Enabling shorter $J4u_{03}$ measurement
(comment #201)

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Background

- $J4u_{03}$ is one of the jitter specifications defined in Clause 179 (179.9.4.6.2).
  - It is a variation of J4u that has been used in previous generations of electrical specifications.
- $J4u_{03}$ measurement requires collecting a large sample of transitions to create a probability distribution estimate with resolution <1e-4.
  - This requires “□ $\times 10^4$" repetitions of the test pattern.
  - The other two jitter specifications (J_{RMS} and EOJ) can be estimated from a much smaller sample size, “□ $\times 10$” repetitions are likely enough.
- On electrical interfaces, it is specified to be measured from either PRBS13Q or PRBS9Q.
  - Measurement of the full sample size with PRBS13Q can take ~ minute.
  - PRBS9Q is 16 times shorter than PRBS13Q, so it enables much faster collection of the same sample size.
- As of D2.2 , $J4u_{03}$ is also a specification of optical IM-DD PMD transmitters.

Problem statement and goal

- Most optical measurements are made with the SSPRQ test pattern.
  - SSPRQ is 8 times longer than PRBS13Q so measurement will be significantly longer than PRBS13Q.
- Beyond the time of the test pattern itself, memory and processing requirements also increase the measurement time.
  - Shorter test times would also benefit measurements of electrical interfaces with PRBS13Q.
- This presentation suggests an option to calculate $J4u_{03}$ from a smaller number of repetitions of a given test pattern.

The existing method

179.9.4.6.2 $J4u_{03}$

Calculation of the jitter parameter $J4u_{03}$ uses the timing of two specific transitions, R03 (from the symbol 0 to the symbol 3) and F30 (from the symbol 3 to the symbol 0). The location of the specific transitions in the test pattern and the threshold levels at which the transition times are extracted are chosen from the measured signal to minimize $J4u_{03}$. The transitions and thresholds in Table 120D–4 (for PRBS13Q) and Table 162–13 (for PRBS9Q) are examples that may be chosen in many practical cases.

For each of the two transitions (i=1 to 2):

— Obtain a set $A_i = \{t_i(1), t_i(2), \ldots\}$ of transition times modulo the period of the pattern. The sizes of each set should be large enough to enable estimation of Jnu_{03} (as defined below) with sufficient accuracy.

— From the set A_i, create an estimated probability distribution $f_i(t)$.

— Denote by Jnu_i the time interval that includes all but 10^{-n} of $f_i(t)$, between the $5 \times 10^{-(n+1)}$ and the $1 - 5 \times 10^{-(n+1)}$ quantiles of $f_i(t)$

Rationale: a specific transition "suffers" from the same ISI, and has the same slope, on each repetition of the test pattern.

Therefore, there are no variations of its timing due to ISI, and thus "data dependent jitter" is excluded from the measurement.

Since each transition appears once per repetition of the test pattern, **the size of each set** is the number of required repetitions of the test pattern.

How to measure faster

- Assume we collect K sets of R03 on K different transitions, instead of one (and similarly for F30).
- The probability distributions $f_{ik}(t)$ of each of the K sets will be different…
  - Obviously, the means are different
  - Other than the mean, if the slopes at the threshold levels of each transition are the same, the distributions should be the same
- If we subtract the mean, we can expect the same distribution, so the K sets can be combined to form a larger set with the same distribution
- The number of repetitions needed to get a set of the required size (“$\square \times 10^4$”) will be reduced by a factor of K.

Free lunch?!

- “if the slopes at the threshold levels of each transition are the same, the distributions should be the same”
  - … the slopes are never exactly the same
  - The distributions of the K subsets may be different for other reasons
  - Any subset that has a wider distribution than others combined with it will have a larger effect on the result (increasing the measured $J4u_{03}$)
- This method has a tradeoff between measurement speed and accuracy, but only in one direction: faster measurement will make the result worse
- Passing a shortened test is sufficient
  - If you don’t pass, you can wait for a longer time to collect the data required in the existing method (a single transition)
  - But if you pass with a “combined set” you don’t have to wait any longer
- For optical measurements with SSPRQ the benefit can be significant

Proposed change

- Add the following in 179.9.4.6.2 (with editorial license):

As a way to reduce the measurement time, the following method may be used.

Each set A_i is created by joining several subsets A_{ik} (k=1 to K), where each value of k corresponds to a different location in the test pattern and the K subsets are shifted to have the same mean. For a given value of i, the K locations in the test pattern are all between the same two levels, and should be chosen such that the distributions of the subsets A_{ik} are as close as possible.

The value of $J4u_{03}$ calculated from the sets A_i created using this method with $K>1$ is an estimate of the value obtained in a full measurement ($K=1$). Meeting the $J4u_{03}$ requirement with $K>1$ is sufficient (but not necessary) to demonstrate compliance.

Extensions

- There is a separate proposal to calculate J4U using a model created by fitting dual-Dirac representations of multiple transitions (similar to the calculation of J_{RMS} in 179.9.4.6.1)
- Would the modified method suggested in this presentation work in this case?
  - Creating a dual-Dirac representation still requires a large enough sample to observe the “Gaussian tail”
  - Assuming several transitions have similar distributions, they can be joined to create a larger sample from which the dual-Dirac can be estimated
  - The error introduced by this method is still in one direction
  - Having one large set instead of K sets of similar slopes will not reduce the accuracy of a model (the K sets are essentially the same point in the model)
- Bottom line: combination of K of similar transitions should be allowed

Summary

- A method for fast estimation of $J4u_{03}$ was presented
- The estimation can only be worse than the “true” value (as currently specified)
- The fast estimate will enable decision that a device passes the test after a shorter time
  - This will be sufficient in case the DUT has enough margin to cover the inaccuracy
  - If the result is not sufficient to pass, the test can be run for the full time to make a final decision
- The proposal is specific for J4u measurements – not proposed for J_{RMS} and EOJ measurements, which are much faster

That’s all!

Questions?