Proposal for 100BASE-T1L PMA Training

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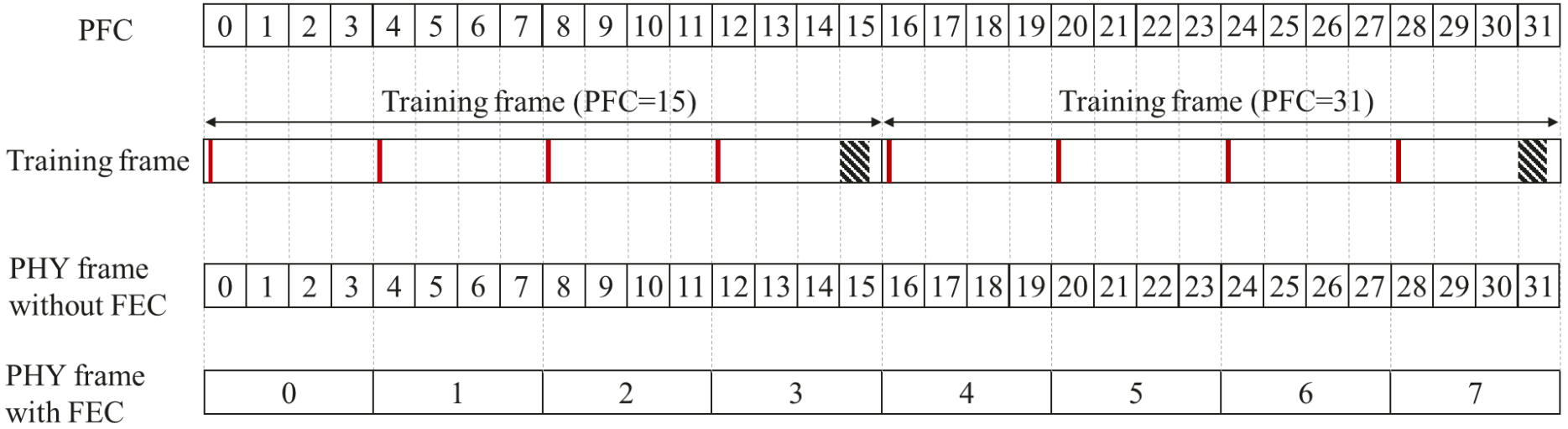
Introduction

- This is a proposal for the training frame, the scrambler, and line coding used for 100BASE-T1L PMA training.

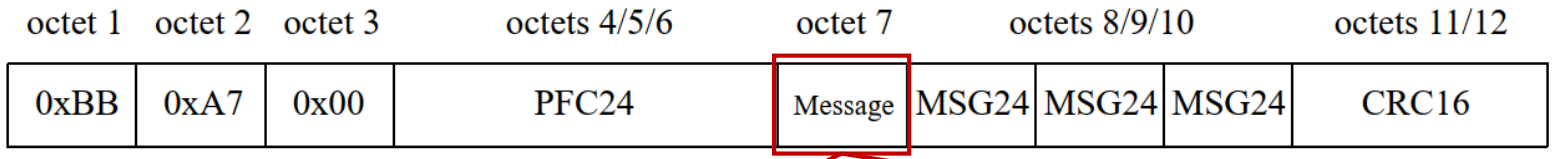
PMA Training Frame

- The PMA training frame follows a similar approach as in Clauses 97. During PMA training, the training frame with indicators is used to establish the PHY frame and block boundaries.
- Each training frame is composed of 16 partial PHY frames. Each partial PHY frame has 128 bits, aligned with the PHY frame without FEC.
- All the bits in each training frame are zero except:
  - The 2nd bit (in red) in every four partial PHY frames is set to 1 to align the PHY frames and facilitate scrambler synchronization.
  - The 12-octet InfoField (in black shadow) in the 16th partial PHY frame.



PHY Control InfoField

- A 12-octet InfoField is used during PMA training to exchange PHY Control information between link partners.
  - Same approach as in Clauses 97, 149, and 165
- CRC16 is the same as Clauses 97, 149 and 165.
- 1-octet Message field (octet 7):
  - Master: same as in Clauses 97, 149 and 165.
  - Slave: The timing_lock_OK<4> bit is replaced by a reserved bit (set to 0), since the Slave starts transmission after timing lock and the PCS synchronization.



Master Message Field

PMA_state <7:6>	loc_rcvr_status <5>	en_slave_tx <4>	reserved <3:0>
00	0	0	0000
00	0	1	0000
00	1	1	0000
01	1	1	0000

Slave Message Field

PMA_state <7:6>	loc_rcvr_status <5>	reserved <4:0>
00	0	00000
00	1	00000
01	1	00000

PHY Control InfoField (Cont.)

- 3-octet PHY capability bits (octets 8/9/10) sent during TRAINING (PMA_state=00) are described in Riesco_3dg_02_10292024 with RS-FEC and sequence order set support capability bit included.
- 3-octet DataSwPFC24 (octets 8/9/10) bits, indicating the partial PHY frame count when the transmitter switches from PAM2 to PAM3, are used during COUNTDOWN (PMA_state=01).
  - DataSwPFC24 shall be set to an integer multiple of 16.

PMA_state = 00

octet 1	octet 2	octet 3	octets 4/5/6	octet 7	octets 8/9/10	octets 11/12
0xBB	0xA7	0x00	PFC24	Message	PHY Capability Bits	CRC16

PMA_state = 01

octet 1	octet 2	octet 3	octets 4/5/6	octet 7	octets 8/9/10	octets 11/12
0xBB	0xA7	0x00	PFC24	Message	DataSwPFC24	CRC16

PHY capability bits (PMA_state = 00)

Octet 8								Octet 9								Octet 10							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
Reserved																SEQen	EEECntrl[1:0]		RSen	Reserved			

- SEQen advertises support for sequence ordered sets
- EEECntrl[1:0] advertises the EEE abilities
- RSen advertises support for RS-FEC

Riesco_3dg_02_10292024

PMA Training Scrambling

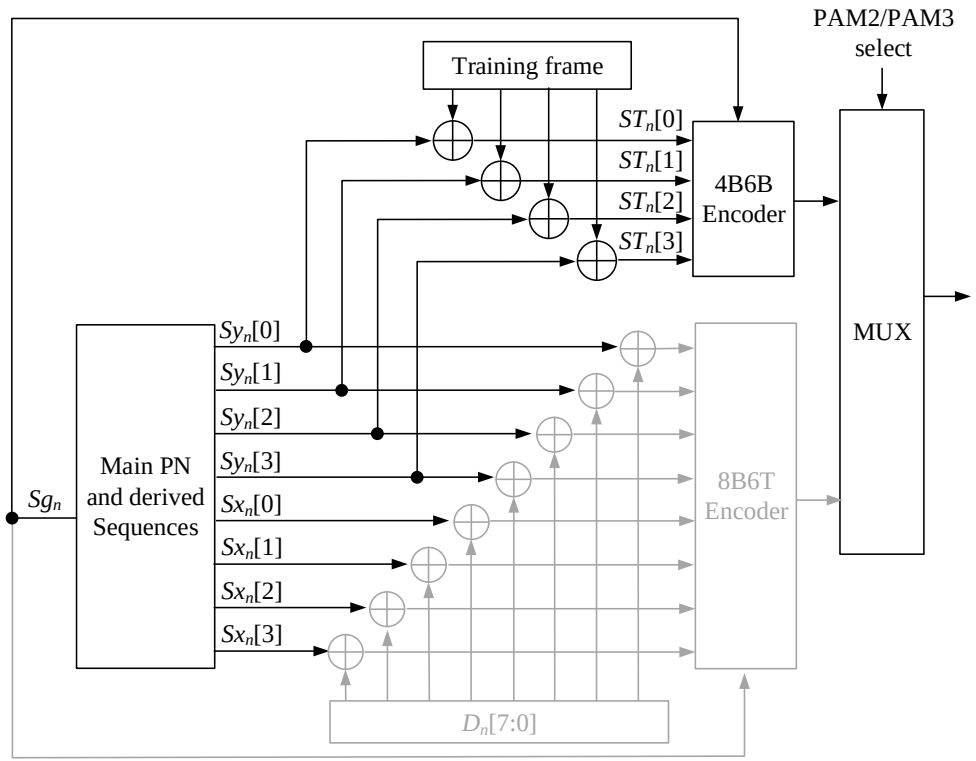
- The training frame with embedded InfoField is XORed with the scrambler bits $Sy_n[3:0]$ (also used in data mode) in nibble width. The 1st bit of each partial PHY frame is scrambled with $Sy_n[0]$ (i.e. $Scr_n[0]$).
  - Setting the 1st bit of the first 15 partial PHY frames to zero, makes $Scr_n[0]$ available on the 1st bit of each nibble except the InfoField, facilitating scrambler synchronization.
- The scrambled nibble $ST_n[3:0]$ during training is expressed as:

$$ST_n[3] = \begin{cases} Sy_n[3] \oplus \text{InfoField}_{(4n+3 \bmod 128)} & 480 \le (n \bmod 512) \le 503 \\ Sy_n[3] & \text{otherwise} \end{cases}$$

$$ST_n[2] = \begin{cases} Sy_n[2] \oplus \text{InfoField}_{(4n+2 \bmod 128)} & 480 \le (n \bmod 512) \le 503 \\ Sy_n[2] & \text{otherwise} \end{cases}$$

$$ST_n[1] = \begin{cases} Sy_n[1] \oplus \text{InfoField}_{(4n+1 \bmod 128)} & 480 \le (n \bmod 512) \le 503 \\ Sy_n[1] \oplus 1 & \text{else if } (n \bmod 128) = 0 \\ Sy_n[1] & \text{otherwise} \end{cases}$$

$$ST_n[0] = \begin{cases} Sy_n[0] \oplus \text{InfoField}_{(4n \bmod 128)} & 480 \le (n \bmod 512) \le 503 \\ Sy_n[0] & \text{otherwise} \end{cases}$$



PAM2 Training Sequence Generation

- The scrambled nibble $ST_n[3:0]$ is mapped to PAM2 6-tuple with bounded running disparity during PMA training.
- Each of the 16 4-bit values corresponds to one code group with non-negative disparity (NND), shown in the right table.
- The running disparity (RD) control rule at the transmitter is described in Tingting_3dg_01a_11132024:
  - If both RD and the disparity of the code group associated with the 4-bit value are positive, then each element of the code group is negated before transmission.
  - If either RD or the disparity of the code group associated with the 4-bit value is zero, then the random bit Sg_n determines whether to negate the code group before transmission.
  - RD is recomputed after transmission of each code group.

4 bits input	NND Code groups					
0000	-1	1	-1	1	-1	1
0001	-1	-1	1	1	-1	1
0010	-1	1	1	1	1	1
0011	1	-1	1	-1	1	1
0100	-1	1	-1	1	1	-1
0101	1	1	1	-1	1	-1
0110	-1	1	1	-1	-1	1
0111	-1	1	-1	-1	1	1
1000	1	1	1	1	-1	-1
1001	-1	-1	-1	1	1	1
1010	-1	-1	1	-1	1	1
1011	-1	-1	1	1	1	-1
1100	1	1	-1	1	1	-1
1101	-1	1	1	-1	1	-1
1110	-1	1	1	1	-1	-1
1111	1	1	-1	-1	1	1

Conclusion

- Propose to use the PAM2 training sequence with a similar PMA Training frame as in Clauses 97, 149, and 165, for 100BASE-T1L.
- Apply the following small modifications to the training frame:
  - Composed of 16 partial PHY frames with 128 bits per partial frame
    - The 2nd bit in every four partial PHY frames is set to 1, to establish PHY frame alignment and facilitate scrambler synchronization.
  - InfoField located in the 16th partial PHY frame:
    - timing_lock_OK not used in the Salve Message field
    - modified PHY capability bits in Riesco_3dg_02_10292024
    - DataSwPFC24 is an integer multiple of 16.
- The training frame is scrambled with the scrambler bits $Sy_n[3:0]$ in a nibble width. The 1st bit of each partial PHY frame is scrambled with $Sy_n[0]$.
- The scrambled bit stream is mapped to PAM2 training sequence with bounded RD, using the proposed 4B6B encoding method.

Q & A