Symbol Error Probabilities for Functional Interface Testing

Supporting Comment 2

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Overview / Related comment

The transmitter Functional Symbol Error histogram was introduced in 802.3dj D2.1

- https://www.ieee802.org/3/dj/public/25_07/cole_3dj_01b_2507.pdf

The symbol error mask was updated in 802.3dj D2.2 based on concerns about test time/ unreasonably small probability values for higher Symbol Error bins

- Test time was undefined, but intent is to specify this as discussed in cole_3dj_01_2601

The flat symbol error mask in the current spec would potentially allow multiple uncorrectable codewords – requiring zero counts for higher symbol errors than would be expected based on the test time resolves this issue

Cl **180** *SC* **180.9.9** *P* **489** *L* **47** # 2

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Comment Type **TR** *Comment Status* **X**

For symbol errors ≥ 9 Table 180-18 specifies flat counts, consistent with a pre FEC BER ~2.3E-4. This implies that a transmitter could have a large error floor and still pass the test. It would be preferable to specify the actual probabilities consistent with a value of ~1e-26 or include no values with an informative note indicating these bins should have no measured occurances.

The measurement time to determine the probabilities for k≥9 in unreasonably long for the 2.4e-5 BER defined in this clause.

SuggestedRemedy

Update the values in Table 180-18 for symbol errors ≥ 9 to remove the flat mask. Remove these values and include a note that these bins should record zero counts.

Proposed Response *Response Status* **O**

Overview

The FEC Histogram test measures the number of corrected symbols per FEC codeword

- For example, 802.3 RS(544,514,10) codewords have 544 10-bit symbols and can correct up to 15 errored symbols
- The FEC histogram test allows screening based on a maximum number of symbol errors expected within the measurement time

The Transmitter functional symbol error histogram defined in clause 180.9.9 provides symbol error probability mask intended to screen transmitters

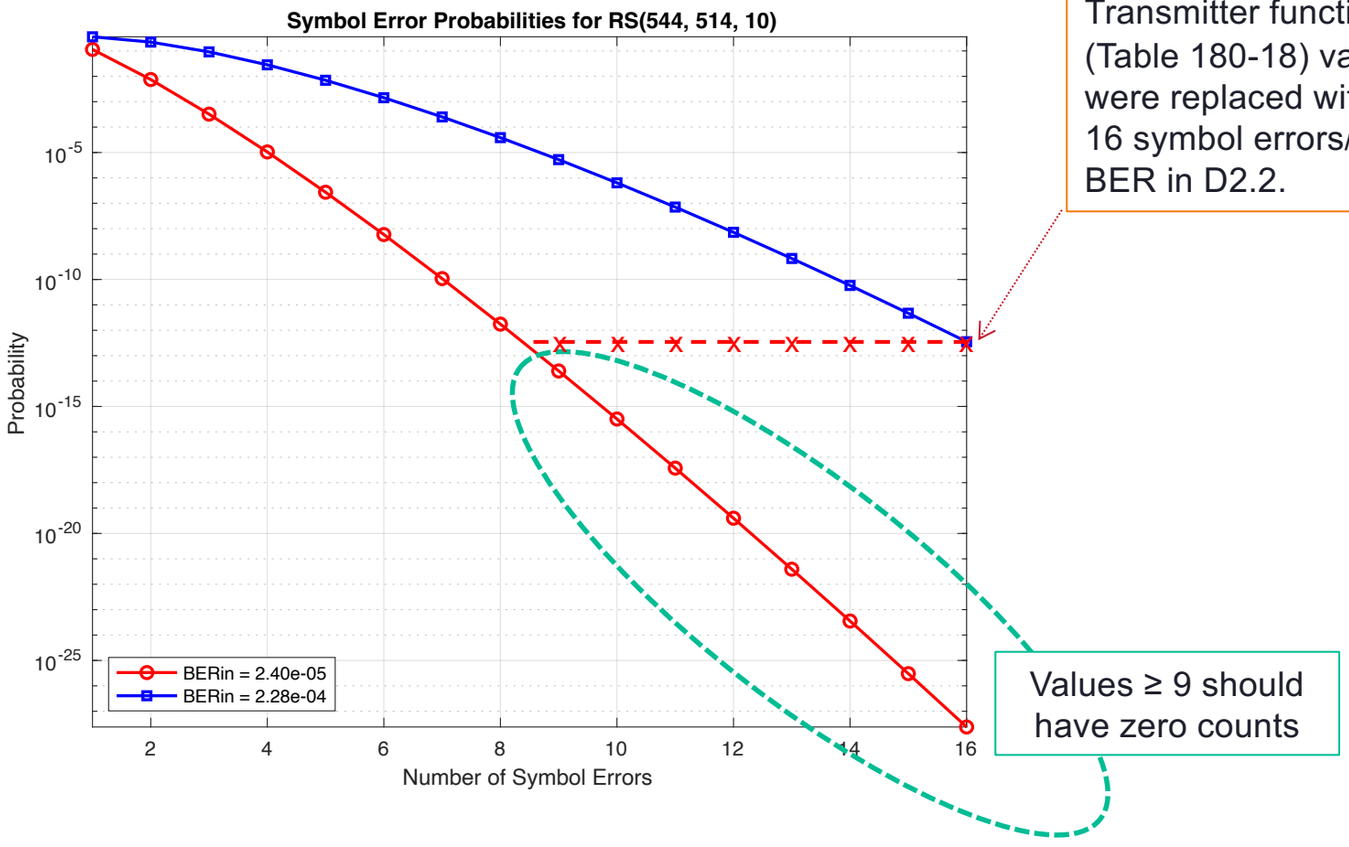
- This is a lane-based test at 212.5 Gb/s
- With 1.5dB power margin the BER is specified at 2.4E-5
- In D2.3 the test time is undefined, and higher bins are defined based on a 10x higher BER

FEC Histogram tests can be used to test individual interfaces to ensure they are meeting their allocated error contributions

Curves in this contribution show the behavior of these histograms assuming random errors

Example of Probabilities

The Functional test is defined with 1.5dB margin, at a 2.4e-5 BER



To deal with low probability values the Transmitter functional symbol error mask (Table 180-18) values for > 8 Symbol errors were replaced with a value corresponding to 16 symbol errors/codeword for a 2.28e-4 BER in D2.2.

Values ≥ 9 should have zero counts

Probabilities for a 2.4E-5 BER

j	Probability P(j)	Status
1	1.1459e-01	Correctable
2	7.4680e-03	Correctable
3	3.2385e-04	Correctable
4	1.0514e-05	Correctable
5	2.7255e-07	Correctable
6	5.8770e-09	Correctable
7	1.0842e-10	Correctable
8	1.7469e-12	Correctable
9	2.4972e-14	Correctable
10	3.2068e-16	Correctable
11	3.7367e-18	Correctable
12	3.9839e-20	Correctable
13	3.9133e-22	Correctable
14	3.5627e-24	Correctable
15	3.0216e-26	Correctable
16	2.3979e-28	Uncorrectable

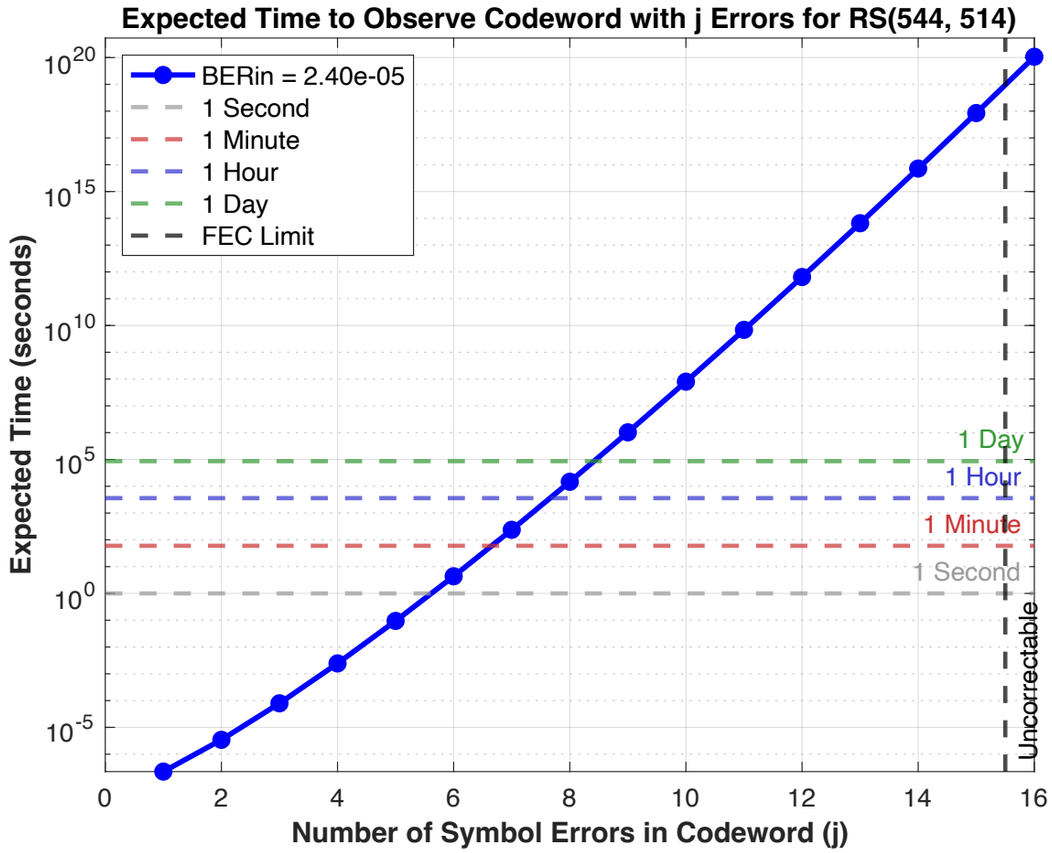
Expected time to one error:

The chart shows the expected time to observe one codeword with 1 ≤ j ≤ 16 symbol errors at 212Gb/s

For the Transmitter Functional Test, Symbol errors of ≥ 8 aren't required for reasonable test times.

- A 1 minute test time is being proposed for this test

For longer term tests, histograms can be considered for analysis of various interfaces



Expected symbol error count for a 60s test for a pre FEC BER of 2.4e-5

Symbol Errors	Expected Count
1	2.7E+08
2	1.7E+07
3	7.6E+05
4	2.5E+04
5	6.4E+02
6	1.4E+01
7	2.5E-01
8	4.1E-03

Note: If an RS FEC decoder is used to measure the symbol errors, 16 is likely not available

Issues with current 802.3dj mask

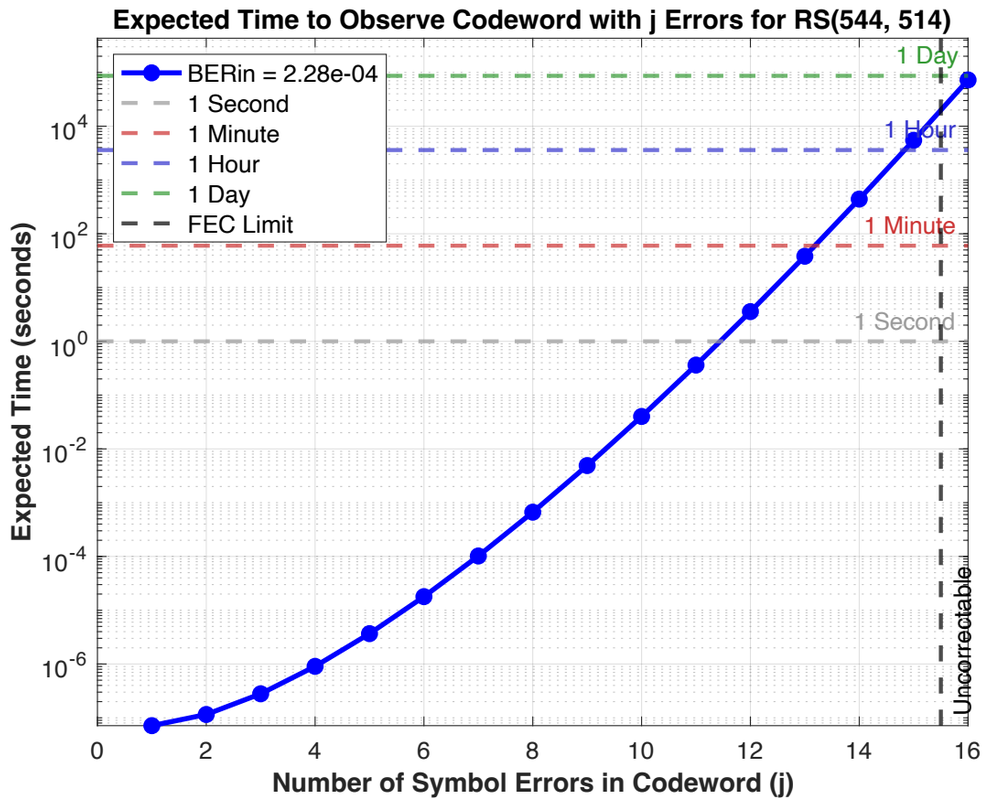
Symbol error bins 1-8 are defined based on a 2.4e-5 BER

Symbol error bins 9-16 are assigned the same probability as bin 16 for a BER of 2.28e-4

- The bins that result in uncorrectable codewords are defined in a way that allows higher counts

In a one-day soak, ~four 16 symbol-error (ie uncorrectable) codewords would pass the test.

Codewords with > 16 symbol errors have no limit applied



Long term histogram tests

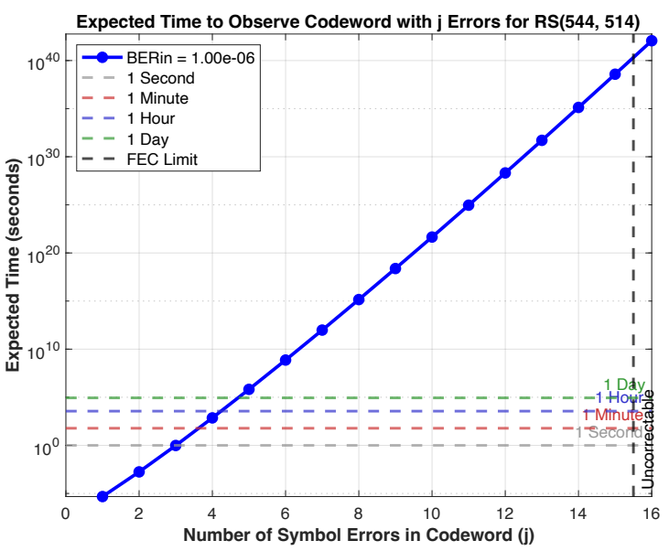
Symbol error histograms have been discussed for longer term testing

- This type of acceptance test can be used to pre-emptively identify situations with symbol errors beyond allocations

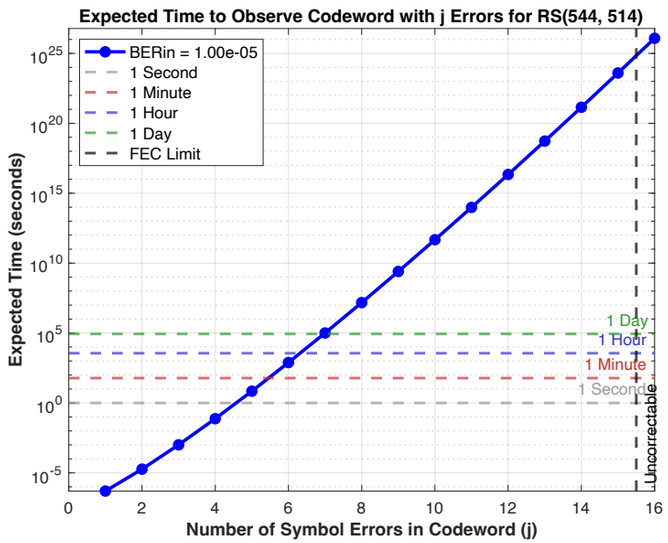
This can be considered as an informative Annex

- This can be considered for inclusion in 802.3dj (≥3.0) if there is sufficient interest

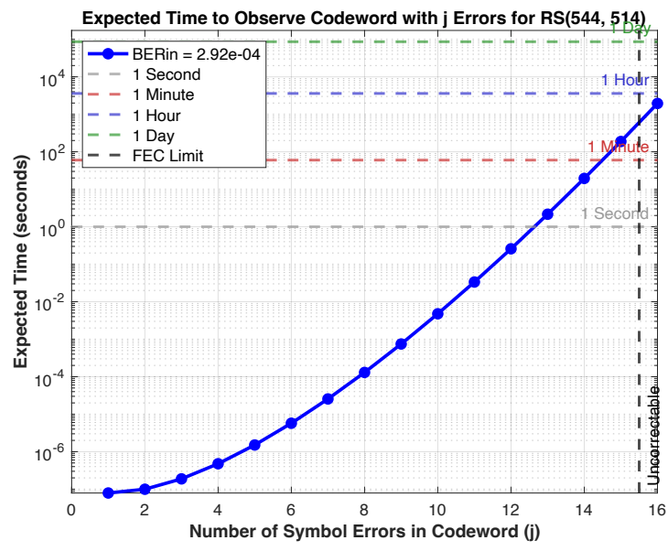
10^{-6}



10^{-5}



2.92×10^{-4}



Summary

Details of the concerns with the current probability mask in the Transmitter functional symbol error histogram test are shown

Expected time to symbol error count can be used to determine which values are reasonable to include in 802.3dj

Longer term tests using FEC symbol histograms are presented

- This is an area that may be worth including in 802.3 to standardize this test type
- Other standards organizations will look to 802.3 for guidance on these tests

Thanks!