TP2/TP3 Progress:
Comments and Suggested Areas for Consensus

Lew Aronson – Finisar

September 27, 2004

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 Cases of Interest**
  - **Discussion of OMA Measurement of Compliance Signals**
- **Potential Areas for Consensus (Preliminary to Motions?)**

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**
  - **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)**
  - **Could Be Very Important in Early Time To Market Implementations**
  - **Use as An Informative Test Probably of Great 'Comfort' to Industry**

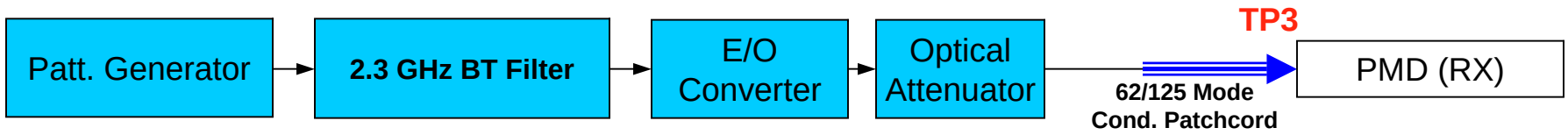
TP2 Discussion (cont)

- **Some Presentations Indicate a Renewed Interest in Center Launch**
- **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 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:



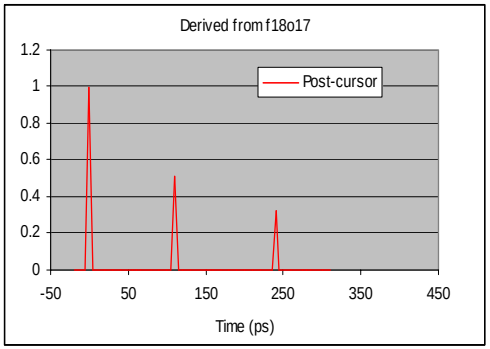
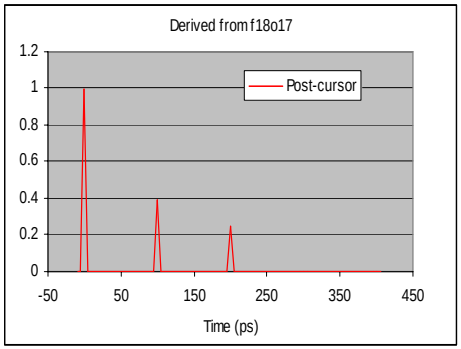
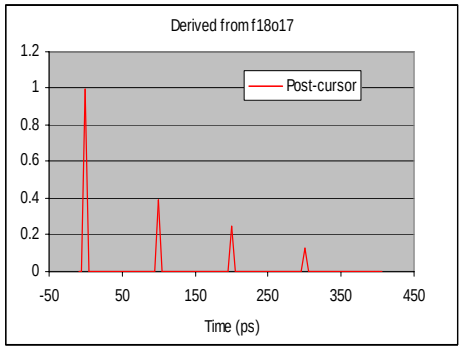
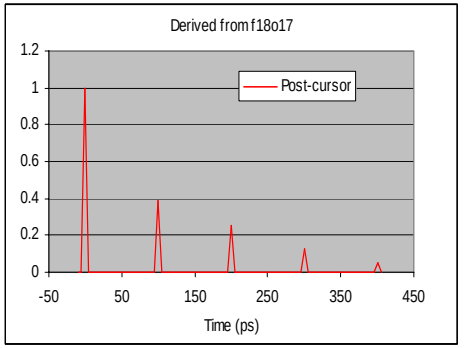
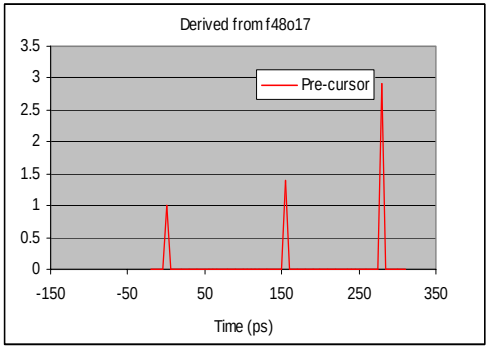
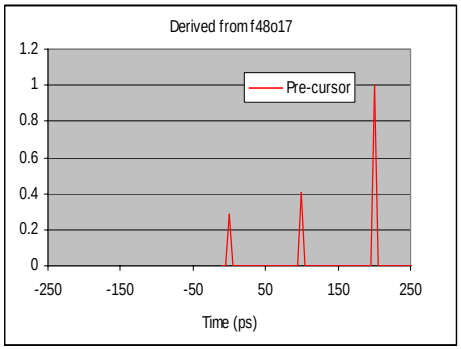
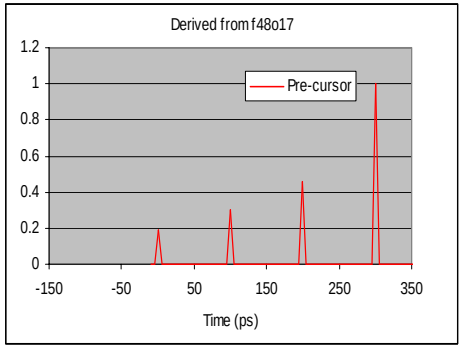
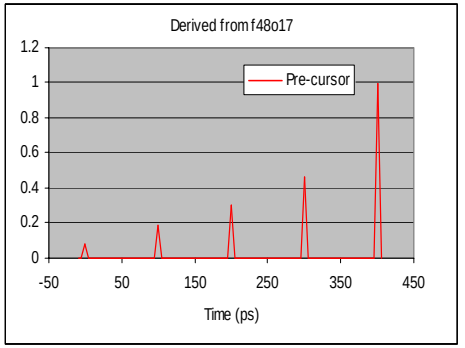
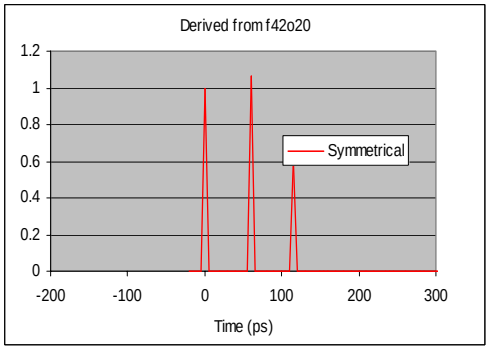
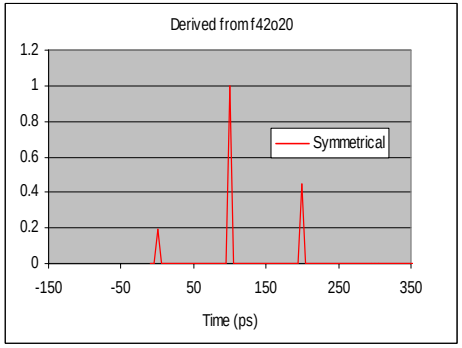
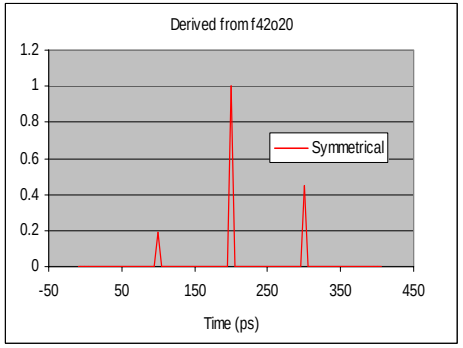
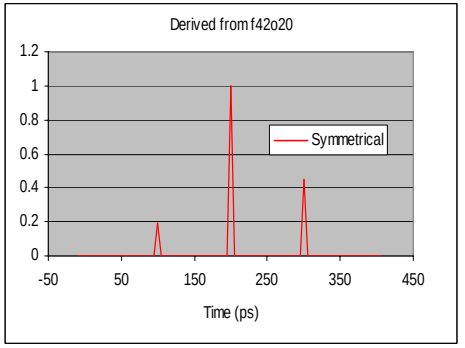
- **Required Sensitivity**
  - ~ Normative Static Stressed Test Sensitivity Spec – RIN and MSL Penalty (- 8.5dBm OMA)
    - Exact Value Would Depend At least on Difference in ISI Penalty relative to Normative Test
  - Do We Need to Account for Lack of SJ Jitter etc in Required Sensitivity?

Popescu/Dawes 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)
    - Suggested as Adequate by Petre
  - 5 Pulse: Best Shape / PIE Fit (+/- 3-26% Errors to PIE)

Popescu/Dawes 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/Dawes Static Test ISI - Discussion

- **Is Fixed ΔT of 1 UI Dangerous?**
  - **Will Coincidence with Likely EDC Tap Spacing Result in Overly Optimistic Performance Relative to Real Channel IPR?**
- **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**
- **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)?**

Discussions on RIN/Modal Noise Interferer

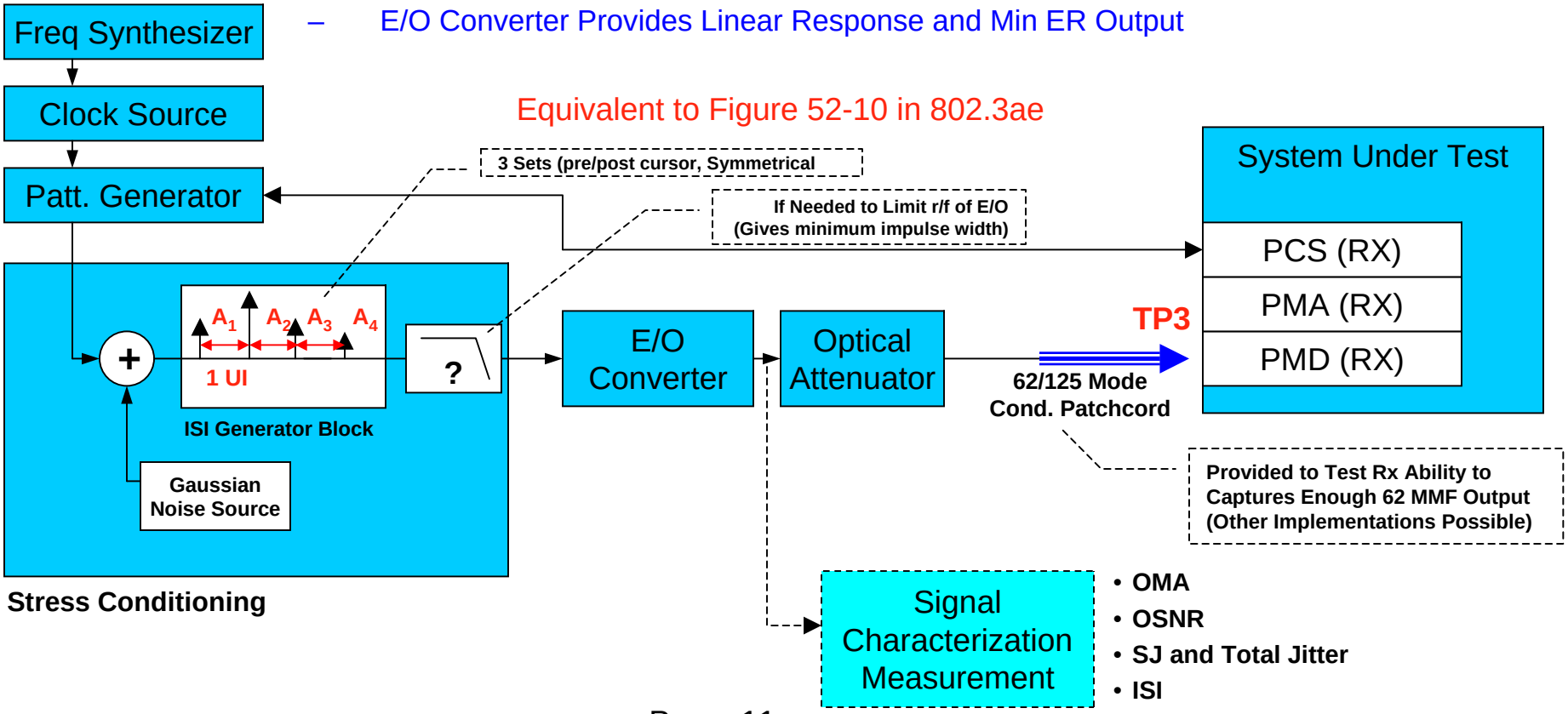
- **Original Proposal**
  - Simulate Combined Effects of 0.4 dB RIN and 0.5 dB High Freq Modal Noise Penalties Using Sinusoidal Interferer
  - Motivated Only by 802.3ae Interferer and Desire to Retain Hardware.
    - (why was that sinusoidal?)
- **Comments Which Followed**
  - RIN is Certainly Opposite 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 ≡ 0.9 dB Penalty

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



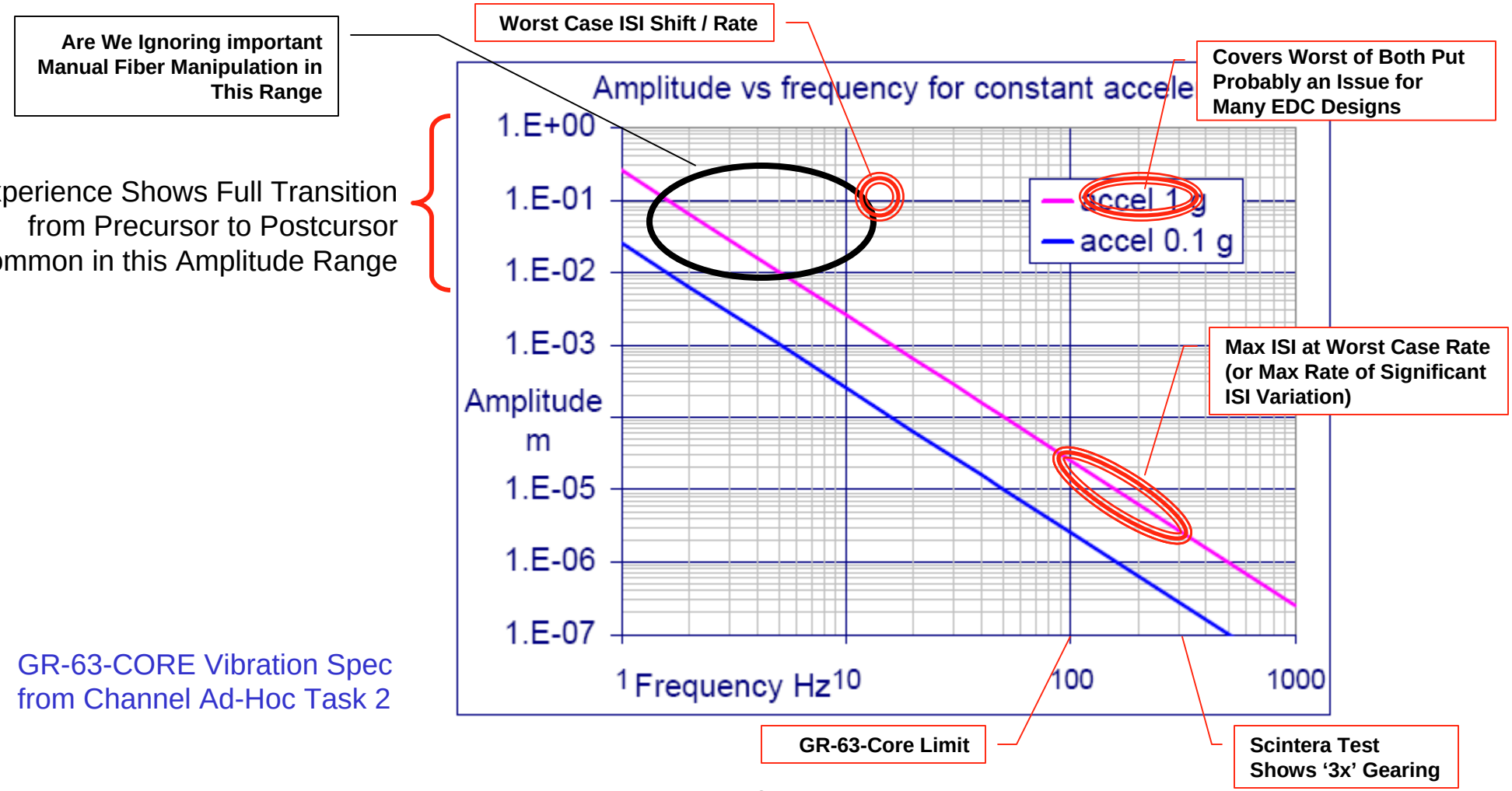
Willcocks/Weiner Dynamic Test ISI

- **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 Dynanmic 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**

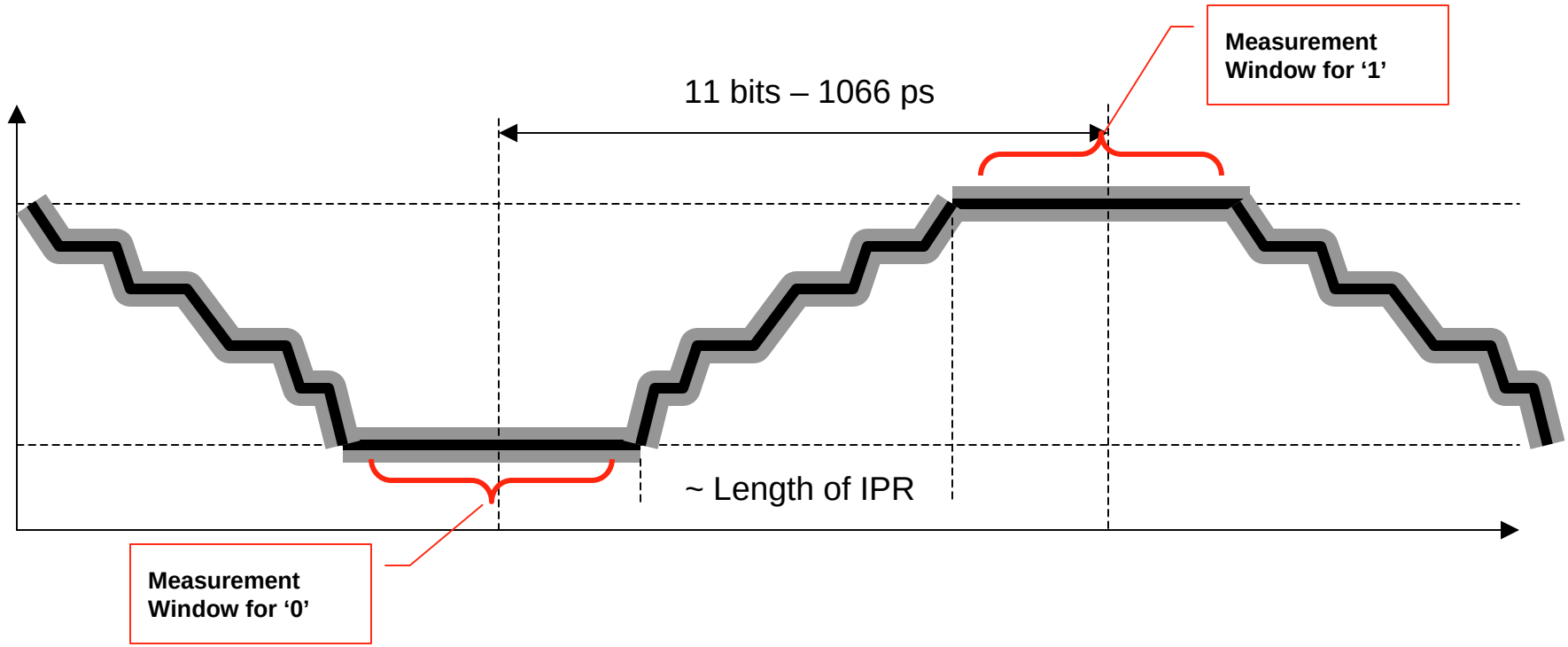
Dynamic Test ISI Considerations

- **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)**
- **Task 2 Should Concentrate on Behavior in These Ranges (or at equivalent limits)**



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**
  - **802.3ae Allows up to 11 '1'/11 '0' Square Wave. Easily Long Enough**



Potential Areas of Consensus

- **TP2 and TP3 Efforts Are Incomplete – Can We Get to Useful D1.0 in November?**
  - **Final Values Dependent on Final Channel Model Results**
  - **Consensus on Certain Issues Could Focus Efforts of Conference Calls/Ad-Hocs**
- **Potential Areas for Consensus (Preliminary to Motions?)**
  - **Retention of TP2 Mask (in addition to proposed new penalty test)**
  - **Informative Sensitivity Test**
    - **Use of 2.3 GHz BT Bandwidth (for 300m link)**
    - **Suggested Sensitivity Value (or at least approach pending final channel values)**
  - **Static Stressed Sensitivity Test**
    - **Use of 3 Impulse Responses for Normative Static Stressed Sensitivity Test**
    - **Use of a 1 UI Based IPR (if it results from the channel mode)**
    - **Use of a 4 peak / Uniform ΔT approximation for Static IPR**
    - **Use of Gaussian Noise Impairment (and certain details)**
  - **Dynamic Penalty Test**
    - **Use the 1 UI / 3 pulse form Proposed By Wilcox/Weiner**
    - **Low Frequency/ Full Swing vs. High Frequency / Partial Swing**
      - **Two Tests? Can We Conclude One is Clearly the Limiting Case?**

Retention of Eye Mask in TP2

- **Can We Reach Consensus on Retaining the TP2 Eye Mask?**
- **Suggest We Retain LR Eye Mask as Part of the TP2 Specification:**
  - **NOT to the Exclusion of a more Rigorous Transmit Penalty.**
  - **Include a Transmit Penalty As Defined in efm/public/may03/optics/dawe_optics_2_0503 to be Added to the Minimum Transmit OMA. This Penalty is Based on Mask Margin to Effectively Factor Out Eye Closure Allowed by –LR Eye Mask.**
  - **If the Proposed Penalty is Found to Allow Useful Cases Not Allowed by Eye Mask, Standard Could Allow Compliance by Transmit Penalty Only.**
  - **Similarly, if Possible, Eye Mask with Closure Penalty Would Be Allowed as Sufficient.**

Accept TP3 Informative Sensitivity Test

- **Do We Have Consensus To Accept an Informative Sensitivity Test Based on a BT Filter for ISI?**
- **Suggest We Accept the Proposed Informative Sensitivity Test as Shown on Slide 5**
  - **Use 2.3 GHz BT Filter for 300m Link**
  - **Use 3.1 Ghz BT Filter for 220m Link**
  - **Leave Exact Required Sensitivity for Further Study**
    - **Likely = Normative Sensitivity – RIN and MSL Penalties – (Difference in ISI Penalties)**

Use of Three IPR Functions for Static Sensitivity Test ISI

- **Do We Have Consensus To Accept the Use of Three Characteristic IPRs for ISI Generator?**
  - **Pre-Cursor, Post-Cursor and Quasi Symmetric**
  - **Final Values to be Determined On Basis of Channel Model**
- **Motivation is Common EDC Sensitivity to Variations to These IPR Types Beyond Metrics Such PIE.**

Use of 1 UI Spacing in ISI Generator for Static Sensitivity Test

- **Do We Have Consensus To On Potential Use ISI Generators Based on 1 UI Peak Spacing?**
  - **Would Apply to Dynamic Penalty Test As Well**
- **A Number of Motivations**
  - **Phyworks Analysis showed 1 UI spacing gave Good Flexibility in Tuning PIE**
  - **Popescu Work Pointed Towards Decent Fits to Fiber Models with 1 UI Based IPR**
  - **Allows Use of Filters Based on 1 or ½ UI Tap Spacing**
- **Possible Difficulties**
  - **Unusually Poor or Excessively Good Performance by EDC Which Has the Same Tap Spacing**

Use of 4 peak Model for Static Sensitivity Test ISI

- **Do We Have Consensus To Accept Up to A 4 Peak ISI Generator for Static Test**
  - **Tradeoff Between Matching Fiber Responses and ISI Complexity with Uniform ΔT Generator**
  - **Popescu Analysis Shows It Allows Decent Matching of Fiber Responses**
- **Simpler Model May Be Possible with Less Reliance on Matching Particular Fiber Response But Wording Would Allow Concluding on a Simpler Function.**

Use of Gaussian Source for Static Stressed Test Noise Impairment

- **Do We Have Consensus To Accept Noise Impairment as Described in Slides 9 and 10?**
  - **Use Gaussian Noise Source with Minimum 10 GHz Bandwidth**
  - **Add Gaussian Noise to Achieve Penalty of 0.9 dB Representing Combined RIN and MSL Penalties**
    - **Penalty as Calculated for Unequalized Links as in 802.3ae Link Models.**
  - **Add Gaussian Noise Source Before Linear ISI Generator**
  - **Calibrate Compliance Signal Using Calculated OSNR from Above and With Same Method to Isolate 0 and 1 levels in OMA Definition.**

Use of 3 Peak Dynamic Penalty Test As Described by Wilcox

- **Do We Have Consensus To Accept the 3 Peak Model for Dynamic Penalty Test**
  - **3 Peak Model with Static Central Peak and Power Varied Between Outer Peaks**
  - **Final values of Peak Heights TBD Based on Channel Model Results**
  - **Final Rate and Dynamic Excursion Definitely TBD based on Channel Model Results**
    - **Likely a Tradeoff Between Full Excursion from Pre- to Post-Cursor at Low Rates and Smaller Excursions at Maximum Rates.**