# BERT bathtub, TDP and stressed eye generator

From discussions in optics track
17-18 Jan 02

Transcribed by

Piers Dawe, Agilent Technologies
Tom Lindsay, Stratos Lightwave

Raleigh, NC, January 2002

# Two problem areas addressed

- 1.  Practical difficulties of jitter bathtub measurement at 10GBd
  - Problem, and alternative: slides 3-8
- 2.  Excessive complexity and immaturity of stressed eye generator
  - Simplification: slides 9-14

# *For* From dawe_1_0102.pdf: BERT bathtub

- BERT really measures low probability events
    (depending on the pattern)
- Good for diagnostics
    - Can separate W and sigma
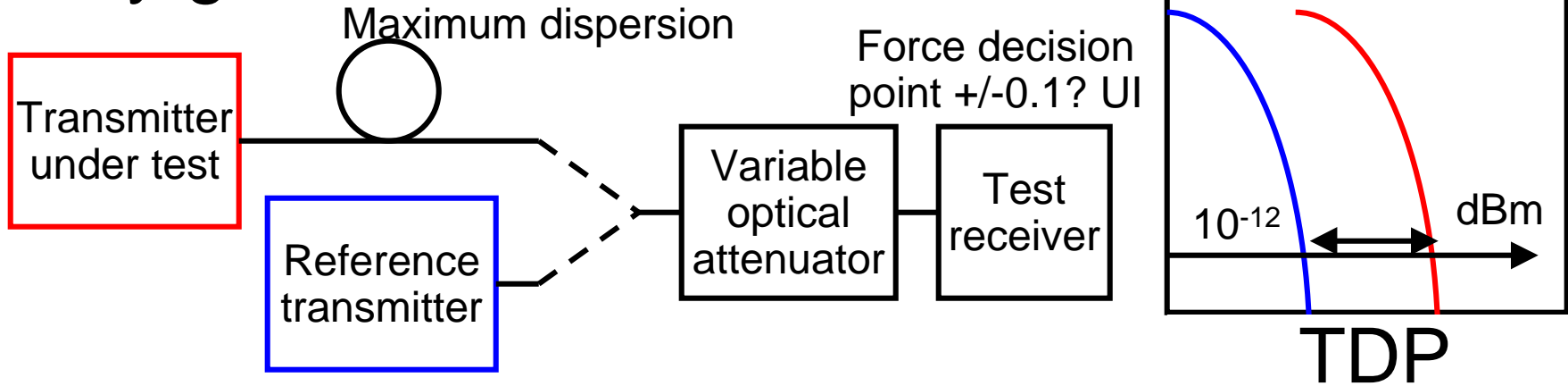- Technique has been tried in at least two labs and can be automated

# *Against*

- Test instrument data dependent jitter consumes a significant fraction of "W" at 10GBd
- DDJ cannot be calibrated out without very detailed edge-by-edge measurements
    - DDJ of DUT and apparatus is correlated: may add, subtract or anything in between
- Unknown errors --> extra margin needed in production test and/or design --> more $$$
    - Slow measurement $$$
- Next generation test equipment addresses the calibration

# Two part alternative to BERT bathtub

- Proposed eye mask
  - Options 1-2 of dawe_1_0102.pdf and comment #113
  - Discussion centred on BASE-L.  BASE-S, E could have different or no change
- Transmitter and Dispersion Penalty test
  - See next four slides
  - Currently used for BASE-E but not S, L

# TDP: Transmitter and Dispersion Penalty

- Test a transmitter by substitution against a very good one

Maximum dispersion

| Transmitter under test |

Reference transmitter

Force decision point +/-0.1? UI

| Variable optical attenuator | | Test receiver |

$10^{-12}$   dBm

TDP

- Screens for total of most relevant effects
  - high probability e.g. ISI, jitter "W"
  - low probability e.g. RIN, BLW, jitter "sigma"
- For BASE-S, dispersion is modal not chromatic: simulated by transversal filter after O to E conversion

# Reference transmitter

- Jitter, pp,1e-12    minimize, <0.2UI
- Edge rate    medium, <25ps
- Over/undershoot    minimize, <10%
- Chromatic properties    N/A (short fiber)
- OMA    nominal
- RIN    minimize, <-136
- BLW    minimize, <5%

# Test channel

- No change from present jitter measurement

# Test receiver

- High frequency response   ~BT4 7.5GHz
- Phase response                    ~BT4 7.5GHz
- Sample offset (& jitter)       +&-0.1UI
- Threshold offset                 minimize
- BLW                                   minimize
- Basic sensitivity               nominal
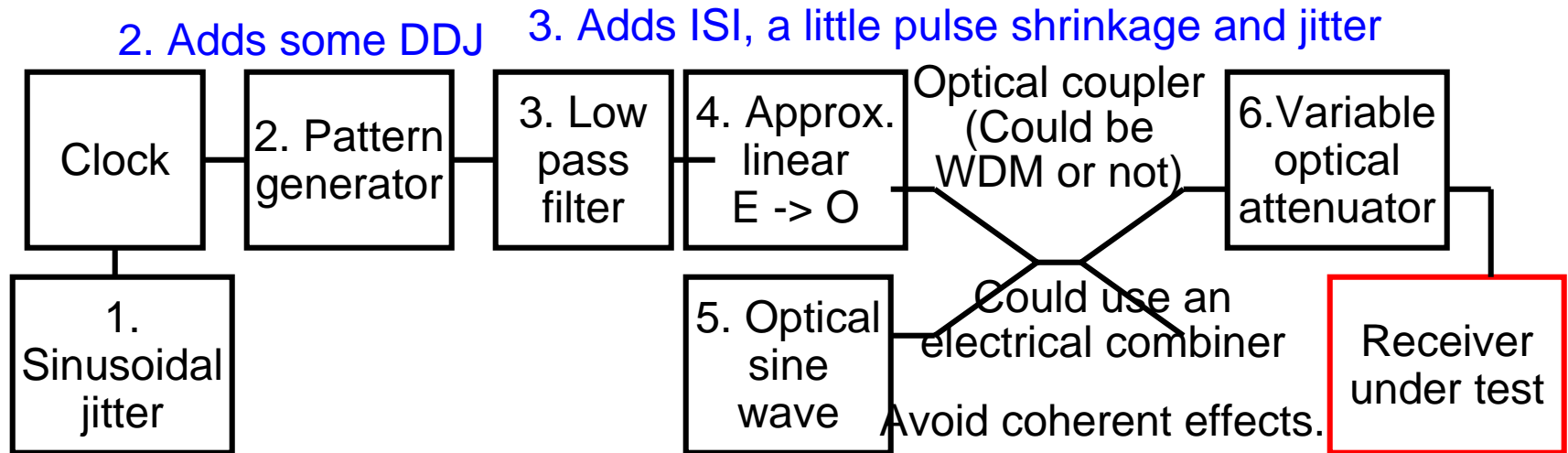- Nonlinearities                   minimize

# Alternative stressed eye generator

How do we specify this?  What parameters?

Use scope to measure.  Look at what?  What pattern?  With 4. Off then calculate?

Which elements are accurate?  If inner eye is key, could take up small errors in VECP/BW in VOA. Linearity and BW of 4 may not be very certain

2. Adds some DDJ        3. Adds ISI, a little pulse shrinkage and jitter

```
[Clock] — [2. Pattern generator] — [3. Low pass filter] — [4. Approx. linear E -> O] — Optical coupler (Could be WDM or not) — [6. Variable optical attenuator]
[1. Sinusoidal jitter]                          [5. Optical sine wave]    Could use an electrical combiner    [Receiver under test]
                                                                          Avoid coherent effects.
```

1.Adds sinusoidal jitter            5. Adds ISI, pulse shrinkage, jitter

Item 5 could be square wave or even a slower pattern

This may overestimate BER because different fraction of worst bits

Frequency limit for item 5?

Leaving out item 3 removes most pulse shrinkage.  Do we really need it?  If not don't need linear E->O

# Simplified stressed Rx test
# (no bathtub calibration)

Combined SJ – sweep to 80MHz

    Amplitude above corner freq          TBD

Pulse shrinkage w/ modulated offset

    Amplitude          TBD

    Frequency          Range TBD

Other controlled vertical closure?          TBD

Edge rates          ~BT4?

OMA & ER          Stressed

RIN          minimize

BLW          minimize

Over/undershoot          minimize (N/A)

# Notes on alternative stressed eye generator

- Simpler than D4.0 but still not very simple
  - D4.0 generator's block diagram had about 20 boxes - see lecheminant_1_0102.pdf

- Note the setup is very similar to Rx upper BW test.  Can same setup achieve both?

- We don't specify the implementation of the test setup, just the outcome

- We aren't adding large DDJ
  - Nothing here to really stress a PLL (depending..)
  - Don't need PLL to measure the stressed eye?
    - This thought to be a benefit
    - If used many km of fiber to affect BW, might need PLL
    - Trigger delay in scope with SJ may require PLL

# Parameters; outcomes

- <u>Possible metric</u>           <u>Affected by block, slide 6?</u>
- *Pulse shrinkage*           *(2) (4) 5*   - specify
- Inner eye vertical        3 4 5 6
- Nominal signal strength   (3) 4 6

  > *Color and italics-coded in groups representing different metrics for similar things*

- Ratio inner/nominal eye vertical  3 5   - specify 2 of 3
- *HF content of signal (relative)  3 (4)*
- *Risetime            3 (4)*
  - *Instead, measure VECP with 1, 5 off - need to find that anyway*
- SJ/DJ total which is not pulse shrinkage   1 (2) (3) (4)
  - specify
- SJ spectrum              1   - specify
- RIN                  4 5   - specify upper limit
- BLW                  4   - specify upper limit
- Frequency of inteferer     5   - specify (wide) range - 100 MHz up?
- No specific DDJ or RJ target: just not gross

# **Sample stressed eye simulation**
## *Simulations done in the meeting (!) by Tom Lindsay*

PRBS7 pattern:
 1 baud
 200 bits
 2 V pk-pk
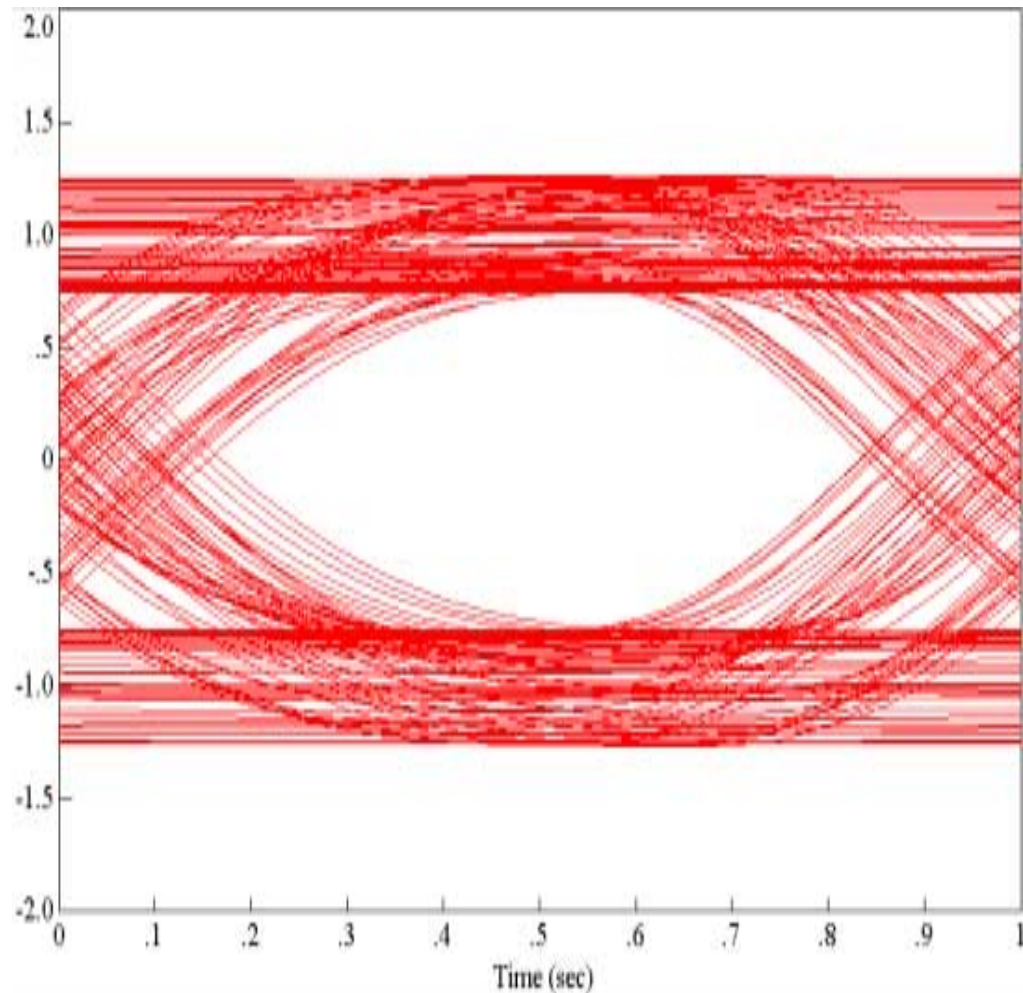BT4 filter:
 0.75 Hz
Phase mod:
 0.02 Hz sine
 0.7 mod depth
Baseline mod:
 0.014 Hz sine
 0.35 V peak

# Alternative to single stressed eye

- There was also a proposal for separate tests to screen against:
  - ISI
  - Sinusoidal jitter
- There was no consensus on whether combined or separated tests were preferable.  More investigation needed ...

# **Four items**

- TDP for BASE-S, L
  - Reference transmitter (high quality)
  - Test receiver for TDP
- Revised eye mask
- "Simplified" stressed eye generator
- ?

  As you can see this is a work in progress ...