Gigabit Transmit Distortion Testing at UNH

Gig TX Distortion

- The purpose of the Gig TX distortion test is to make sure the DUT does not add so much distortion to the transmitted signal that the link partner's receiver cannot interoperate with the DUT
- The test is not performed with a link partner
  - A special PHY test mode is defined
  - A special test set-up + post-processing is defined
  - Compliance to this test cannot be determined by customers

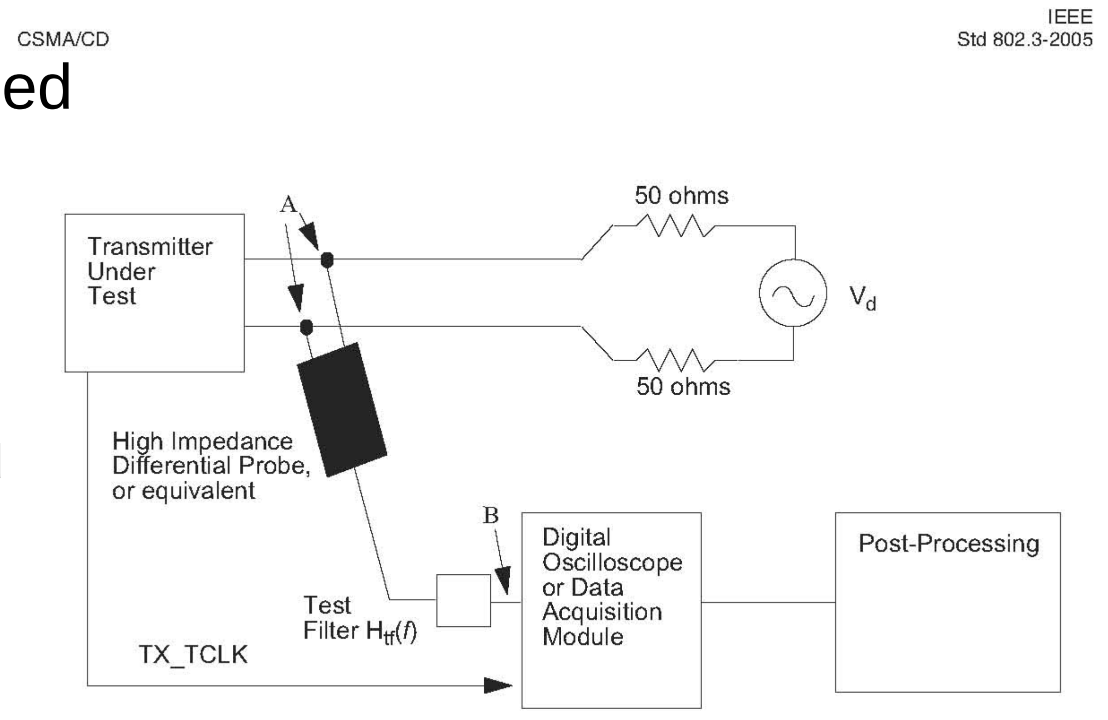


Figure 40–24—Transmitter test fixture 3 for distortion measurement

Gig TX Distortion

- The test that was written by the IEEE to measure transmit distortion is open to interpretation. The following assessment of the interpretation is offered on the UNH web site:

"Since the peak distortion value varies with phase offset, the next issue at hand is to determine the definition of "peak transmitter distortion." There are several possible interpretations of this:

1. The minimum peak distortion value measured with varying phase
2. The maximum peak distortion value measured with varying phase
3. The average peak distortion value measured with varying phase
4. The peak distortion value measured at a constant phase

UNH Website

Since reference [1] specifies the measurement must be made at an arbitrary phase, option 4 is discarded. Option 3 is also discarded as the average distortion value vs. phase does not guarantee that a device would pass with arbitrary phase offset. This option may produce a false pass.

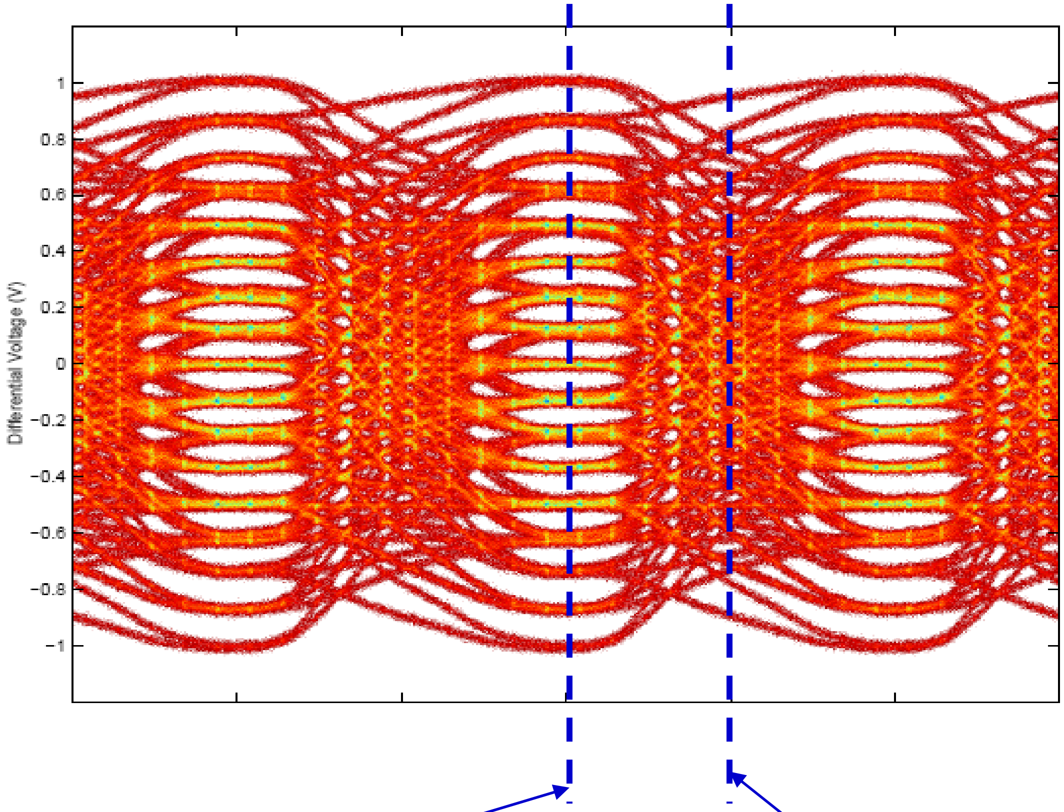
Option 1 sounds feasible to produce a result that is under 10mV. The minimum peak distortion value measured with varying phase might indicate the delay between the reference clock and the RJ45 connector, which, in theory, is the ideal time to measure the distortion of the waveform. However, we can't be certain of the ideal time to sample the waveform.

Thus, the standard set by the IOL is that the peak transmitter distortion shall be the maximum peak distortion value measured with varying phase. This way, all sampling phase offsets are tested. This means that all points in figure 40.G-1 must be below 10mV to be given a passing value.“

- UNH indicates that the reason they can't use #1 is that they can't be certain of the ideal time to sample the waveform, which results in using the more conservative option #2.

Where will the Receiver Sample the Data ?

- Transmit Eye Diagram*



***From Cisco's UNH report pg 15**

The receiver <u>must</u> sample during the open eye interval

"Ideal" sampling instant (interval) <u>~near center</u>

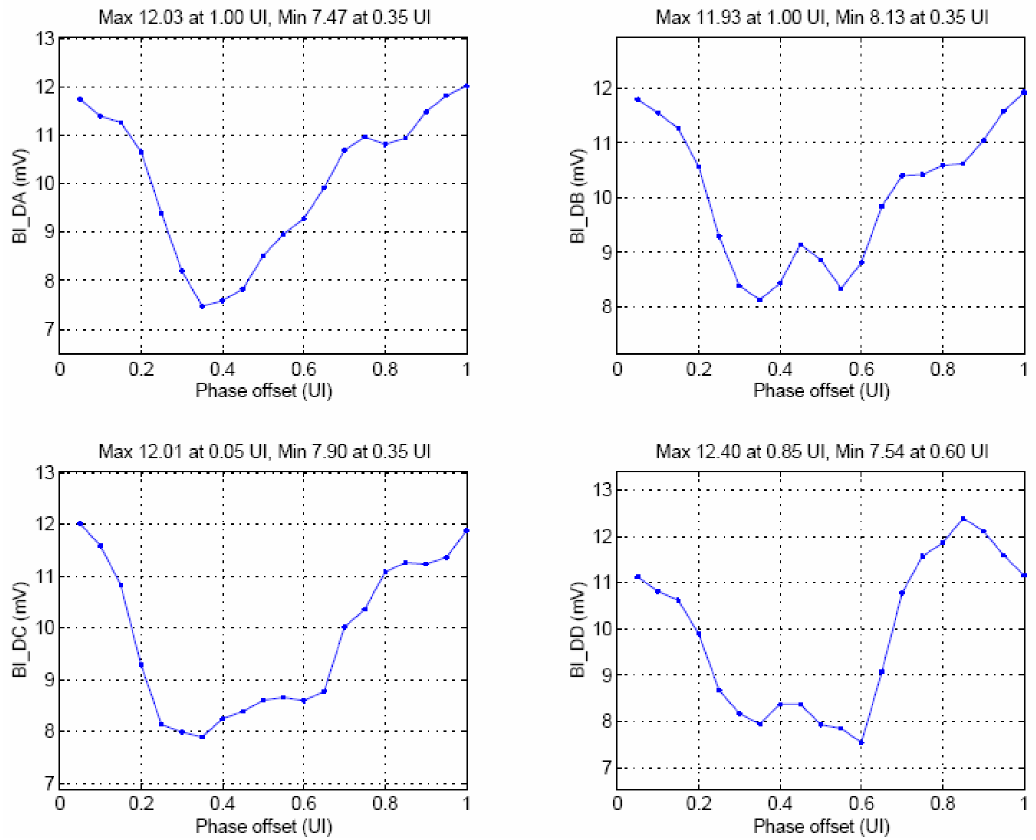
Receiver cannot recover data with this sampling phase <u>Distortion does not matter here</u>

Gig TX Distortion II

- In implementation, PHY receivers use a clock recovery to locate the widest opening of the eye diagram and sample at that point. In Cisco's UNH report on p. 16, the center of the sample period, where the widest point of the eye would exist and the PHY receiver would be trying to sample the data, Gig TX distortion is below the 10mV level.

Physical Medium Attachment Test Suite v2.4 Report
DUT: Cisco Systems, Inc IP Phone 7975G P4

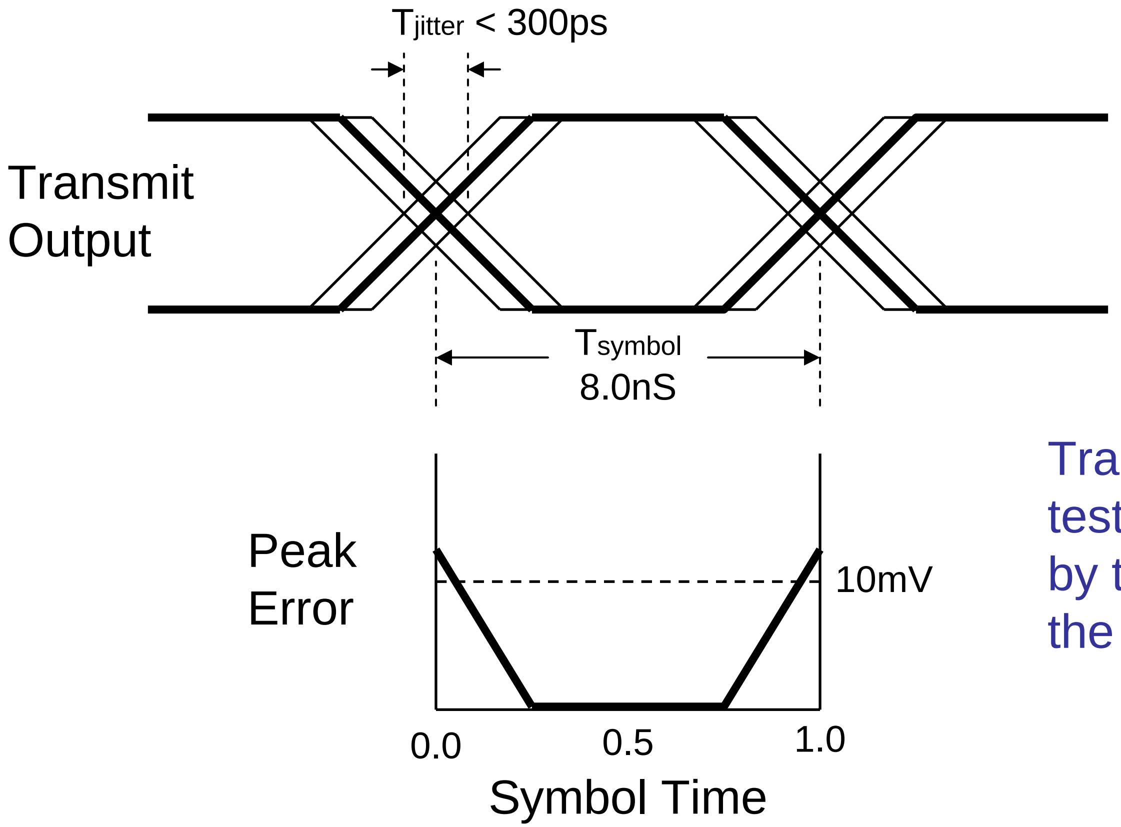
Figure 11: Peak Distortion vs. Phase Offset



From UNH report

Consistency Between Transmit Jitter and Transmit Distortion Specifications

- PHY operating with allowed transmit jitter will not be able to meet 10mV distortion spec *if the distortion spec must be met at the edges*



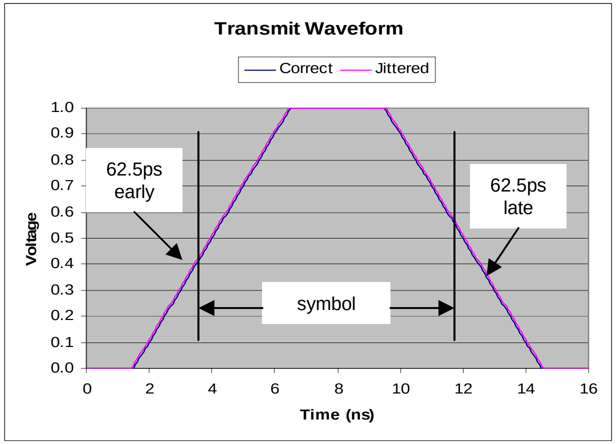
Transmit distortion test not impacted by transmit jitter in the eye opening ✓✓

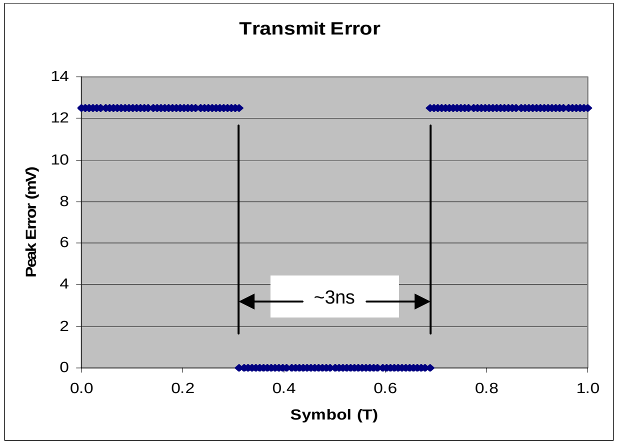
Defining the “Settled” Interval for Transmit Distortion Testing

- Currently defined transmit distortion test is sensitive to transmit clock jitter during the rise/fall time of the transmitter
  - Error voltage will be contaminated by jitter during transitions
  - Portion of error contributed by distortion cannot be determined during transitions
  - Appropriate place to apply test is after the rise/fall time where the waveform has settled to it’s final value
- Clause 40.6.1.2.3 specifies a 5ns rise/fall time (note #3)
  - 3ns of 8ns (37.5%) of UI will be free from effects of jitter
  - Recommend to use 30% for ease of testing
    - Ie: measure error voltage at 10 phases, require 3 of these measurements to be below 10mW

Example: Peak Error w/ Linear Rise/Fall Time

- Maximum step change of transmit output = 1.0V differential
- Rate of change = 1V/5ns at symbol transition
- Jitter per edge = 125ps / 2 = 62.5ps (clause 40.6 allows for 300ps)
- Peak error = 62.5ps / 5ns * 1.0V = 12.5mV





The peak error due to jitter at the edge of a symbol can exceed 12.5mV
Peak error should be measured at opening of eye
(i.e. near center of symbol).