TP2 Tests and Specifications (test limits)

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General approach

- Our basic purpose is to write specifications and tests for the standard
  - "Present a proposal for TP2 signaling parameters and associated conformance testing at the September Meeting"
- First, we need to create a test framework
  - A test framework will provide definition/meaning/interpretation for our specs
- Second, we can work the values within the framework
- So, this presentation proposes test methods first
  - Many values are placeholders

General test objectives

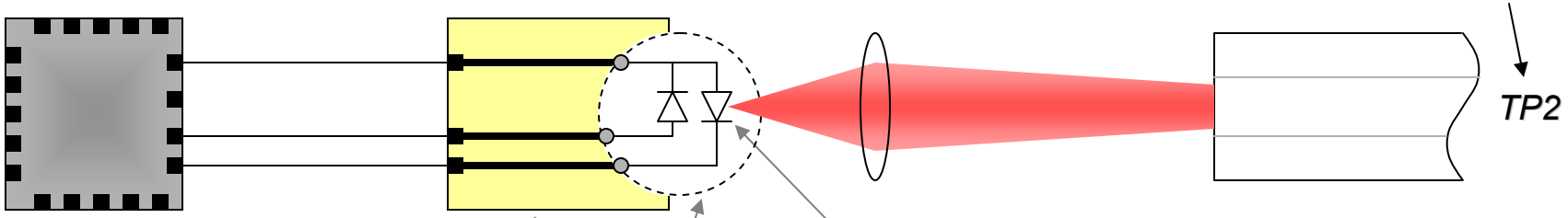
- Simple & flexible
  - Low cost, low test times, etc.
  - Without unnecessary constraints

    vs.
- Rigorous
  - Assure interoperability

- Rigorous does not necessarily mean a test has to be complex
- However, there may still be tradeoffs required, challenge is to find the right balance

TP2 components & impairments

Specification defined only at TP2
(everything else is implementation detail)



Clock
- Crystal
- Synth

Driver
- III-V
- SiGe
- CMOS

Interconnect
- Rogers, etc.
- FR-4

Attach
- Flex
- Leads

Package
- Microwave
- TO-can

E/O
- EML
- DFB
- FP
- VCSEL

Optics
- Isolator
- Lens

MMF
- *Launch conditions outside scope*

Decreasing cost

Clock
- RJ
- Other jitter

Driver
- Edge rates
- Overshoot and ringing
- RJ & other jitter
- Baseline wander
- DDJ
- DCD
- Additive noise

Electrical coupling
- Frequency loss
- Reflections and resonances
- Baseline wander
- Crosstalk pickup

Laser
- Edge rates
- Overshoot and ringing
- DCD
- *Difference* in rising and falling edge rates
- *Difference* in overshoot and ringing
- RIN on logic 1
- RIN on logic 0
- λ dispersion (negligible)

Optics
- Task2 channel group

Original drawing by John Ewen, JDSU

Categorization of TP2 impairments

		Correctable	Uncorrectable	Correlated (shows in averaged waveform)	Uncorrelated (lost in averaged waveform)
Clocking					
	RJ		X		X
	Other contributed jitter		X		X
Driver					
	Edge rates	X		X	
	Overshoot and ringing	X		X	
	Contributed RJ & other jitter		X		X
	Contributed DDJ	X		X	
	Baseline wander	?		X	
	DCD	?		X	
	Additive noise		X		X
Electrical coupling					
	Frequency loss	X		X	
	Reflections and resonances	X		X	
	Baseline wander	?		X	
	Crosstalk pickup		X		X
Laser					
	Edge rates	X		X	
	Overshoot and ringing	X		X	
	DCD	?		X	
	Difference in rising and falling rates		X	X	
	Difference in overshoot and ringing		X	X	
	RIN on logic 1		X		X
	RIN on logic 0		X		X
	Spectral dispersion (at TP3. negligible)	X		X	

Testing should account for all impairments and determine or limit their (combined) penalties.
Every impairment can be distinguished as correlated or uncorrelated. This defines test directions.
Last column impairments (noises, jitter, etc.) are all uncorrectable – set limit that aligns with budget.
2nd to last column impairments (ISI) are correctable/uncorrectable, so test should distinguish impact.

Specific TP2 test objectives

- In addition to general test objectives…
- Distinction of correctable and uncorrectable impairments for LRM imposes a **new** need
  - For relevance to actual impairments and penalties, we need tests for correctable and uncorrectable terms
  - These tests must align with the correctable and uncorrectable terms in the budget
- Tie TP2 metrics to interoperability requirements at TP3
  - Signal at TP3 is what counts
  - Common interface as TP3 tests
  - Approach being used in other standards
- Tests should be no more complex than LR

S/LR test methods not optimum for LRM

- 802.3ae uses 2 system tests for TP2
  - Mask (high probability, qualitative)
  - TDP (all probabilities, quantitative, addresses performance at TP3)
  - FYI, RIN is not required as a system test
- Mask is insufficient
  - Does not accurately bear on performance at TP3 related to interaction of TP2 and cable plant
    - TP3 is what counts, mask can put unnecessary constraints on TP2
  - Does not distinguish correctable and uncorrectable
  - Does not guarantee capture of low probability impairments
  - LR mask coordinates allow uncorrectable penalty of 3 dB
    - Not in budget
- TDP method is complex
  - Could distinguish correctable and uncorrectable with added HW reference EDC, but…
  - Expensive reference HW (Tx, Rx, channel), yet inconsistent results
  - Complicated lab configuration, difficult calibration, time-consuming

Proposals

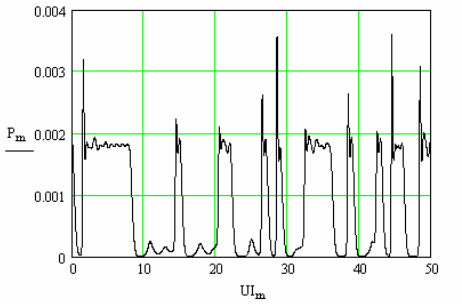
Correlated test

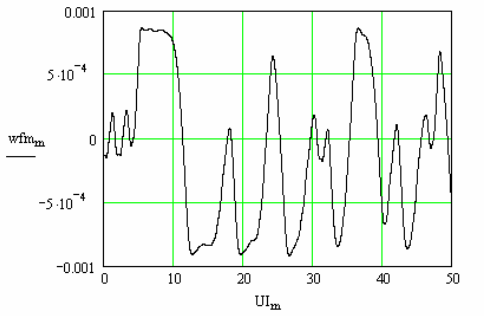
Uncorrelated test

Correlated test – summary

- Use (a portion of) Mixed pattern per 802.3ae
  - Pattern “trigger”
- Use scope averaged waveform capture for data dependent effects
  - Averaging isolates uncorrelated impairments from this test
- Run waveform through simulated channel and simulated “standard” EDC Rx to determine penalty
  - Uses common lab HW Rx
  - Less complex than LR
    - Does not require HW ref channel & Tx
  - Repeatable and consistent
  - Can test vs. multiple channels in SW (if necessary)
- Impose penalty back onto transmitter (per TDP)
  - Places burden of penalty on DUT Tx, not on all units

Correlated test - block diagram





Mixed data pattern

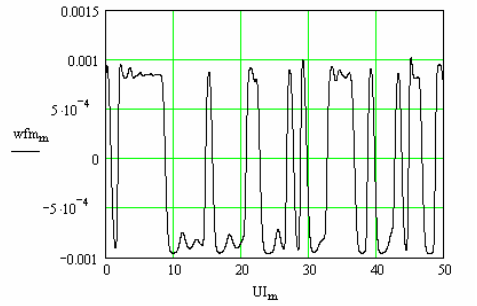
TP2 input

Captured Waveform (scope with 7.5 GHz filter)

A

B

Reference fiber model(s)



Reference Rx

white noise

FFE

Filter

n-Tap

E

Slicer

$\{x_k\}$

m-Tap

Details of filter, EDC, determination of coefficients, and calculation of penalty value are TBD

Decision Feedback

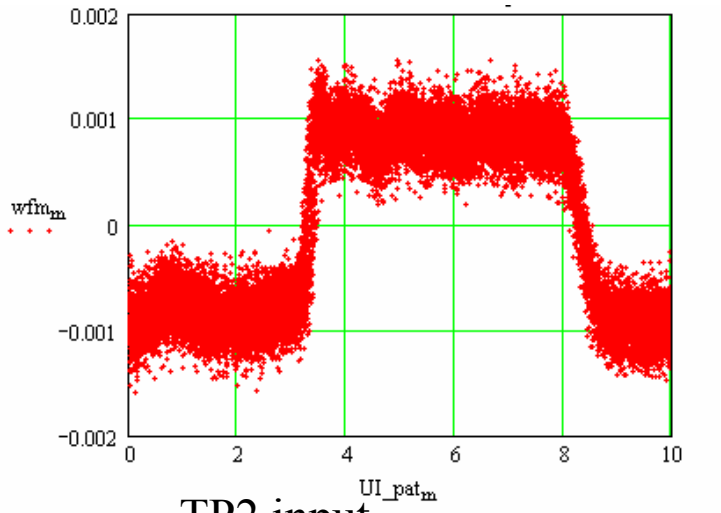
Correlated test – details

- ISI test pattern (John Ewen, JDSU has more details)
  - BnBi, repeats every ~1.64 usec
  - 348 bit sub-sequence contains at least one of every combination of 7 bits (per PRBS7)
    - Preceded by unique 15-bit key
  - Add PRBS7 for component testing
- Test hardware (oscilloscope)
  - Requires pattern trigger and ability to capture keyed sequence
  - 7.5 GHz Bessel-Thomson filter
  - Average at least 16 waveforms
  - Equivalent sample spacing not coarser than 10 psec
- Reference fiber models
  - TP2 and TP3 should use same fiber model(s)
    - including back-back?
- Reference Tx
  - TP2 and TP3 should use same pulse shape(s) and rise/fall times
- Reference Rx
  - Includes 7.5 GHz filter in scope
  - Details of filter, EDC, determination of coefficients, and calculation of penalty value are TBD
    - Based on Intel and/or ClariPhy earlier works?
- Penalty & OMA
  - System otherwise fully operational, full duplex asynchronous traffic
  - Penalty relative to reference Tx through fiber models
    - Goal to match PIE(s) with TP3 to have common specs for interoperability
  - Penalty < 2 dB (goes in Table 68-3)
  - OMA = OMA_min + largest_penalty (Table 68-3)
    - OMA_min currently at -4.5 dBm

Uncorrelated test – summary

- Use square wave pattern per 802.3ae
  - Pattern “trigger”
- Capture persistence waveform on scope
  - Uses common lab HW Rx
  - Similar complexity as LR
- Direct connection (avoid HW fibers or extra filters)
- Set top/bottom masks to limit relative overshoot
- Measure / limit vertical and horizontal relative histograms
- Correlated/correctable impairments isolated from test

Uncorrelated test - block diagram

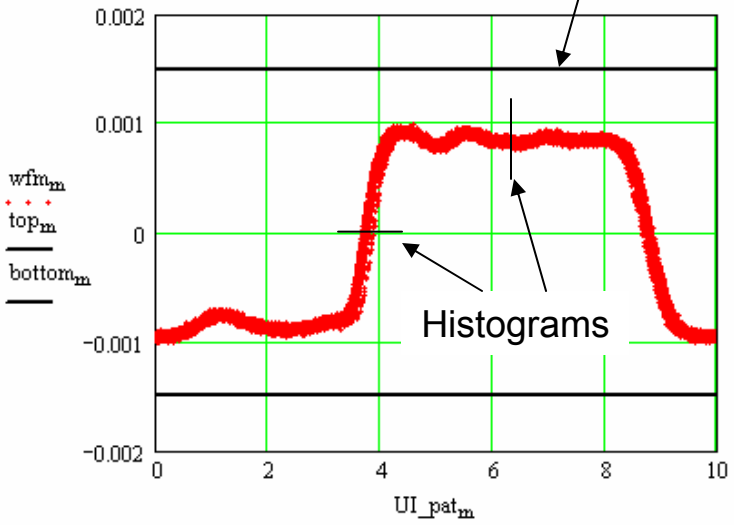


Square wave data pattern

TP2 input

Captured Waveform (scope with 7.5 GHz filter)

Overshoot masks (2)



Uncorrelated test – details

- Test pattern
  - Repetitive square wave pattern (4-11 1's followed by same # of 0's)
- Test hardware (oscilloscope)
  - Pattern trigger (could be done on eye with bit-trigger…)
    - 4 MHz golden PLL (high-pass jitter filter)
  - 7.5 GHz Bessel-Thomson filter
  - Infinite persistence mode
  - Accumulate 250-300 hits in each histogram
- Test limits
  - System otherwise fully operational, full duplex asynchronous traffic
  - Scale limits to waveform per OMA
  - Set overshoot masks at Y=0.4, same as LR (goes in Table 68-3)
  - Set 1% UA-height jitter histogram limits to … (Table 68-3)
    - 0.03 UI rms; 0.12 UI pk-pk
  - Set 1% UI-width vertical "noise" histogram to … (Table 68-3)
    - 0.03 UA rms; 0.12 UA pk-pk
  - Relevance to budget?
    - Is the RIN penalty adequate, or is another small penalty required?