Error Statistics Analysis on 802.3ck Channels

Xiang He
hexiang9@huawei.com

2019-03-14

www.huawei.com

HUAWEI TECHNOLOGIES CO., LTD.

Background

- FEC interleaving was discussed in gustlin_3ck_01_1118.

- anslow_3ck_01_1118 & anslow_3ck_01_0918 compared many options including interleaving two FEC codewords to form a 100G lane, and 2:1 and 4:1 bit-muxing.

  - It was shown that symbol interleaving outperformed 2:1 or 4:1 bit muxing.

- Precoding effects for DFE based model was also studied (zhang_3ck_01a_0918).

- he_3ck_01a_0119 simulated four cases based on contributions above, provided results showing the benefit of symbol interleaving.

  - Case 1 – 1 codeword,   1 lane, direct symbol output
  - Case 2 – 1 codeword,   2 lanes, bit mux
  - Case 3 – 2 codewords, 1 lane, symbol mux
  - Case 4 – 2 codewords, 2 lanes, bit mux

- Requests for error statistics were received, to show how errors were distributed in the thousands of codewords, and how many burst errors were there.

HUAWEI

Simulation Setup

- The simulations were done based one channel data provided in mellitz_3ck_adhoc_02_081518.
    - The data in this presentation was based on "CaBP_BGAVia_Opt2_28dB".
    - This work is done with ADC-based SerDes model, with precoding turned off.
- **TX side:**
    - Matlab environment generates the RS(544,514) FEC codewords;
    - Perform the 10-bit symbol distribution and interleaving/bit-muxing;
    - Modulates the signal stream and sends them over channels that suffer of insertion loss and cross talk.
- **RX side:**
    - Equalization is provided by the CTLE whose output is connected to the ADC, followed by the FFE/DFE equalization.
    - The received demodulated codewords are error corrected and statistics extracted.
- 5000 codewords per encoder is simulated for error statistics analysis in this presentation.
    - Simulations were based on Case 1.

HUAWEI

Error Statistics – ICN = 1.2 mV

ICN = 1.2 mV	
BER_pre = 5.4334E-4	
Consecutive Errors	Occurrences
1	4196
2	2345
3	1448
4	209
5	113
6	15
7	8
8	1
9	0

Errors per CW	Percentage
1	36.66%
2	14.56%
3	11.22%
4	10.30%
5	6.06%
6	4.12%
7	3.22%
8	2.74%
9	2.02%
10	1.40%
11	1.32%
12	1.14%
13	0.94%
14	0.64%
15	0.64%
16	0.62%
17	0.40%
18	0.14%

Errors per CW	Percentage
19	0.30%
20	0.14%
21	0.22%
22	0.10%
23	0.12%
24	0.12%
25	0.08%
26	0.08%
27	0.04%
28	0.04%
29	0.04%
30	0.06%
31	0.04%
32	0.02%
33	0.02%
34	0.00%
……….	0.00%
40	0.02%

HUAWEI

Error Statistics – ICN = 1.0 mV

ICN = 1.0 mV	
BER_pre = 4.2836E-4	
Consecutive Errors	**Occurrences**
1	3352
2	1857
3	1156
4	158
5	79
6	10
7	4
8	0
9	0

Errors per CW	Percentage
1	44.42%
2	14.52%
3	10.86%
4	8.54%
5	4.60%
6	3.88%
7	2.82%
8	2.30%
9	1.50%
10	1.34%
11	0.88%
12	0.78%
13	0.68%
14	0.44%
15	0.36%
16	0.54%
17	0.30%
18	0.16%

Errors per CW	Percentage
19	0.08%
20	0.10%
21	0.16%
22	0.06%
23	0.12%
24	0.06%
25	0.04%
26	0.06%
27	0.08%
28	0.02%
29	0.06%
30	0.02%
31	0.04%
32	0.00%
33	0.00%
……….	0.00%
37	0.04%
38	0.08%

HUAWEI

Error Statistics – ICN = 0.8 mV

ICN = 0.8 mV	
BER_pre = 3.8419E-4	
Consecutive Errors	**Occurrences**
1	3018
2	1700
3	1025
4	134
5	73
6	4
7	3
8	0
9	1

Errors per CW	Percentage
1	13.46%
2	9.44%
3	7.64%
4	4.58%
5	3.74%
6	3.08%
7	1.92%
8	1.46%
9	0.94%
10	0.88%
11	0.74%
12	0.44%
13	0.48%
14	0.26%
15	0.26%
16	0.30%
17	0.12%
18	0.18%

Errors per CW	Percentage
19	0.16%
20	0.14%
21	0.12%
22	0.08%
23	0.04%
24	0.08%
25	0.02%
26	0.00%
27	0.00%
28	0.08%
29	0.04%
30	0.04%
31	0.04%
32	0.04%
33	0.08%
34	0.04%
35	0.00%
36	0.00%

HUAWEI

Error Statistics – ICN = 0.7 mV

ICN = 0.7 mV	
BER_pre = 3.3441E-4	
Consecutive Errors	Occurrences
1	2565
2	1391
3	985
4	110
5	61
6	4
7	3
8	0
9	1

Errors per CW	Percentage
1	13.70%
2	8.78%
3	7.02%
4	4.20%
5	3.20%
6	2.68%
7	1.72%
8	1.18%
9	0.90%
10	0.78%
11	0.58%
12	0.48%
13	0.44%
14	0.14%
15	0.12%
16	0.22%
17	0.18%
18	0.14%

Errors per CW	Percentage
19	0.12%
20	0.04%
21	0.02%
22	0.02%
23	0.06%
24	0.04%
25	0.00%
26	0.02%
27	0.02%
28	0.04%
29	0.00%
30	0.02%
31	0.00%
32	0.02%
33	0.00%
34	0.00%
35	0.04%
36	0.02%
38	0.02%

HUAWEI

Summary

- **Burst error exists regardless of receiver architecture**
  - Bursts as long as 14 were observed.
  - Many bursts were observed despite of low DFE tap values. (0.30 in this case)
  - DFE taps is only one cause for burst errors.

- **2:1 interleaved FEC could help to improve performance for CR/KR channels.**

HUAWEI

THANK YOU