

Why probability of less than $1e-11$ is not necessary for AUI links

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Related to D3.1 comments 200 and 201

Introduction

- Comments 200 and 201 suggest that counting zero errors in 10 seconds is adequate for testing AUI bins with probability requirements of less than $1e-11$.
- Further off-line discussions have modified this proposal, as it was pointed out that zero errors in a bin in 10 seconds is not equivalent to a probability of less than $1e-11$.
- There are $3.9e8$ FEC Codewords in 10 seconds at 200G so at 95% confidence zero errors in a bin is equivalent to a probability of less than $7.7e-9$
- The proposal therefore is modified to require zero error counts in all bins that have a probability requirement of less than $8e-9$.

Analysis

- Inspecting tables 176D-11 for all the variations of p the smallest value of k (Test symbols per test block) that this criterion (probability $<8e-9$) would apply to for C2M is $k=6$. For C2C in table 176C-6 the smallest value of k is 5.
- In order to have an uncorrectable codeword it is necessary that there are 16 or more FEC symbol errors in a codeword. That means that the rest of the link must be creating at least 10 additional FEC symbol errors for C2M and 11 additional FEC symbol errors for C2C.
- The following slide shows the probability of having the additional 10 FEC symbol errors from other ISL's within the link for C2M. The probabilities are taken from tables 180-20, 176C-6 and 176D-11 and are all for $P=1$ which is the worst case. The total probability is less than $3e-6$.
- That combined with the probability of zero errors in the bin ($7.7e-9$) gives a total probability of less than $2.2e-14$ which meets with some margin the allowed uncorrectable codeword error rate (BLER) from 174A of $2.4e-13$.

Possible ways of the additional 10 errors occurring .

Results are for P=1 which is worst case. Some other conservative assumptions are made.

Additional Errors for 10 additional errors										
in PMD		In other C2M		in c2c A		in c2c B		Total		
Number	Probability	Number	Probability	Number	Probability			Number	Probability	Cumulative probability
10	6.40E-07	0	0.89	0	1.00E+00	0	1.00E+00	10	5.70E-07	5.70E-07
9	5.30E-06	1	0.11	0	1.00E+00	0	1.00E+00	10	5.83E-07	1.15E-06
9	5.30E-06	0	0.89	1	4.20E-02	0	1.00E+00	10	1.98E-07	1.35E-06
9	5.30E-06	0	0.89	0	1.00E+00	1	4.20E-02	10	1.98E-07	1.55E-06
8	3.90E-05	2	7.50E-03	0	1.00E+00	0	1.00E+00	10	2.93E-07	1.84E-06
8	3.90E-05	1	0.11	0	1.00E+00	1	4.20E-02	10	1.80E-07	2.02E-06
8	3.90E-05	1	0.11	1	4.20E-02	0	1.00E+00	10	1.80E-07	2.20E-06
8	3.90E-05	0	0.89	1	4.20E-02	1	4.20E-02	10	6.12E-08	2.26E-06
8	3.90E-05	0	0.89	2	9.10E-04	0	1.00E+00	10	3.16E-08	2.29E-06
8	3.90E-05	0	0.89	0	1.00E+00	2	9.10E-04	10	3.16E-08	2.33E-06
7	2.50E-04	3	3.20E-04	0	1.00E+00	0	1.00E+00	10	8.00E-08	2.41E-06
7	2.50E-04	2	7.50E-03	1	4.20E-02	0	1.00E+00	10	7.88E-08	2.48E-06
7	2.50E-04	2	7.50E-03	0	1.00E+00	1	4.20E-02	10	7.88E-08	2.56E-06
7	2.50E-04	1	0.11	1	4.20E-02	1	4.20E-02	10	4.85E-08	2.61E-06
7	2.50E-04	1	0.11	2	9.10E-04	0	1.00E+00	10	2.50E-08	2.64E-06
7	2.50E-04	1	0.11	0	1.00E+00	2	9.10E-04	10	2.50E-08	2.66E-06
7	2.50E-04	0	0.11	3	1.30E-05	0	1	10	3.58E-10	2.66E-06
7	2.50E-04	0	0.89	0	1.00E+00	3	1.30E-05	10	2.89E-09	2.67E-06

Further analysis and comments.

- The probability of having the extra errors is dominated by the PMD, and to a lesser extent the additional C2M.
- Based on a similar analysis in backup the probability of having 9 additional errors is less than $1.9e-5$. i.e. even if $k=7$ for the AUI the BLER criterion is still met.
- It is extremely likely that if the $K=6$ and $K=7$ pass this criterion the probabilities of bins $k=8$ to $K=16$ will be negligibly small
- Based on a similar analysis in backup the probability of having 11 additional errors for C2C is less than $5e-7$.
- Requiring extrapolation to bin 16 is unnecessary and could lead to false failures due to statistical variation in the bin counts and the possibility that there is some error correlation.

Conclusion and proposal.

- The criterion of having zero errors in 10 seconds for all values of k with a probability of less than $8e-9$ is acceptable.
- Add the following note to sections 176C.6.4.4 and 178D.8.11
Note: In order to predict whether a receiver meets the BLER requirement in a short test time, a ten second test can be used. Provided that zero test symbol errors per test block are obtained for all required probabilities of less than $8e-9$ it is highly likely that the BLER requirement is met.

Backup

Possible ways of the additional 9 errors occurring.

Results are for P=1 which is worst case. Some other conservative assumptions are made.

Additional Errors for 9 additional errors										
in PMD		In other C2M		in c2c A		in c2c B		Total		
Number	Probability	Number	Probability	Number	Probability			Number	Probability	Cumulative probability
9	5.30E-06	0	0.89	0	1.00E+00	0	1.00E+00	9	4.72E-06	4.72E-06
8	3.90E-05	1	0.11	0	1.00E+00	0	1.00E+00	9	4.29E-06	9.01E-06
8	3.90E-05	0	0.89	1	4.20E-02	0	1.00E+00	9	1.46E-06	1.05E-05
8	3.90E-05	0	0.89	0	1.00E+00	1	4.20E-02	9	1.46E-06	1.19E-05
7	2.50E-04	2	7.50E-03	0	1.00E+00	0	1.00E+00	9	1.88E-06	1.38E-05
7	2.50E-04	1	0.11	0	1.00E+00	1	4.20E-02	9	1.16E-06	1.50E-05
7	2.50E-04	1	0.11	1	4.20E-02	0	1.00E+00	9	1.16E-06	1.61E-05
7	2.50E-04	0	0.89	1	4.20E-02	1	4.20E-02	9	3.92E-07	1.65E-05
7	2.50E-04	0	0.89	2	9.10E-04	0	1.00E+00	9	2.02E-07	1.67E-05
7	2.50E-04	0	0.89	0	1.00E+00	2	9.10E-04	9	2.02E-07	1.69E-05
6	1.40E-03	3	3.20E-04	0	1.00E+00	0	1.00E+00	9	4.48E-07	1.74E-05
6	1.40E-03	2	7.50E-03	1	4.20E-02	0	1.00E+00	9	4.41E-07	1.78E-05
6	1.40E-03	2	7.50E-03	0	1.00E+00	1	4.20E-02	9	4.41E-07	1.82E-05
6	1.40E-03	1	0.11	1	4.20E-02	1	4.20E-02	9	2.72E-07	1.85E-05
6	1.40E-03	1	0.11	2	9.10E-04	0	1.00E+00	9	1.40E-07	1.86E-05
6	1.40E-03	1	0.11	0	1.00E+00	2	9.10E-04	9	1.40E-07	1.88E-05
6	1.40E-03	0	0.11	3	1.30E-05	0	1	9	2.00E-09	1.88E-05
6	1.40E-03	0	0.89	0	1.00E+00	3	1.30E-05	9	1.62E-08	1.88E-05

Possible ways of the additional 8 errors occurring.

Results are for P=1 which is worst case. Some other conservative assumptions are made.

Additional Errors for 8 additional errors										
in PMD		In other C2M		in c2c A		in c2c B		Total		
Number	Probability	Number	Probability	Number	Probability			Number	Probability	Cumulative probability
8	3.90E-05	0	0.89	0	1.00E+00	0	1.00E+00	8	3.47E-05	3.47E-05
7	2.50E-04	1	0.11	0	1.00E+00	0	1.00E+00	8	2.75E-05	6.22E-05
7	2.50E-04	0	0.89	1	4.20E-02	0	1.00E+00	8	9.35E-06	7.16E-05
7	2.50E-04	0	0.89	0	1.00E+00	1	4.20E-02	8	9.35E-06	8.09E-05
6	1.40E-03	2	7.50E-03	0	1.00E+00	0	1.00E+00	8	1.05E-05	9.14E-05
6	1.40E-03	1	0.11	0	1.00E+00	1	4.20E-02	8	6.47E-06	9.79E-05
6	1.40E-03	1	0.11	1	4.20E-02	0	1.00E+00	8	6.47E-06	1.04E-04
6	1.40E-03	0	0.89	1	4.20E-02	1	4.20E-02	8	2.20E-06	1.07E-04
6	1.40E-03	0	0.89	2	9.10E-04	0	1.00E+00	8	1.13E-06	1.08E-04
6	1.40E-03	0	0.89	0	1.00E+00	2	9.10E-04	8	1.13E-06	1.09E-04
5	7.00E-03	3	3.20E-04	0	1.00E+00	0	1.00E+00	8	2.24E-06	1.11E-04
5	7.00E-03	2	7.50E-03	1	4.20E-02	0	1.00E+00	8	2.21E-06	1.13E-04
5	7.00E-03	2	7.50E-03	0	1.00E+00	1	4.20E-02	8	2.21E-06	1.15E-04
5	7.00E-03	1	0.11	1	4.20E-02	1	4.20E-02	8	1.36E-06	1.17E-04
5	7.00E-03	1	0.11	2	9.10E-04	0	1.00E+00	8	7.01E-07	1.18E-04
5	7.00E-03	1	0.11	0	1.00E+00	2	9.10E-04	8	7.01E-07	1.18E-04
5	7.00E-03	0	0.11	3	1.30E-05	0	1	8	1.00E-08	1.18E-04
5	7.00E-03	0	0.89	0	1.00E+00	3	1.30E-05	8	8.10E-08	1.18E-04

Possible ways of the additional 11 errors occurring in C2C.

Results are for P=1 which is worst case. Some other conservative assumptions are made.

Additional Errors for 11 additional errors for C2C										
in PMD		In C2M A		in C2M B		in other C2C		Total		
Number	Probability	Number	Probability	Number	Probability			Number	Probability	Cumulative probability
11	7.10E-08	0	0.89	0	0.89	0	1.00E+00	11	5.62E-08	5.62E-08
10	6.40E-07	1	0.11	0	0.89	0	1.00E+00	11	6.27E-08	1.19E-07
10	6.40E-07	0	0.89	1	0.11	0	1.00E+00	11	6.27E-08	1.82E-07
10	6.40E-07	0	0.89	0	0.89	1	4.20E-02	11	2.13E-08	2.03E-07
9	5.30E-06	2	7.50E-03	0	0.89	0	1.00E+00	11	3.54E-08	2.38E-07
9	5.30E-06	1	0.11	0	0.89	1	4.20E-02	11	2.18E-08	2.60E-07
9	5.30E-06	1	0.11	1	0.11	0	1.00E+00	11	6.41E-08	3.24E-07
9	5.30E-06	0	0.89	1	0.11	1	4.20E-02	11	2.18E-08	3.46E-07
9	5.30E-06	0	0.89	2	7.50E-03	0	1.00E+00	11	3.54E-08	3.81E-07
9	5.30E-06	0	0.89	0	0.89	2	9.10E-04	11	3.82E-09	3.85E-07
8	3.90E-05	3	3.20E-04	0	0.89	0	1.00E+00	11	1.11E-08	3.96E-07
8	3.90E-05	2	7.50E-03	1	0.11	0	1.00E+00	11	3.22E-08	4.28E-07
8	3.90E-05	2	7.50E-03	0	0.89	1	4.20E-02	11	1.09E-08	4.39E-07
8	3.90E-05	1	0.11	1	0.11	1	4.20E-02	11	1.98E-08	4.59E-07
8	3.90E-05	1	0.11	2	7.50E-03	0	1.00E+00	11	3.22E-08	4.91E-07
8	3.90E-05	1	0.11	0	0.89	2	9.10E-04	11	3.47E-09	4.95E-07
8	3.90E-05	0	0.11	3	3.20E-04	0	1	11	1.37E-09	4.96E-07
8	3.90E-05	0	0.89	0	0.89	3	1.30E-05	11	4.02E-10	4.97E-07