Alternative optical Tx eye-mask for 10GBASE-R modules (Clause 52)

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Proposal

- Add an alternative optical transmitter eye-mask test for 10GBASE-R optical modules, to allow the use of a statistical eye mask test, with appropriately revised eye-mask coordinates and a maximum ratio of $5x10^{-5}$ hits per sample.

Why: The optical Tx eye-mask test issue

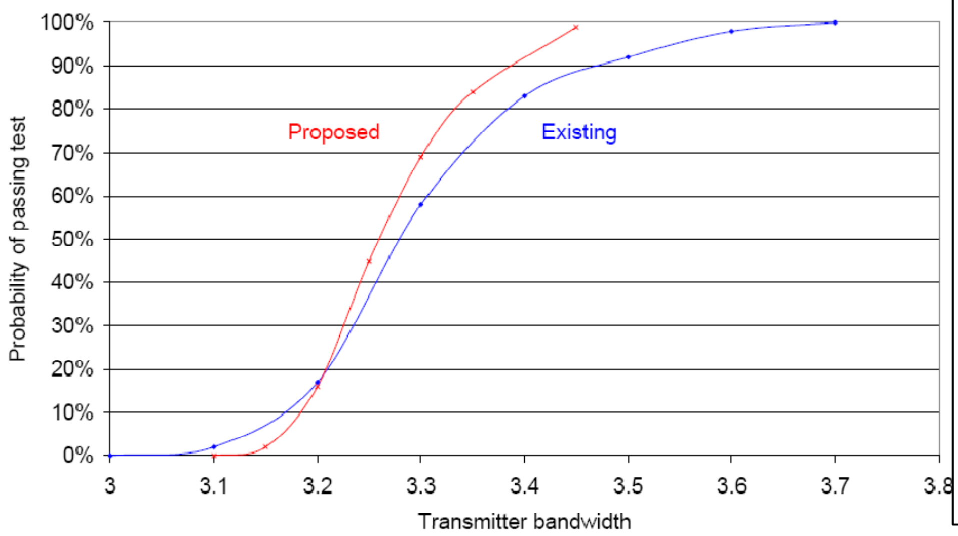
- The current optical transmitter eye-mask test for 10GBASE-R optical transmitters is commonly implemented as a zero hit eye-mask test.
- A zero hit eye-mask test has several drawbacks
  – Eye mask margin is determined by a single rare event – poor repeatability
    - Eye-mask measurements by different parties are difficult to correlate
  – Larger numbers of samples make the test even less repeatable !
- The single hit criterion causes a large range in device performance between all-passing and all-failing. Failing good devices adds cost.

Statistical eye mask approach

- Statistical eye-mask tests allow a maximum (non-zero) ratio of mask hits to samples taken. They were adopted in recent standards 802.3aq and 802.3ba.
  - They are better than zero hit eye-mask tests:
    - More accurate and repeatable
    - Faster and lower test cost for similar quality of test
    - Eye-mask margin measurements are largely independent of number of samples (provided the number of samples >> hit ratio)
- Anticipated benefits to 10GBASE-R community:
  - Better discrimination between ‘good’ and ‘bad’ transmitters
    - See simulation work in Pete Anslow presentation ‘10GBASE-S/L/E eye mask’, and measurements reported in this presentation http://www.ieee802.org//3/maint/email/pdf9albvcMFYq.pdf
  - Better consistency between module maker and module user tests
  - Lower module test cost

Eye mask test methods compared - simulation

- Simulation – Pete Anslow's presentation
  http://www.ieee802.org//3/maint/email/pdf9albvcMFYq.pdf



Existing:

- current clause 52 eye mask coordinates, no hits allowed inside the eye mask

Proposed:

- Eye mask coordinates below; up to $5x10^{-5}$ hit ratio allowed

X1	X2	X3	Y1	Y2	Y3
0.235	0.395	0.45	0.235	0.265	0.4

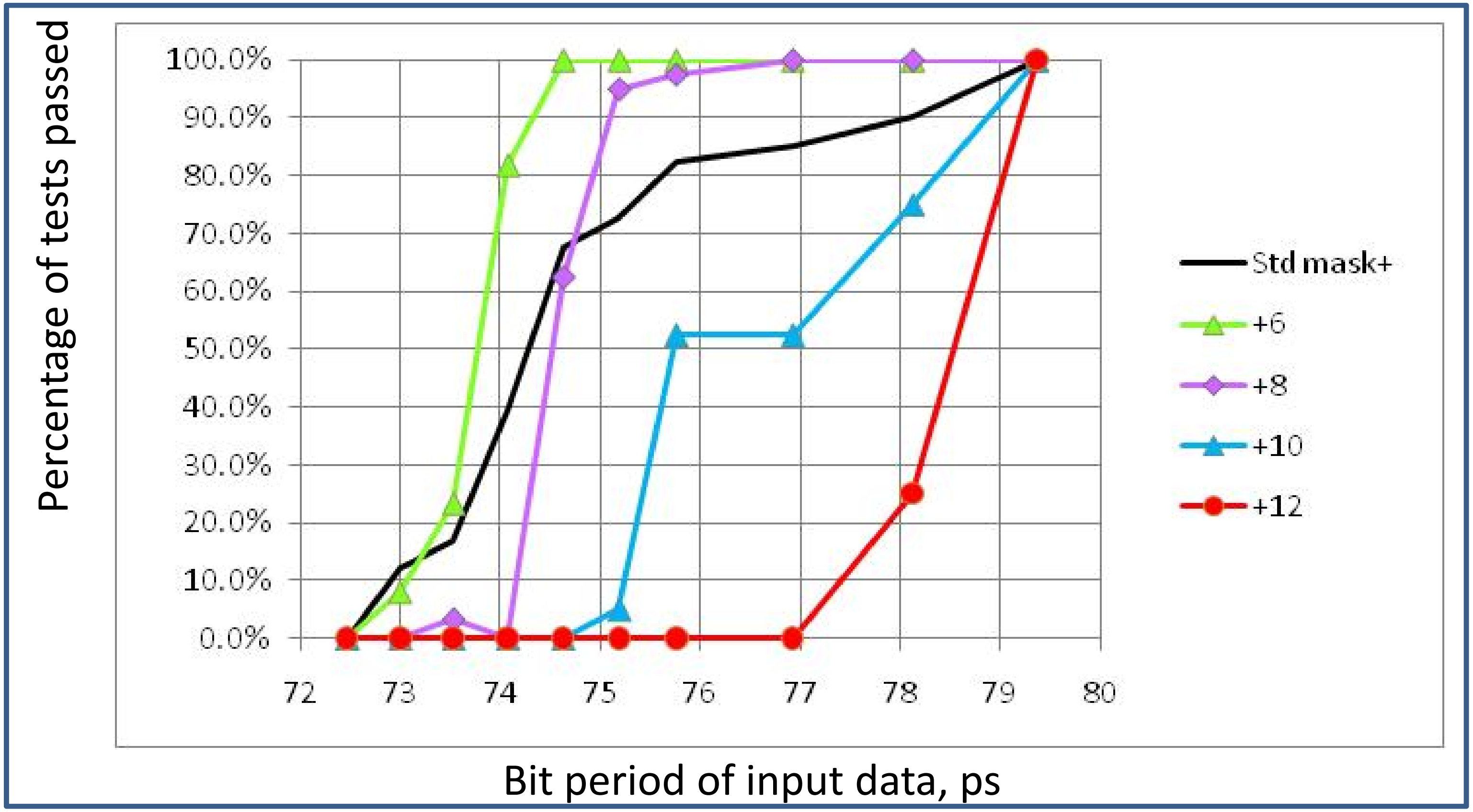
- The proposed eye mask test shows better discrimination of 'good' and 'bad' transmitters (steeper slope)
  - The proposed eye mask test plot crosses the existing eye mask test plot at around 15%.
  - In practice, the existing eye mask test has not allowed a significant number of 'bad' transmitters into the field (perhaps <1 to 10%, otherwise we would know about it !)
  - A specific marginal transmitter which has a significant (>1 to 10%) chance of passing the existing eye mask test, should have a similar probability of passing an equivalent eye mask test (i.e. plots of the probability of passing each test vs transmitter quality should cross at that percentage value of passing)

Eye-mask test methods compared - measurements

- A comparison of pass/fail rates for transmitter eye mask tests was made:
  - the 10GBASE-R standard zero-hit eye mask from clause 52

    and
  - a set of test eye masks scaled from the clause 52 mask coordinates, with max hit ratio of $5x10^{-5}$
    - + 6%, +8%, +10%, +12%
- A total of approx 1800 mask measurements were made using a typical SFP+ 10G SR compliant module. 500,000 samples / UI were taken, allowing up to 25 hits in the mask area for a hit ratio $\leq 5x10^{-5}$
- In order to produce a marginal transmitter eye, the input data rate to the module was increased to between 12.8 GHz and 13.8 GHz. The resulting transmit eye has greater jitter and ISI. Eye mask coordinates were scaled with bit rate and eye height, per standard procedure.

Measurement results



- The eye mask coordinates and the measured results for the +6% eye mask agree very closely with the simulations in Pete Anslow's '10GBASE-S/L/E eye mask': the clause 52 eye mask and the +6% eye mask have ~15% pass rate at the same input data bit period.
- All the hit ratio masks have significantly steeper slopes (better discrimination between good and bad transmitters) than the 0 hit eye mask

Conclusions

- A comparison of the clause 52 optical transmitter eye mask test and a set of scaled eye masks with max hit ratio of $5x10^{-5}$ has been made. The hit ratio eye masks all show better discrimination between good and bad transmitters.
- The measured results for the +6% mask confirm the simulations in Pete Anslow's '10GBASE-S/L/E eye mask'.

- An alternative eye mask test is proposed which allows up to $5x10^{-5}$ hits, with eye mask coordinates:

X1	**X2**	**X3**	**Y1**	**Y2**	**Y3**
0.235	0.395	0.45	0.235	0.265	0.4

Proposed changes to Clause 52

- Add a row to each of tables 52-7, 52-12, 52-16

Transmitter eye mask definition A {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}	
Transmitter eye mask definition B {X1, X2, X3, Y1, Y2, Y3} Hit ratio 5×10^{-5} per sample	{0.235, 0.395, 0.45, 0.235, 0.265, 0.4}	

- Add a footnote to both transmitter eye mask definitions in each of tables 52-7, 52-12, 52-16: "Either transmitter eye mask definition A or B may be used. A transmitter is not required to comply with both definitions."
- Add text to Clause 52.9.7 to introduce the hit ratio method: In the first paragraph change "Measurements should be made as defined by IEC 61280-2-2" to "Measurements should be made as defined by IEC 61280-2-2 with the eye mask definition A coordinates, or as defined by 86.8.3.2 with the eye mask definition B coordinates. The two sets of coordinates (A and B) are given in Table 52–7, Table 52–12 or Table 52–16 as appropriate. A transmitter is not required to comply with both definitions."
- If the text above is added to section 52.9.7 then the existing PICS entry covers the existing and alternative eye mask tests.

OM7	Transmit eye	52.9.7	10.3125 GBd shall qualify for 10GBASE-W and 10GBASE-R use, measurement at 9.95328 GBd shall qualify for 10GBASE-W use only	M	Yes [ ]

Back up

Table of eye mask co-ordinates used in measurements

Eye mask	X1	X2	X3	Y1	Y2	Y3	Hits allowed
Clause 52	0.25	0.4	0.45	0.25	0.28	0.4	0
+6 %	0.235	0.394	0.447	0.235	0.267	0.4	5×10^{-5}
+8 %	0.23	0.392	0.446	0.23	0.262	0.4	5×10^{-5}
+10 %	0.225	0.39	0.445	0.225	0.258	0.4	5×10^{-5}
+12 %	0.22	0.388	0.444	0.22	0.254	0.4	5×10^{-5}

Note: the +6% mask coordinates are almost identical to the alternative eye mask coordinates proposed in '10GBASE-S/L/E eye mask' by Pete Anslow

Proposed alternative eye mask:

{X1, X2, X3, Y1, Y2, Y3} = {0.235, 0.395, 0.45, 0.235, 0.265, 0.4} with 5×10^{-5} hits allowed

Illustration of existing and proposed eye mask coordinates