Jitter and noise measurements in presence of crosstalk and 802.3bj

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Total Jitter Measurement (TJ) etc. measurements in presence of crosstalk are used in 802.3

- TJ and similar (TJ, J9, RJ) measurements are present in 802.3ba and likely to be used to verify the .3bj simulations and in the compliance verification.
- Since crosstalk is a significant impairment to the standard, some measurements are done in presence of crosstalk.
- The measurements can be typically done with a BERT or an oscilloscope
- The oscilloscope measurement/TJ extrapolation is faster and more sensitive due to the oscilloscope's lower jitter/noise floors…
- …but oscilloscopes jitter measurement/TJ extrapolation in presence of crosstalk are reported to be burdened with a significant error.
- The goal of this presentation is to make you aware of this and start a dialog towards solutions. There is no magic bullet here.

State of jitter measurements

- Oscilloscope jitter tools often exhibit difficulty when measuring and extrapolating jitter in the presence of long patterns (PRB31) and crosstalk; this is –at least partially- the reason the standard doesn't recommend oscilloscopes for many of its jitter measurements.
- Jitter measurements done with a BERT can handle the PRBS31 pattern; however such measurements are not particularly fast or convenient.
- Thus shorter patterns are sometimes used by the implementers; this enables the use of oscilloscopes but leads to increased pessimisms due to crosstalk.
  Assuming that there is a case for oscilloscopes to be used in the jitter measurements, here is the crux of the problem:

Jitter measurement in the presence of crosstalk, BUJ

- Crosstalk-caused jitter typically presents as a Bounded Uncorrelated Jitter (BUJ).
  In traditional oscilloscope-based jitter measurement methodology the more spectrally complex BUJ components (e.g. Non-Periodic BUJ, NP-BUJ) are not distinguished from RJ, leading to error in RJ and in TJ estimate.
  This is well known and was documented e.g. in
  "*Method of BER Analysis of High Speed Serial Data Transmission in Presence of Jitter and Noise*", Zivny at all, DesignCon 2007.
  Next slide shows the summary from that paper:

TJ and RJ results as a function of length of the aggressor PRBS pattern

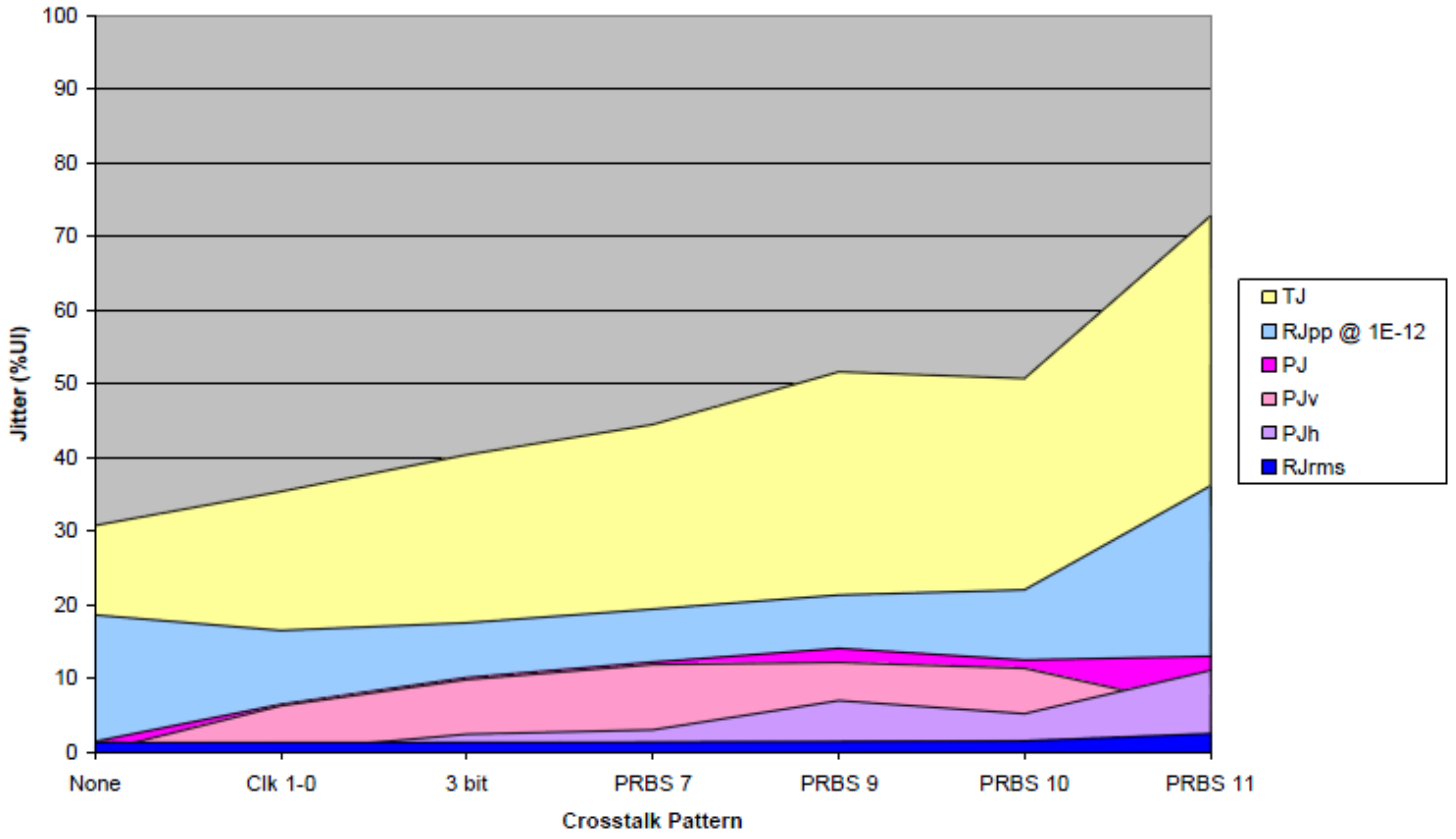


Figure 13 Jitter Measurements as Function of Crosstalk Pattern

This particular sampling oscilloscope measuring one particular DUT in 2007 is a good example of the problem. Other systems' results discussed below.

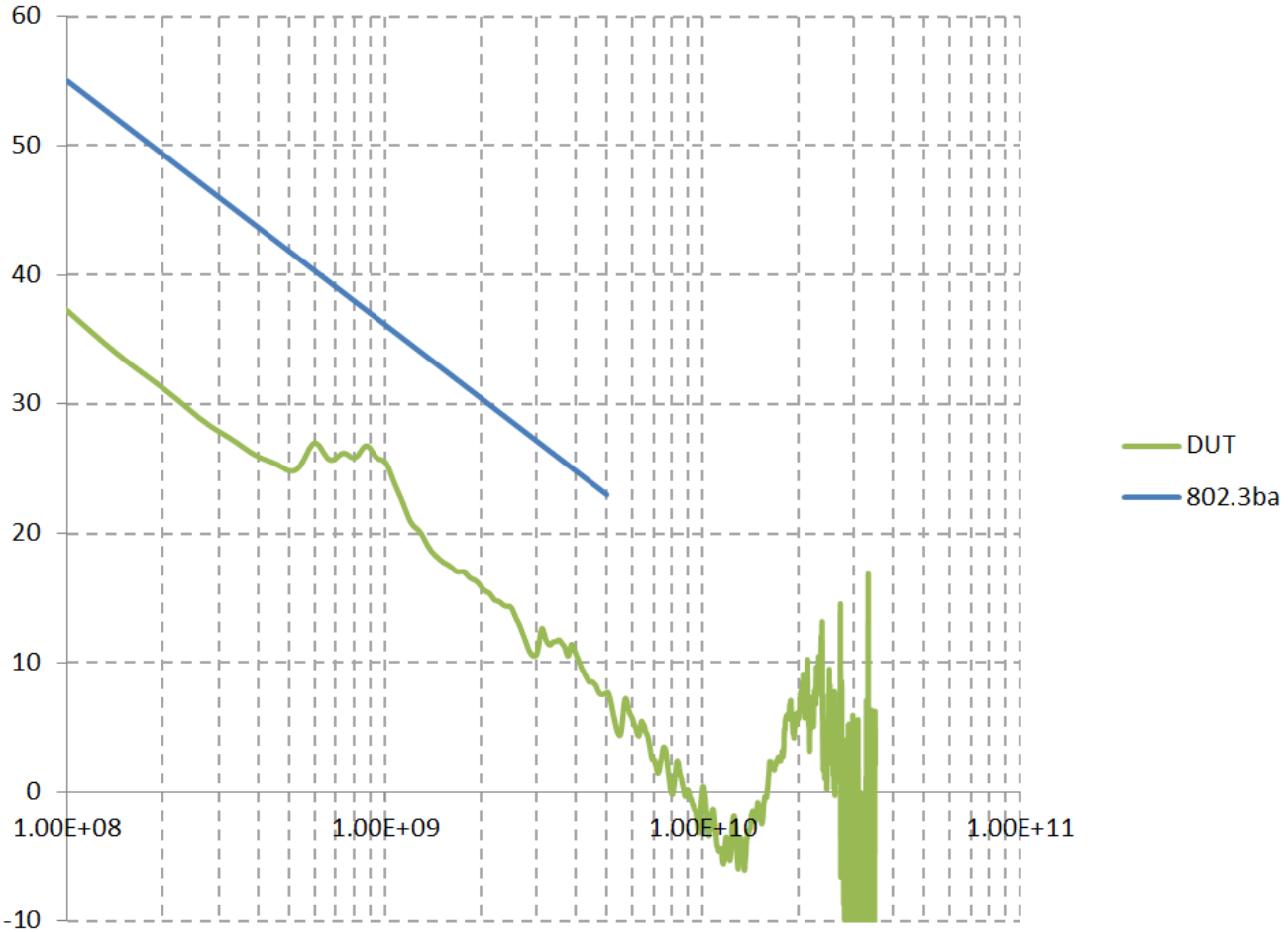
Experiment: measurements of jitter in the presence of crosstalk over several oscilloscopes

Experiment setup:

- Strong asynchronous FEXT crosstalk
  - Intentionally worse ICR than realistic communication channel (next slide)
  - victim at 10 Gb/s, aggressor at 10.3125 Gb/s
  - DUT has two parallel runs on the FR4 (one victim, one aggressor)

Experiment's DUT: ICR …

Insertion loss vs. crosstalk as a function of frequency



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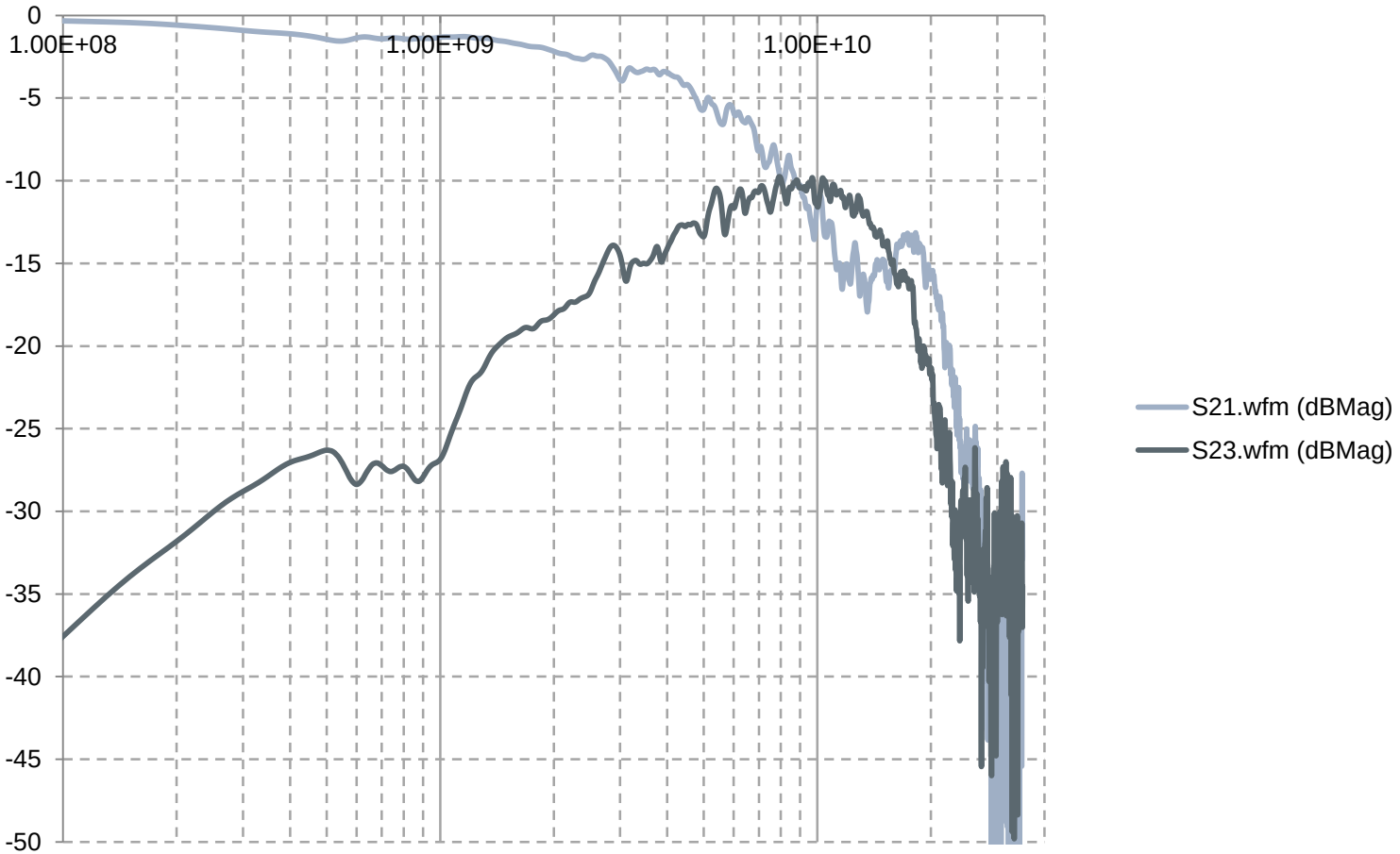
Experiment's DUT: Insertion Loss, FEXT

The DUT used in slides 6 through 10: magnitude of Insertion loss, crosstalk as a f(f)



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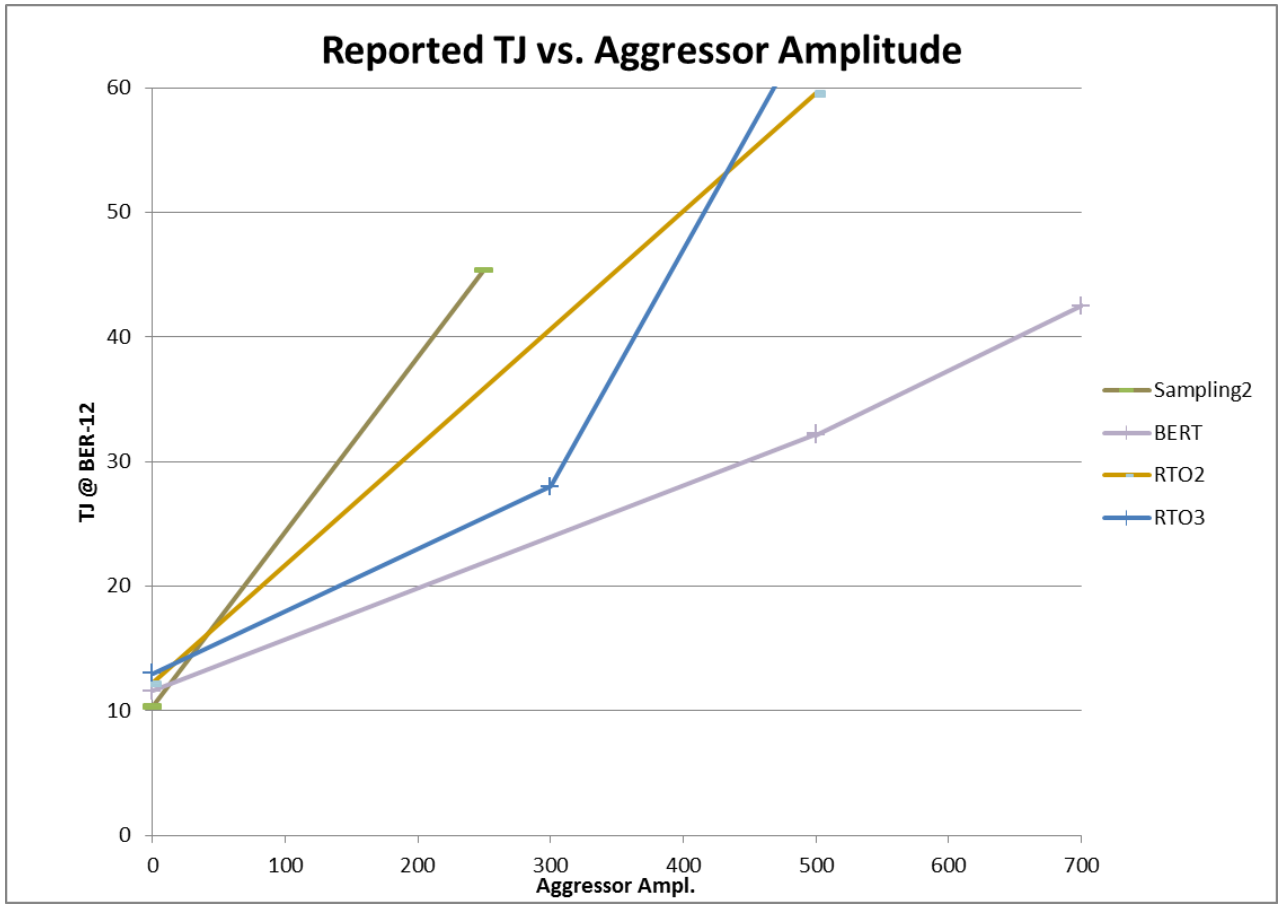
Experiment results: TJ



- Assuming that the value measured with the BERT receiver is a reference, a error plot can be shown (next slide)

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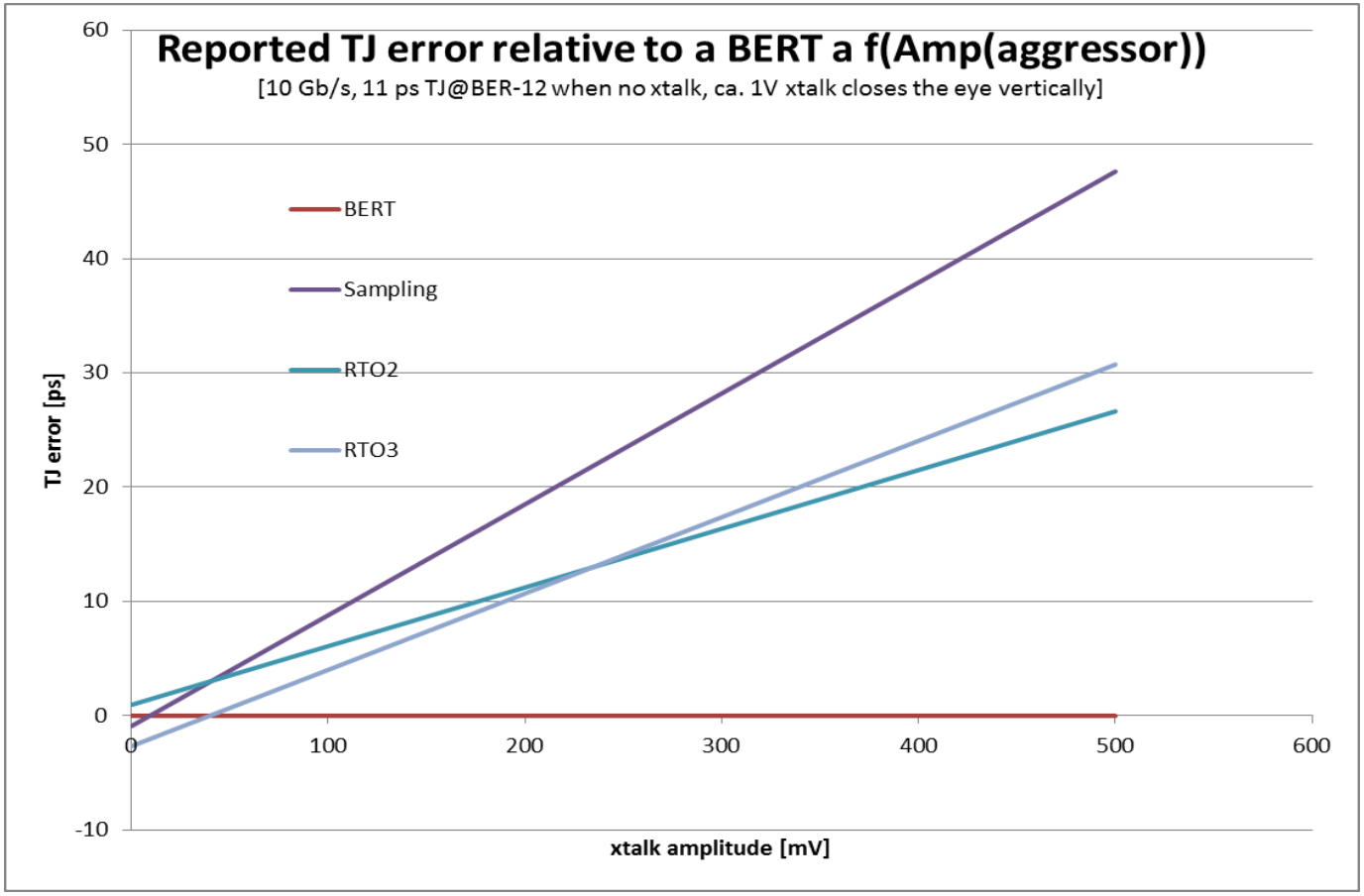
Experiment results: TJ error relative to a BERT result

- Oscilloscope measurements of jitter generally pessimistically bundle BUJ or NP-BUJ into RJ, and then over-report TJ as well.



(fitted 2-param. results). Results as of Q1 2011.

Jitter measurements of different measurement systems – sensitivity to crosstalk-induced BUJ.

- Oscilloscope measurements / extrapolations of jitter pessimistically bundle BUJ or NP-BUJ into RJ, and then over-report TJ as well.
  - Jitter results (RJ, TJ) depend strongly on Aggressor Pattern complexity
    - PRBS31 being the worst, PRB7 typically not causing a large error (graph above used PRBS15 aggressor)
  - In case of Real-time oscilloscopes Jitter result also depends on Record Length (longer is better)
- Exact mechanism of the problem is implementation dependent
  - If there is interest more details is available, not discussed here.
- Noise:
  Although not discussed, the results for vertical impairments are matching the jitter analysis – the vertical eye closure at BER-12 appears pesimistic

Total Jitter Measurement (TJ) etc. measurements in presence of crosstalk: consideration for 802.3bj

In summary:

- Jitter and Noise measurements are useful for simulation verification during the WG effort and for compliance test in the finished standard
- The issue raised here can negatively impact your result, so please take it into consideration
- Also consider:
  - Improvements are vendor-dependent
  - Verify at least some measurements with a BERT receiver
  - Contact your vendor to maximize the accuracy of such measurement
  - Talk to us

Next steps

- Is a more accurate oscilloscope measurement of jitter desirable for the standard?
- Accurate jitter measurement with an oscilloscope requires shorter victim patterns; is that acceptable?
- If yes, what additional analysis is needed?
  - E.g. information on the size of the problem with signals more representative of the current .3bj channels might be needed
- Joint vendors recommendation possible?

Thank you,

prz