Link Training baseline for eight-lane PMDs

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Background

- The PMD Control Function “Link training” in IEEE 802.3-202x Cl 136.8.11 is specified for one-lane, two-lane, and four-lane backplane and copper cable interfaces.
- Link training in IEEE Std. 802.3-2022 Cl 136.8.11 specifies only 4 different PRBS13 polynomials for 50 Gbps/lane and 100 Gbps/lane rates

Table 136–8—Training patterns

p	Polynomial_*p*, *G*(*x*)	Default seed bits[a]	Initial output, PAM2	Initial output, PAM4	Initial output, PAM4 with precoding
0	$1 + x + x^2 + x^{12} + x^{13}$	0000010101011	0030330330000	1031320220111[b]	1301200200101
1	$1 + x^2 + x^3 + x^7 + x^{13}$	0011101000001	3030303030333	3030213021333	3122012201212
2	$1 + x^2 + x^4 + x^8 + x^{13}$	1001000101100	0303333033030	1212332133031	1102120121301
3	$1 + x^2 + x^5 + x^9 + x^{13}$	0100010000010	3330300030330	2231210121221	2032013201110

[a]The leftmost bit in the sequence corresponds to the initial value of S0 and the rightmost bit corresponds to the initial value of S12.
[b]This is equivalent to the PRBS13Q test pattern defined in 120.5.11.2.1.

Problem Statement

- IEEE P802.3df expands the number of lanes to eight.
- The number of PRBS13 polynomials defined (4) is less than the number of supported lanes (8)
- Solutions are needed to de-correlate the training sequences between lanes
  - See https://www.ieee802.org/3/bj/public/nov12/lusted_3bj_02_1112.pdf

Proposed Direction

- Part A - For eight-lane copper solutions using 100 Gbps/lane signaling (i.e. 800GBASE-CR8 and 800GBASE-KR8):
  - Reuse the existing polynomials across the additional 4 lanes (lanes 4-7 respectively) with new default seed bits
  - Maximizes reuse of IEEE P802.3ck era Physical Layer implementations

- Part B - For copper solutions using 200Gbps/lane signaling
  - Define four new PRBS13 polynomials and assign them to the 4 new lanes (lanes 4-7 respectively)
  - Greater reduction in crosstalk correlation

Part A: 800GBASE-CR8 and 800GBASE-KR8

Details

- It is anticipated that first generation eight-lane 800GbE hosts will heavily leverage IEEE P802.3ck 100G/lane PMD specifications
  - Built upon 4-lane PMD building blocks
- Reuse the existing polynomials and select new initial seeds
  - Adding new PRBS13 polynomials to these designs may be challenging
- Space the initial seeds approximately half-pattern distance
  - PRBS13 has 8192 values; set spacing ~4096 UI apart
  - Separation is longer than equalizer length but smaller than skew limit
- Each PMD lane has a unique signature (combination of polynomial choice and initial seed choice)

Training Pattern Details for PMD lanes [4:7]

Create new table in Cl 162
based on Table 136-8 contents for P=[0:3]

	P	Polynomial_p, G(x)	Default seed bits(a)	Initial output, PAM2(b)	Initial output, PAM4(b)	Initial output, PAM4 with precoding(b)
	0	1 +x + x^2 +x^12 + x^13	0000010101011	0030330330000	1031320220111	1301200200101
	1	1 +x^2 + x^3 +x^7 + x^13	0011101000001	3030303030333	3030213021333	3122012201212
	2	1 +x^2 + x^4 + x^8 + x^13	1001000101100	0303333033030	1212332133031	1102120121301
	3	1 +x^2 + x^5 + x^9 + x^13	0100010000010	3330300030330	2231210121221	2032013201110
Lane_4	4	1 +x + x^2 +x^12 + x^13	1111110100110	3030000303303	3030001313212	3122223012011
Lane_5	5	1 +x^2 + x^3 +x^7 + x^13	1100011101110	0003030003033	0113130013133	0103213103212
Lane_6	6	1 +x^2 + x^4 + x^8 + x^13	0000001101000	3300303000300	2300212111300	2131102323000
Lane_7	7	1 +x^2 + x^5 + x^9 + x^13	0011000100111	3333000333030	2232000322031	2033131202210

Reuse polynomials

New seed values

Seed details

- These specific new seeds were selected to ensure that the initial PAM4 precoder state is initialized to 0 at the beginning of each training pattern, so that P(j–1)=0 in Equation (135–1) for the first PAM4 symbol of the training pattern.
  - Lane_4 default seed is offset 4094 of the original seed of slide 2 for p=0
  - Lane_5 default seed is offset 4098 of the original seed of slide 2 for p=1
  - Lane_6 default seed is offset 4086 of the original seed of slide 2 for p=2
  - Lane_7 default seed is offset 4094 of the original seed of slide 2 for p=3

More Details

- Consistent with IEEE Std. 802.3-2022 Clause 136.8.11:
  - The PRBS generator for each lane shall implement each of four generator polynomials defined
  - The polynomial used in each lane i is selectable by identifier_i
  - The default identifier for each lane is its lane number
  - At the start of the training pattern, the state of the PRBS generator shall be set to the specified seed value.
  - The default value of seed_i shall be the value given in a table for p = i.

Unchanged from IEEE Std. 802.3-2022

Clause 45 changes

- In Table 45-3 PMA/PMD registers, update the PMD training pattern entry
  - 1.1450 through 1.1457 | PMD training pattern, lanes 0 to 7 | 45.2.1.68
- In Cl 45.2.1.168,
  - Change the sub-clause title to be
    - PMD training pattern lanes 0 through 7 (Register 1.1450 through 1.1457)
  - Change the second sentence in the first paragraph to be:
    - The assignment of bits in the PMD training pattern lanes 1 through 7 registers are defined similarly to lane 0.
  - Change the last sentence in the second paragraph to be:
    - The default identifiers are (binary): for lane 0, 00; for lane 1, 01; for lane2, 10; for lane 3, 11; for lane 4, 00; for lane 5, 01; for lane 6, 10; for lane 7, 11.

Clause 45 changes - 2

- Update second sentence after Table 45-133 to reflect that the same polynomial with the same initial seeds (having the same p identifier) should not be used on adjacent lanes….

Table 45–133—PMD training pattern lane 0 bit definitions

Bit(s)	Name	Description	R/W[a]
1.1450.15:14	Seed	Two most significant bits of PRBS13 seed	R/W
1.1450.13	Reserved	Value always 0	RO
1.1450.12:11	Polynomial identifier	Identifier (0, 1, 2, or 3) selecting polynomial for PRBS	R/W
1.1450.10:0	Seed	11 bit, binary seed for sequence	R/W

[a]R/W = Read/Write, RO = Read only

Register bits 12:11 contain a 2-bit identifier that selects the polynomial used for training in the particular PMD lane according to the definition in 92.7.12. The polynomial identifier for each lane should be unique; two lanes having the same identifier could impair operation of the PMD control function. The default identifiers are (binary): for lane 0, 00; for lane 1, 01; for lane 2, 10; for lane 3, 11.

Part B: 200 Gbps/lane PMDs

Pattern Details

- Hosts using 200 Gbps/lane signaling are not likely to be constrained by 4-lane PMD building blocks
- Use a different PRBS13 polynomial per lane
  - PRBS13 sequences with different polynomials are practically uncorrelated
- Consistent with IEEE Std. 802.3-2022 Clause 136.8.11:
  - The PRBS generator for each lane shall implement each of eight generator polynomials defined
  - The polynomial used in each lane i is selectable by identifier_i
  - The default identifier for each lane is its lane number
  - At the start of the training pattern, the state of the PRBS generator shall be set to the value seed_i.
  - The default value of seed_i shall be the value given in a table for p = i.

Proposed Additional Training Patterns

New table in new PMD Clause XXXX

Unchanged from Table 136-8

P	Polynomial_p, G(x)	Default seed bits(a)	Initial output, PAM2(b)	Initial output, PAM4(b)	Initial output, PAM4 with precoding(b)
0	1 +x + x^2 +x^12 + x^13	0000010101011	0030330330000	1031320220111	1301200200101
1	1 +x^2 + x^3 +x^7 + x^13	0011101000001	3030303030333	3030213021333	3122012201212
2	1 +x^2 + x^4 + x^8 + x^13	1001000101100	0303333033030	1212332133031	1102120121301
3	1 +x^2 + x^5 + x^9 + x^13	0100010000010	3330300030330	2231210121221	2032013201110
4	1 +x^2 + x^6 + x^10 + x^13	1111100100111	0303030330330	1312131320321	1233210331201
5	1 +x^2 + x^7 + x^11 + x^13	0001011000001	0030333303330	1021322212331	1332111102123
6	1 +x^2 + x^8 + x^12 + x^13	0010010111010	0003300000330	1113311011230	1012101323300
7	1 +x^3 + x^4 + x^8 + x^13	1110100000001	0003033030300	0012033030301	0011303122132

Note (a): The leftmost bit in the sequence corresponds to the initial value of S0 and the rightmost bit corresponds to the initial value of S12.
Note (b): Transmission order is left to right, top to bottom
P(4) goes with lane_4, P(5) goes with lane_5, P(6) goes with lane_6, P(7) with lane_7

Cl 45 Changes

- In Cl 45.2.1.168,
  - update Table 45-133 to define register 1.1450 bit 13 (and corresponding registers 1.1451-1.1457) to be the highest bit of the polynomial identifier

Bit(s)	Name	Description	R/W
1.1450.15:14	Seed	Two most significant bits of PRBS13 seed	R/W
1.1450.13:11	Polynomial identifier	Identifier (0, 1, 2, 3, 4, 5, 6 or 7) selecting polynomial for PRBS	R/W
1.1450.10:0	Seed	11 bit, binary seed for sequence	R/W

  - change the last sentence in the second paragraph to be:
    - The default identifiers are (binary): for lane 0, 000, for lane 1, 001; for lane2, 010; for lane 3, 011; for lane 4, 100; for lane 5, 101; for lane 6, 110; for lane 7, 111.

Thanks!

Straw Poll

- For 800GBASE-CR8 and 800GBASE-KR8, I would support part A proposed in lusted_3df_01_220914 slides 6-11
- Y, N, A

Straw Poll

- For the 200 Gbps/lane copper PMDs, I would support part B proposed in lusted_3df_01_220914 slides 13-15
- Y, N, A

Possible Motion

- Move to adopt the link training baseline for 800GBASE-CR8 and 800GBASE-KR8 PMDs in lusted_3df_01_220914 slides 6-11
- M:
- S:
- Technical (>=75%)
- Results