A new TP2 test and specification framework for LRM

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Purpose and sequence

- Purpose
  - "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 is necessary to define and provide meaning/interpretation for the specs
- Second - we can work the values within the framework
- So, this presentation proposes a test framework first
  - Many values are placeholders

General framework objectives

- Necessary and sufficient
  - No unnecessary constraints, implementation-independence
- Simple & flexible
  - Low cost, low test times

vs.

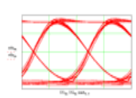
- Accurate
  - Assure interoperability
- Accurate does not necessarily require complexity
  - Tradeoffs may be needed; challenge is to find right balance
  - Accuracy has priority for important metrics

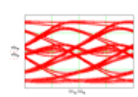
Proposed framework concept
- a preview -

- Summary
  - Distinguishes correctable and uncorrectable impairments
  - Based around a single common interface: TP3
  - Uses mix of simulation with measurements
- Reference: stress test(s) for TP3 input
  - Emulates “worst-case” target range of channels
  - Characterizable by EDC metrics and noise
  - Includes reference Tx
- Requirement: virtual TP3 output not more stressful than TP3 input
  - Use same range of channels as TP3?
  - Characterized by EDC metrics and noise

Transmitter under test

TP2 Channel model(s)





virtual TP3 output signal…

not more stressful to ***an EDC Rx*** than…

TP3 input test signal

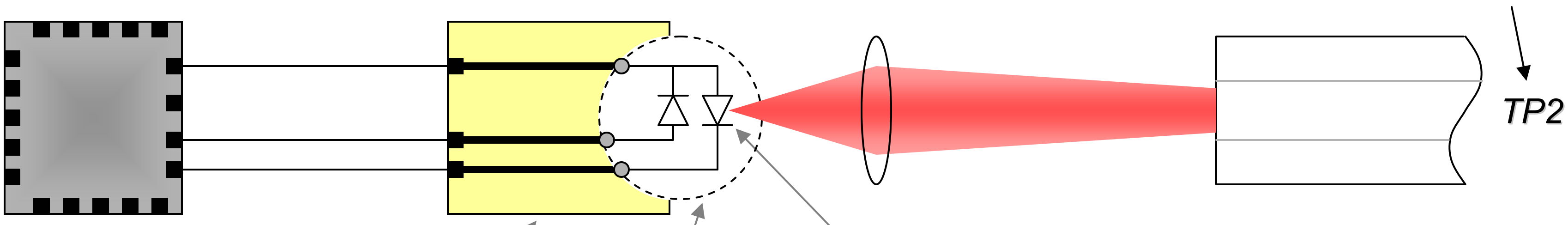
EDC Receiver

TP2 and LRM

a look at issues

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	X	
	Overshoot and ringing	X	X	X	
	DCD	?		X	
	RIN on logic 1		X		X
	RIN on logic 0		X		X
	Spectral dispersion (negligible)	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 – test should distinguish / limit penalties.

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 how EDC deals with actual impairments, need tests that appropriately weigh correctable and uncorrectable terms – that “look at the signal with EDC-colored glasses”
- Tie TP2 metrics to interoperability requirements at TP3
  - Signals at TP3 are what count
    - Use common interface as TP3 Rx tests (unless independence between TP2 and TP3 penalties is proven)
- More repeatable and less complex than LR

LR test methods not optimum for LRM

- 802.3ae uses 2 system tests for TP2
  - TDP (virtual TP3, all probabilities, quantitative)
  - Mask (high probability, qualitative)
  - FYI, RIN is not required as a system test
- TDP method would be complex in HW
  - Would require HW reference EDC
  - Stable HW channel references impossible
  - Expensive reference HW (Tx, Rx), yet possible variability
  - Complicated lab configuration & calibration, time-consuming

LR test methods not optimum for LRM, cont'd
- LR eye mask -

- TDP assures budget compliance in LR
  - Mask is mostly qualitative
- LR mask would allow penalties not in budget
  - est. between ~1 dB of correctable and ~3 dB of uncorrectable
  - Would need to **tighten** mask to work within budget
- Mask cannot distinguish correctable and uncorrectable
  - Would put unnecessary constraints on correctable impairments and restrict flexibility
- Does not test interaction of TP2 and cable plant, so may not accurately predict performance at TP3

Proposals

Correlated test

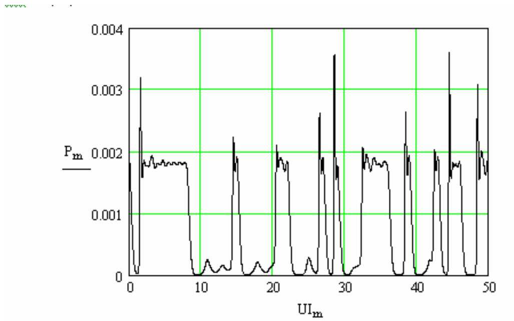
&

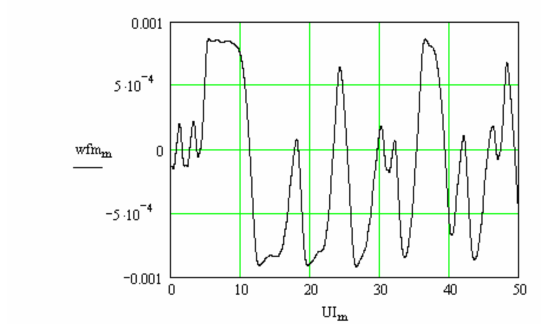
Uncorrelated test

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 simulate EDC-based metrics
  - Does not require HW ref channel & Tx
    - Less complex than LR
  - Repeatable and consistent
  - Can test vs. multiple channels in SW (if necessary)

Correlated test - concept diagram





Mixed data pattern

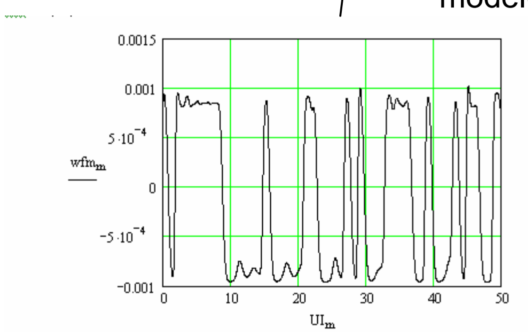
TP2 input

Captured Waveform (scope with 7.5 GHz filter)

A

B

Reference fiber model(s)



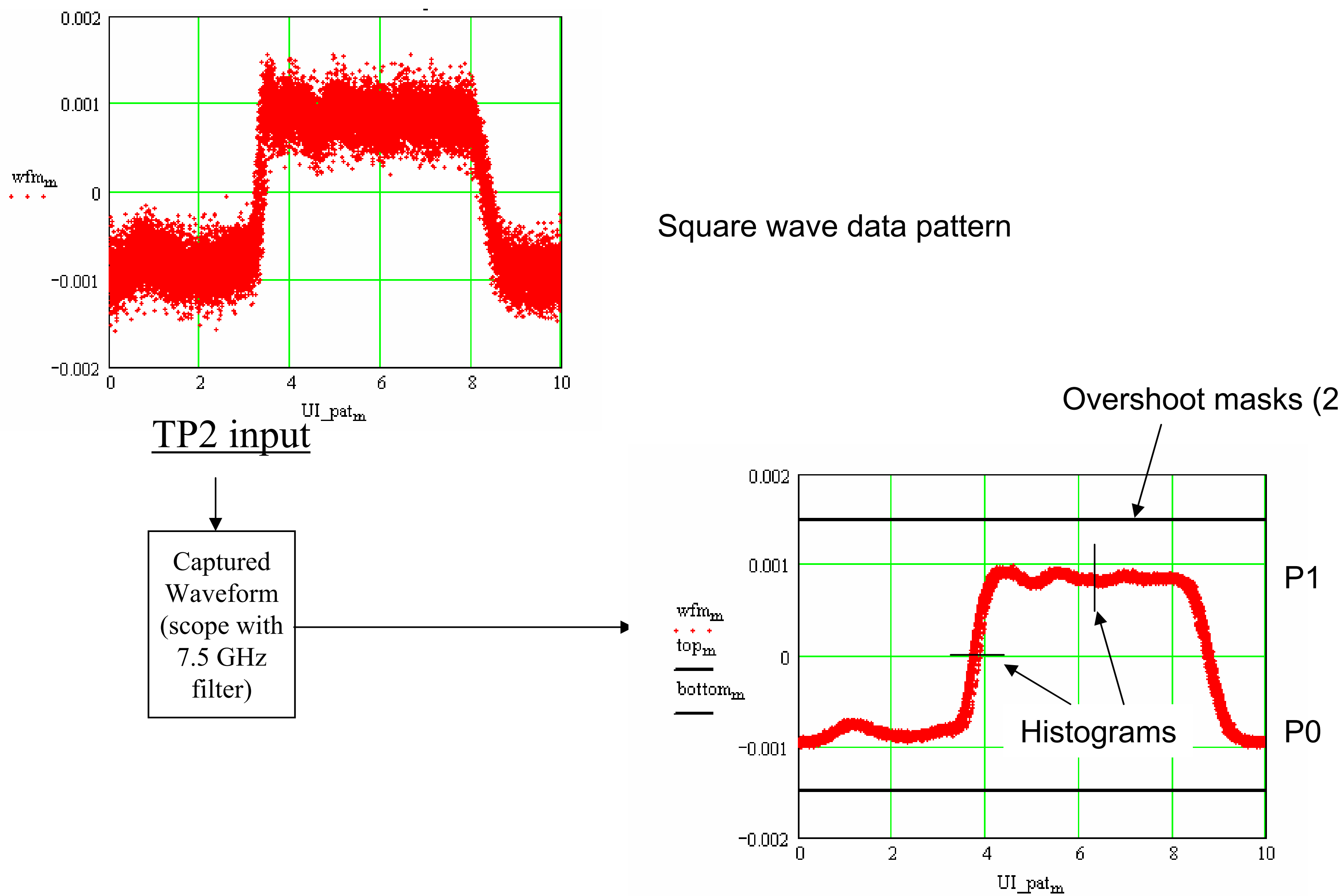
EDC metric(s)

Metric details are TBD, but several options have been proposed and demonstrated. All calculate penalties to be compared to a limit. An informative equalized graphical view may also be possible.

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 (again, avoid HW fibers or extra filters)
  - Done at TP2 – difference from virtual TP3 does not matter for small uncorrelated penalties
- Measure / limit vertical & horizontal histograms
  - Relative to OMA & 1 UI
  - Use P1 vertical histogram (usually higher noise (RIN))
- Set top/bottom masks to limit relative overshoot
- Correlated/correctable impairments isolated from test

Uncorrelated test - concept diagram



Notes on budget

- Tests and budget must track
  - Account for both correctable and uncorrectable terms
  - Iterative process

Possible details

Appendix

Correlated test – possible 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
  - Effects of longer patterns? Assumed fixed penalty based on common practice? Component test, like RIN?
- 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
  - Are fiber models required, or are TP2 and channel penalties sufficiently independent?
  - If fiber models are used, TP2 and TP3 should use same model(s)
    - Including back-back?
    - Use TP3 ISI generator as (one of) the “fibers”?
- Reference Tx
  - TP2 and TP3 should use same pulse shape(s) and rise/fall times
    - Recommend LR 47.1 psec Gaussian
- Reference Rx
  - Includes 7.5 GHz filter in scope
  - Details of EDC metric are TBD
    - Calculate penalty (see Swenson methods) - is Intel method unique?
    - Include 1000BASE-T method to limit nonlinearities, then calculate penalty
    - Informative equalized graphical view or equivalent?
- Penalty & OMA
  - System otherwise fully operational, full duplex asynchronous traffic
  - Penalty based on difference of OMA, compared to ref_Tx + channel(s), to produce Q=7 at slicer input
  - Penalty < 1-2 dB (goes in Table 68-3)
  - OMA = OMA_min + largest_penalty (Table 68-3) – put penalty back onto DUT
    - OMA_min currently at -4.5 dBm (no change)
    - No changes to limits on max TP2 powers
    - OR, other relationship to budget?
  - Do the test and budget track?

Uncorrelated test – possible 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?