Test Symbol Error Extrapolation

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802.3dj ad-hoc

Overview

Clause 180.9.15 calls out extrapolation of the measured symbol errors in order to reduce test time.

Since the error distribution isn't likely to be linear, extrapolation beginning at 1 symbol-error/block will reduce the accuracy of the extrapolation

Two related comments were submitted on D3.0 with different solutions, the intent of this contribution is to facilitate comment resolution.

NOTE—If the statistical projection is modeled accurately by a linear fit extrapolation, a means to provide statistical projection of the measured histograms (see174A.9.3) in order to reduce test time follows. Extrapolate the measured histogram to $H_m^{(i)}(16)$ using a line determined by a linear fit of $\log_{10}(H_m^{(i)}(k))$, for $k = 1$ to n, where n is the largest value of k, where all bins from 0 to n have a count greater than 2.

Receiver Error mask

Table 180–20—Receiver error mask

Test symbol errors per test block, k (see 174A.9.5)	Probability $H_{max}(k)$			
	$p = 1$	$p = 2$	$p = 4$	$p = 8$
1	3.6×10^{-1}	3.3×10^{-1}	2.3×10^{-1}	1.3×10^{-1}
2	2.2×10^{-1}	1.0×10^{-1}	3.5×10^{-2}	1.0×10^{-2}
3	9.2×10^{-2}	2.1×10^{-2}	3.6×10^{-3}	5.1×10^{-4}
4	2.8×10^{-2}	3.3×10^{-3}	2.7×10^{-4}	1.9×10^{-5}
5	7.0×10^{-3}	4.0×10^{-4}	1.6×10^{-5}	5.5×10^{-7}
6	1.4×10^{-3}	4.1×10^{-5}	8.2×10^{-7}	1.3×10^{-8}
7	2.5×10^{-4}	3.5×10^{-6}	3.5×10^{-8}	2.7×10^{-10}
8	3.9×10^{-5}	2.7×10^{-7}	1.3×10^{-9}	4.7×10^{-12}
9	5.2×10^{-6}	1.8×10^{-8}	4.1×10^{-11}	7.1×10^{-14}
10	6.4×10^{-7}	1.1×10^{-9}	1.2×10^{-12}	9.6×10^{-16}
11	7.1×10^{-8}	5.8×10^{-11}	3.1×10^{-14}	1.2×10^{-17}
12	7.2×10^{-9}	2.9×10^{-12}	7.5×10^{-16}	1.3×10^{-19}
13	6.7×10^{-10}	1.3×10^{-13}	1.6×10^{-17}	1.2×10^{-21}
14	5.8×10^{-11}	5.6×10^{-15}	3.3×10^{-19}	1.1×10^{-23}
15	4.7×10^{-12}	2.2×10^{-16}	6.1×10^{-21}	9.1×10^{-26}
16	3.8×10^{-13}	8.3×10^{-18}	1.1×10^{-22}	6.9×10^{-28}

Cl **180** *SC* **180.9.15** *P* **491** *L* **18** # I-226

Maniloff, Eric Ciena Corporation

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

Current text for block error extrapolation performs a linear fit from 1 to n. Because this is unlikely to be linear, it would be more accurate to only extrapolate over the 4 highest bins with sufficient counts.

SuggestedRemedy

Replace: "If the statistical projection is modeled accurately by a linear fit extrapolation, a means to
provide statistical projection of the measured histograms (see174A.9.3) in order to reduce test time
follows. Extrapolate the measured histogram to Hm(i)(16) using a line determined by a linear fit of
log10(Hm(i)(k)), for k = 1 to n, where n is the largest value of k, where all bins from 0 to n have a count
greater than 2."

With

"If the statistical projection is modeled accurately by a linear fit extrapolation, a means to provide statistical projection of the measured histograms (see174A.9.3) in order to reduce test time follows. Extrapolate the measured histogram to Hm(i)(16) using a line determined by a linear fit of log10(Hm(i)(k)), for k = n-3 to n, where n is the largest value of k, where all bins from n-3 to n have a count greater than 2." Make similar changes in Clauses 181, 182, 183.

Proposed Response *Response Status* **O**

Cl **180** *SC* **180.9.15** *P* **491** *L* **18** # I-296

Dudek, Michael Marvell

Comment Type **T** *Comment Status* **X**

The note could be misinterpreted as suggesting extrapolation is also needed for higher probabilites resulting in failures with random errors where the measurements meet the requirement without extrapolation

SuggestedRemedy

Insert "for Hm(i)(k) less than 10^-6"before "Extrapolate the measured histogram......" Also in 180.9.16. Make the equivalent changes in clauses 181, 182 and 183 .

Proposed Response *Response Status* **O**

Approaches comparison

Data points with test blocks containing > 2 symbol errors are used to extrapolate

- Currently this is done from 1 to n where n is the largest bin with > 2 symbol errors/test block

Comment 226 proposes using the 4 points with the highest number of symbol errors > 2

- Extrapolation uses bins n-3 to n.

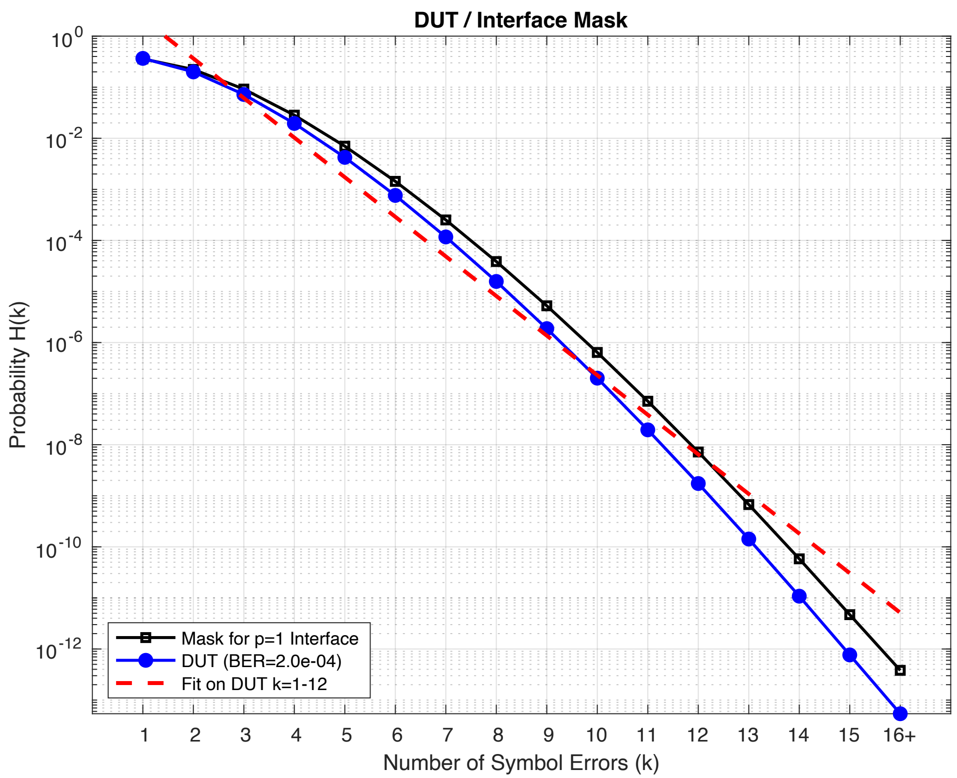
Comment 296 proposes using points with probability ≤ 1e-6

- This will result in varying numbers of points
- For some BER's there may be only two points – statistical variation of last point is a concern

ran_3dj_elec_01_240822 analyzed Symbol Error histograms with added Tx jitter versus LPF BW

- https://www.ieee802.org/3/dj/public/adhoc/electrical/24_0822/ran_3dj_elec_01_240822.pdf
- Some curves have zero or one point with a probability of ≤ 1E-6
- With random data the slope becomes steeper as bin count increases
- With added jitter the slope can become less steep as bin count increases

Example of current definition



The figure shows the Symbol error mask in black

The blue line shows expected probabilities for a DUT BER of 2e-4 assuming random errors

- For a 1 min test ~4 instances of 12 symbol errors are expected for a single lane 212G interface

The red line is a linear fit from 1 to 12 symbol errors

- This is the extrapolation defined in D3.0

Options Comparison

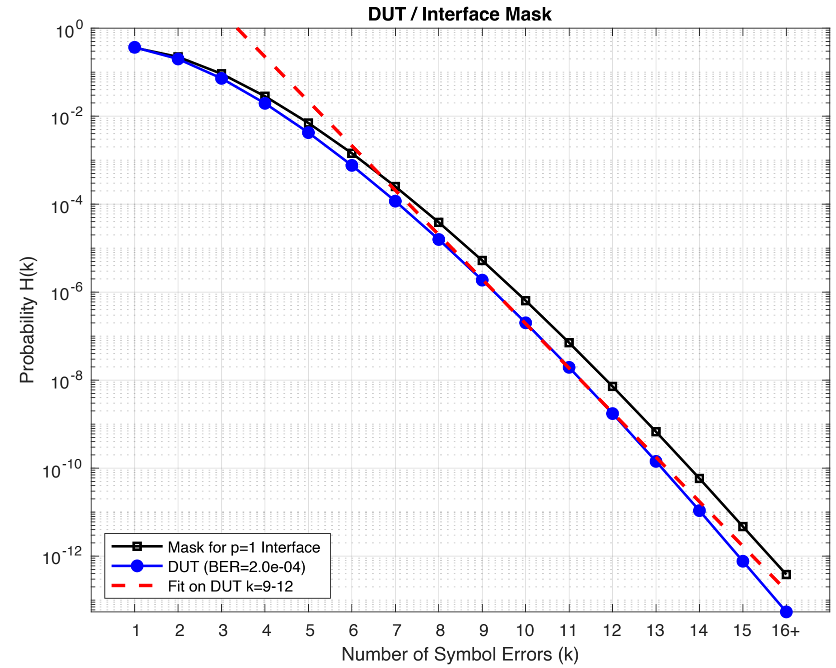
Top plot:

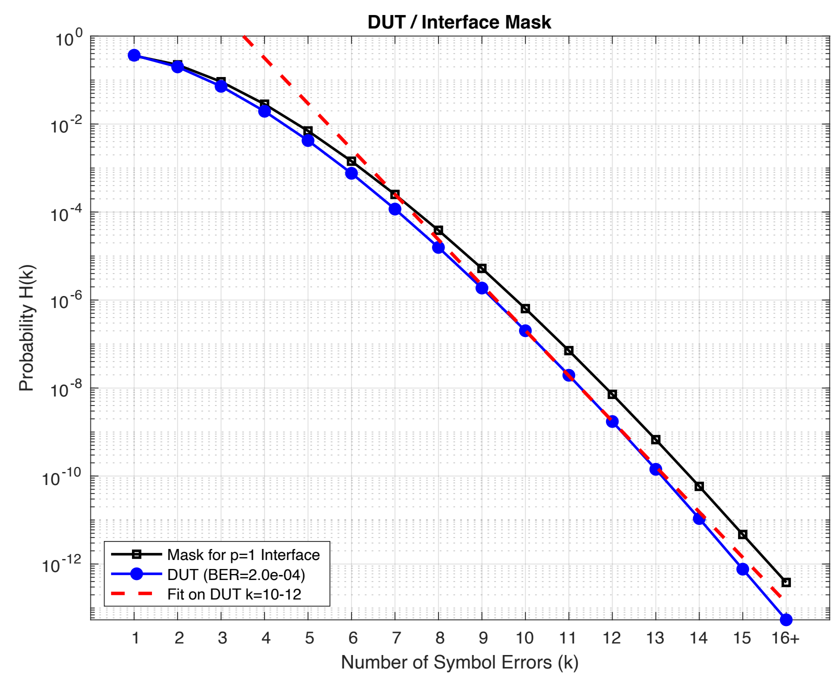
- Fit using k = 9-12, based on bin 12 having > 2 occurrences
- Fit will use highest 4 points

Bottom plot:

- Fit on k= 10-12, based on bin 12 having > 2 occurrences AND bin 10 being < 1e-6

Both extrapolations are an improvement





Highest Bin statistical variation

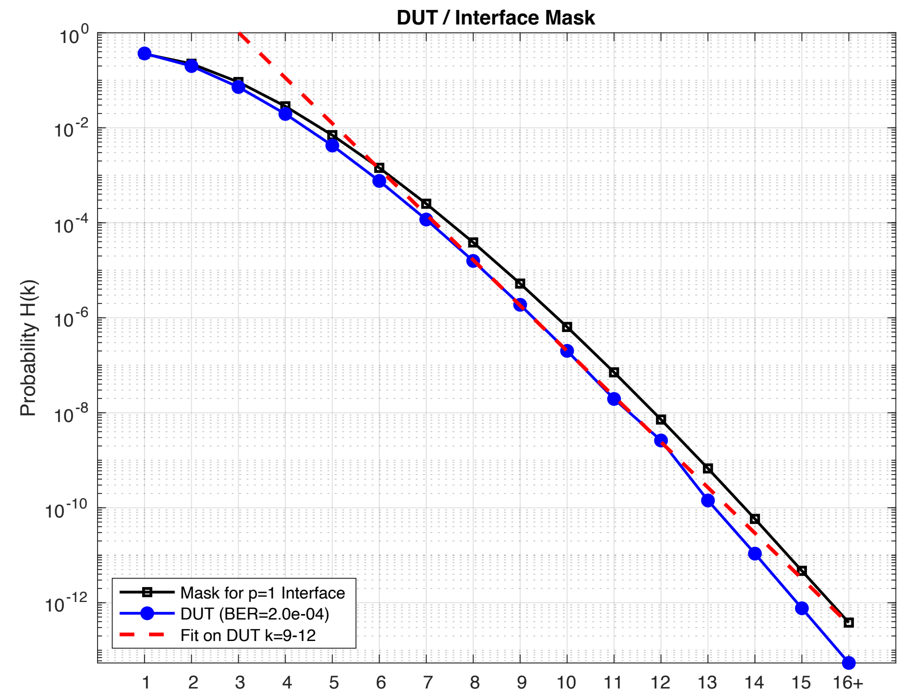
Because the points used in current definition are those with only 3 events, there will be variations in last point

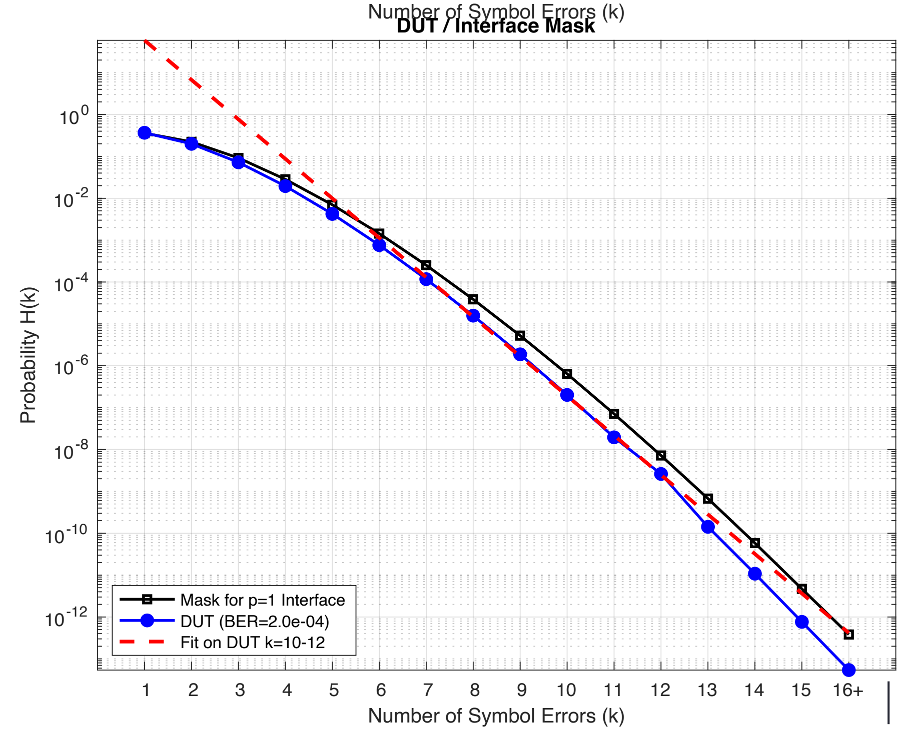
On the right curves for a 2E-4 BER are shown, with bin 12 being a 10% probability (mean = 4, 6 counts ~10% probability)

Using two counts in highest bin may be too low

In this case probability screen to ≤1e-6 has 3 bins

Using 4 bins is slightly closer to correct.





Summary

The current approach to extrapolation using all bins with > 2 symbol error counts does not provide accurate extrapolation

Two proposed approaches have been provided:

- Using a probability screen for events with ≤ 1E-6 probability to exclude lower bins
- Using the four highest counts

Concern with the probability screen is variable numbers of points, as low as 1 or 2 in some cases

Preference is for a fixed number of points

- Three or Four would be options

Including a bin with only three counts may make this approach susceptible to errors

- There are no comments on this, but we may want to move to only using bins with ≥ 10 counts

Thanks!