



PAM2 Training Frame Alignment Proposal

**IEEE P803.2an Task Force
San Antonio, November '04**

Brett McClellan

Objectives

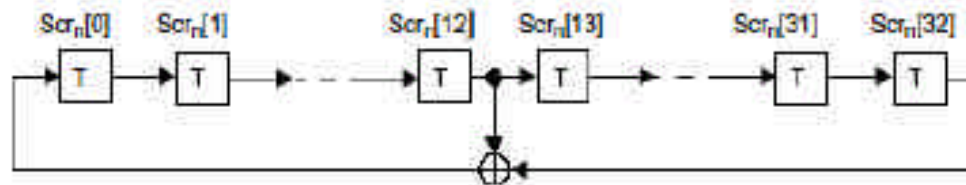
- **Seki_2_0904 list the following startup objectives**
 - Recover timing and adaptive filter coefficients
 - Establish polarity correction, pair swap, pair deskew
 - Establish LDPC block boundary
- **This proposal addresses all three objectives using the PAM2 training pattern.**



PAM2 Training Signal

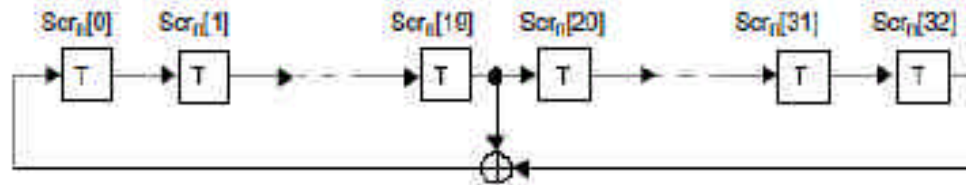
Side stream scrambler: (ref IEEE802.3 40.3.1.3.1)

Side-stream scrambler employed by the MASTER PHY



$$g_m(x) = 1 + x^{13} + x^{33}$$

Side-stream scrambler employed by the SLAVE PHY



$$g_s(x) = 1 + x^{20} + x^{33}$$

Seki_2_0904

PAM2 Training Signal cont.

Generation of bits $Sy_n[3:0]$

$$Sy_n[0] = Scr_n[0]$$

$$Sy_n[1] = g(Sy_n[0]) = Scr_n[3] \wedge Scr_n[8]$$

$$Sy_n[2] = g(Sy_n[1]) = Scr_n[6] \wedge Scr_n[16]$$

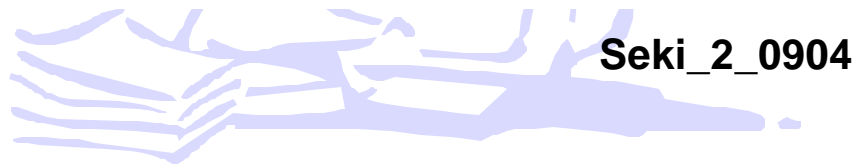
$$Sy_n[3] = \begin{cases} g(Sy_n[2]) = Scr_n[9] \wedge Scr_n[14] \wedge Scr_n[19] \wedge Scr_n[24] & \text{if } (loc_rcvr_pma_status = NG) \\ g(Sy_n[2]) \wedge Sy_n[0] = Scr_n[9] \wedge Scr_n[14] \wedge Scr_n[19] \wedge Scr_n[24] \wedge Scr_n[0] & \text{else} \end{cases}$$

$$g(x) = x^3 + x^8$$

Generation of Transmit symbol vector

$$A = \begin{cases} 7 & \text{if } (Sy_n[0] = 0) \\ -7 & \text{else} \end{cases} \quad B = \begin{cases} 7 & \text{if } (Sy_n[1] = 0) \\ -7 & \text{else} \end{cases}$$
$$C = \begin{cases} 7 & \text{if } (Sy_n[2] = 0) \\ -7 & \text{else} \end{cases} \quad D = \begin{cases} 7 & \text{if } (Sy_n[3] = 0) \\ -7 & \text{else} \end{cases}$$

This PMA training signal can meet objectives of polarity correction, pair swap, pair deskew.



Current Issues

- **Pair Swap**
 - For unexpected pair swap detection, pair A should be distinct from the other pairs yet still psuedo-random as in 1000BASE-T.
 - For fast startup, pair A detection should be fast.
- **LDPC block frame alignment**
 - Pair A may be used to establish the LDPC block boundary



PAM2 Training Sync Bit

- **Sync Bit Generation**

$$Sy_n[0] = \begin{cases} \neg Scr_n[0] & \text{for } n = k \cdot 128, k = 1, 2, 3, \dots \\ Scr_n[0] & \text{else} \end{cases}$$

- **Achieves the startup objectives**

- **Pair A transmit sequence is still psuedo-random for timing and EQ training.**
- **Pair A is easily determined for pair swap detection**
- **LDPC block boundary is easily and quickly determined**

PAM2 Training Sync Bit (updated)

- **Sync Bit Generation**

$$Sy_n'[0] = \begin{cases} !Sy_n[0] & \text{for } n = k \bullet 128, k = 1, 2, 3, \dots \\ Sy_n[0] & \text{else} \end{cases}$$

$$A = \begin{cases} 7 & \text{if } (Sy_n'[0] = 0) \\ -7 & \text{else} \end{cases}$$

- **Achieves the startup objectives**

- Pair A transmit sequence is still psuedo-random for timing and EQ training.
- Pair A is easily determined for pair swap detection
- LDPC block boundary is easily and quickly determined

Simple Frame Synchronization

- **Four steps**

1. Find the LFSR sequence match for length $L < 128$
2. Wait for the sync bit
3. Verify additional sync bits
4. Establish start of frame boundary
 - Note LFSR match test continues through steps 2 and 3

- **Fast LDPC block boundary detection**

- Can be done in 1 frame
- Extremely robust in 2 frames

Detection Example

- For $L = 33$, and frame boundary established on the 2nd sync bit
 - Probability of False Detection over random data
 - $\text{PFD} < 2^{-33} \cdot 2^{-128} < 4\text{E-}49$
 - $> 1\text{E}32$ years at 800MHz
 - Maximum sync time < 2 frames
 - $< 320\text{ns}$ for 128 baud frame
 - Compare to 128 frames ($20 \mu\text{s}$) for Clause 49 type “slip” synchronization

Conclusion

- **PAM2 training frame alignment pattern achieves the startup objectives.**
 - psuedo-random sequence
 - Pair A is easily determined
 - Denotes LDPC block boundary
- **Minor change to Seki's proposal.**
- **Very simple hardware implementation.**

