TP2/TP3 Progress:
Comments and Suggested Areas for Consensus

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Outline

- **TP2 Compliance Test**
  - **Discussion of Issues Raised**
  - **Argument in Favor of Retaining Eye Mask**
  - **Conditioned Launch Test**
- **TP3 Compliance Test**
  - **Simple Informative Sensitivity Test**
  - **Normative Stressed Sensitivity Test**
    - **Progress on ISI Generator Details**
    - **Discussion of Compliance Signal Noise Impairment Options**
  - **Normative Dynamic Adaptation Speed Test**
    - **Progress on ISI Generator for Test**
    - **Discussion of Speed/Amplitude Limits**
    - **Discussion of Ultimate Need For Dynamic Adaptation Test**
  - **Discussion of OMA Measurement of Compliance Signals**
- **Potential Areas for Consensus (Preliminary to Motions?)**
  - **For the D1.0 Document Not Covered in Comment Resolution**
  - **Those Helpful in Focusing Further TP2 and TP3 Activity**

TP2 Discussion

- **TP2 Calls Raised Issues of Limitation of Eye Mask Test**
  - **Allows Penalties Not in Link Budget (up to 3 dB (?) of eye closure, no linearity issues etc.)**
    - **Potentially Mitigated by Simple Eye Closure Penalty (I.e. mask margin as in efm/public/may03/optics/dawe_optics_2_0503)**
  - **Probably Does Not Allow For Useful Cases Where Penalties Are Correctable by EDC**
    - **Slower (lower cost?) Transmitters**
- **Proposal for New Transmitter Penalty Test (lindsay_1_0904)**
  - **Based on Recording and Analyzing Averaged Transmitter Waveform (Convolve with ISI Model)**
  - **No New Hardware, Only Software Addition to Usual Instruments**
  - **Could Complete Supersede (eliminate) Mask Test**
- **Potential Risks Of Using Above Transmitter Penalty and No Mask Test**
  - **Substantial Time to Finalize Test Details and Verify Adequacy**
  - **Long Time Until Commercial Solutions Available (I.e. integration into scopes etc)**
    - **Variations in 'homebrew' test in the meantime**
  - **No Obvious Goals (at least Until Test Finalized and Examples Shown) For TX Design**
- **Reasons/Options to Retain Mask Test**
  - **Could Be Very Important in Early Time To Market Implementations, 'Comfort' to the Industry**
  - **Mask Test May Not be Necessary to EDC Operation, But Could Be Sufficient**
    - **Probably Need to Establish at Least an Eye Closure Penalty (remember we still have RIN Penalty n Budget)**
    - **Could Then Establish That Compliance with Eye Mask is At Least One Option for Compliance (Unless Test Allows IMPORTANT Cases of Uncorrected Penalty)**
  - **Suggestion to Have New type of Mask Test.**
    - **Eye Mask of Averaged (necessarily short pattern) So Mask Deals Only With Deterministic Processes**

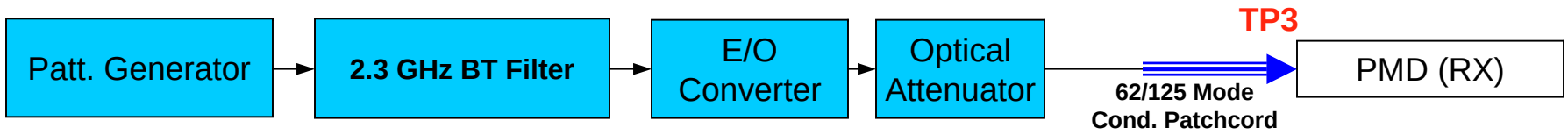
TP2 Discussion (cont)

- **Some Presentations Indicate a Renewed Interest in Center Launch**
- **Other Suggestions Are That It Works Only With Wide Spectral Width Lasers (I.e. FP) or Simply That We Just Haven't Tested Rigorously With Respect to Modal Noise**
- **Would Greatly Change Proposed Encircled Flux Test at TP2**
- **While It Goes Against Established Thinking, It Is Worth Considering**
  - **Straightforward Implementation: SM Launch**
    - **Possibly with external SM/MM CL Patchcord to Mitigate Connector Offset Issues/ But Does This Make Sense (I.e. that a shortly following bad connector doesn't ruin things)**
    - **But Eliminating Integrated Launch is Limitation**
    - **If Direct Launch Into MMF Can Be Used Than It Would be a Great Solution**
  - **SM Launch Gives Dual-Use Module for Free**
    - **Not an Objective (and shouldn't be) but Probably of Some Value**
- **Worth Careful Study But We Should Downselect This or Previous Conditioned Launch Ideas as Quickly as Practical.**

TP3- Simple Informative Sensitivity Test

- **Goals:**
  - EDC Relevant Test Equivalent to Informative Basic Sensitivity Test in 802.3ae
  - Differs from Standard Sensitivity in that Lack of ISI penalty Would Shift Required Sensitivity Substantially Below Normal Link Range. Force EDC to Have Excessive AGC Capability
  - Low Noise, No SJ Signal with Simple ISI Block
  - Provide Simplest Test For Use in Day-to-Day Measurements Such as Manufacturing
- Considerations
  - Test Need Not Have Perfect Match of ISI Difficulty to Worst (99 Percentile) Channel
  - Seeks Similar ISI Magnitude so Required Sensitivity is in/near Range of Normal RX OMA
- Popescu Analysis has Provided Justification for BT Bandwidth
  - 2.3 GHz BT for ISI Roughly Matches Quasi Symmetric Max. PIE 300m Cambridge Fibers
  - Presumably 220m Test Would Scale Bandwidth Larger (~ 3.1 GHz)

Specific Proposal:



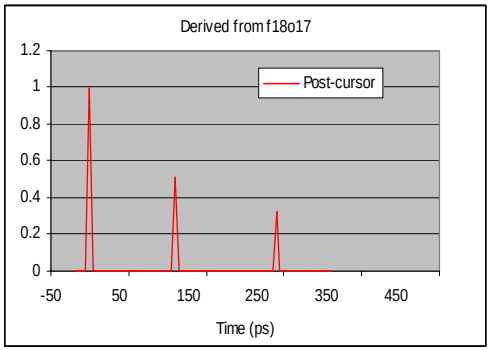
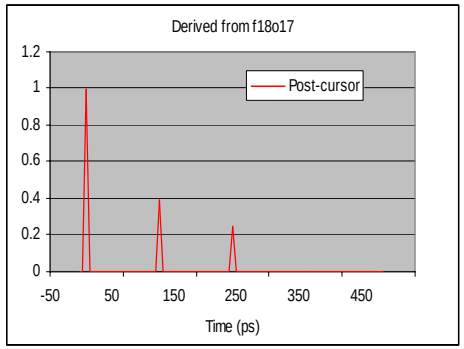
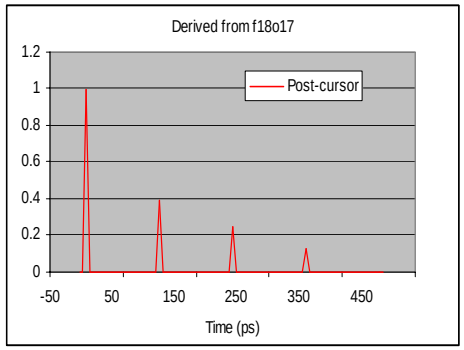
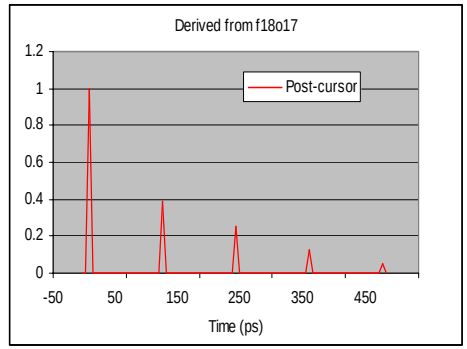
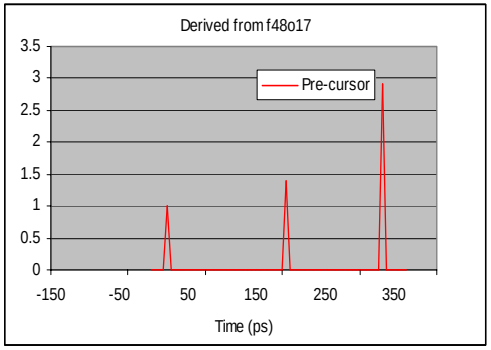
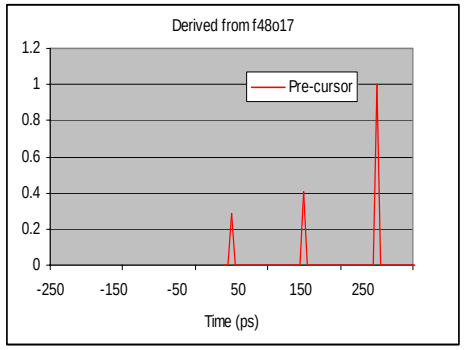
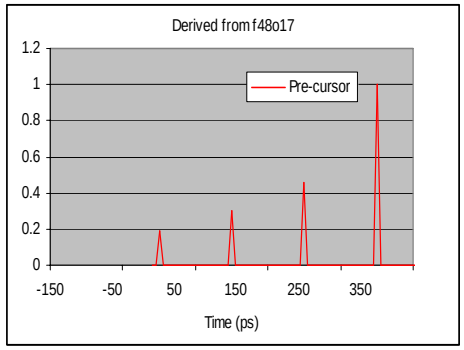
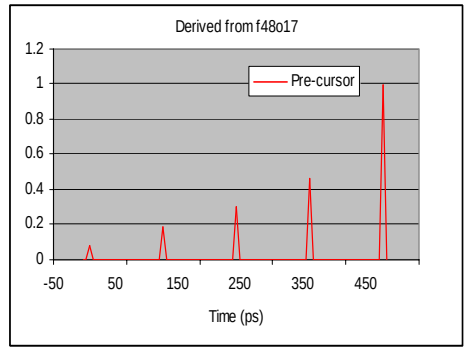
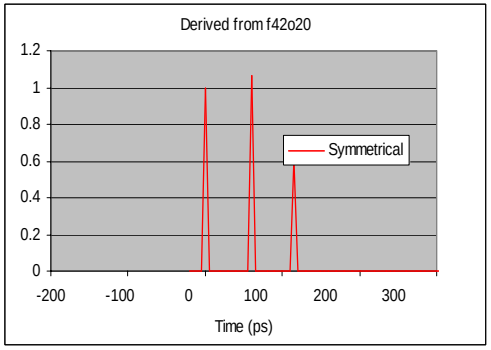
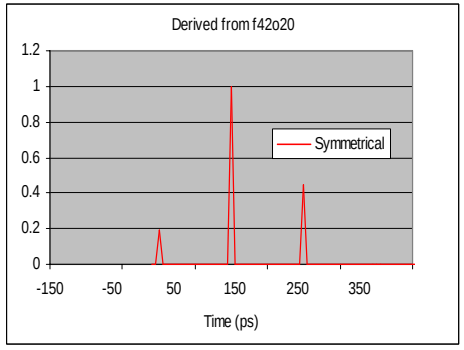
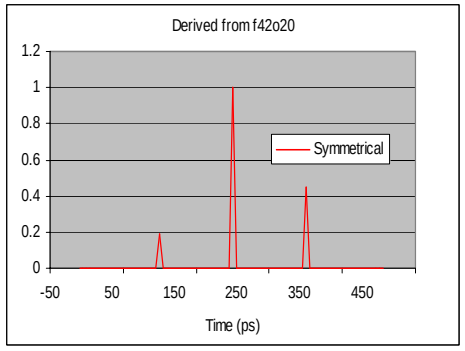
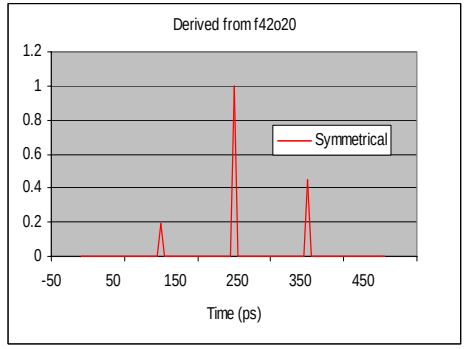
- **Required Sensitivity**
  - ~ Normative Static Stressed Test Sensitivity Spec – RIN and MSL Penalty (- 8.5dBm OMA)
    - Exact Value Would Depend At least on Difference in ISI Penalty relative to Normative Test
  - Do We Need to Account for Lack of SJ Jitter etc in Required Sensitivity?

Popescu/Dawe Static Test ISI

- **Generated 3 Pulse ISI Fits to Cambridge Model IPR Curves**
  - Used 300m Model and 30 ps rise/fall Transmitter Model (too fast?)
- **Concluded that We Should Consider 3 Impulse Response Groups:**
  - Post-Cursor, Pre-Cursor and (Quasi-)Symmetric
  - Based on EDC Performance Variations and Grouping of Cambridge Model IPR Cases
- **Solutions Attempt Best Fit to 3 Particular Cambridge Fibers Which Are Examples of Each Type**
- **Calculated First with Arbitrary ΔT**
  - Good Shape Fit, Good PIE fit (Errors?) to These Particular Fibers
  - Inconvenient to Implement (ΔTs different within and between tests)
- **Calculated Next with Fixed ΔT of 1 UI w/ 3 , 4 or 5 Peaks**
  - 3 Pulse: Poorer Shape / PIE Fit (+/- 20-30% Errors to PIE)
  - 4 Pulse: Better Shape / PIE Fit (+/- 7-26% Errors to PIE)
    - Initially Suggested as Adequate by Petre, Though Recent Presentations Favor 5
  - 5 Pulse: Best Shape / PIE Fit (+/- 3-26% Errors to PIE)

Popescu/Dawe Static Test ISI

- **Here's what they all look like in comparison:**

	Fits with Arbitrary ΔT	Fits with 1 UI ΔT – 3 Pulse	Fits with 1 UI ΔT – 4 Pulse	Fits with 1 UI ΔT – 5 Pulse
Post-Cursor				
Pre-Cursor				
Symmetric				

Popescu/Dawe Static Test ISI - Discussion

- **Is Fixed ΔT of 1 UI Dangerous?**
  - **Will Coincidence with Likely EDC Tap Spacing Result in Overly Poor or Good Performance**
- **Use of 30 ps Rise/Fall in Model of TX Pulse Shape**
  - **Puts Tight Requirement on Test Source E-O Converter and Passive Connections**
  - **Example:**
    - **DM FP Laser as E-O May be Best for Spectral Reasons but 30 ps May Be Difficult.**
    - **FP Source + Modulator Good but 1310 Modulators More Difficult to come by.**
  - **Can We Get Reasonable Alignment with Slower Source (say 47 ps r/f)?**
- **Exact Match of Specific Fibers Probably Not Critical**
  - **Flexibility Would Allow Symmetric Post-Cursor and Pre-Cursor Tests**
  - **Would Justify Fixed ΔT Models with Otherwise Poorer Fits to Specific Fibers**
  - **Ultimately Turns Into Debate onto How to Write Test:**
    - **Method 1: Mimic these 3 Fiber Impulses as Well as Possible – Requires Describing Pulses (I.e. a detailed Table), Will Look Mysterious Without History and Does Not Suggest Implementation**
    - **Method 2: Use 4 (or 3 or 5) Peak ISI Generator (I.e. Prescribe the Generator)**
    - **Method 3: Use 3 or 4 or 5 Peaks as a Language of Defining the ISI, But Specify It Must Be Met To A Certain Accuracy (Petre's PSR metric for example) – Allows Freedom But Suggests Implementation**

Discussions on RIN/Modal Noise Interferer

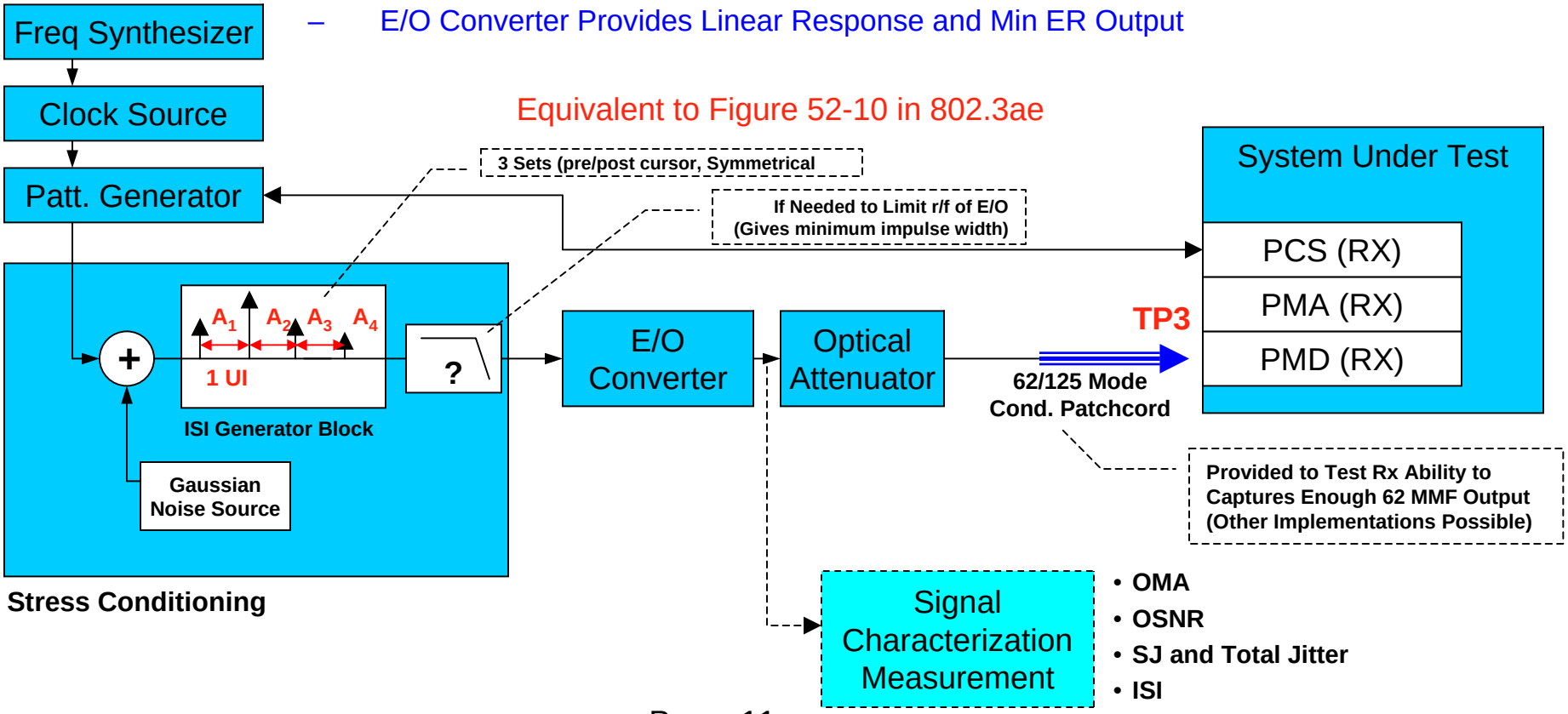
- **Original Proposal**
  - Simulate Combined Effects of 0.4 dB RIN and 0.5 dB High Freq Modal Noise Penalties Using Sinusoidal Interferer
  - Motivated Only by 802.3ae Interferer and Desire to Retain Hardware.
    - (why was that sinusoidal?)
- **Comments Which Followed**
  - RIN is Certainly Opposite of Sinusoidal Interferer.
    - Well Approximated by Broadband (White) Gaussian Amplitude Noise
  - Modal Noise is Probably More Complex But Sinusoid Probably Bad Approximation
- **Proposals Which Followed**
  - Used PRBS as Broader Source
  - Use White Gaussian Noise Source of > 10 GHz Min Bandwidth
- **Conclusion:**
  - Gaussian Noise Addition is Practical.
    - Good Simulation of RIN
    - If Not Good Simulation for Modal Noise, Probably Errs on High Side as EDC Stressor
  - Use Gaussian Noise to Generate 0.9 dB Penalty Which at Worst Will Err a Bit on High Side
  - Add Gaussian Noise to Signal so Total of Original, Gaussian Noise $\equiv$ 0.9 dB Penalty
  - Might Break Down if Modal Noise Much Worse. Adopt it Until Then.

Discussions on RIN/Modal Noise Interferer - cont

- **Original Proposal Showed Noise Impairment after ISI Generator**
- **Certainly a Mistake as Noise Impairment of TX Should be Colored by ISI**
  - **Should Add Gaussian Noise Impairment Before ISI Generator**
- **Requires ISI Generator to be Linear**
  - **E.g. Flip-Flop Implementation in Popescu Probably Not Suitable**
- **Test Signal Would Be Calibrated by Measuring OSNR (value in RX table)**
  - **(Optical Signal to Noise Ratio, common scope function)**
  - **OSNR calculated to Correspond to 0.9 dB Noise Penalty**
  - **Measure in Portion of Signal Used for OMA Calibration**
    - **(see OMA discussion)**

TP3- Normative (Static) Stressed Sensitivity Test

- **Current Proposed Parameters (to be included in 10GBASE-LRM receive characteristics table)**
  - 4 Peak Impulse Response.
    - **3 Sets (precursor, post cursor, symmetric with A1, A2, A3, A4 per Popescu)**
    - **Δt = 1 UI**
    - **Linear Response Generator to Color Added Gaussian Noise (Won't color E-O RIN)**
  - Choose One Sinusoidal Jitter Frequency and Amplitude from the 10GBASE-LR Mask
    - **Keeps Test Time Manageable. Already min of 3 x 1e-12 BER measurements**
  - Add Broadband Gaussian Interferer to Generate S/N Equivalent to 0.9 dB Penalty Assumed in Link Budget. Calculate and define as specific S/N
  - E/O Converter Provides Linear Response and Min ER Output



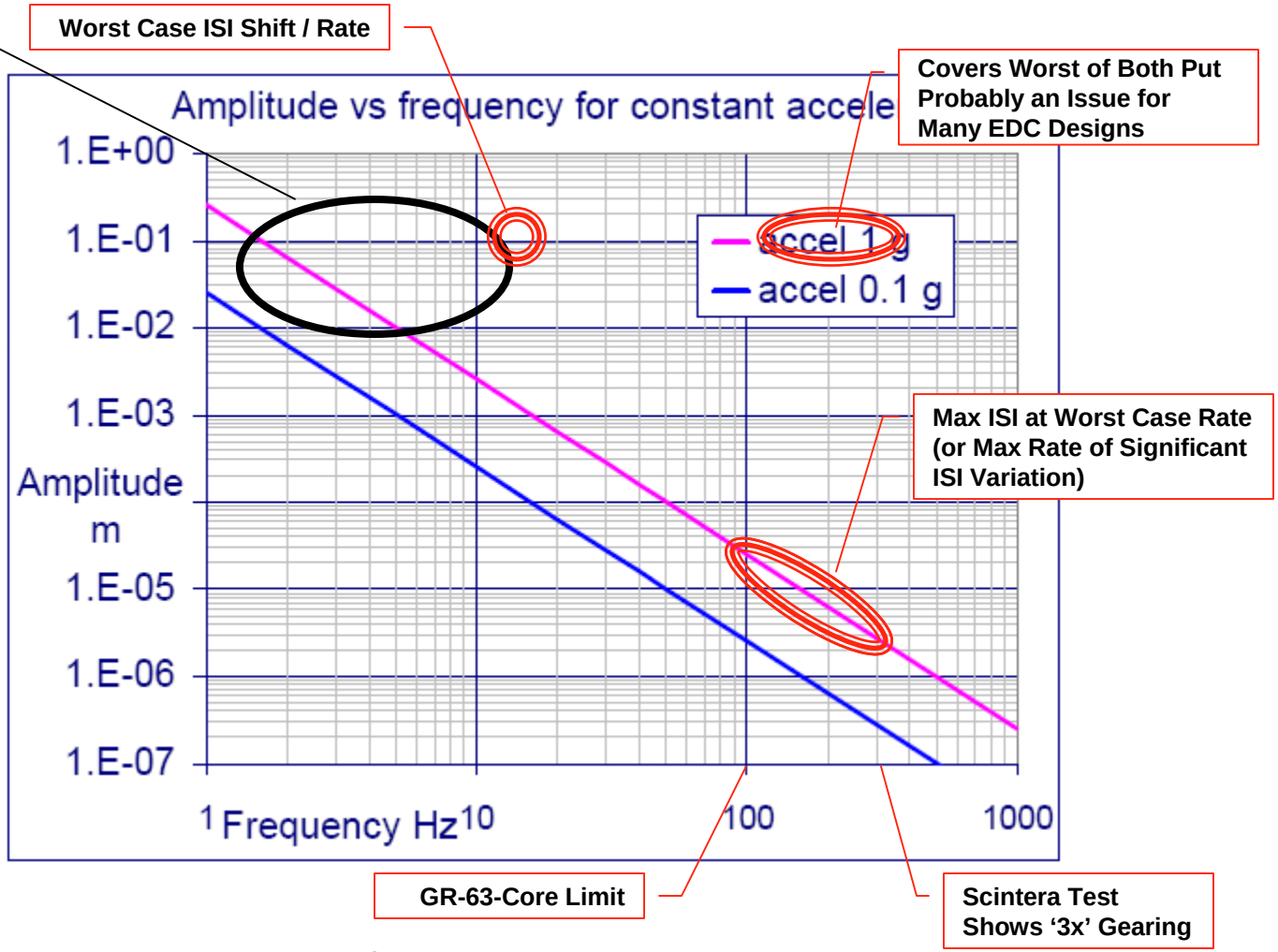
Willcocks/Weiner Dynamic Test ISI

- **Started with (A_1 = 0 –> a) / 1 / (A_2 = a – A_1) 3 Peak Model**
- **Considered Range of Fixed ΔT of Different Values**
- **Considered a = 0.5 to 0.8**
- **Constraint was Best PIE-L AND Best PIE-D Fit to Cambridge Limits**
  - **Yielded ΔT = 1 UI, a =0.55**
- **Proposed Dynamic Test as Full Sinusoidal Swing Between 0 and a at 1 KHz**

- **Comments From Others Relating to ISI Range vs. Speed:**
  - **Martin Lobel: 1 KHz and Full Range of Willcocks Model is Too Hard**
  - **Same Comments Offline from Abhijit**
  - **Jonathon King: Full Range Only Likely at Much Lower Rate (~10 Hz)**
  - **Seems That Two Regimes Fit Reasonable Test:**
    - **Subset Range of Willcocks at High Speed (1 kHz?) – I.e. say A_1 / A_2 of 0.2/0.35 to 0.35/0.2**
    - **Full Range of Willcocks Test ay Low Speed (10 Hz)**
    - **Will Final Channel Group Work Motivate Two Dynamic Tests?**
      - **Let's Hope Not (6 x 1e-12 tests), Only Way Out is Deciding One Stress is Worse**

Dynamic Test ISI Considerations

- **Look at Two Limits:**
  - **Max Rate of Worst ISI Changes (full pre-cursor to post-cursor)**
  - **Max ISI Changes at Worst Case Rate (or max rate of significant ISI shifts)**



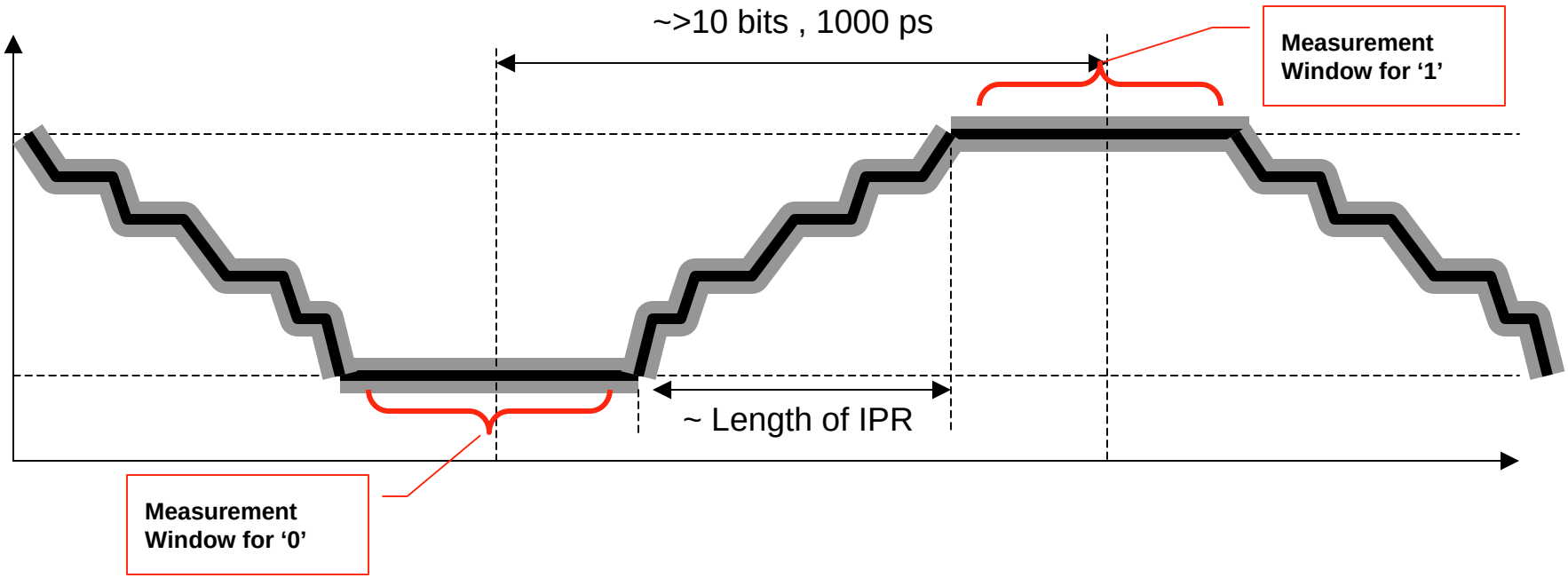
GR-63-CORE Vibration Spec from Channel Ad-Hoc Task 2

Rethink Dynamic Test Altogether?

- **Chart From Task2 Group Suggests Dynamic Adaptation May Not Need a Test**
  - **Large Impulse Response Changes Are So Slow Nobody Doubts EDC Follows Them**
  - **Fast Impulse Response Changes Are So Small Nobody Thinks They Are Significant**
- **Seems Like Conclusion is No Need For Dynamic Adaptation Penalty and Related Test**
  - **And of Course No Need to Dwell on Details and Other Issues.**
- **How Did We Get Here?**
  - **Early Experience With EDC Links Showed Failure on Fiber Manipulation**
  - **Fiber Manipulation Showed Dynamic Impulse Responses Changes**
  - **In Absence of Quantitative Data on Impulse Response Change Rates Adaptation Capability Seemed Like a Culprit.**
- **If Not Adaptation, What Causes Link Failure on Manipulation?**
  - **Modal Noise From Perturbation.**
    - **I.e. Very High Speed Changes With No Hope of Adaptation, thus No Need for Penalty Test.**
    - **Need To Study to Accurately Allocate Noise Penalty (and hope its not too large)**
  - **Polarization? Again Probably not Adaptation Related Failure**
  - **Perturbation Cycles Through Many Bad Cases. – Points to Need to Better Study Worst Case**
- **All of This is Important But Not Justification for Dynamic Penalty Test**
  - **Drop It, and Reconsider If a Reasonable Argument for it Reemerges**

OMA Measurement Discussion

- **OMA Measurement Definition Required for Basic TX and RX Specs as Well as TP2 and TP3 Tests**
  - TP2 OMA Measurement Should Be Able To Use 802.3ae Definition Unless TP2 Compliance Test Allows Very Non-Standard Transmit Signal (New Transmit Penalty test, Abandoned Eye Mask etc)
  - TP3 Compliance Signal Calibration and Measurement of Received Signal of Real Links is More Complex
- **Recommend Square Wave Test Pattern Method Similar to 802.3ae Clause 52.9.5**
  - **A Square Wave Test Pattern of Length Longer (at least 1.5x) than IPR Duration + Rise/Fall of TX/RX Ref Receiver Allows Clear Isolation of 0 and 1 Levels as in 802.3ae OMA test**
  - **For TP2, Want to Test Out of System, and 4 Bits Good Enough**
  - **For TP3 Signal Conformance, Just Use Longer Square Wave (Suggest >1.5x Final Stressed Test IPR Length)**



Potential Areas of Consensus

- **Suggested Areas Where We Can Reach Consensus on D1.0**
  - **TP2: Retention of Eye Mask in Some Form**
    - **Is it Practical To Leave in LR Mask for Now?**
  - **TP3: Adopt Informative Sensitivity Test with 2.3 GHz BT, and –8.5 dBm OMA**
  - **TP3: Adopt Static Stressed Test**
    - **Include Gaussian Noise Source and Position After ISI Generator**
    - **Include Definition of OMA Measurement To Enable Signal Calibration**
  - **TP3: Drop Dynamic Test, Related Penalty**
    - **Only Reconsider if New Justification Emerges for Task 2 Study Group.**
- **Suggested Areas of Consensus on Focusing TP2/3 Study Groups**
  - **Improve TP2 Mask Test To Justify Leaving it In**
  - **Formally Agree on Using 3 ISI Tests (Pre,Post cursor, Quasi-Symmetric)**
    - **Further Agree on Constraining to Mirror Pre and Post-Cursor?**
  - **Agree on 'Language' of the ISI Test?**
    - **Suggest 4 or 5 Pulse Uniform ΔT Description,**
  - **If Successful Does TP3 Simply Await Final Channel Model?**

Retention of Eye Mask in TP2

- **For Purpose of D1.0, Can We Agree To Retain an Eye Mask of Some Form?**
  - **Not To the Exclusion of Further Transmit Penalty Test**
- **Are We Prepared to Start with the –LR Eye Mask in Document or Is Further Development Necessary?**
- **In Any Case If We Keep Eye Mask, Suggest We Resolve TP3 Group Pursue the Following:**
  - **Develop Means to Strengthen Eye Mask Usefulness in Ensuring EDC Performance**
    - **Method for Deriving Eye Closure Penalty to Add to Min OMA**
    - **Change to Averaged Form of Eye Mask (reconstructed from short pattern TBD). Eliminate Random Considerations.**
  - **Develop More Rigorous Software Transmit Penalty Test as Proposed by Lindsay**
    - **Concentrate on Determining Whether Test Allows Important Launches Not Allowed by Eye Mask**

Adopt TP3 Informative Sensitivity Test in D1.0

- **Do We Have Consensus To Accept an Informative Sensitivity Test Based on a BT Filter for ISI in D1.0?**
- **Suggest We Accept the Proposed Informative Sensitivity Test as Shown on Slide 5**
  - **Use 2.3 GHz BT Filter**
    - **Derived for 300m, But Seems Acceptable Even if Link Distance Reduced?**
    - **If Link Distance Less, Easy to Change**
  - **Establish Informative Sensitivity Target**
    - **Sensitivity = Normative Sensitivity – RIN and MSL Penalties**
    - **Enter Value in D1.0 Based on Resolution of Other Matters at Time**
      - **-8.5 dBm OMA with Current Model**
      - **Could be Increased with Elimination of Dynamic Penalty Test**

Adopt TP3 Static Stressed Sensitivity Test in D1.0

- **Suggest We Have Consensus To Adopt The Static Stressed Test (as Previously Described With Following Changes:**
  - **Change Noise Impairment to Gaussian Noise Source Nominally Flat to > 10 GHz**
  - **Add Noise Impairment Before ISI Generator**
  - **Add Noise impairment To Achieve Optical S/N Ratio Derived From Total RIN and Modal Noise Penalties in Budget (Values Still TBD But Equivalent to Current 0.9 dB Penlaty).**
  - **Define OMA and OSNR Measurement Method For Calibrating Compliance Signals**
    - **Defined To Match TP2 Method As Closely As Possible But With Longer Pattern.**
    - **Use Square Wave of >= 10 bits, Measure OMA and OSNR on Resulting 'Flat' 0 and 1 Levels**

Don’t Include Dynamic Adaptation Test in D1.0

- **Based On Current Direction of Time Variations Study, Not Enough Justification for Test**
  - **Remove Dynamic Adaptation Penalty From TP3 Table and Budget**
    - **(Include in Implementation Penalty in Budget?)**
  - **Do Not Include Test Definition In Any Form**

- **Only Reconsider Later if New Evidence Shown That Adaptation Practically Limits Tolerance of Channel Time Variations**

Potential Areas of Consensus to Guide Remaining TP3 Work

- **Agree That We Can and Should Have 3 Impulse Response Functions For ISI Generator**
  - **3 Tests: Pre-Cursor, Post-Cursor, Quasi Symmetric**
- **Agree On How Closely We Want To Base On Specific Fiber Examples**
  - **Suggest We Don't Model Perfectly on Fiber**
  - **Suggest Pre- and Post-Cursor Should Be Mirrors Of Each Other**
  - **Suggest We Define Desired Function and Some Metric (Petre's PSR) On How Close Signal Must Be**
- **Agree On Manner of Representing Signal (and Thus Constrain Details)**
  - **Suggest Defining Function Based on Nominal Pulse Response, Multiple Peaks with Uniform ΔT**
  - **Minimize Number of Peaks While Retaining Character of Fiber Shape Including DMD Span**
  - **Use ΔT = 1.0 UI if Data Suggests**
- **Overall, Allow Variations of Implementation But Be Suggestive of Specific Implementations.**

- **Do Channel Modeling Results To Date Suggest We Should Stop Considering PIE-L Metric?**
  - **Even Ideal FFE Appears Inadequate**
  - **Simplifies Convergence of Channel results and Tests.**