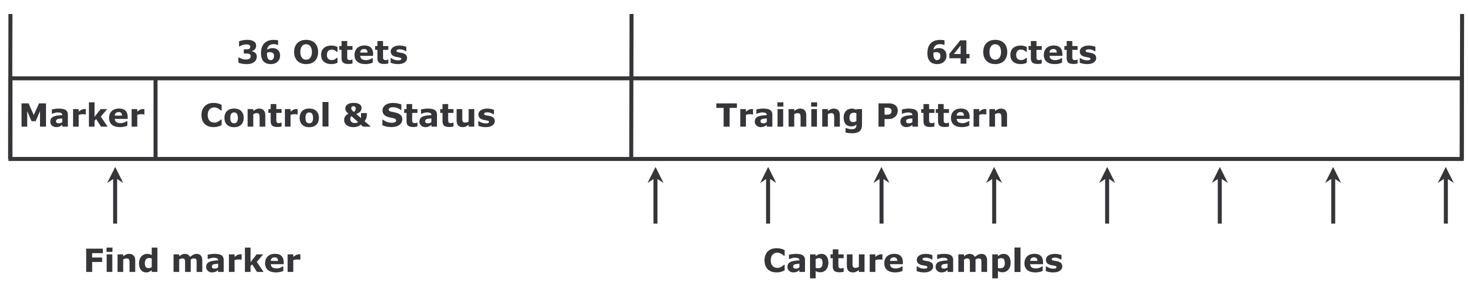
Requirements for Initialization

- **Procedure needs to be efficient**
  - Minimize initialization time
  - Minimize complexity, but allow for flexible implementations
    - Hardware, software, or mix
  - Minimize cost (silicon area)
- **Basic requirements of training pattern**
  - Data content should be random
    - Initialize FFE to average or nominal conditions, essentially centering it's capability
    - Swings (pattern extremes) are handled adaptively by DFE
  - Data content should cycle through all possible FFE combinations
- **Basic procedure**
  - Training pattern is transmitted
  - Receiver monitors incoming data, collects statistics to evaluate coefficient updates
    - Statistics are integrated over a large number of samples, upwards of 1000
  - Receiver sends coefficient update commands to transmitter
  - Cycle completes until convergence

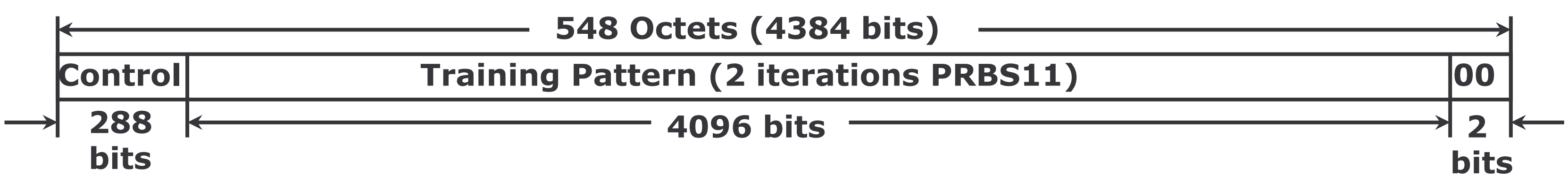
Design implications of current training pattern definition

- **Sample capture will be relatively slow compared to baud rate**
  - Consider a hardware implementation running at 160MHz
    - Currently defined training pattern length would only result in 8 samples per pattern
- **Training pattern is found by identifying the marker position**
  - This implies subsequent iterations of the training cycle will have the same sample capture points
- **Capturing 1000 samples would require 125 iterations of the training cycle**
  - However the statistics will contain info from only 8 distinct patterns!!
  - 10us elapsed time, but 36% of it spent in overhead
- **Software solution would not be realistic with such a definition**
  - Samples taken only have a 64% likelihood of landing in training pattern period



Proposed changes to training frame structure

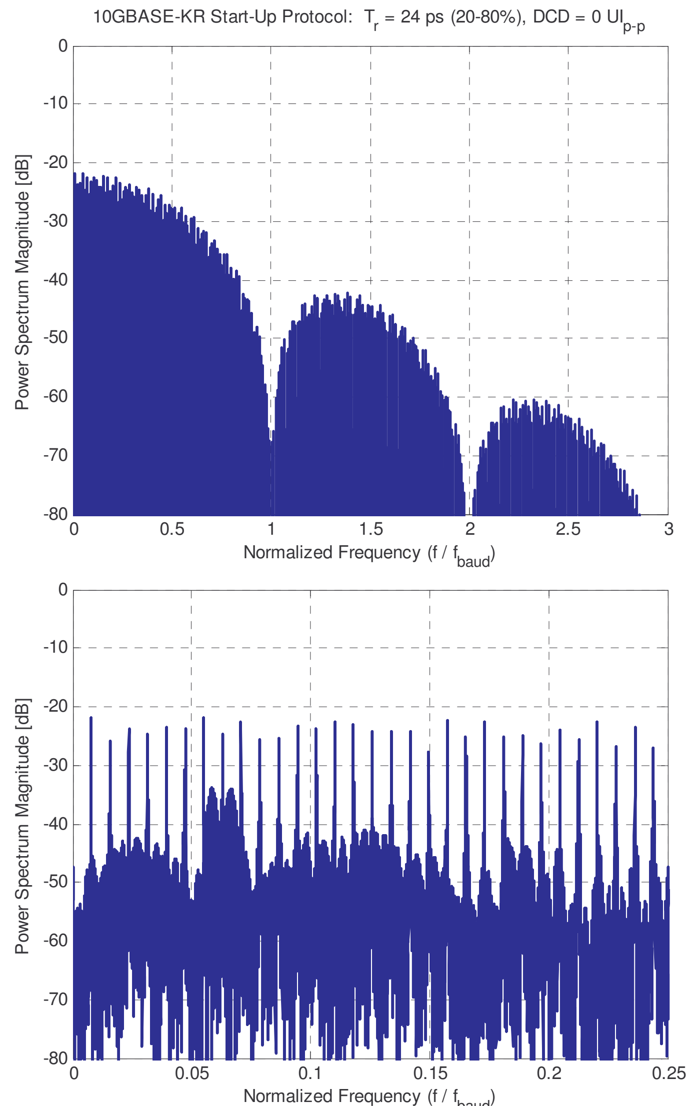
- **Lengthen the training pattern period to 512 octets**
  - Increases efficiency of training relative to overhead
    - 6.6% control overhead vs. 36% with current definition
  - Simplifies sampling approach – receiver can “train through” overhead section
    - No need to search for markers, start, and stop
    - Enables software approaches
  - Capturing 1000 samples would take 6.4us
    - vs. 10us for current approach
- **Change training pattern to a PRBS11 generated stream**
  - Provides increased randomization with improved EMI characteristics
  - Pattern seeded to all 1’s at start of each cycle
  - Final 2 bits of 512 octet field set to ’00’
    - Provides DC balance



EMI Advantages of PRBS11

10GBASE-KR Training Signaling Using PRBS-7

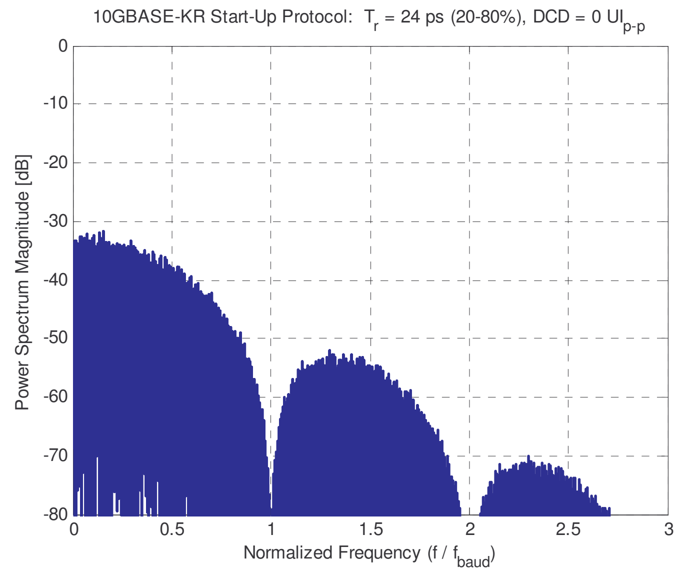
- **4-octet frame marker**
- **32-octet control channel**
- **512-octet training pattern**
  - PRBS-7 ($x^7 + x^6 + 1$)
- **Spectral peaking attributed to repetition of PRBS-7 in the training field**

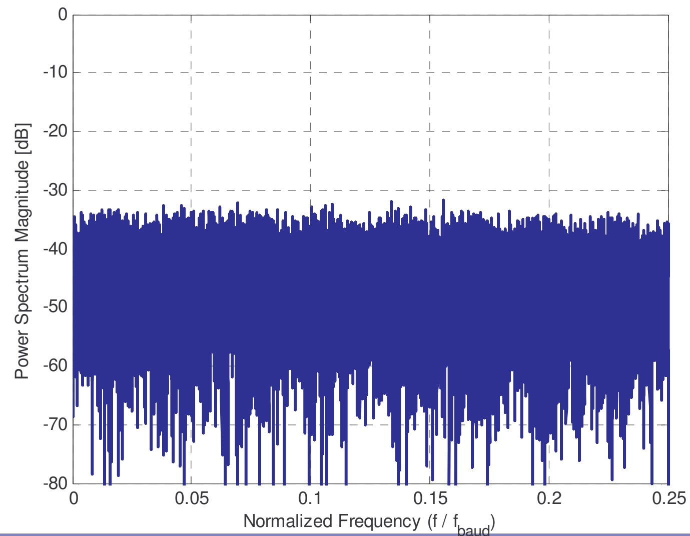


Simulations by Agere Systems

Change Training Pattern to PRBS-11

- **4-octet frame marker**
- **32-octet control channel**
- **512-octet training pattern**
  - PRBS-11 ($x^{11} + x^9 + 1$)
- **Longer PRBS polynomial reduces peaking by ~10dB**





Simulations by Agere Systems

Recommended Changes:

- **Increase training pattern length to 512 Octets**
- **Change training pattern to PRBS11**
  - 1 seed at start of each iteration
  - Final 2 bits of 512 Octet field set to '00'b

General Information

- **10GBASE-KR Transmitter Model**
  - 1 V_{pk} differential output amplitude (2 V_{p-p})
  - 24 ps rise time (20-80%), Gaussian pulse shape
  - No jitter (including duty cycle distortion)
  - No transmit equalization ($c_{-1} = 0$, $c_0 = 1$, $c_1 = 0$)
- **Power Spectral Density Estimate**
  - Fast Fourier Transform of 32,768 10GBASE-KR baud
  - 16 samples/baud