

Error ratio requirements in receiver tests

(In support of comments #52, #85, #94, #105,
and #106 against D3.0)

Adee Ran, Cisco

Comment I-52

<i>Cl</i> 178	<i>SC</i> 178.9.3.3	<i>P</i> 394	<i>L</i> 45	# I-52
Brown, Matthew		Qualcomm		
<i>Comment Type</i>	T	<i>Comment Status</i>	X	
Draft 2.2 comment #220 changed BER _{total} in Table 178-10 from 2.92E-4 to 2.921E-4. However, the BER _{max} value in Table 178-10, and the mask values in Table 178-11 were not correspondingly updated. A similar problem exists in Table 179-12/13, Table 180-19/20, Table 181-17/18, and Table 185-15/16.				
<i>SuggestedRemedy</i>				
Update Table 178-10, Table 179-12, Table 180-19, Table 181-17, and Table 185-15, changing BER _{max} to the different of BER _{total} and BER _{added} . Accordingly update the mask values in Table 178-11, Table 179-13, Table 180-20, Table 181-18, and Table 185-16, A contribution will be provided with the updated BER _{max} and mask values.				

Per the the suggested remedy:

- BER_{total} is 2.921e-4 in all tables.
- BER_{added} is specified for each clause in the “Error ratio allocation” subclause (e.g. 178.2).
- **BER_{max} should be set to the difference.**

The mask values for Table 178-11, Table 179-13, Table 180-20, Table 181-18, and Table 185-16 are provided in subsequent slides.

Table 178-10

Table 178-10—Error Ratio Parameters

Parameter name	Value
<i>P</i> 200GBASE-KR1 400GBASE-KR2 800GBASE-KR4 1.6TBASE-KR8	1 2 4 8
BLER limit	1.45×10^{-11}
BER_{total}	2.921×10^{-4}
BER_{added}	1.6×10^{-5}
BER_{max}	2.76×10^{-4} 2.761

$$2.921 \times 10^{-4} - 1.6 \times 10^{-5} = 2.761 \times 10^{-4}$$

Similar change needed in Table 179-12

Table 180-19

Table 180-19—Error ratio parameters

Parameter name	Value
<i>p</i> 200GBASE-DR1 400GBASE-DR2 800GBASE-DR4 1.6TBASE-DR8	1 2 4 8
BLER limit	1.45×10^{-11}
BER_{total}	2.921×10^{-4}
BER_{added}	6.4×10^{-5}
BER_{max}	2.28×10^{-4}

2.281

$$2.921 \times 10^{-4} - 6.4 \times 10^{-5} = 2.281 \times 10^{-4}$$

Similar changes needed in Tables 181-17 and 185-15

Calculation of error histograms

174A.9.5 Error mask test method using PMA measurements

$$H_{\max}(k) = \frac{n!}{k!(n-k)!} \text{RSSER}^k (1 - \text{RSSER})^{n-k} \quad (174A-5)$$

$$\text{RSSER} = 1 - (1 - 2\text{BER}_{\max})^5 \quad (174A-6)$$

The expected BLER is met if, for each lane i , $H_m^{(i)}(k)$ is less than $H_{\max}(k)$ for all $k > 0$.

The result of these equations was calculated for the BER_{\max} values in:

- Table 176C-5 (8e-6, unchanged)
- Table 176D-9 (2.4e-5, unchanged)
- Table 180-19, Table 182-17, and Table 185-15 (updated to 2.281e-4)
- Table 178-10 and Table 179-12 (updated to 2.761e-4)

A calculation spreadsheet is provided with this presentation.

Comment I-105

D3.0

Table 176C-6—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	4.3×10^{-3}	2.2×10^{-3}	1.1×10^{-3}	5.4×10^{-4}
2	9.4×10^{-6}	2.4×10^{-6}	5.9×10^{-7}	1.5×10^{-7}
3	1.4×10^{-8}	1.7×10^{-9}	2.1×10^{-10}	2.6×10^{-11}
4	1.5×10^{-11}	9.1×10^{-13}	5.6×10^{-14}	3.3×10^{-15}
5	1.3×10^{-14}	3.9×10^{-16}	1.2×10^{-17}	3.4×10^{-19}
6	9.1×10^{-18}	1.4×10^{-19}	2.1×10^{-21}	2.9×10^{-23}
7	5.6×10^{-21}	4.2×10^{-23}	3.1×10^{-25}	2.0×10^{-27}
8	3.0×10^{-24}	1.1×10^{-26}	3.9×10^{-29}	1.2×10^{-31}
9	1.4×10^{-27}	2.6×10^{-30}	4.5×10^{-33}	6.6×10^{-36}
10	6.2×10^{-31}	5.5×10^{-34}	4.6×10^{-37}	3.1×10^{-40}
11	2.4×10^{-34}	1.1×10^{-37}	4.2×10^{-41}	1.3×10^{-44}
12	8.5×10^{-38}	1.8×10^{-41}	3.5×10^{-45}	5.0×10^{-49}
13	2.8×10^{-41}	2.9×10^{-45}	2.7×10^{-49}	1.7×10^{-53}
14	8.4×10^{-45}	4.3×10^{-49}	1.9×10^{-53}	5.4×10^{-58}
15	2.4×10^{-48}	6.0×10^{-53}	1.2×10^{-57}	1.6×10^{-62}
16	6.3×10^{-52}	7.7×10^{-57}	7.4×10^{-62}	4.1×10^{-67}

Calculation with $BER_{\max} = 8e-6$

k	p=1	p=2	p=4	p=8
1	4.2E-02	2.1E-02	1.1E-02	5.4E-03
2	9.1E-04	2.3E-04	5.8E-05	1.5E-05
3	1.3E-05	1.7E-06	2.1E-07	2.6E-08
4	1.4E-07	8.9E-09	5.5E-10	3.3E-11
5	1.2E-09	3.8E-11	1.2E-12	3.4E-14
6	8.8E-12	1.4E-13	2.0E-15	2.9E-17
7	5.4E-14	4.2E-16	3.0E-18	2.0E-20
8	2.9E-16	1.1E-18	3.9E-21	1.2E-23
9	1.4E-18	2.6E-21	4.4E-24	6.6E-27
10	5.9E-21	5.4E-24	4.5E-27	3.1E-30
11	2.3E-23	1.0E-26	4.1E-30	1.3E-33
12	8.2E-26	1.8E-29	3.4E-33	5.0E-37
13	2.7E-28	2.9E-32	2.6E-36	1.7E-40
14	8.1E-31	4.3E-35	1.9E-39	5.4E-44
15	2.3E-33	5.9E-38	1.2E-42	1.6E-47
16	6.1E-36	7.5E-41	7.3E-46	4.1E-51

Major change

Comment I-85

D3.0

Table 178-11—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	3.3×10^{-1}	3.5×10^{-1}	2.6×10^{-1}	1.6×10^{-1}
2	2.5×10^{-1}	1.3×10^{-1}	4.8×10^{-2}	1.4×10^{-2}
3	1.3×10^{-1}	3.3×10^{-2}	6.0×10^{-3}	8.8×10^{-4}
4	4.7×10^{-2}	6.1×10^{-3}	5.5×10^{-4}	3.9×10^{-5}
5	1.4×10^{-2}	9.1×10^{-4}	4.0×10^{-5}	1.4×10^{-6}
6	3.5×10^{-3}	1.1×10^{-4}	2.4×10^{-6}	4.1×10^{-8}
7	7.4×10^{-4}	1.2×10^{-5}	1.2×10^{-7}	9.9×10^{-10}
8	1.4×10^{-4}	1.1×10^{-6}	5.5×10^{-9}	2.1×10^{-11}
9	2.3×10^{-5}	8.7×10^{-8}	2.2×10^{-10}	3.9×10^{-13}
10	3.3×10^{-6}	6.4×10^{-9}	7.6×10^{-12}	6.3×10^{-15}
11	4.5×10^{-7}	4.2×10^{-10}	2.4×10^{-13}	9.2×10^{-17}
12	5.5×10^{-8}	2.5×10^{-11}	6.9×10^{-15}	1.2×10^{-18}
13	6.2×10^{-9}	1.4×10^{-12}	1.8×10^{-16}	1.4×10^{-20}
14	6.5×10^{-10}	7.1×10^{-14}	4.4×10^{-18}	1.6×10^{-22}
15	6.4×10^{-11}	3.4×10^{-15}	1.0×10^{-19}	1.5×10^{-24}
16	6.4×10^{-12}	1.6×10^{-16}	2.1×10^{-21}	1.4×10^{-26}

Calculation with $BER_{\max} = 2.761e-4$

k	p=1	p=2	p=4	p=8
1	3.3E-01	3.5E-01	2.6E-01	1.6E-01
2	2.5E-01	1.3E-01	4.8E-02	1.4E-02
3	1.3E-01	3.3E-02	6.0E-03	8.8E-04
4	4.7E-02	6.2E-03	5.5E-04	3.9E-05
5	1.4E-02	9.1E-04	4.0E-05	1.4E-06
6	3.5E-03	1.1E-04	2.4E-06	4.1E-08
7	7.4E-04	1.2E-05	1.2E-07	9.9E-10
8	1.4E-04	1.1E-06	5.5E-09	2.1E-11
9	2.3E-05	8.8E-08	2.2E-10	3.9E-13
10	3.4E-06	6.4E-09	7.6E-12	6.3E-15
11	4.5E-07	4.2E-10	2.4E-13	9.2E-17
12	5.5E-08	2.5E-11	7.0E-15	1.2E-18
13	6.3E-09	1.4E-12	1.8E-16	1.4E-20
14	6.6E-10	7.2E-14	4.5E-18	1.6E-22
15	6.4E-11	3.4E-15	1.0E-19	1.6E-24
16	5.9E-12	1.5E-16	2.1E-21	1.4E-26

Minor corrections (insubstantial)

Similar change needed in Table 179-13

Comment I-94

D3.0

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}

Calculation with $BER_{\max} = 2.281e-4$

k	p=1	p=2	p=4	p=8
1	3.6E-01	3.3E-01	2.3E-01	1.3E-01
2	2.2E-01	1.0E-01	3.5E-02	1.0E-02
3	9.2E-02	2.1E-02	3.6E-03	5.1E-04
4	2.8E-02	3.3E-03	2.7E-04	1.9E-05
5	7.0E-03	4.0E-04	1.6E-05	5.5E-07
6	1.4E-03	4.1E-05	8.2E-07	1.3E-08
7	2.5E-04	3.5E-06	3.5E-08	2.7E-10
8	3.9E-05	2.7E-07	1.3E-09	4.7E-12
9	5.3E-06	1.8E-08	4.2E-11	7.1E-14
10	6.4E-07	1.1E-09	1.2E-12	9.6E-16
11	7.1E-08	5.8E-11	3.2E-14	1.2E-17
12	7.2E-09	2.9E-12	7.5E-16	1.3E-19
13	6.8E-10	1.3E-13	1.6E-17	1.2E-21
14	5.9E-11	5.6E-15	3.3E-19	1.1E-23
15	4.7E-12	2.2E-16	6.1E-21	9.1E-26
16	3.6E-13	8.1E-18	1.1E-22	6.9E-28

Minor corrections (insubstantial)

Similar changes needed in Tables 181-16 and 185-16

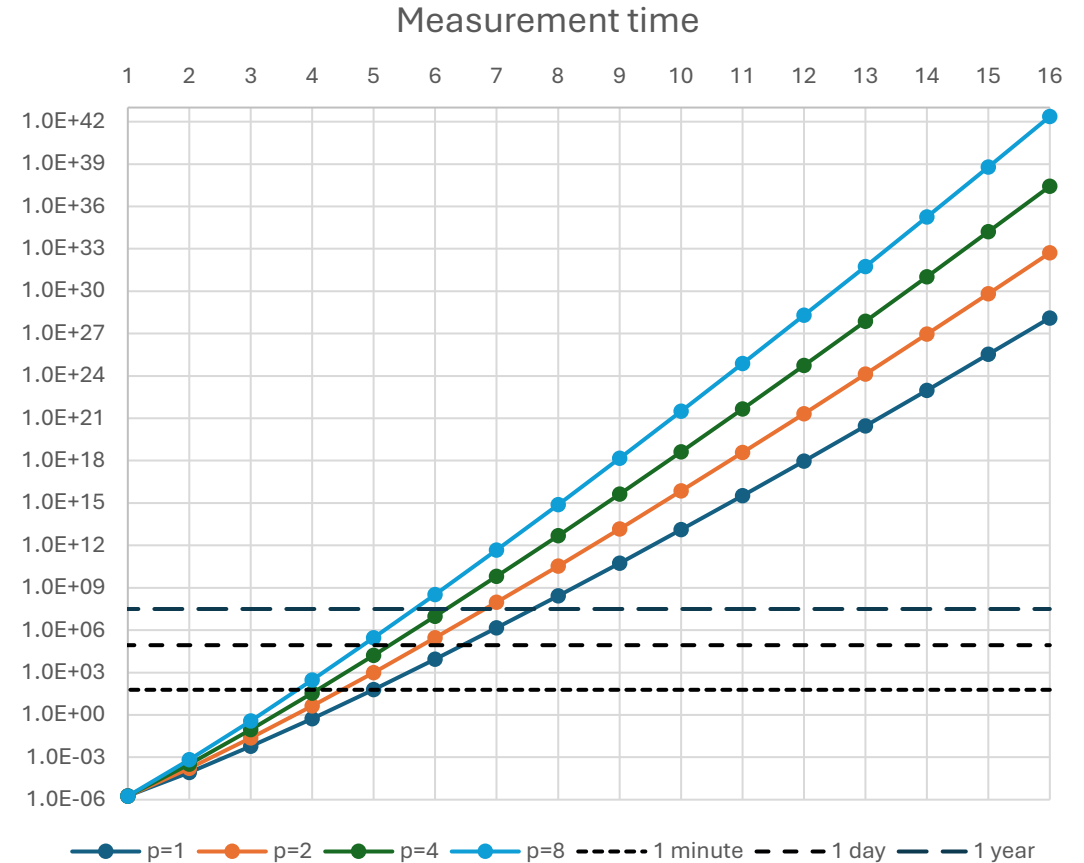
Comment I-106

- Per 174A.9.5: “The expected BLER is met if, for each lane i , $H_m^{(i)}(k)$ is less than $H_{\max}(k)$ for all $k > 0$ ”.
- measurement should be long enough to verify that the event probability is lower than the required value.
 - Typically, measurement time is defined as least 3 times the mean time between events (if no events are observed).
 - The number 3 is associated with a confidence level of 95% and is insignificant in this case.
- I calculated the required times for each value in each table.
 - Verifying the largest values of k is not feasible/practical (especially with AUIs or with $k > 1$), making the requirement impossible to verify without some extrapolation.
 - A similar issue exist in optical PMD clauses and is addressed by informative notes. The electrical PMDs and AUIs do not have such notes.

Table 176C-5 (corrected values)

k	p=1	p=2	p=4	p=8
1	1.8E-06	1.8E-06	1.8E-06	1.8E-06
2	8.5E-05	1.7E-04	3.3E-04	6.6E-04
3	5.9E-03	2.3E-02	9.2E-02	3.8E-01
4	5.4E-01	4.3E+00	3.5E+01	2.9E+02
5	6.3E+01	1.0E+03	1.6E+04	2.8E+05
6	8.7E+03	2.8E+05	9.4E+06	3.4E+08
7	1.4E+06	9.3E+07	6.3E+09	4.7E+11
8	2.6E+08	3.5E+10	4.9E+12	7.8E+14
9	5.6E+10	1.5E+13	4.3E+15	1.5E+18
10	1.3E+13	7.1E+15	4.3E+18	3.1E+21
11	3.3E+15	3.7E+18	4.6E+21	7.3E+24
12	9.4E+17	2.1E+21	5.6E+24	1.9E+28
13	2.9E+20	1.3E+24	7.3E+27	5.6E+31
14	9.5E+22	9.0E+26	1.0E+31	1.8E+35
15	3.3E+25	6.5E+29	1.6E+34	6.2E+38
16	1.3E+28	5.1E+32	2.6E+37	2.3E+42

More than a minute
 More than a day
 more than a year



Annex 176D

k	p=1	p=2	p=4	p=8
1	6.7E-07	6.3E-07	6.1E-07	6.0E-07
2	1.0E-05	1.9E-05	3.8E-05	7.4E-05
3	2.4E-04	8.9E-04	3.5E-03	1.4E-02
4	7.3E-03	5.5E-02	4.4E-01	3.6E+00
5	2.8E-01	4.3E+00	6.9E+01	1.2E+03
6	1.3E+01	4.0E+02	1.3E+04	4.7E+05
7	7.1E+02	4.4E+04	3.0E+06	2.2E+08
8	4.4E+04	5.6E+06	7.6E+08	1.2E+11
9	3.1E+06	7.9E+08	2.2E+11	7.5E+13
10	2.4E+08	1.2E+11	7.3E+13	5.3E+16
11	2.1E+10	2.2E+13	2.7E+16	4.2E+19
12	1.9E+12	4.2E+15	1.1E+19	3.7E+22
13	2.0E+14	8.7E+17	4.7E+21	3.5E+25
14	2.2E+16	2.0E+20	2.2E+24	3.8E+28
15	2.5E+18	4.8E+22	1.1E+27	4.3E+31
16	3.2E+20	1.2E+25	6.2E+29	5.5E+34

More than a minute
 More than a day
 more than a year

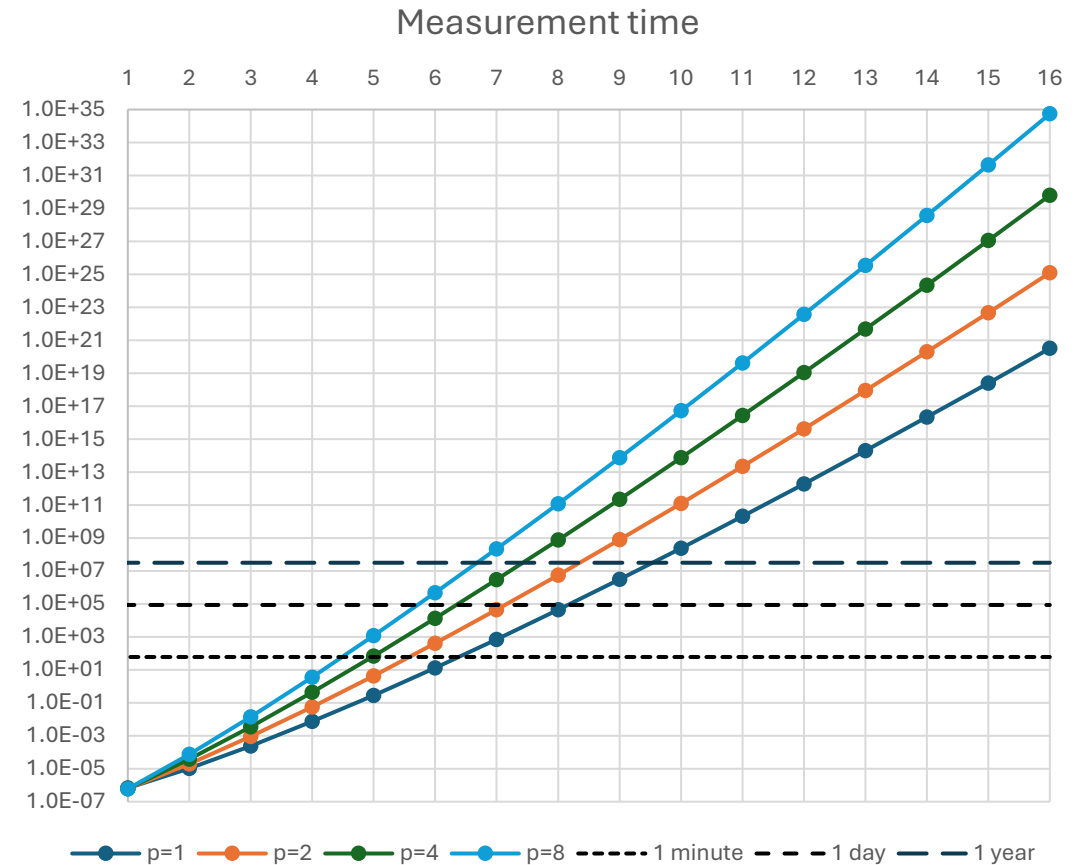


Table 178–10, Table 179–12

k	p=1	p=2	p=4	p=8
1	2.3E-07	1.1E-07	7.4E-08	6.2E-08
2	3.1E-07	2.9E-07	4.0E-07	6.6E-07
3	6.1E-07	1.2E-06	3.2E-06	1.1E-05
4	1.6E-06	6.2E-06	3.5E-05	2.4E-04
5	5.5E-06	4.2E-05	4.8E-04	6.9E-03
6	2.2E-05	3.4E-04	7.9E-03	2.4E-01
7	1.0E-04	3.3E-03	1.5E-01	9.7E+00
8	5.6E-04	3.6E-02	3.5E+00	4.6E+02
9	3.4E-03	4.4E-01	8.8E+01	2.5E+04
10	2.3E-02	6.0E+00	2.5E+03	1.5E+06
11	1.7E-01	9.1E+01	7.9E+04	1.0E+08
12	1.4E+00	1.5E+03	2.8E+06	7.9E+09
13	1.2E+01	2.7E+04	1.0E+08	6.7E+11
14	1.2E+02	5.4E+05	4.3E+09	6.1E+13
15	1.2E+03	1.1E+07	1.9E+11	6.2E+15
16	1.3E+04	2.5E+08	9.1E+12	6.7E+17

More than a minute
 More than a day
 more than a year

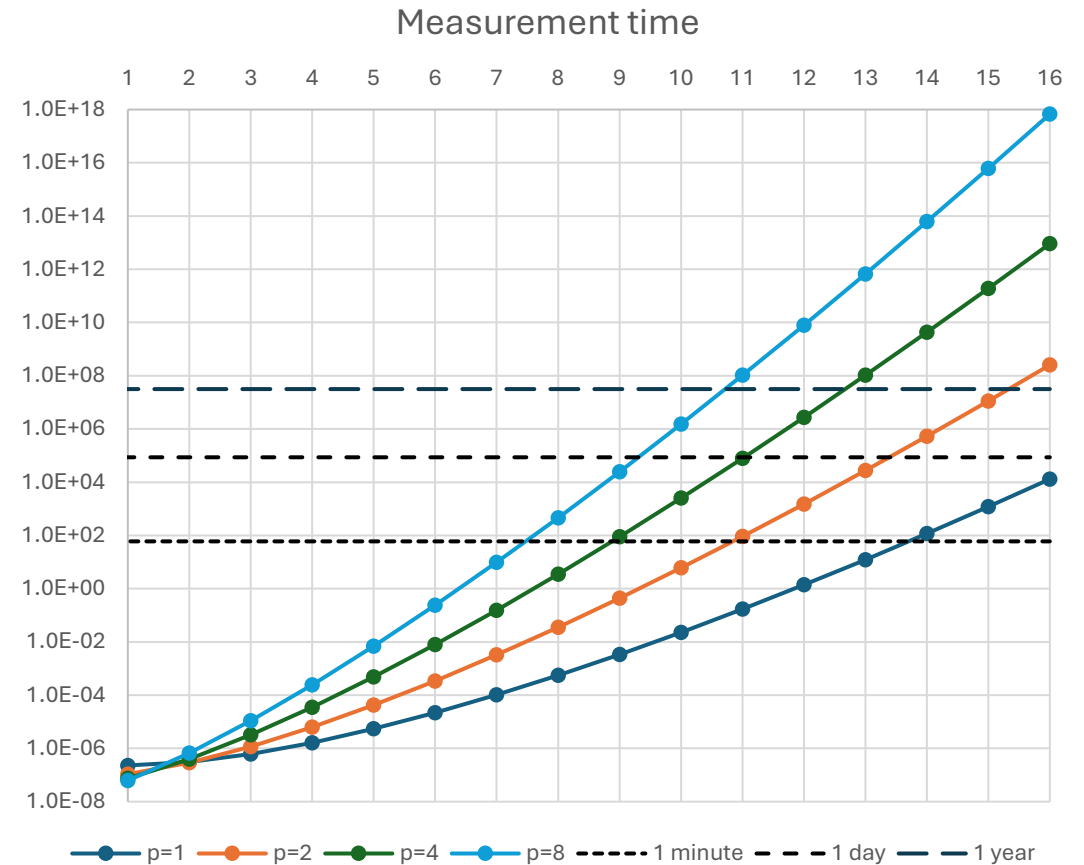
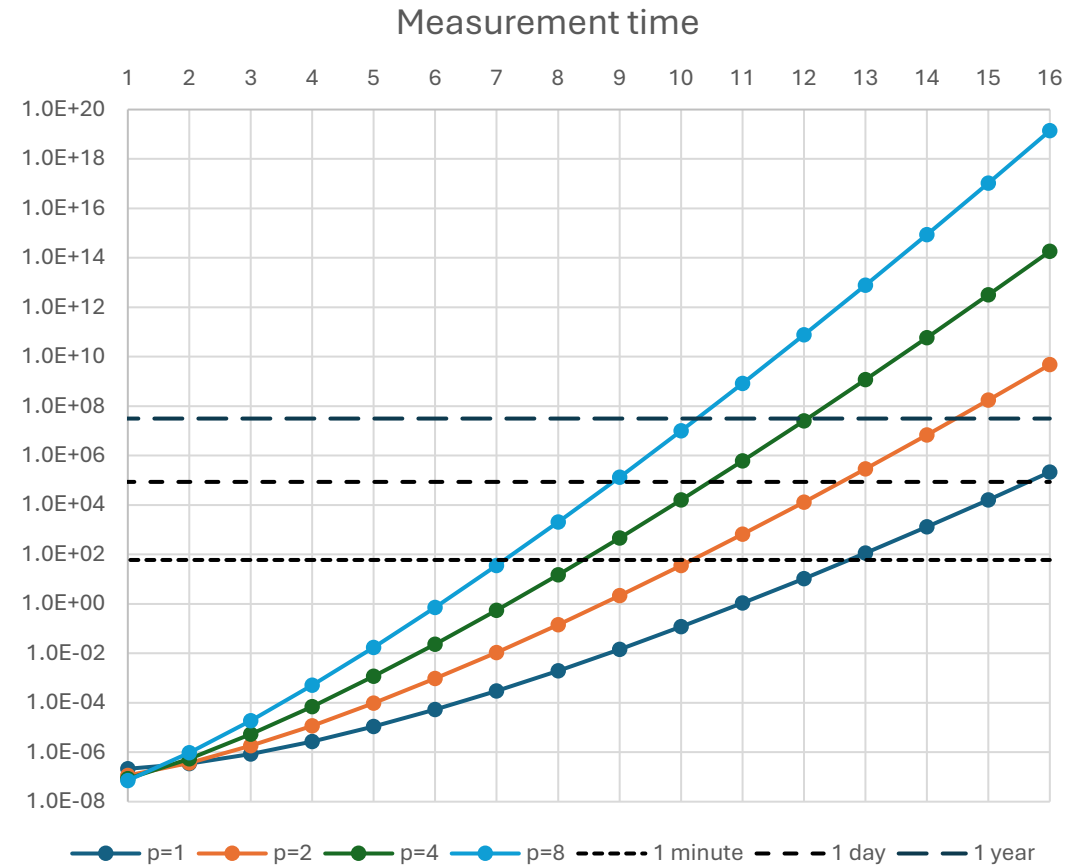


Table 180–19, Table 182–17, Table 185–15

k	p=1	p=2	p=4	p=8
1	2.1E-07	1.1E-07	8.4E-08	7.2E-08
2	3.4E-07	3.7E-07	5.5E-07	9.4E-07
3	8.4E-07	1.8E-06	5.4E-06	1.9E-05
4	2.7E-06	1.2E-05	7.1E-05	5.1E-04
5	1.1E-05	9.6E-05	1.2E-03	1.7E-02
6	5.3E-05	9.5E-04	2.3E-02	7.2E-01
7	3.0E-04	1.1E-02	5.5E-01	3.6E+01
8	2.0E-03	1.4E-01	1.5E+01	2.0E+03
9	1.5E-02	2.1E+00	4.6E+02	1.3E+05
10	1.2E-01	3.6E+01	1.6E+04	1.0E+07
11	1.1E+00	6.6E+02	6.1E+05	8.3E+08
12	1.1E+01	1.3E+04	2.6E+07	7.6E+10
13	1.1E+02	2.9E+05	1.2E+09	7.8E+12
14	1.3E+03	6.9E+06	5.9E+10	8.6E+14
15	1.6E+04	1.7E+08	3.2E+12	1.1E+17
16	2.2E+05	4.8E+09	1.8E+14	1.4E+19

More than a minute
 More than a day
 more than a year



Suggested remedy for Comment I-106

- Add the following NOTE after Table 176C-6, **based on 180.9.16:**
NOTE—If the statistical projection is modeled accurately by a linear fit extrapolation, a means to provide statistical projection of the measured histograms (see 174A.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 $\log_{10}(H_m^{(i)}(16))$, for $k = 1$ to n , where n is the largest value of k for which all bins from 0 to k have a count greater than 2.
- Add similar notes after Table 176D-10, Table 178-11, and Table 179-13.