802.3dj Annex 174A histogram bin 16 definition
In support of comment R2-142

Eric Maniloff – Ciena

September 2026

IEEE P802.3dj – September Interim

Supporters

Chris Cole – Coherent
Ali Ghiasi – Ghiasi Quantum
Norm Swenson – Nokia
Michael He - Terahop
Eric Bernier – Huawei
Mark Kimber – Semtech
Howard Heck – TE
Ahmad El-Chayeb – Keysight
Piers Dawe – Nvidia
Pavel Zivny – Lumilens
Leon Bruckman – Nvidia
Jeffery Maki – HPE (Support Alternative)
Laurent Alloin – Ciena

Original Comment

Technical	**752**	**174A9.5**	**49**	174A.9.5 is inconsistent with the definition and use of histogram bin 16 elsewhere in Annex 174A. 174A.9.2 defines test_block_error_bin_i_16p as the counter for test blocks with 16 or more test-symbol errors. 174A.9.3 correspondingly defines Hm(i)(16) as the probability of 16 or more test-symbol errors. This interpretation is also preserved by the saturated-bin convolution in 174A.9.4. Furthermore, 174A.9.6 and 174A.9.7 use the final histogram bin, He(16), as the measured BLER. Since BLER is the ratio of uncorrectable FEC codewords, this bin must include all test blocks with 16 or more errors. However, Equation 174A-5 calculates Hmax(16) using the binomial probability for exactly 16 errors. This excludes test blocks with 17 or more errors and therefore does not define the mask for the uncorrectable-codeword bin described in 174A.9.2 and 174A.9.3. Equation 174A-5 should specify that the binomial expression applies to bins 0 through 15, while the value for bin 16 is the cumulative probability of 16 or more errors. Tables derived from this mask should also identify the final value as “16 or more” or “16+,” rather than exactly 16 and update these values. For example this changes the last row of Table 180-20 to: [3.8E-13, 8.3E-13, 1.1E-22, 6.9E-28]	Revise Equation 174A-5 and the associated text in 174A.9.5 so that the histogram mask uses exact probabilities for bins 0 through 15 and a cumulative probability for bin 16. For k = 0 through 15, calculate Hmax(k) as the probability of exactly k test-symbol errors using the existing binomial expression. For k = 16, calculate Hmax(16) as the probability of 16 or more test-symbol errors by summing the binomial probabilities for all error counts from 16 through n. Revise the associated tables and descriptions to identify the final histogram value as “16 or more” or “16+,” rather than exactly 16. This will make Equation 174A-5 consistent with the 17-bin histogram definition in 174A.9.2 and 174A.9.3, the saturated-bin convolution in 174A.9.4, and the use of He(16) as the BLER in 174A.9.6 and 174A.9.7. Update values for row 16 in: Table 178–11, Table 179–14, Table 180-20, Table 185–16

Introduction

Comment R2-142 identified an error in Annex 174A's equations calculating the error mask based on the error histogram measurement

The original suggested resolution was to change the equation and all associated values to correct the error.

- The editorial team expressed concern that this was too wide of a scope at this stage in the process

Rather than modifying the equation, the suggested resolution is to identify the difference in a note, clarifying that the calculated values are sufficiently accurate for use as a block error mask.

Background: test block error histogram

174A.9.3 defines the error histogram measurement: each test block of 544/p test symbols is checked and its errored symbols counted.

- The block is tallied into the bin for that count: 0, 1, 2, ... 15.
- Blocks with 16 or more errored symbols all fall into one final bin.

Dividing each bin count by the block count gives $Hm^{(i)}(k)$: the measured probability of k errored symbols per block on lane i.

- Equation (174A–5) gives Hmax(k), the limit mask: the histogram for random errors at BERmax = BERtotal – BERadded.

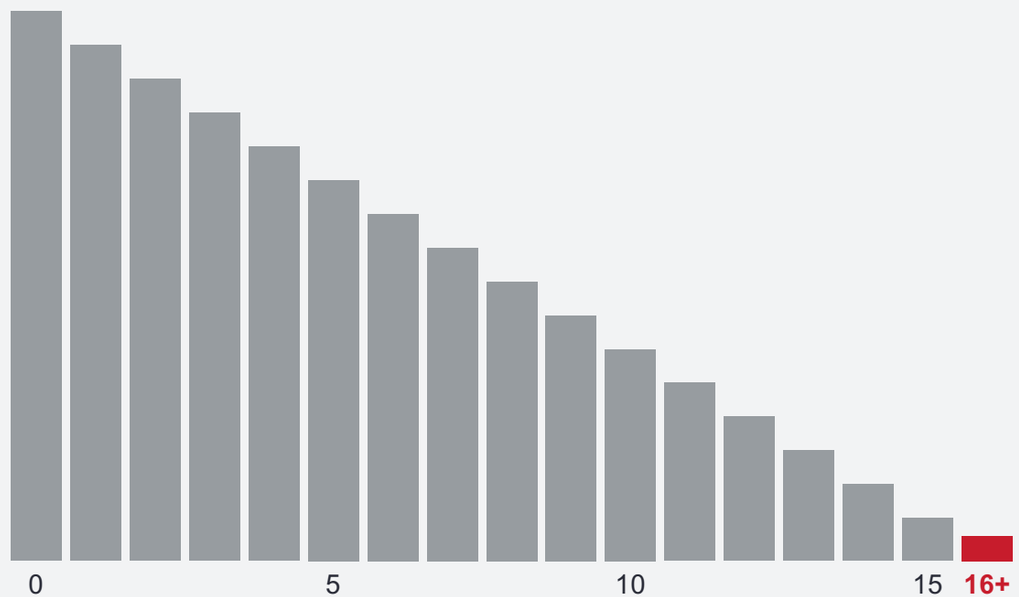
Relation to RS(544,514,10)

A test block relates to an RS(544,514,10) codeword: 544 ten-bit symbols with 30 parity symbols, up to 15 symbol errors are correctable.

Bins 0-15 are codewords the FEC decoder corrects; bin 16 is exactly the uncorrectable case, 16 or more symbol errors.

Bin 16 is therefore the codeword (block) error probability the BLER limits of 174A.5/174A.6 are written against.

Probability of a test block having k errored symbols



Bins 0-15: exactly k errors

Bin 16: 16 or more errors, accumulated into one tail bin

The inconsistency: definition versus equation

DEFINITION — 174A.9.3

$Hm(i)(16) = P(k \geq 16)$

Bin 16 is a tail: 16 or more test-symbol errors in a block; bins 0–15 are exactly k.

The 174A.9.2 counters agree — test_block_error_bin_i_16p counts blocks with 16 or more errors.

EQUATION (174A–5)

$Hmax(16) = P(k = 16)$

A single binomial term C(n, k) × RSSER^k × (1 – RSSER)^(n–k), n = 544/p.

At k = 16 it returns exactly 16 errors — no summation over k = 16 to n is applied.

174A.9.5 pass criterion: Hm(i)(k) < Hmax(k) for all k > 0 — the limit mask does not match the histogram it is measured against.

The difference between the tail and the point probability, at the maximum BER specified in this annex is ~9%

Carries forward into BLER via BER_added: in 174A.9.6/9.7 Hm is measured, so its tail is correct, and Equation (174A–5) only builds the error histogram for BER_added. In 174A.9.5, the entire mask Hmax(k) is affected.

Internally inconsistent, and not measurable

INTERNALLY INCONSISTENT

Same bin, two treatments

174A.9.4 treats bin 16 correctly as a tail, summing the k ≥ 16 terms in the convolution hconv[Hx, Hy].

In 174A.9.6 and 174A.9.7 the reported BLER is He(16), a tail: Hm is measured as 16-or-more and hconv preserves it. Equation (174A–5) enters as Ha(k), the BER_added term.

So the measurement is not understated — only the exactly-16 term is: the whole mask in 174A.9.5, the BER_added term in 174A.9.6/9.7.

AS DEFINED AND COUNTED

The FEC decoder cannot report exactly 16

A block error is an uncorrectable codeword — 16 or more symbol errors.

A PMA test block counter could in principle bin exactly 16, but the counters of 174A.9.2 are defined as 16-or-more (test_block_error_bin_i_16p).

An RS-FEC decoder cannot report exactly 16 at all: beyond its correction capability it only flags the codeword as uncorrected. 174A.11.2's FEC_uncorrected_cw_counter counts codewords with more than 15 symbol errors, and 174A.11.3 sets Hm(16) from that counter.

Every form of bin 16 defined in this annex — PMA test block counters and PCS FEC counters alike — is a 16-or-more quantity, and the FEC counter cannot be anything else.

Only Equation (174A–5) treats bin 16 as exactly 16, so the limit is the one term in the method with no measurable counterpart.

Impact on the error mask

The probability of exactly 16 errors is always less than the probability of 16 or more errors.

Hmax(16) is therefore understated relative to a rigorous tail-based limit.

The mask is tighter, not looser — the error is in the conservative direction.

- A lane that should fail cannot pass because of this mask discrepancy; at worst a compliant lane is held to a slightly stricter limit.
- Where Equation 174A-5 is used with BERadded to calculate BLER though, bin 16 is understated.

At the BER values specified in this annex the two quantities are close, because the binomial terms above k = 16 fall off rapidly.

- For example, p=1 in Table 180-20, receiver error max — ~6% different.
  - 3.6E-13 for exactly 16 test symbol errors
  - 3.8E-13 for 16+ symbol errors
- The difference grows to ~9% at the maximum BER specified in this annex.

Proposed remedy

Retain Equation (174A–5) and the related tables unchanged.

Add the following NOTE to 174A.9.5:

- *NOTE—Equation 174A-5 calculates Hmax(16) as the probability of exactly 16 test-symbol errors, rather than the probability of 16 or more test-symbol errors specified for bin 16 in 174A.9.3. For the BER values specified in this annex, the exact-16 value is a sufficiently accurate and conservative approximation to the 16-or-more value.*

(could be removed)

Minimal editorial impact: one NOTE, no changes to equations, tables, or test procedures.

Removes the ambiguity for implementers reading 174A.9.3, 174A.9.5, and 174A.9.6 together.

Alternative resolution for discussion (original suggestion)

Correct Equation (174A-5) and the affected tables.

- For k = 0 through 15, Hmax(k) remains the probability of exactly k test-symbol errors, using the existing binomial expression.
- For k = 16, Hmax(16) becomes the probability of 16 or more test-symbol errors, summing the binomial terms from 16 through n.
- Revise Equation 174A-5 and the associated text in 174A.9.5, identifying the final histogram value as “16 or more” (“16+”) rather than exactly 16.
- Update the values in row 16 of Table 178–11, Table 179–14, Table 180–20, Table 185–16, and 176C-6.

Consistent with the 17-bin histogram definition used throughout 174A.

Equation 174A-5 also generates Ha(k), the added-BER histogram, in 174A.9.6, 174A.9.7 and 174A.11.4; there the truncation understates the reported BLER rather than tightening a limit.

174A.9.3 requires histogram values to sum to one; the exact-16 form does not, so Hmax is not a histogram by the annex's own definition.

Offered for discussion.

Backup

Table Updates

Update row 16 using these values p = [1 2 4 8]

178-11: [6.4e-12 1.6e-16 2.1e-21 1.4e-26]

179-14: [6.4e-12 1.6e-16 2.1e-21 1.4e-26]

180-20: [3.8e-13 8.3e-18 1.1e-22 6.9e-28]

185-16: [3.8e-13]

176C-6: [6.1e-36 7.6e-41 7.3e-46 4.1e-51]

176D-11: [2.4e-28 3.1e-33 3.1e-38 1.8e-43] * (no change in these values)