

Package Impact Data

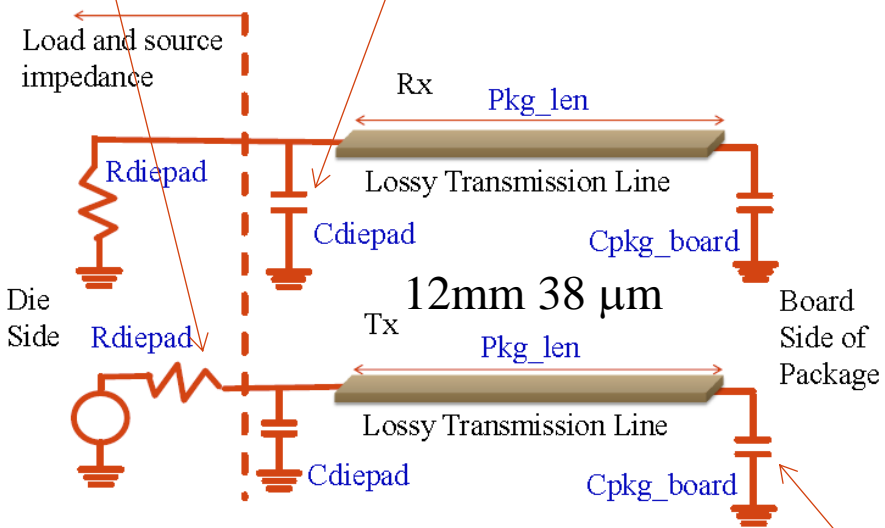
Richard Mellitz, Intel Corporation
07-03-2013

- IEEE802.3bj clause 93a package measured at TP0a.
- IEEE802.3bj clause 93a package impact on the Hirose Channel
- Observations

Review of IEEE802.3bj clause 93a package model

55 Ω 250ff

Simplest Useful Package Modeling

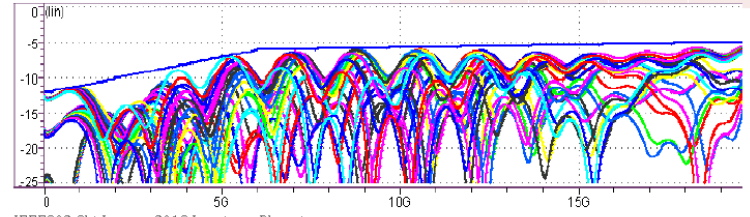


4 IEEE 802.3bj Task Force IEEE802.3bj January 2013 Interim – Phoenix

TP0a Suggested RL Limit

- Suggest that the measured return loss @TP0a/TP5a be higher than:
 $RL@TP > aF + b$ (F in GHz) between F1 and F2
- Excluding the combination of high impedance PKGs + low impedance driver one can get:
 (Still allowing a low impedance driver)

F1	F2	a	b
0.05	6	-1	12.05
6	19	-0.075	6.45



15 IEEE802.3bj January 2013 Interim – Phoenix

http://www.ieee802.org/3/bj/public/jan13/mellitz_3bj_01b_0113.pdf

http://www.ieee802.org/3/bj/public/jan13/benartsi_3bj_01a_0113.pdf

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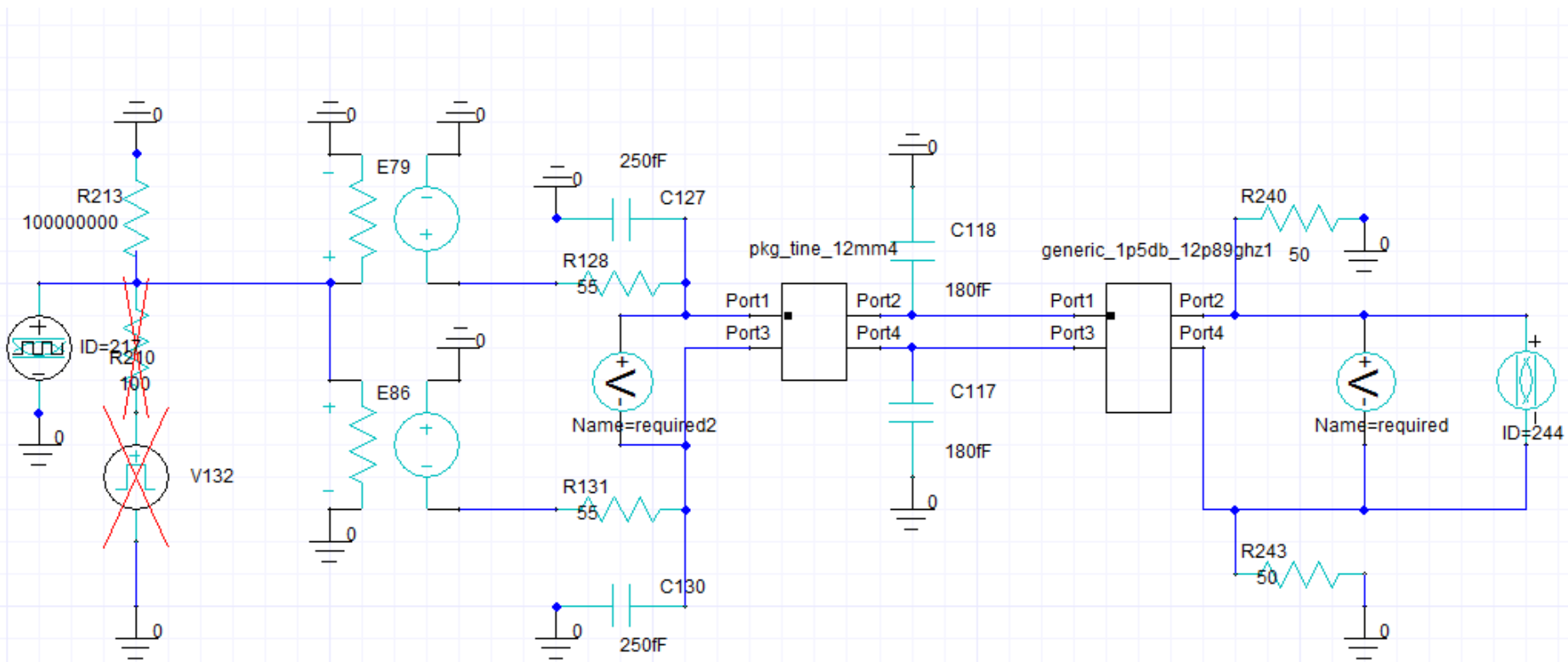
IEEE 802.3bm Task Force CAUI_4_adhoc

180ff

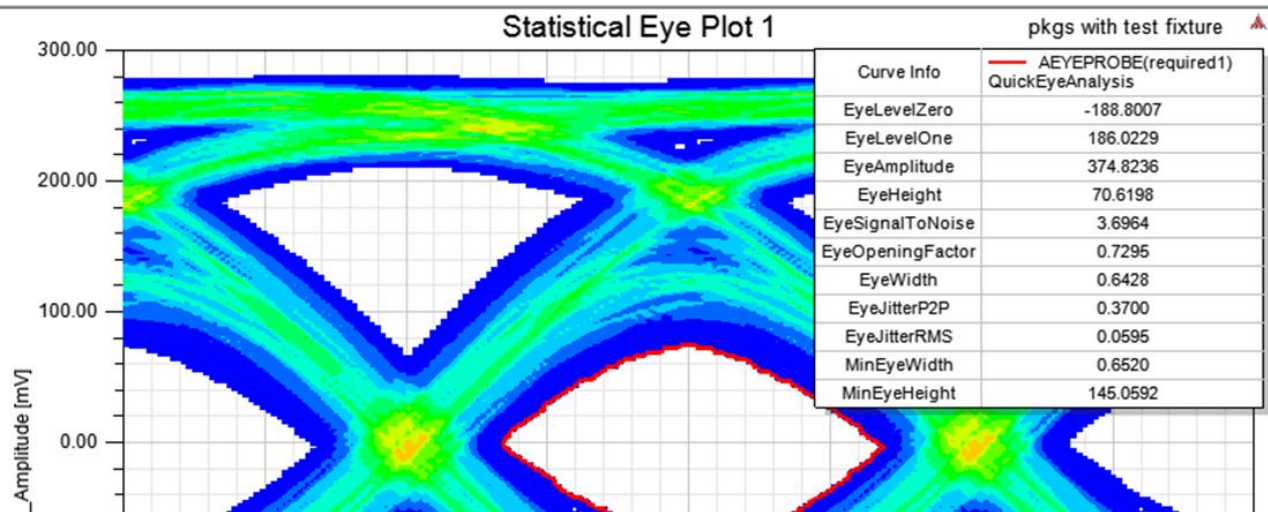
Simulation conditions

- 800 mV P-P ideal drive 1ps Trf into package die side
 - Package limits TP0 risetime.
- IEEE802.3bj package.
http://www.ieee802.org/3/bj/public/jan13/benartsi_3bj_01a_0113.pdf
- 0.38 ps rms random jitter
- 5.4 ps uniform jitter
- Package s-parameter were the original source s-parameter 4 port s-parameter for clause 93a.
- PRBS11 data pattern

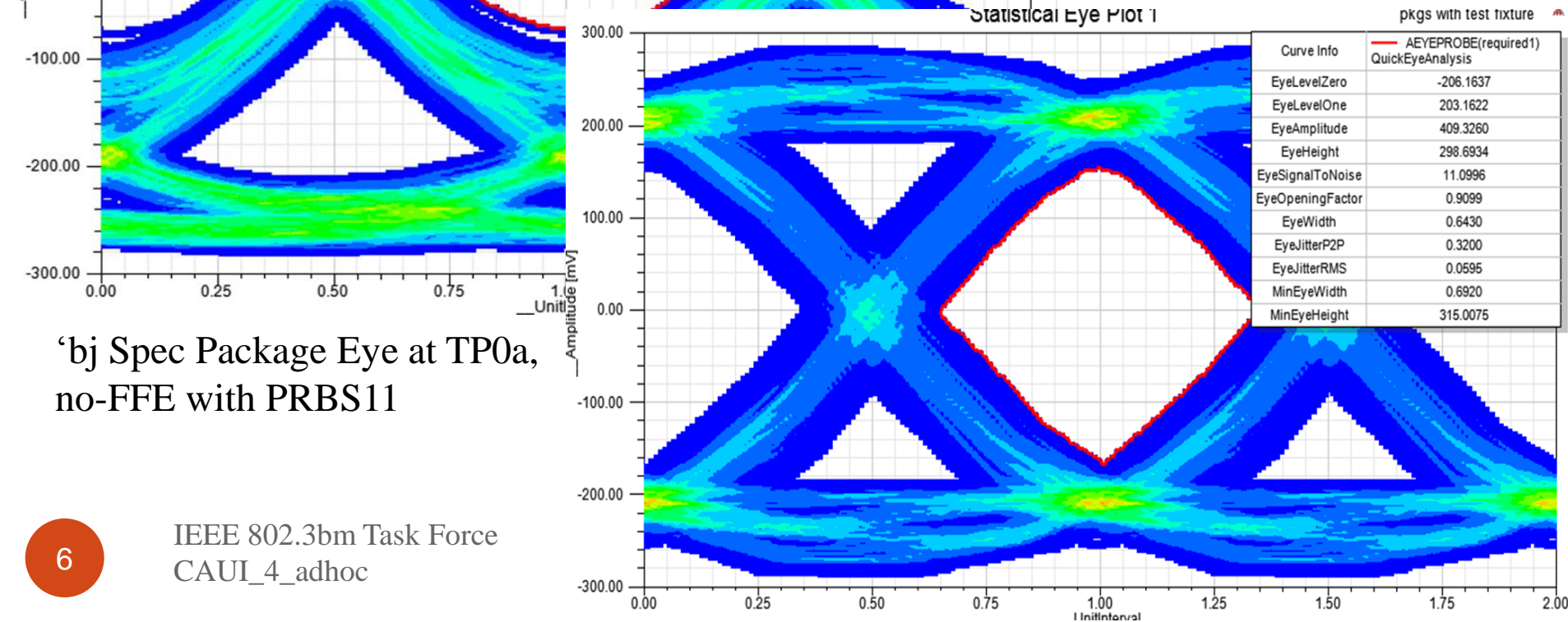
Simulation Circuit



Does an Eye Mask Make Sense?



‘bj Spec Package Eye at TP0a,
Optimum FFE with PRBS11
FFE Taps = [-0.126 0.742 -0.132]

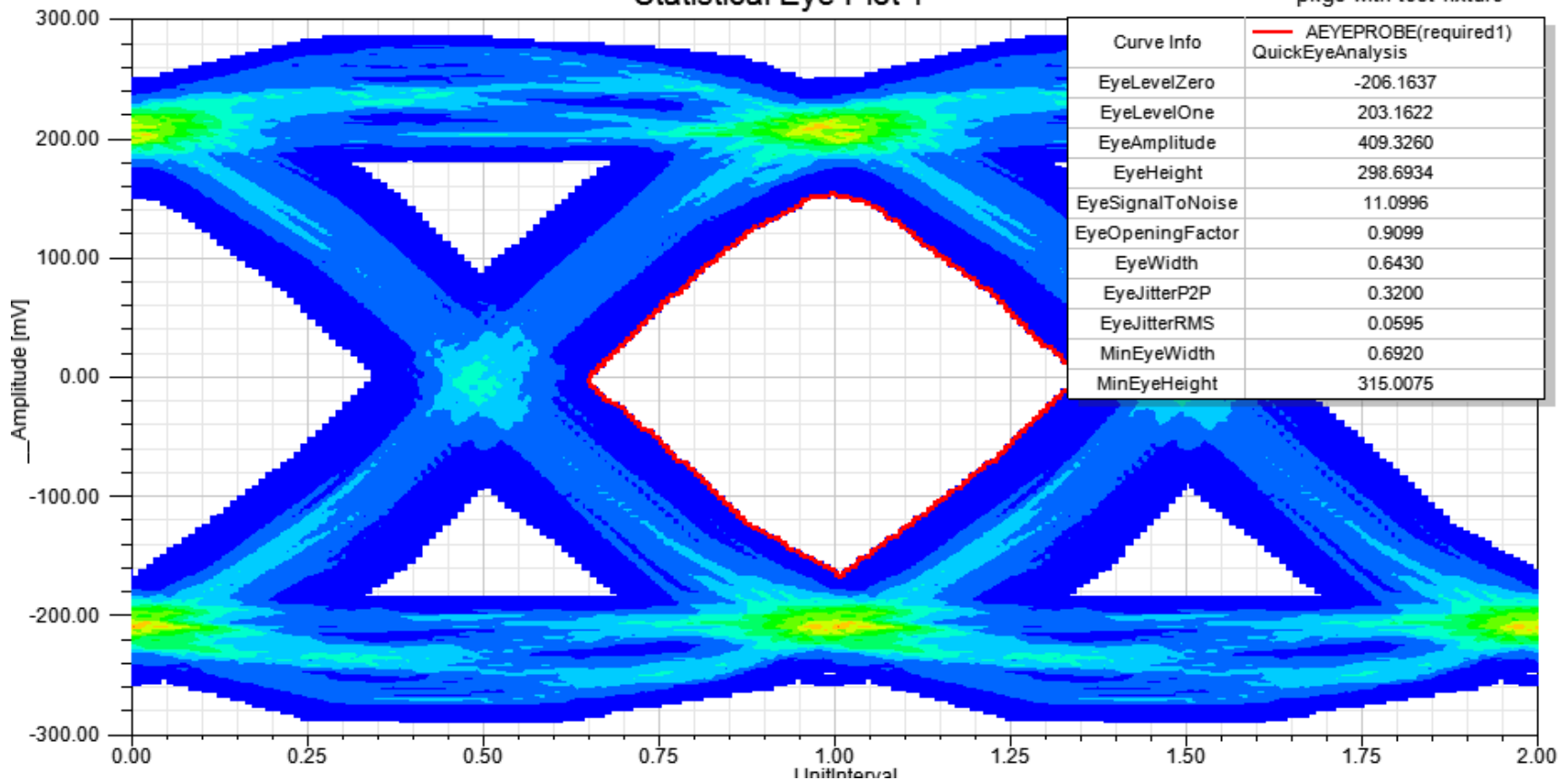


‘bj Spec Package Eye at TP0a,
no-FFE with PRBS11

'bj Spec Package Eye at TP0a, tuned FFE with PRBS11

Statistical Eye Plot 1

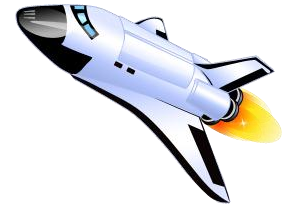
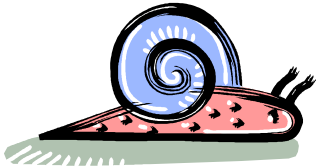
pkgs with test fixture



FFE Taps = [-0.126 0.742 -0.132]

The problem

- The 'bj package is optimistic for large chips!
 - 12 mm is ok for a small device
 - A router/switch chip will likely require 30+mm
- Interconnect does not advance as fast as silicon!



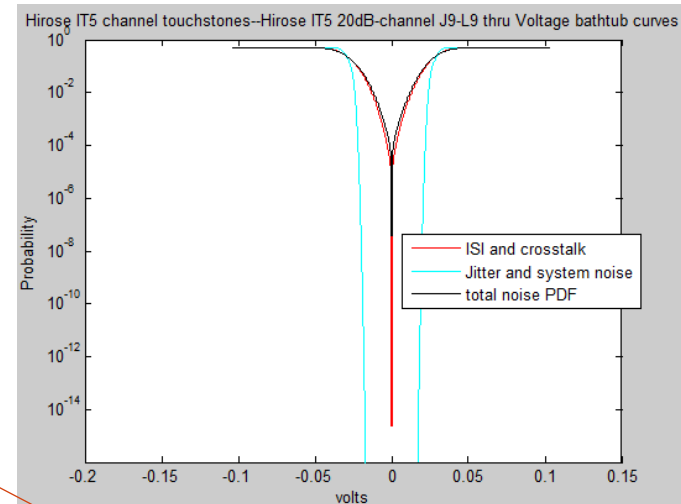
Let's not ignore practice switch packages



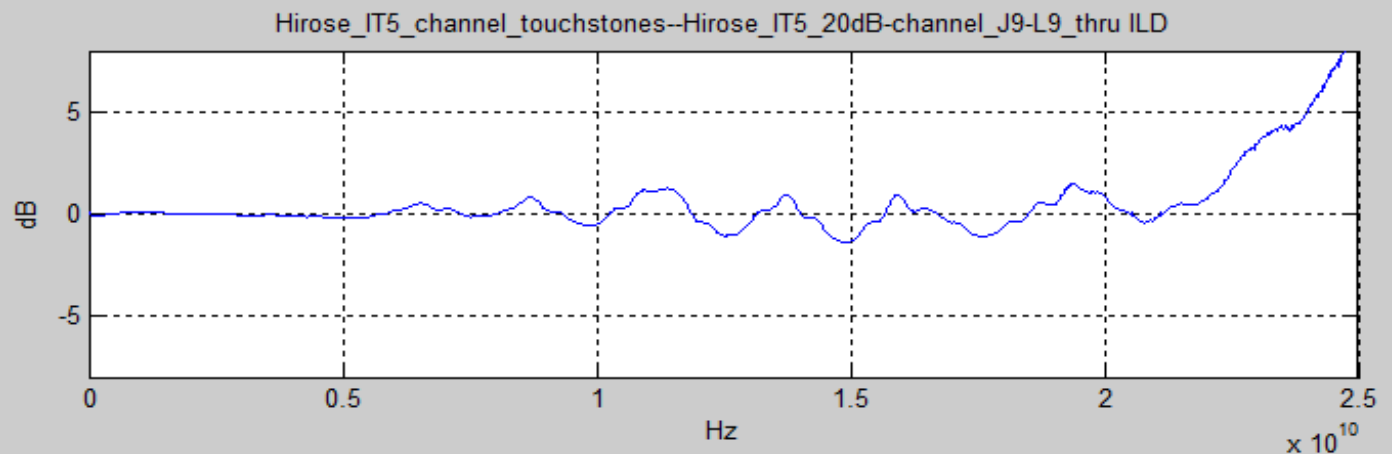
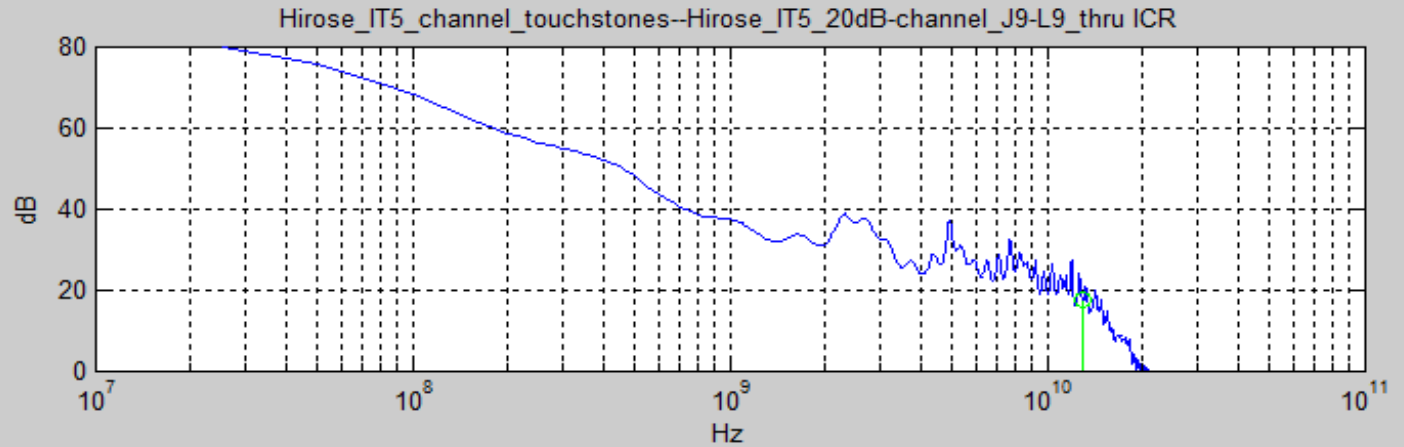
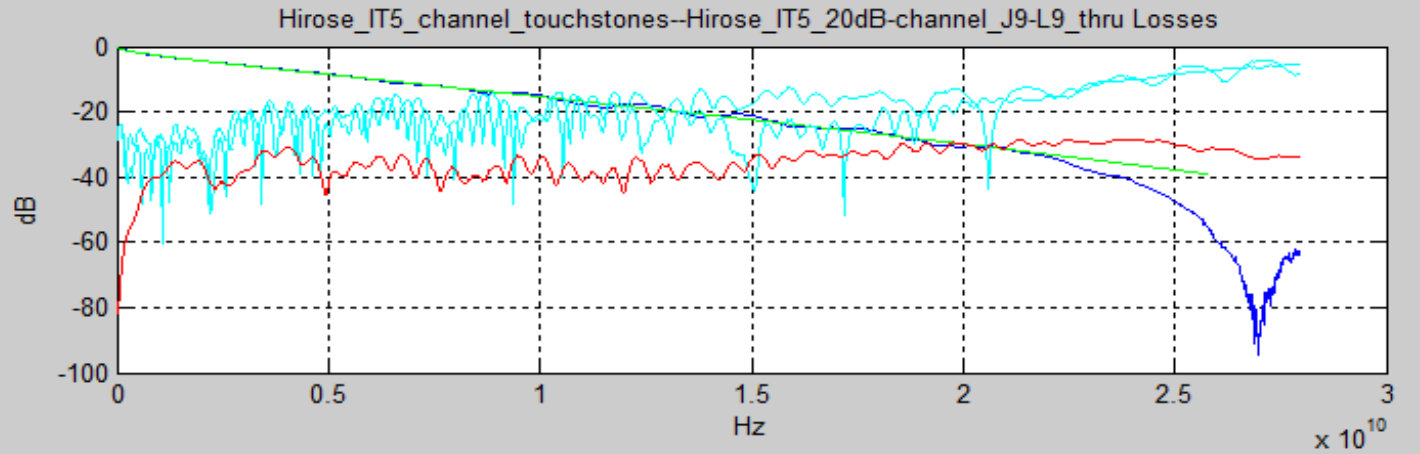
Hirose_IT5_channel_touchstones does not pass COM because of reflections and crosstalk.

● COM = -4.5 dB

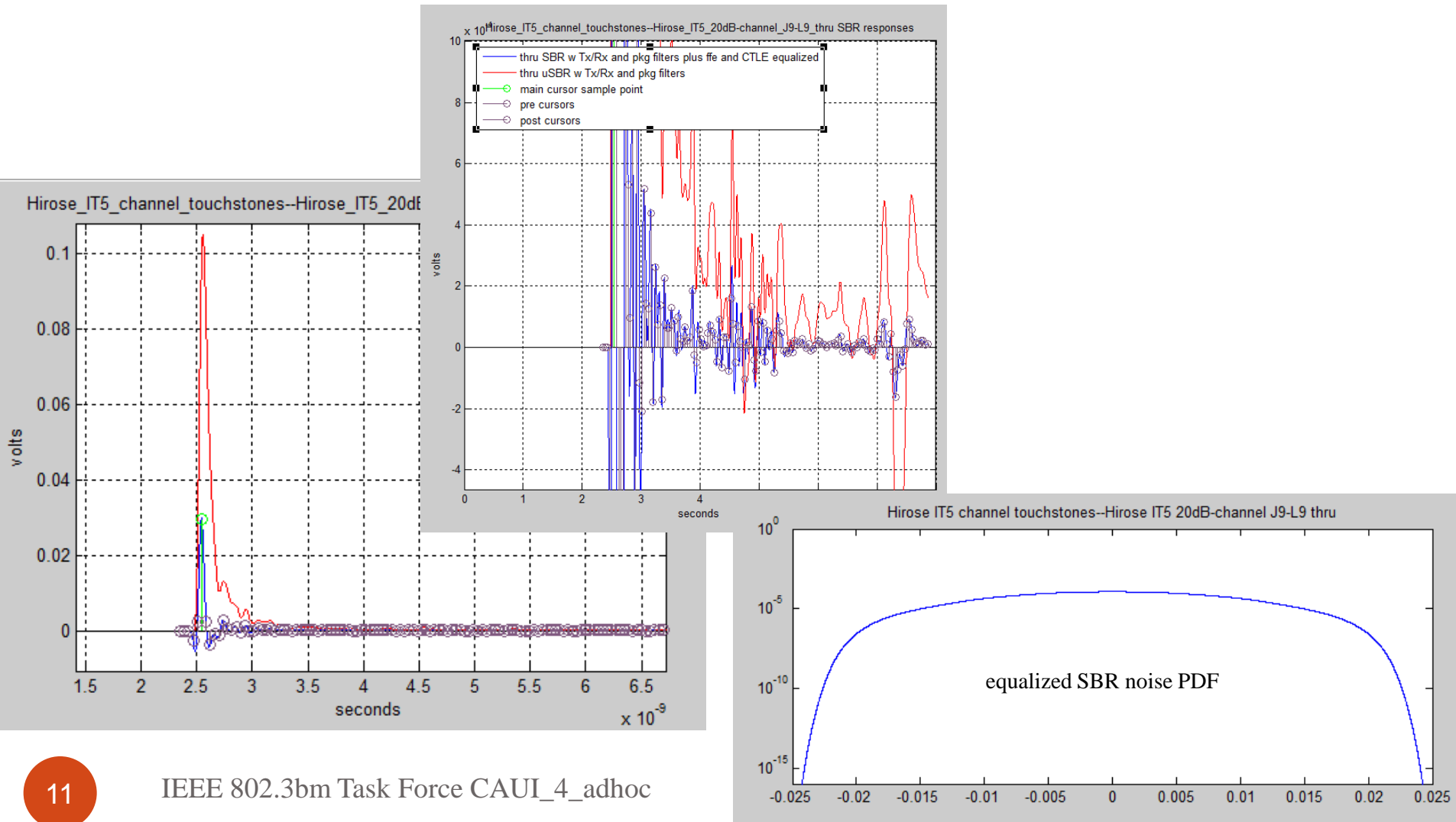
```
channel_operating_margin_dB: -4.5721
    peak_interference_mV: 49.9570
peak_channel_interference_mV: 44.6900
    peak_ISI_mV: 24.3430
    peak_MDXTK_interference_mV: 25.8030
        icn_mV: 7.0411
peak_MDNEXT_interference_mV: 24.7740
peak_MDFEXT_interference_mV: 2.8230
available_signal_after_eq_mV: 29.5114
    fit_loss_dB_at_Fnq: 19.4065
        IL_dB_at_Fnq: 18.6434
        baud_rate_GHz: 25.7813
            ILD_RMS: 0.3966
                equivalent_ISI_ICN: 0.0035
                    ctile_zero_poles_acdcgaindB: [2.8790e+09 2.5781e+10 6.4453e+09]
                        acdcgaindB: -7
                            txle_taps: [-0.1400 0.6000 -0.2600]
                                dfe_taps: [0x1 double]
                                    sci_noise_FD_RMS: 0.2015
                                        cci_noise_TD_BER: 0.0258
max_peak_interference_at_BER: 0.0447
    FOM: 11.4209
        dfe4_rss: 0
```



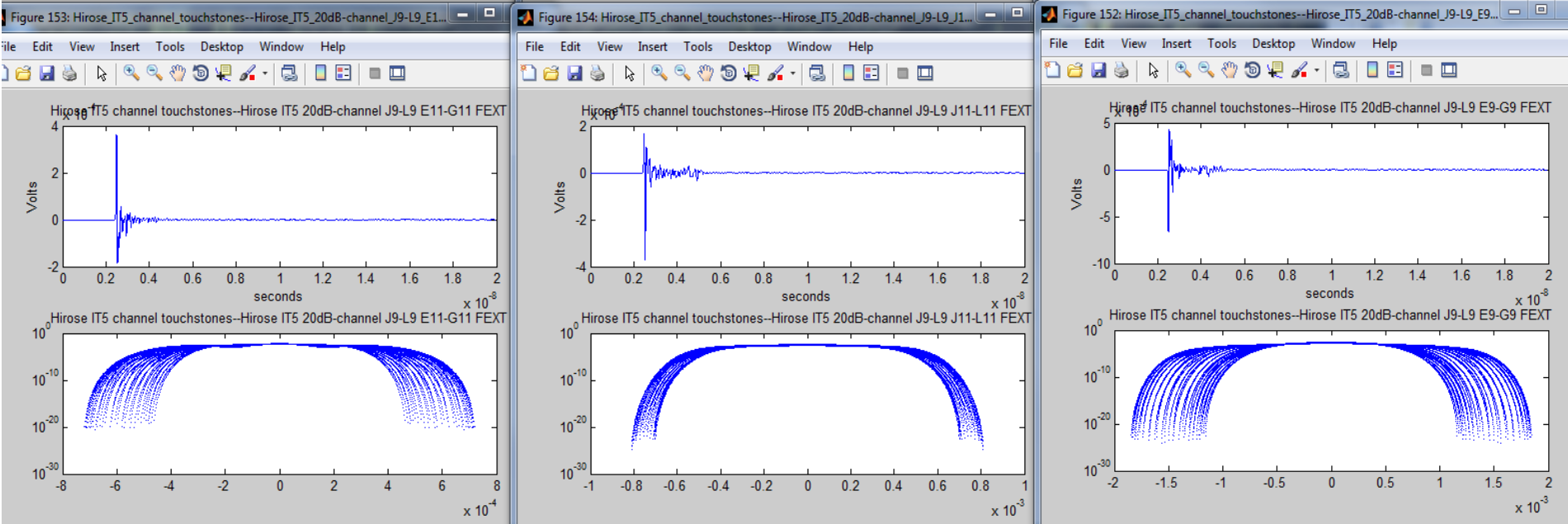
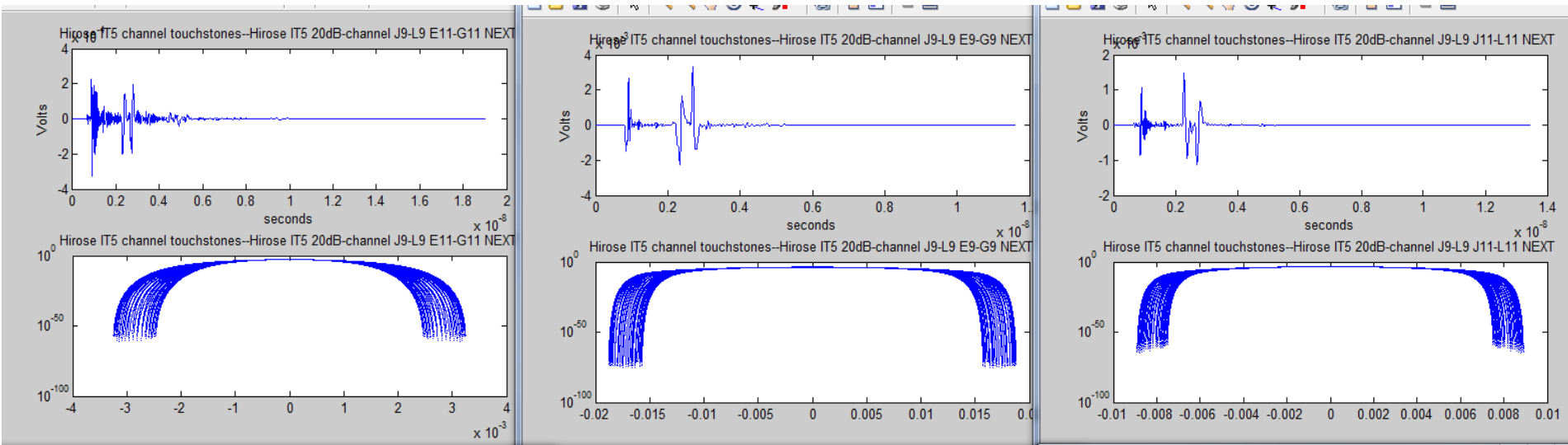
Frequency Domain



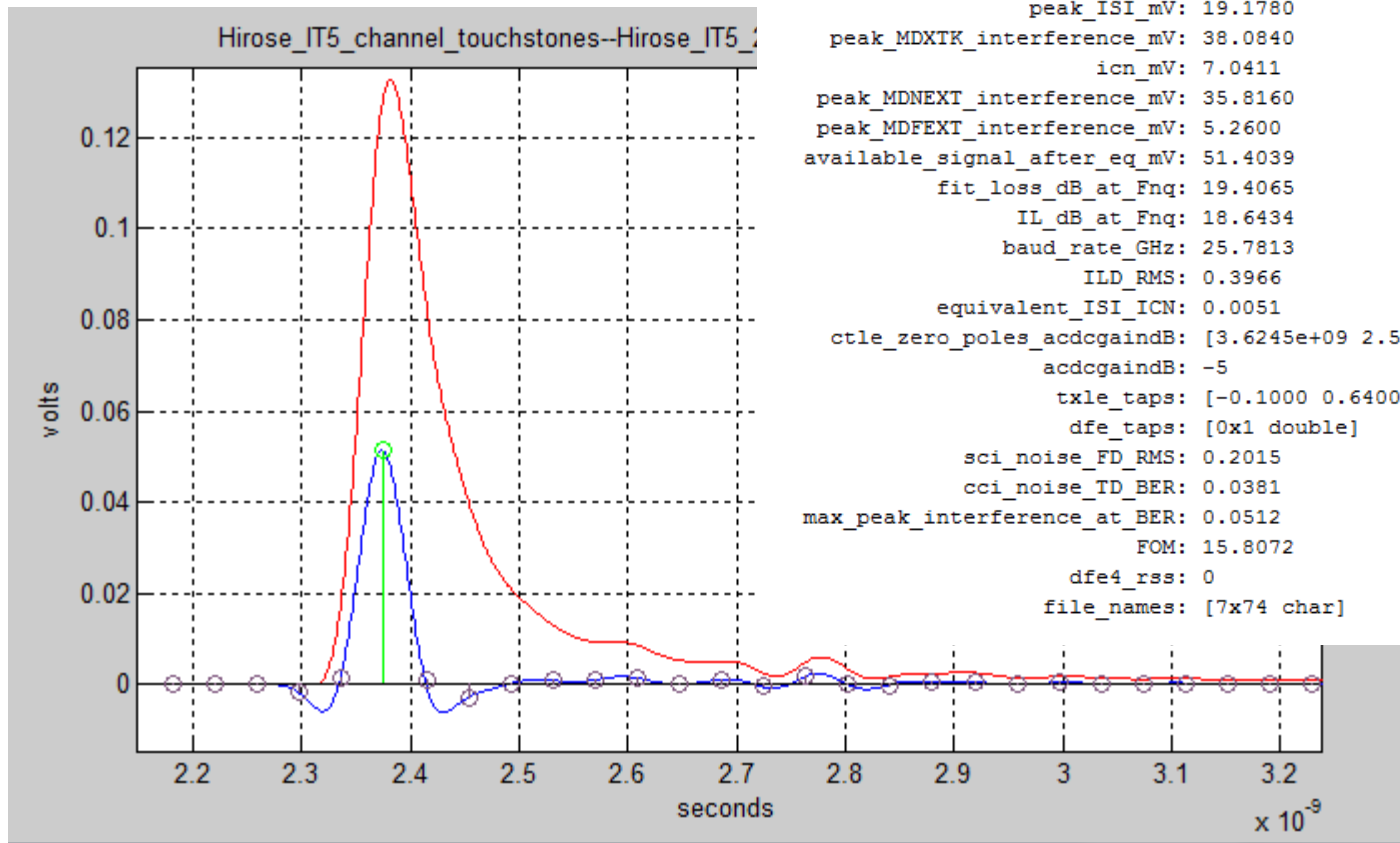
Thru SBR's and equalized SBR noise PDF



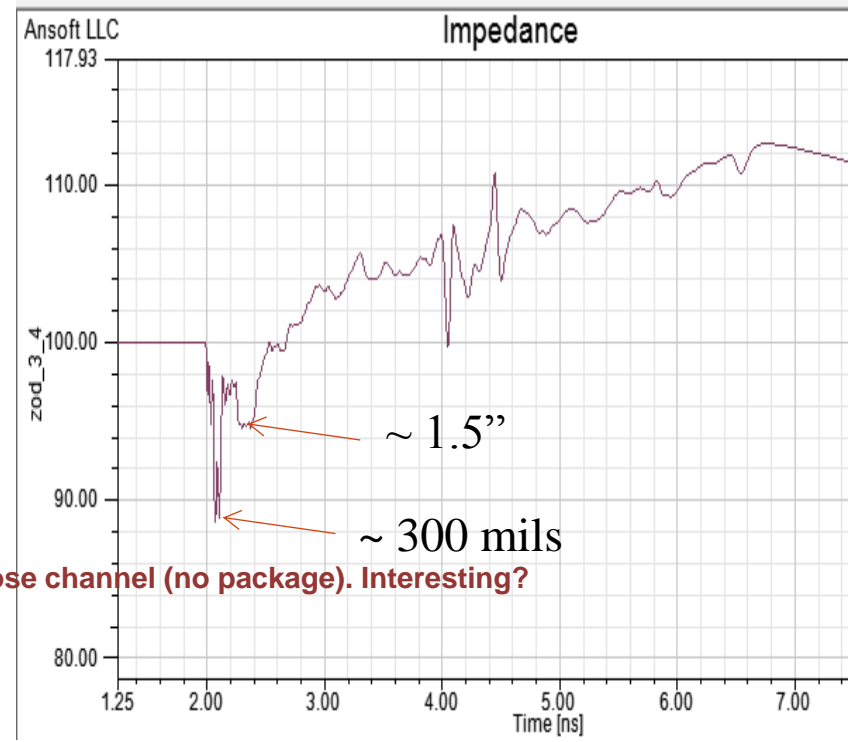
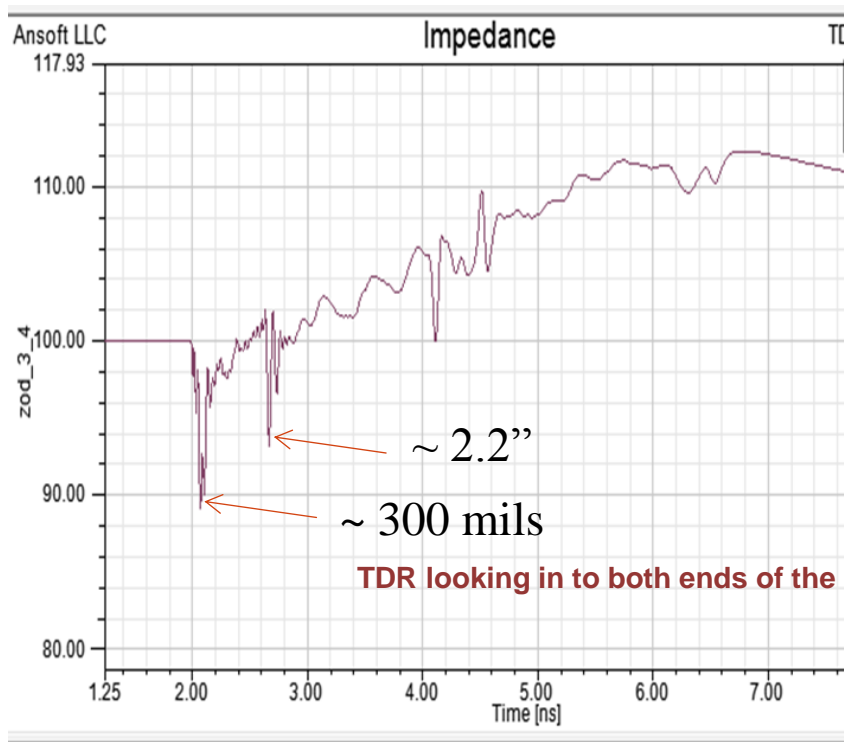
Crosstalk is not that small (25 mV peak at BER 1e-15)



COM without package improves to -1 dB 😊...😞



TDR shows reflections near the ends of the channel.



The impact of package re-reflection will be quite large

Add DFE20 (no package) and COM goes to about 2.7dB

```
channel_operating_margin_dB: 2.7084
  peak_interference_mV: 68.5070
peak_channel_interference_mV: 54.8350
  peak_ISI_mV: 13.4990
  peak_MDXTK_interference_mV: 48.3940
    icn_mV: 7.0411
  peak_MDNEXT_interference_mV: 45.8000
  peak_MDFEXT_interference_mV: 6.3600
available_signal_after_eq_mV: 93.5743
  fit_loss_dB_at_Fnq: 19.4065
  IL_dB_at_Fnq: 18.6434
  baud_rate_GHz: 25.7813
  ILD_RMS: 0.3966
  equivalent_ISI_ICN: 0.0065
ctle_zero_poles_acdcgaindB: [6.4453e+09 2.5781e+10 6.4453e+09]
  acdcgaindB: 0
  txle_taps: [-0.1200 0.8400 -0.0400]
  dfe_taps: [20x1 double]
  sci_noise_FD_RMS: 0.2015
  cci_noise_TD_BER: 0.0484
max_peak_interference_at_BER: 0.0548
  FOM: 18.9994
  dfe4_rss: 0.1595
  file_names: [7x74 char]
```

We still have a lot of crosstalk

More variations

- COM = 4.45 dB w/ 1 crosstalk dfe20 no package

```
com_d2p1_02_0613('config_com_ieee8023_93a_d2p1=CAUI-4_test.xls', 0, 1, ...  
    '..\channels\ieee802p3bm\Hirose_IT5_channel_touchstones\Hirose_IT5_20dB-channel_J9-L9_thru.s4p', ...  
    'Hirose_IT5_20dB-channel_J9-L9_E9-G9_NEXT.s4p')
```

- COM = 2.5 dB w/ 1 crosstalk dfe20 + package

- COM = 6.6 dB w thru only dfe20 + package

```
com_d2p1_02_0613('config_com_ieee8023_93a_d2p1=CAUI-4_test.xls', 0, 0, ...  
    '..\channels\ieee802p3bm\Hirose_IT5_channel_touchstones\Hirose_IT5_20dB-channel_J9-L9_thru.s4p')
```

- COM = -.9 dB w thru no dfe + package

- COM = -.9 dB w thru no dfe + package

- Need at least DFE5 to get passing COM w/no crosstalk and package

Observations

- Channel with reflections close to the end of the channel like in a BGA break out can be amplify package anomalies.
- Crosstalk at BER $1e-15$ can may be troublesome.
- Specifying a EYE Mask with realistic switch package seems challenging.
- Perhaps measuring a step response at TP0a and determining COM may worth exploring.
 - Requires developing procedure with some similarity to clause 93c

COM table

Parameter	Setting			Operational Control		
Coding/Port Type	CAUI-4			INCLUDE_CTLE	1	
Signal Rate (fb)	25.78125	GHz		INCLUDE_TX_RX_FILTER	1	
[c(-1) c(1)]	[-.18 -.38]			DEBUG	1	
Nb	0	UI		DISPLAY_WINDOW	1	
Gdc, for CTF	-16	dB		CSV_REPORT	1	
Av	0.4	V		SAVE_RESP	0	
Af	0.4	V		GET_FD	1	
An	0.6	V		INC_PACKAGE	1	
L	2			IDEAL_RX_TERM	0	
DER0	1.00E-15			USE_EXTERNAL_PARAM	0	
CC1	3	Min COM dB		RESULT_DIR	.\test_results\	
sigma_rj	0.01	UI		RX_CALIBRATION	0	
Add	0.07	UI		BREAD_CRUMBS	1	
sigma_r	5.00E-04	V				
eta_0	6.40E-08	V ² /GHz		Data for informative calculations		
PDF_bin_size	1.00E-06	V		f_v	4	*fb
Samples Per UI	32			f_f	4	*fb
Port Order	[1 3 2 4]			f_n	4	*fb
CTF_step	1	dB				
TXFFE_step	0.02					
bmax(1)	1					
bmax(2..Nb)	1					
f_r	0.75	*fb				
package_tl_gamma	complex([-0.0010037 -0.0003539 -0.001027 0 -1.178e-05], [0 -0.003355 -0.03818 0 3.363e-05])					
package_tl_rho	complex([0.0011007 3.679e-18 -0.0003235 -1.021e-20 1.722e-07], [0 -0.008124 -3.545e-20 7.44e-06 -1.8e-21])					
C_d	2.50E-04	nF				
R_d	55	Ohm				
C_p	1.80E-04	nF				
z_p	12	mm				
WGN_step	0.0005	v rms				