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LiveWebcast

How to Perform Key COM Transmitter and Receiver Measurements on 100G Designs

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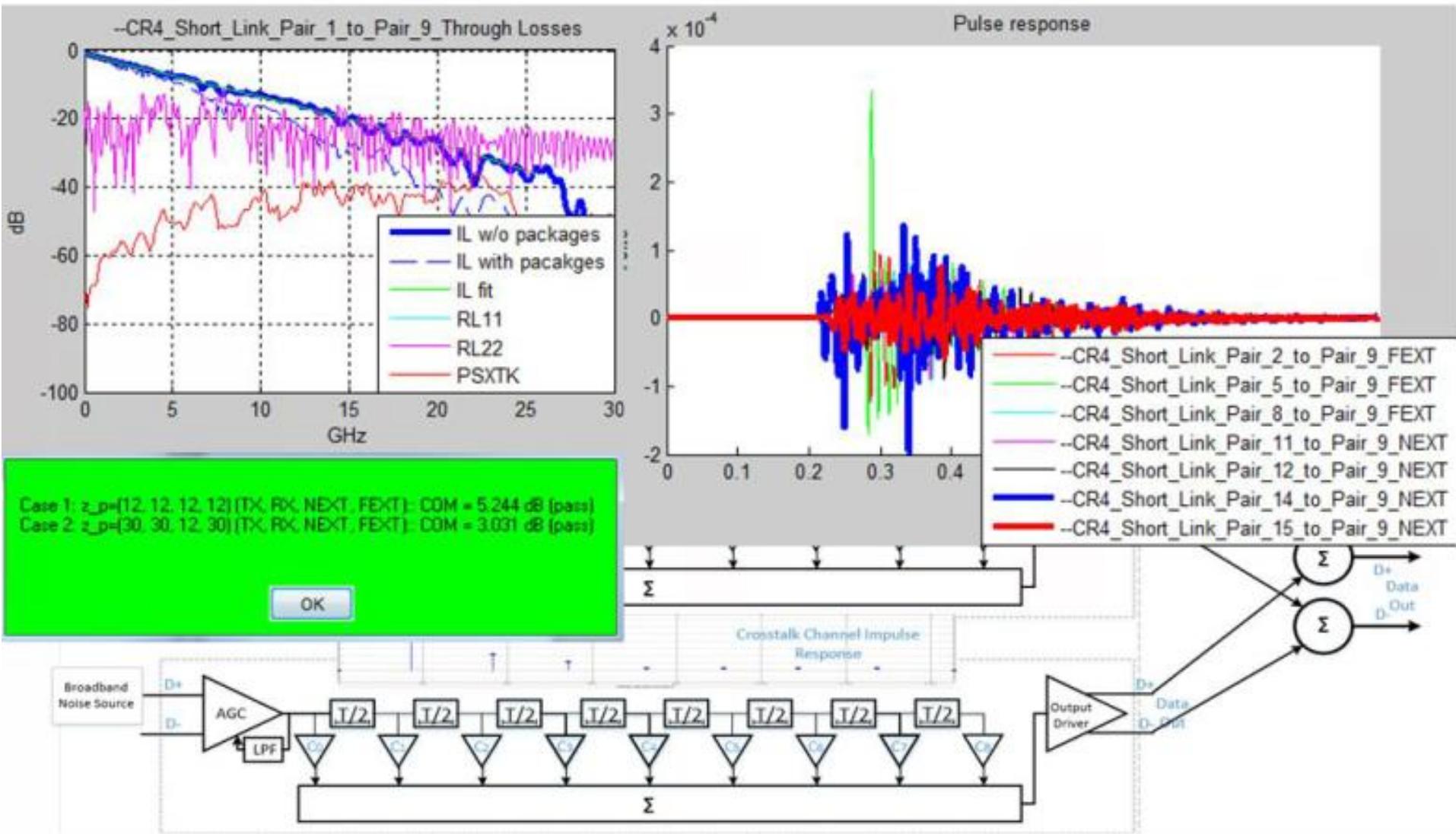
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How to Perform COM, Transmitter and Receiver Measurements on 100G Designs



ABSTRACT

How to Perform COM, Transmitter and Receiver Measurements on 100G Designs

The characterization of emerging 100G-KR4/CR4-based silicon requires attention to test techniques and methods outlined in the IEEE p803.3bj specification. This Lightwave Webinar will discuss methods of performing COM and other key Transmitter measurements. It will also provide measurement tips to successfully calibrate a receiver subsystem to be conformant to COM specs for testing.

References:

- I "Analysis of contributed channels using the COM method", A. Ran, R. Mellitz. IEEE 802.3bj Task Force Meeting, San Diego, CA July 2012 http://www.ieee802.org/3/bj/public/jul12/ran_01a_0712.pdf
- II "Time-Domain Channel Specification: Proposal for Backplane Channel Characteristic Sections" IEEE 802.3bj Task Force", R. Mellitz, C. Moore, M. Dudek, M. Li, A. Ran. IEEE 802.3bj Task Force Meeting, San Diego, CA July 2012 http://www.ieee802.org/3/bj/public/jul12/mellitz_01_0712.pdf
- III "IEEE P802.3bj™/D3.1: Draft Standard for Ethernet Amendment 2:Physical Layer Specifications and Management Parameters for 100 Gb/s Operation Over Backplanes and Copper" February 2014
- IV "The state of IEEE 802.3bj 100Gb/s Backplane Ethernet", M. Brown, M. Dudek, A Healey, E Kochuparambil, L Artsi, R Mellitz, C Moore, A Ran, P. Zivny. DesignCon January 2014
- V "Channel Operating Margin (COM): Evolution of Channel Specifications for 25Gbps and Beyond", R Mellitz, A Ran, M Li, V Ragavassamy. DesignCon January 2013
- VI "Issues with SNDR specification in clauses 92/93", A Ran IEEE 802.3bj Task Force Meeting September 2013
- VII "Proposal for CAUI-4 Package, Reference Receiver, and COM Parameters In Support of Comment 105,106, 107,108,111, 112," R Mellitz, A Ran IEEE 802.3bm, September 2013

AGENDA

How to Perform COM, Transmitter and Receiver Measurements on 100G Designs

Testing at 100G: Overview:

- Channel Operating Margin topology view

- Channel Operating Margin and noise parameters

Electrical Characteristics: TX and Channel

- TX Testing and review of tools used for Rx calibration

- TX Linear fit to the measured waveform

- COM Channels

- COM Reference Model

- COM Channel examples and dependence on η_0 noise parameters

Electrical Characteristics: Receiver

- RX Possible Solutions

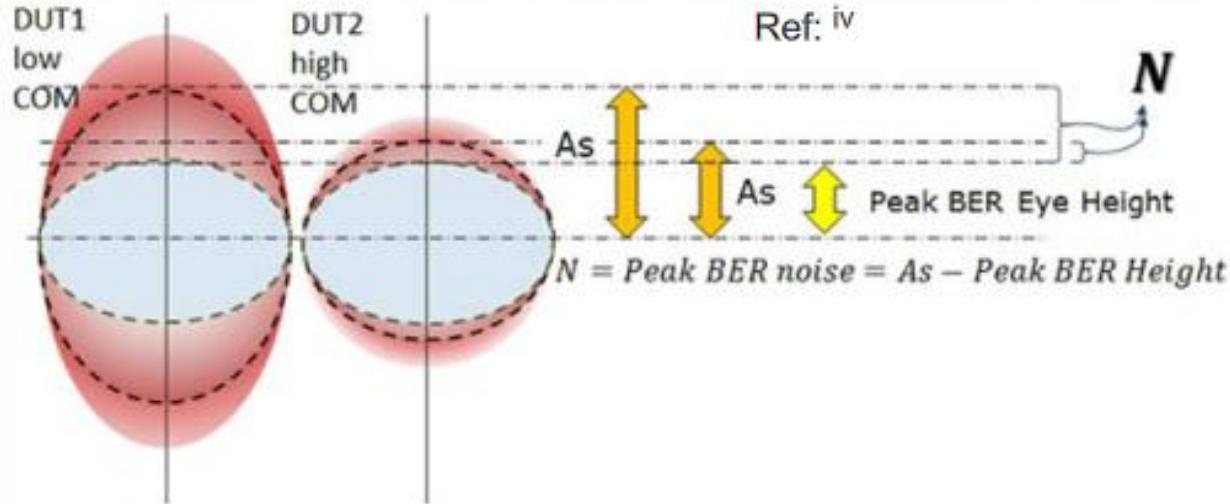
Conclusions and Summary

Testing at 100G: Overview

The 100 Gigabit Ethernet design currently underway in IEEE P802.3bj has pushed modern silicon and test tools to the point where new tools and methods developed for the design task at hand^{iv}.

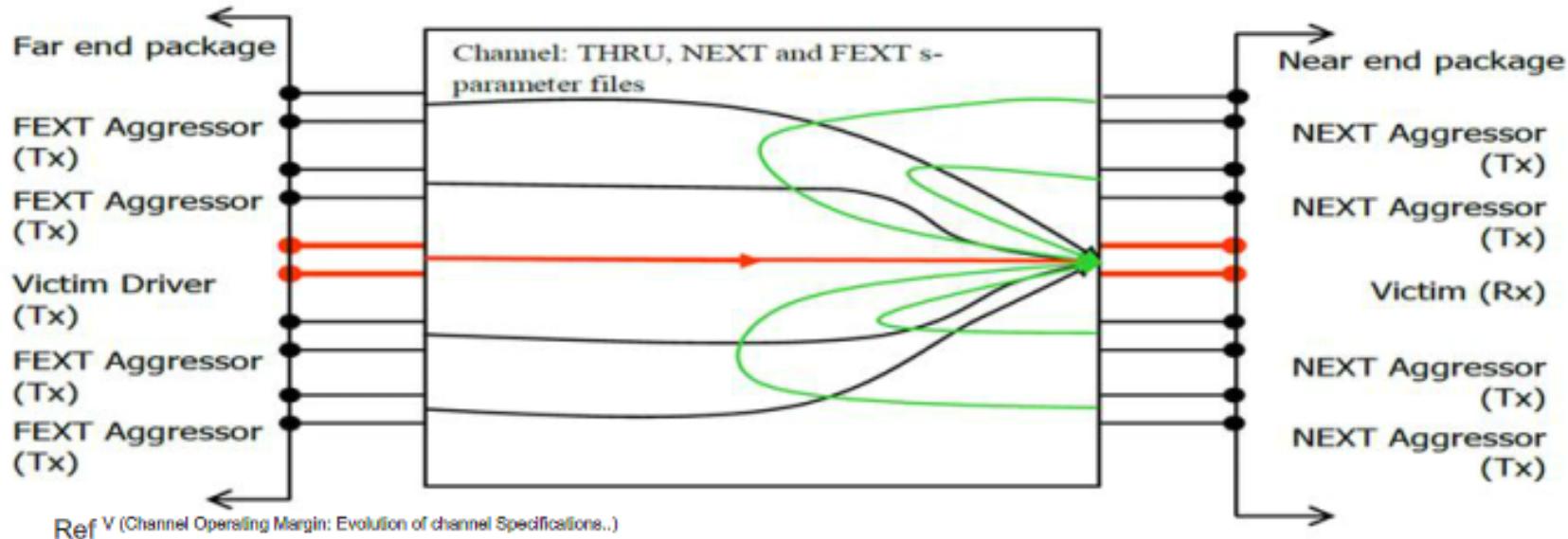
Overall channel loss allowances from 100G die to die are as high as 40dB, (1000mV delivers 10mV to receiver) which illustrates the need for the unique degree of attention this standards applies to receiver testingⁱⁱⁱ.

Channel Operating Margin (COM) was born out of a need for a unifying budget tool with the objective of serving the industries link margin needs while allowing design trade-offs for all the system specifications.



Channel Operating Margin (COM) Topology View

- The key idea with the introduction of COM, is that the 25Gbps design space is too confined to just brick-wall in every direction (mask for loss, mask for IDL, mask for return loss, x-talk etc.); rather one wants to offer an elastic bag of constraints that different implementations will stretch differently... And as long as you stay within the bag, it all interoperates.
- For compliance testing a designer needs to test out most of the corners which the bag might stretch into. This is what makes Rx verification a challenge.



P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

Draft Amendment to IEEE Std 802.3-2012

IEEE P802.3bj/D3.1
13th February 2014

The Channel Operating Margin (COM) is a figure of merit for a channel derived from a measurement of its scattering parameters. COM is related to the ratio of a calculated signal amplitude to a calculated noise amplitude as defined by Equation (93A-1).

$$COM = 20\log_{10}(A_s/A_{ni}) \quad (93A-1)$$

- The A_{ni} is the magnitude of convolved noise parameters which ensures a detector error ratio can be met. This is a complex to physical parameter to evaluate in the spec, as it's the convolution of several interference and noise distributions.
 - COM A_{ni} includes the convolution of two key noise terms:
 - The first: $p_G(y)$ is a true Gaussian noise term with specified zero mean and variance
$$p_G(y) = \frac{\exp(-y^2/(2\sigma_G^2))}{\sqrt{2\pi\sigma_G^2}} \quad (93A-40)$$
 - The second: $p_{DD}(y)$ is from the amplitude noise resulting from dual-Dirac jitter.
- $p_n(y) = p_G(y) * p_{DD}(y)$
- COM A_{ni} also includes the data dependent amplitude interference terms derived from combined influence of modeled through insertion loss and crosstalk coupling from adjacent lanes.

Electrical Characteristics: Channel Components

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

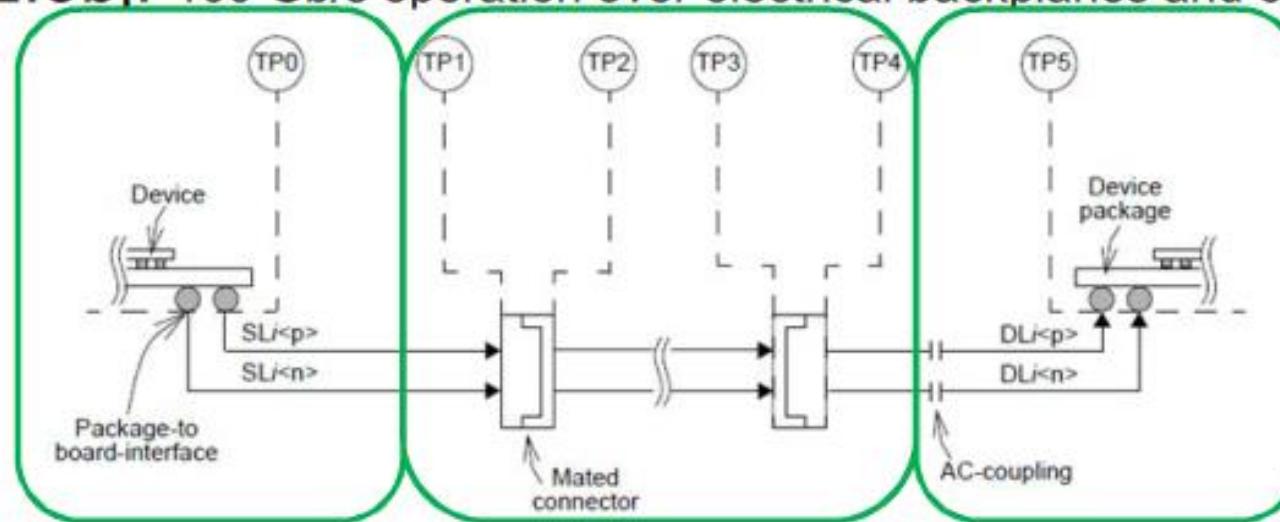


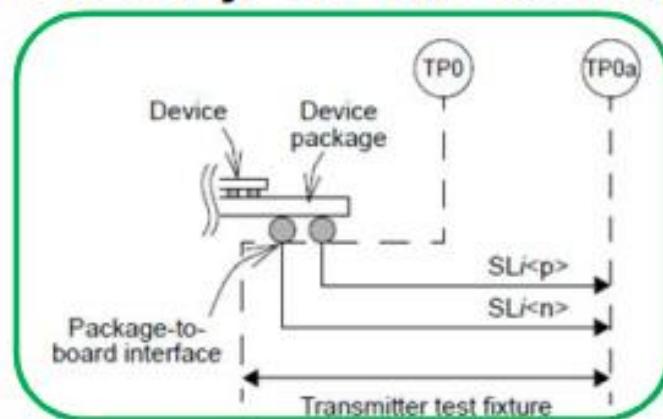
Figure 93B-1—Reference model (one direction from one lane is illustrated)

Table 93B-1—Description of channel components

Test points	Description
TP0 to TP1	The printed circuit board between the transmitter and the separable connector closest to the transmitter. TP1 is defined to be the interface between the board and connector plug.
TP2 to TP3	The electrical path from the separable connector closest to the transmitter to the separable connector closest to the receiver. TP2 and TP3 are defined to be the interface between connector receptacle and the printed circuit board.
TP4 to TP5	The printed circuit board between the receiver and the separable connector closest to the receiver. TP4 is defined to be the interface between the board and connector plug. It is recommended that the AC-coupling capacitors are implemented between TP4 and TP5.
TP0 to TP5	The electrical backplane channel as defined in 93.9 and 94.4. TP0 and TP5 are defined to be the interface between the device package and the printed circuit board.

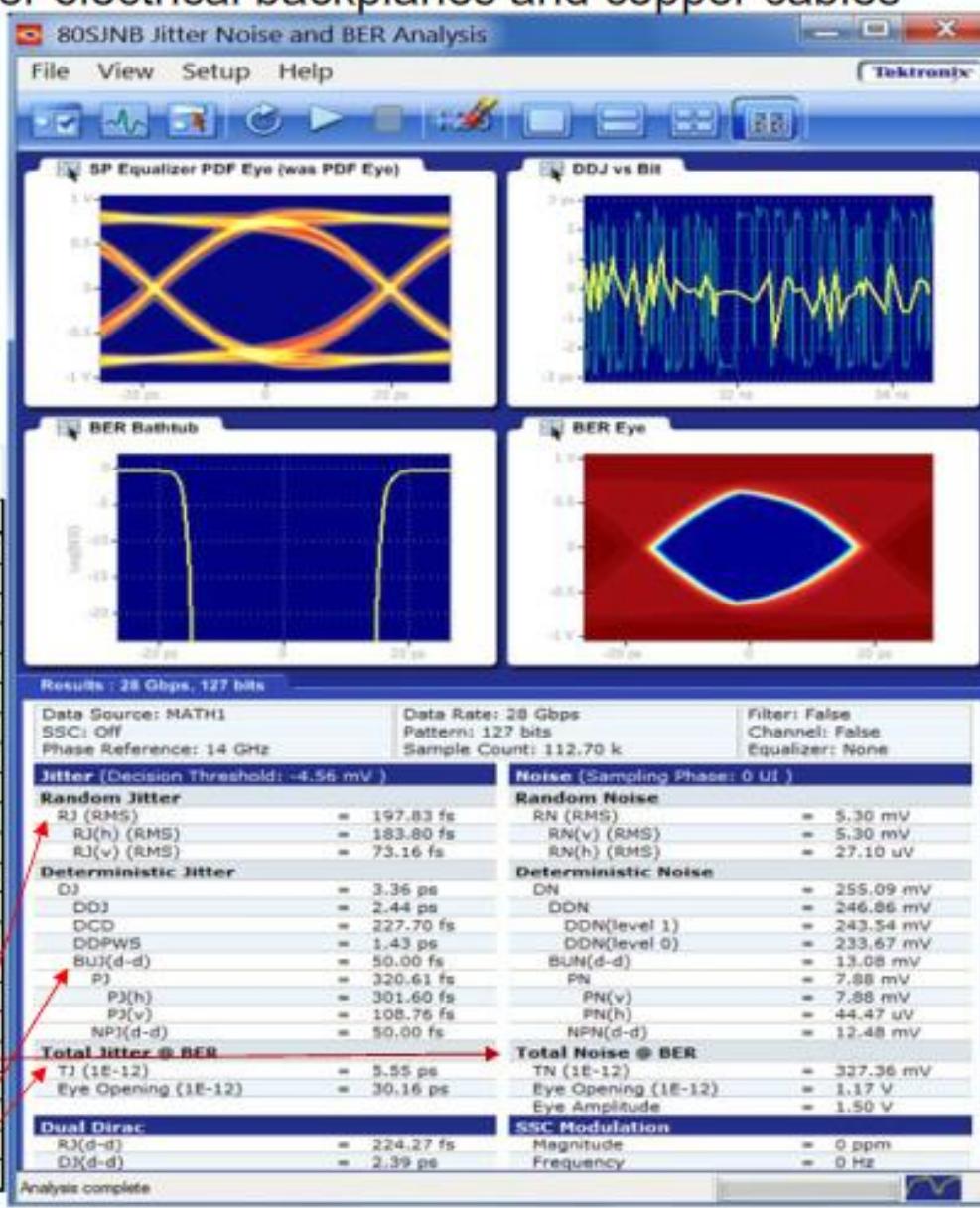
Electrical Characteristics: TX (no COM here.. yet)

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables



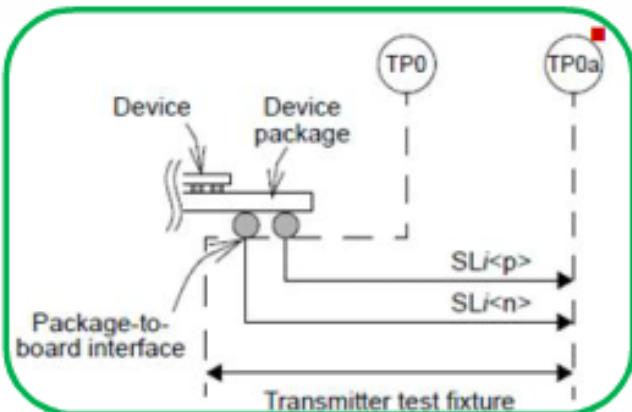
Summary of transmitter characteristics at TP0a (100G-KR4)

Parameter	Value	Units
Signalling rate	25.78125±100 ppm	Gbd
Differential peak-to-peak output voltage (max.)		
Transmitter disabled	30	mV
Transmitter enabled	1200	mV
DC common-mode output voltage (max.)	1.9	V
DC common-mode output voltage (min.)	0	V
AC common-mode output voltage (RMS, max.)	12	mV
Differential output return loss (min.)	Equation (93-3)	dB
Common-mode output return loss (min.)	Equation (93-4)	dB
Output waveform		
Steady-state voltage vf (max.)	0.6	V
Steady-state voltage vf (min.)	0.4	V
Linear fit pulse peak (min.)	$0.71 \times vf$	V
Normalized coefficient step size (min.)	0.0083	-
Normalized coefficient step size (max.)	0.05	-
Pre-cursor full-scale range (min.)	1.54	-
Post-cursor full-scale range (min.)	4	-
Signal-to-noise-and-distortion ratio (min.)	27	dB
Output jitter (max.)		
Even-odd jitter	0.035	UI
Effective bounded uncorrelated jitter, peak-to-peak	0.1	UI
Effective total uncorrelated jitter, peak-to-peak	0.18	UI



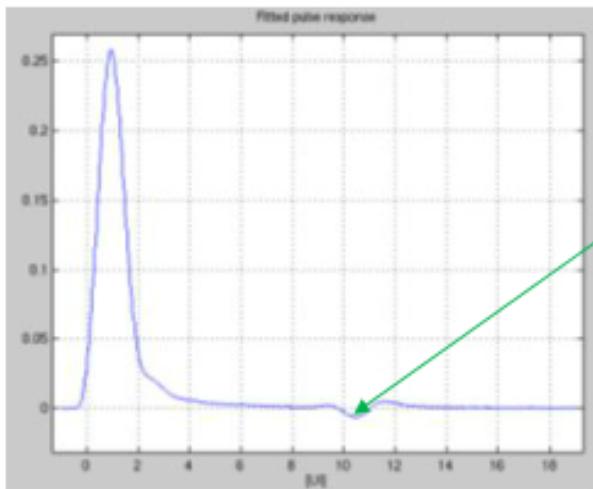
Electrical Characteristics: TX Linear fit to the measured waveform

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables



The transmitter evaluation is based on the linear fit impulse response extracted from the transmitter waveform, or more precisely the fitting error of this fit. The fitting error corresponds to the amount of non-compensable ISI imperfections, for example long Reflections. Interestingly the error also captures crosstalk disturbance from non-aligned but coherent aggressors.

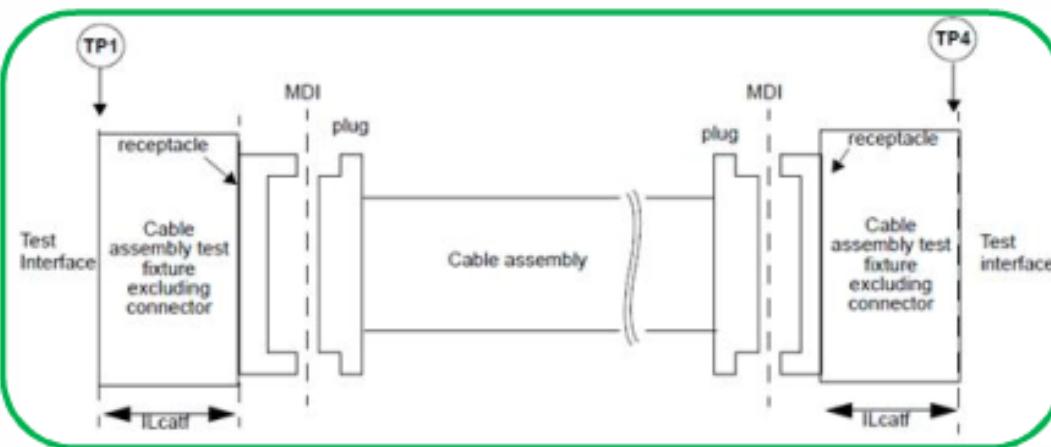
- First Fitted pulse response extracted from the Tx waveform on a Oscilloscope, illustrates a .05% fit error which shows that most of the imperfections are equalizable.
- The second pulse response shows the Tx after a 8.25" host channel board, and shows a normalized fit error of .5%



Electrical Characteristics: Channel (COM starts here)

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

- Cable assembly Channel Operating Margin (COM) must be greater than 3dB.
- Obtain COM (MATLAB) from IEEE public site and monitor carefully as versions are rapidly progressing.
<http://www.ieee802.org/3/bj/public/tools.html>
- Extract all permutations of Through, NEXT and FEXT scattering parameters, and enter into the COM tool.
 - 1 Through (SDD21) data set
 - 3 Far End Crosstalk (FEXT) data sets
 - 4 Near End Crosstalk (NEXT) data sets



- CR4_Short_Link_Pair_1_to_Pair_9_Through.s4p
- CR4_Short_Link_Pair_2_to_Pair_9_FEXT.s4p
- CR4_Short_Link_Pair_5_to_Pair_9_FEXT.s4p
- CR4_Short_Link_Pair_8_to_Pair_9_FEXT.s4p
- CR4_Short_Link_Pair_11_to_Pair_9_NEXT.s4p
- CR4_Short_Link_Pair_12_to_Pair_9_NEXT.s4p
- CR4_Short_Link_Pair_14_to_Pair_9_NEXT.s4p
- CR4_Short_Link_Pair_15_to_Pair_9_NEXT.s4p

Electrical Characteristics: COM reference model

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

- The η_0 (η₀) One-sided Gaussian noise spectral density is configured in the COM measurement (amongst many other parameters) by way of the input configuration table, which is unique for KR4, KP4, CR4 and CAUI-4.

Input randomly chosen from
 L -level alphabet

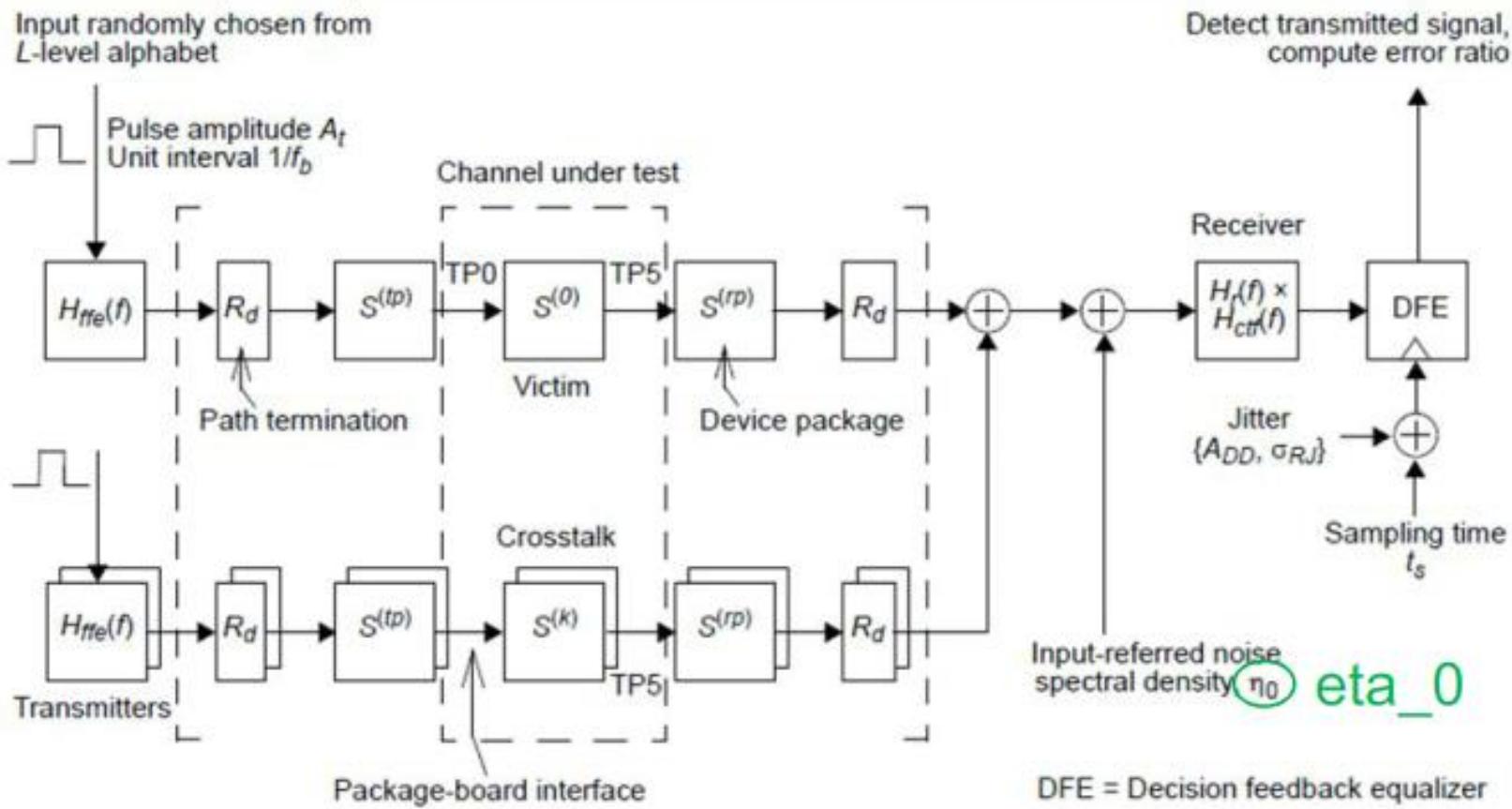
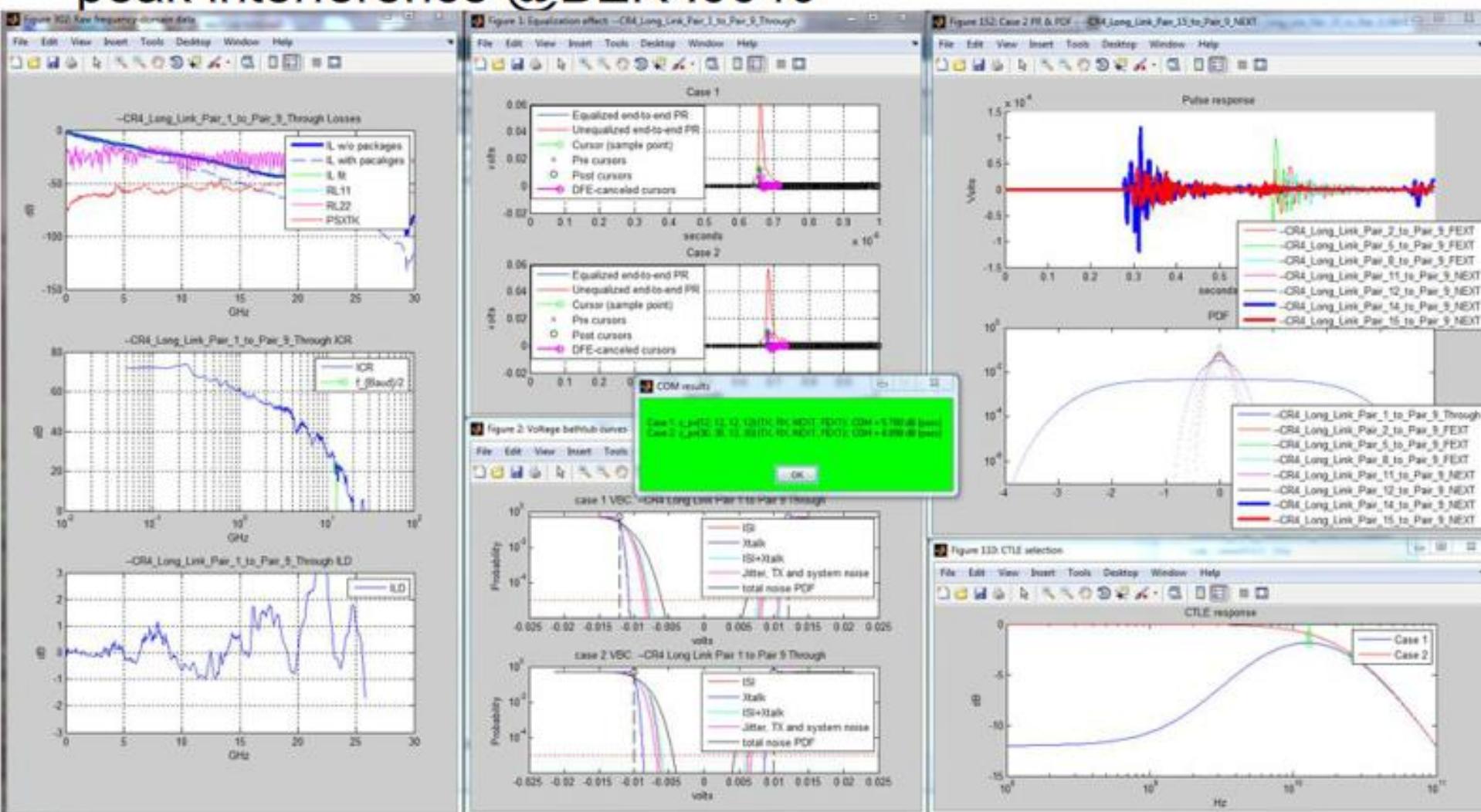
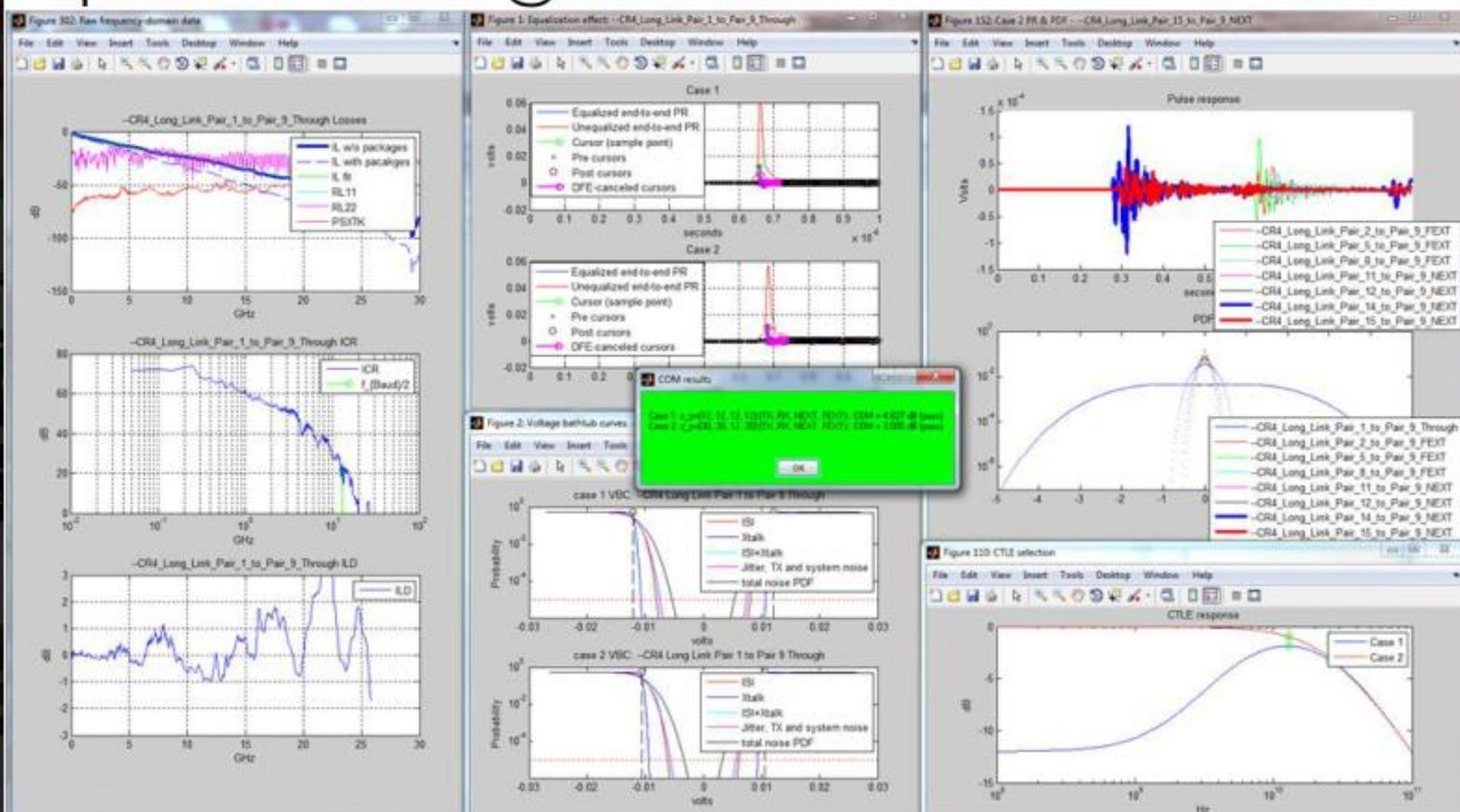


Figure 93A-1—COM reference model

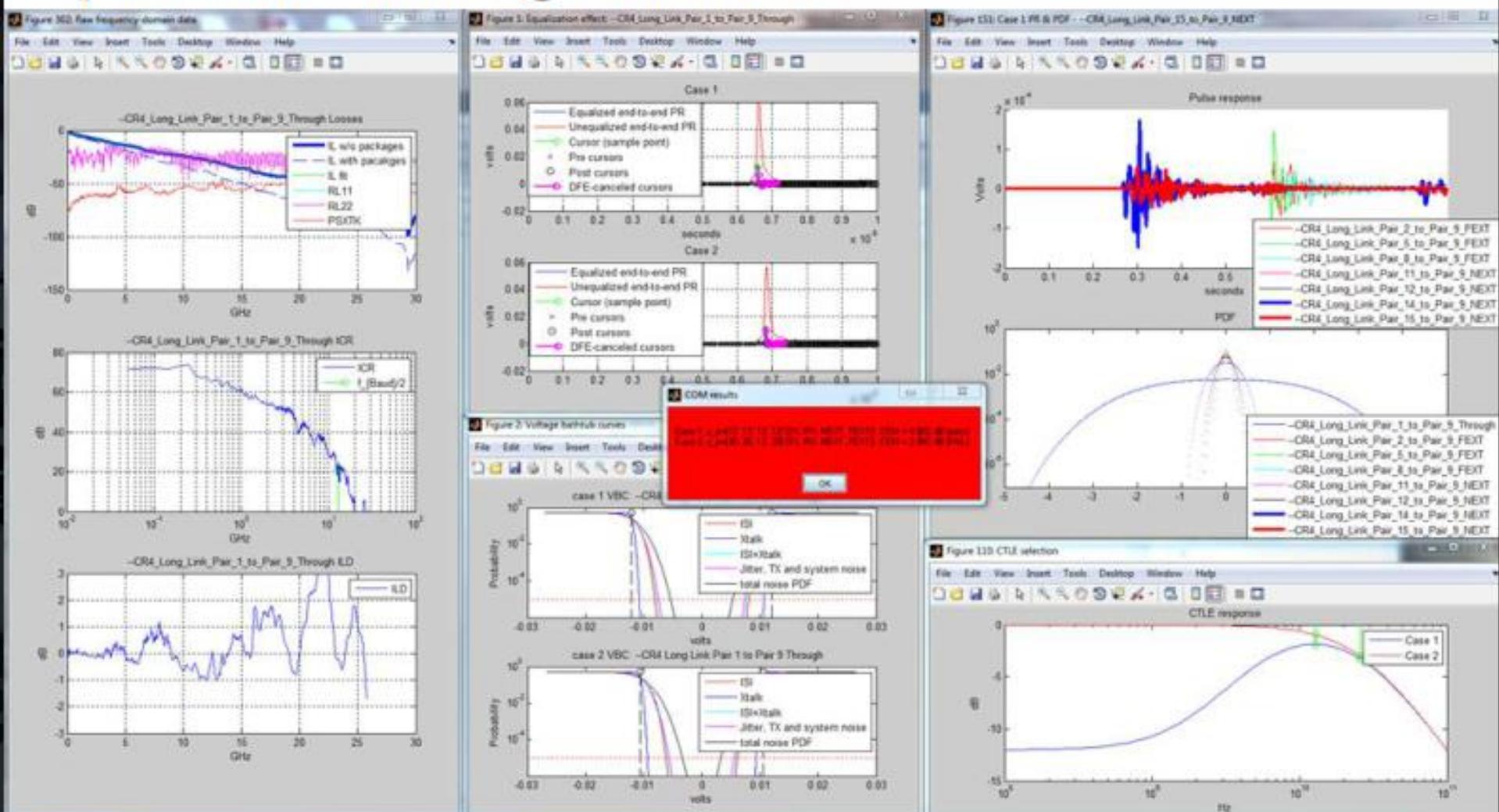
Example Conformant Long COM channel eta_0 (Random Noise) set to 0 peak interference @BER .0040



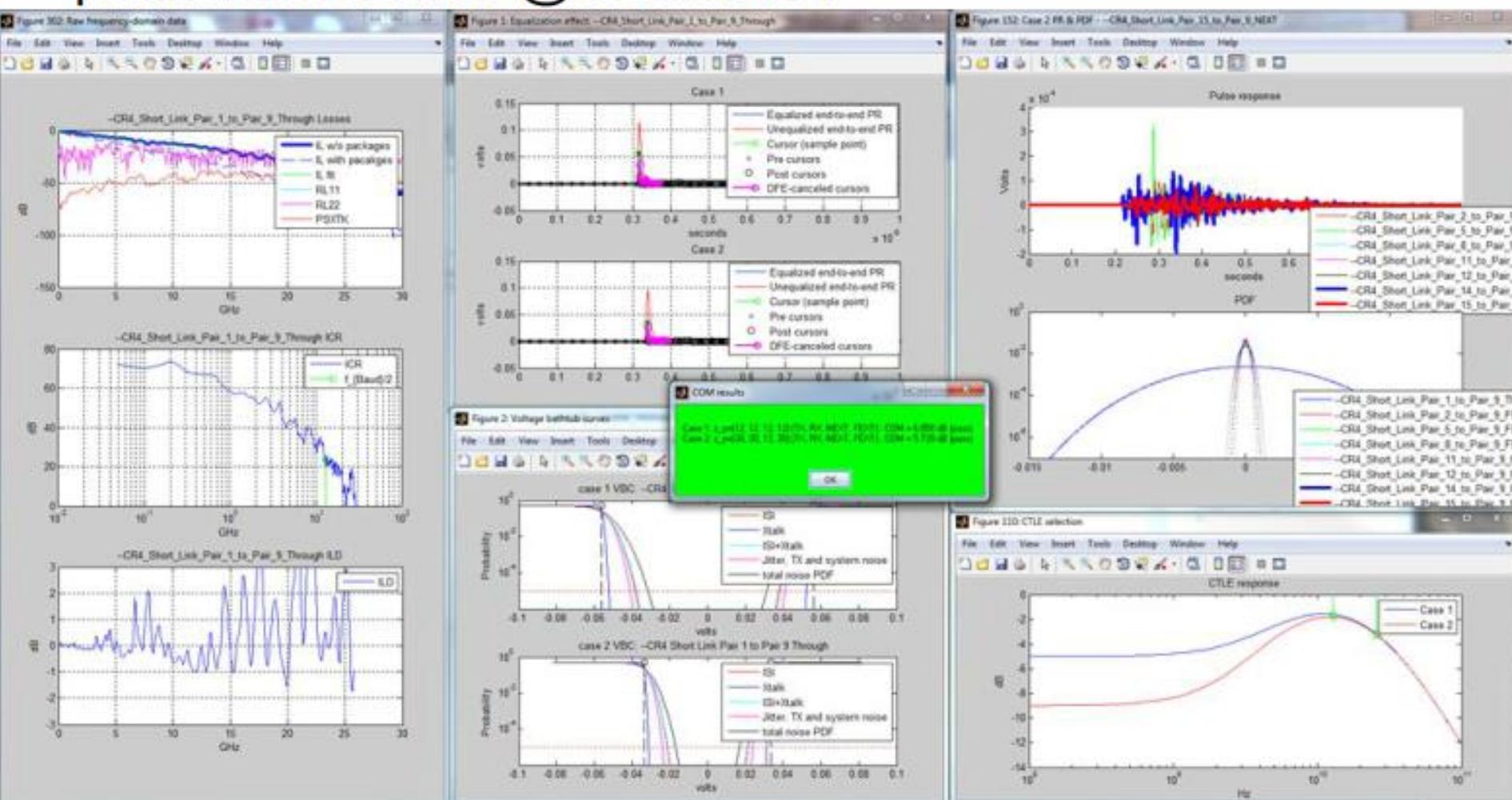
Example Conformant Long COM channel eta_0 (Random Noise) set to 4.6e-8v^2/GHz peak interference @BER .0048



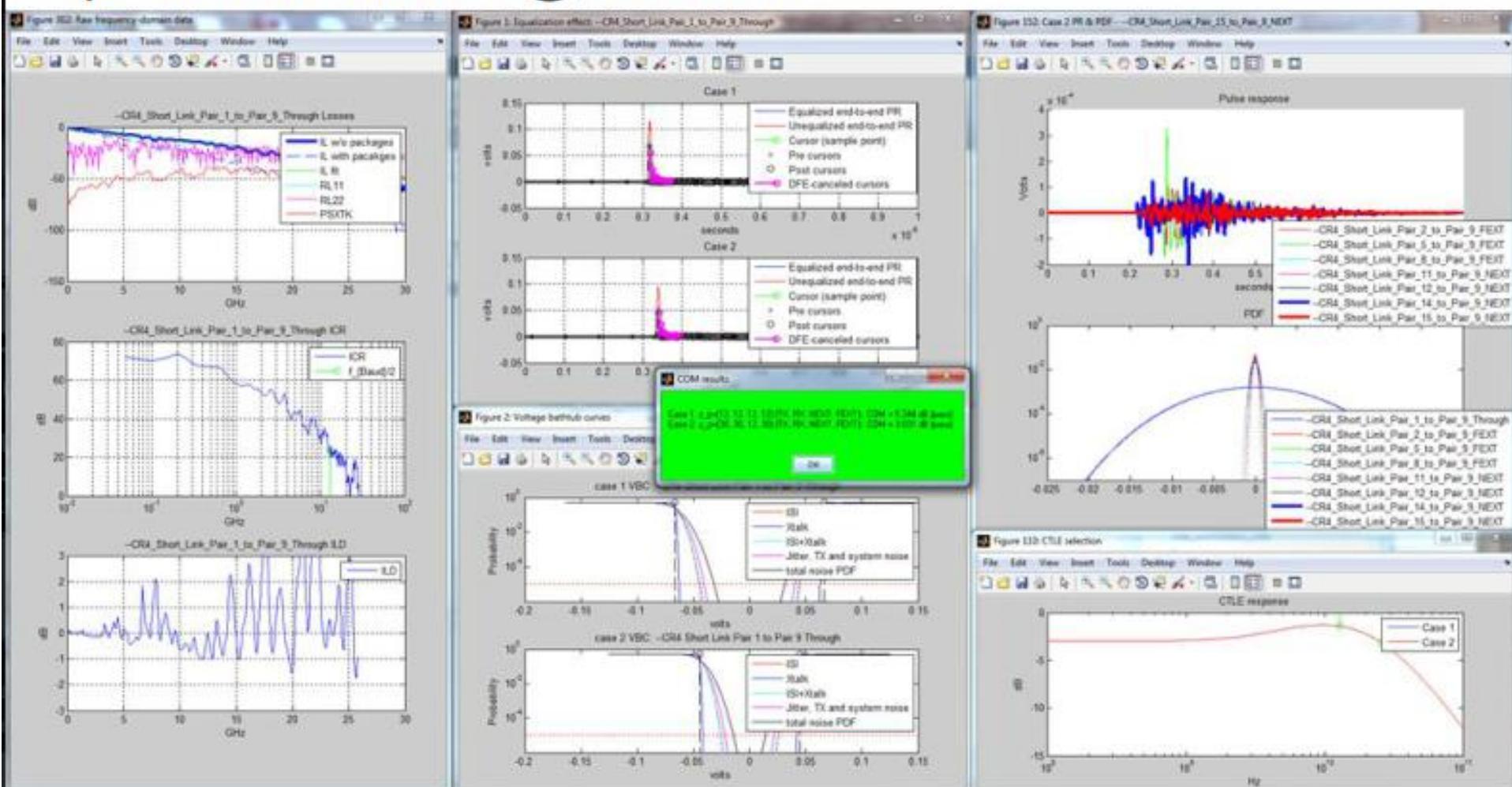
Example Non-Conformant Long COM channel eta_0 (Random Noise) set to 4.7e-8v^2/GHz peak interference @BER .0048



Example Conformant Short COM channel eta_0 (Random Noise) set to 0 peak interference @BER .0131



Example Conformant Short COM channel eta_0 (Random Noise) set to 15.5E-6 peak interference @BER .012



Electrical Characteristics: Receiver Test

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

- Start with a COM conformant channel of 3dB or higher.
- Calibrate test channel against fitted insertion loss and noise detailed in section 93C.2.

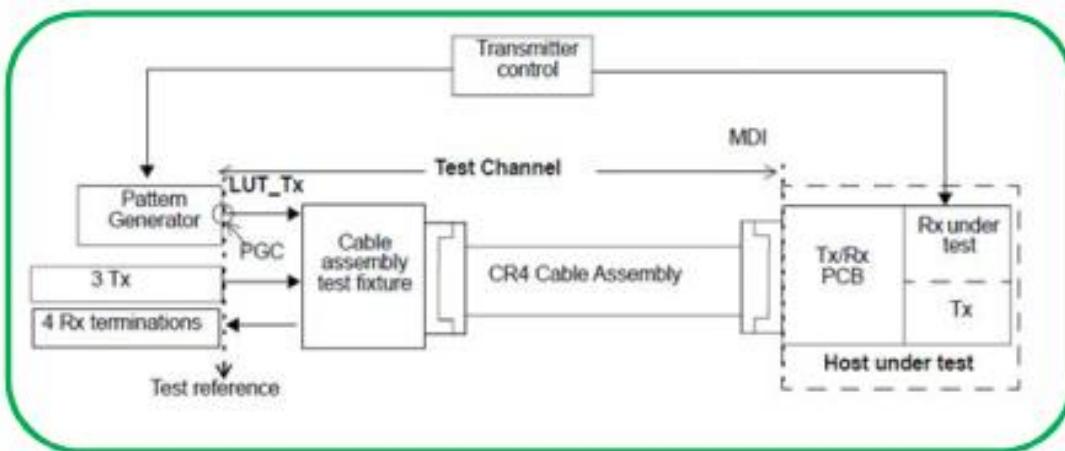


Table 92-8—100GBASE-CR4 interference tolerance parameters

Parameter	Test 1 values	Test 2 values	Units
RS-FEC symbol error ratio ^a	10^{-4}	10^{-4}	
Fitted insertion loss coefficients	$a_1 = 1.7$ $a_2 = 0.546$ $a_4 = 0.01$	$a_1 = 4.3$ $a_2 = 0.571$ $a_4 = 0.04$	$\text{dB}/\sqrt{\text{GHz}}$ dB/GHz dB/GHz^2
Applied SJ ^b (peak-to-peak)	0.1	0.1	UI
Applied RJ (RMS)	0.01	0.01	UI
Even-odd jitter	0.035	0.035	UI
COM (max)	3	3	dB

^aThe FEC symbol error ratio is measured in step 11 of the receiver interference tolerance method defined in 93C.2.

^bApplied SJ frequency >100 MHz, specified at TP0.

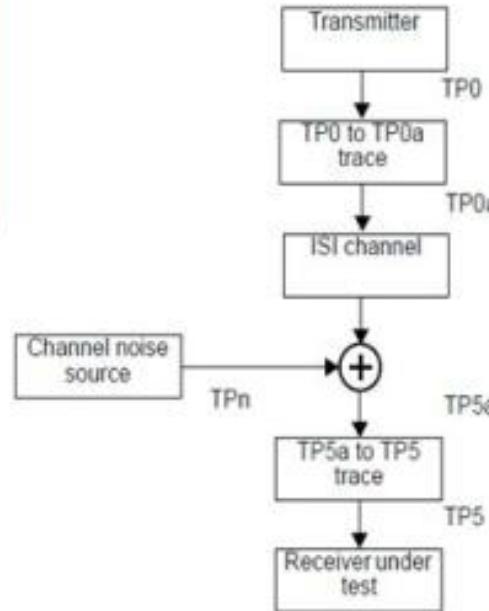
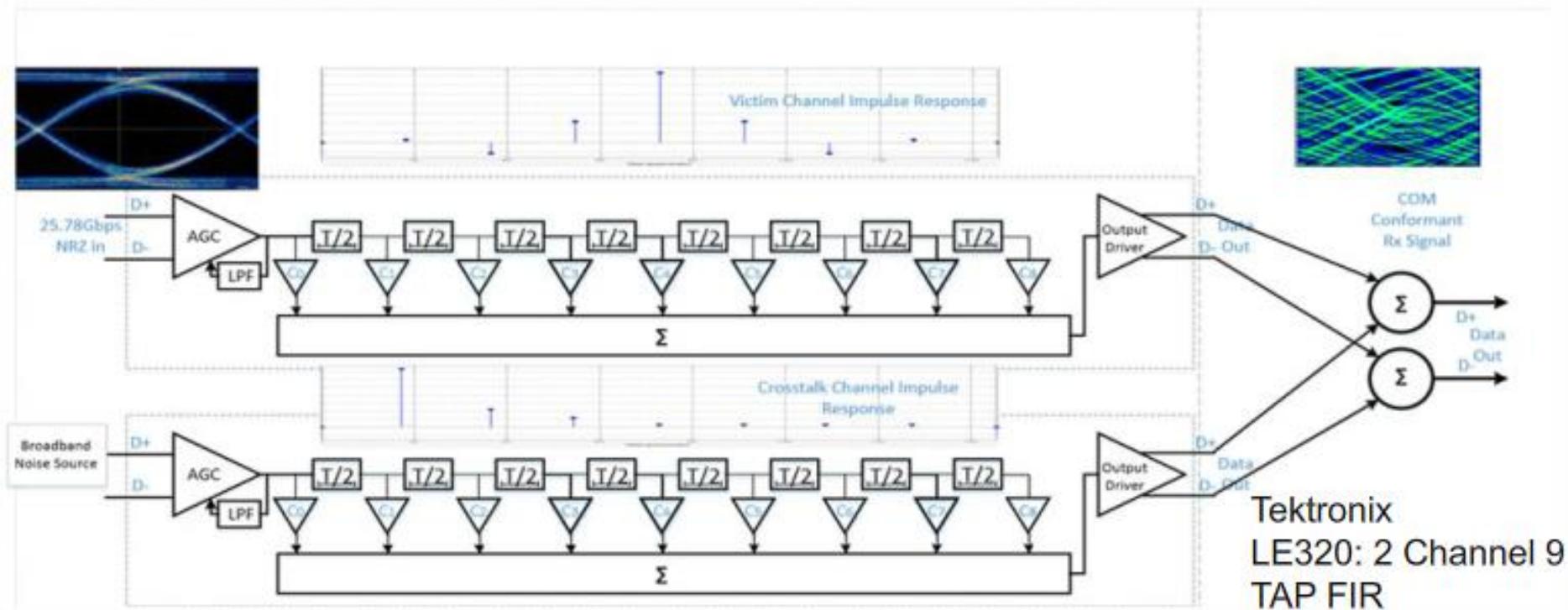


Figure 93C-2—Interference tolerance test setup

Electrical Characteristics: RX Possible Solutions

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

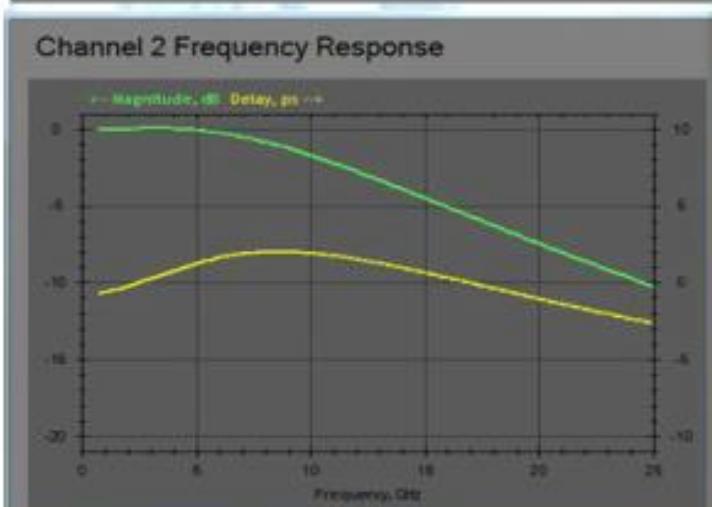
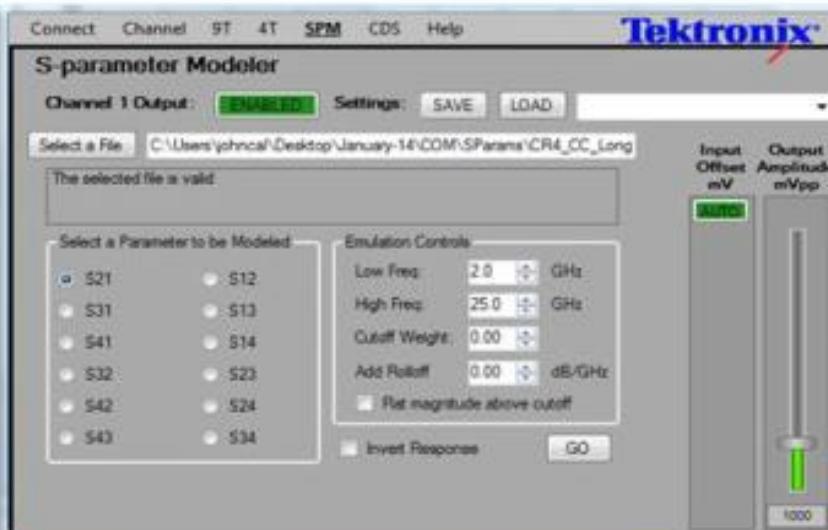
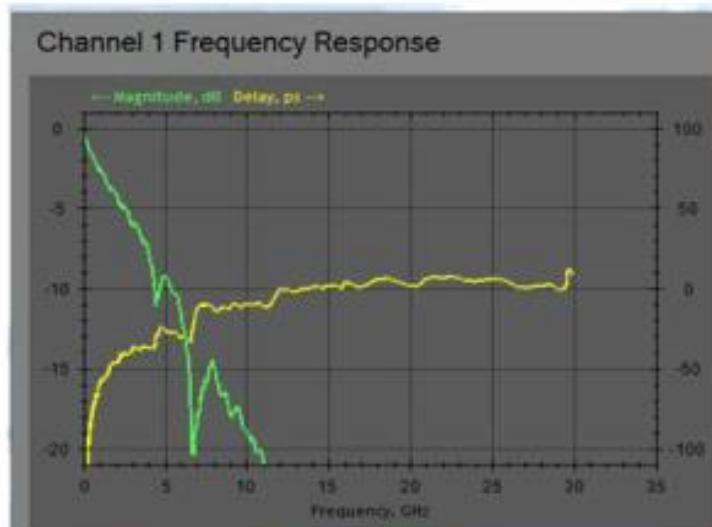
- Applying a two channel FIR based solution is a *potential* way of solving the complexities of generating wide ranging COM conformant Rx test signals. Variable and independent channel output drivers permit one to mix varying degrees of Loss profiles with filtered (fbaud/2) Random Noise, providing a maximally stressed test signal used to verify receivers BER.



Electrical Characteristics: RX Possible Solutions

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

- Long Channel (High Loss) CR4 Thru Model loaded into Equalizer



Electrical Characteristics: Summary

P802.3bj: 100 Gb/s operation over electrical backplanes and copper cables

- Given the utility of COM for 100 Gb/s designs, one can expect COM to appear in other standards beyond 100GBASE-CR4, 100GBASE-KR4, and 100GBASE-KP4. And indeed, COM is now being incorporated into another standard, specifically the CAUI-4 chip-to-chip specification in the IEEE P802.3bm 40 Gb/s and 100 Gb/s Fiber Optic Task Force. In [7] its demonstrated using COM that in order to support a 20 dB chip-to-chip channel at a BER of 10-15 for CAUI-4, a receiver capability of a 4-tap DFE or equivalent is required. Ref^{vii}.
- Any channel that passes COM may be used for RX compliance measurements. The wide variability of electrical configurations possible here make this landscape very broad.
- COM is a simulation and compliance tool, which is essential in any 802.3bj channel and receiver testing strategy.

Conclusions

- Preliminary silicon verification can be performed with a combination of a DSA8300 Equivalent Time instruments with a complimentary multi channel BERT and LE320 linear equalizer.
- 100G Tx & Rx Testing
- Tektronix is carefully tracking and contributing to 802.3bj spec developments.
 - The 100G specs reflect extremely tight Jitter margins and instrument floors have never been under more scrutiny for their intrinsic jitter floors.



Instruments Shown: DSA8300 + 80E010B, BSA286CL + CR286A, LE320, PPG3202, PED3202



It's Time for Questions

You can submit a question using the question tool on your screen.



Thank you for attending.

More questions?

Contact our speaker via Chris Loberg at
Christopher.j.loberg@tek.com.

Or go to www.tek.com/100g

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