KEYSIGHT

Jitter operations (179.9.4.7) at TP1a (33dB) Version 1.4

Presented to IEEE P802.3dj Task Force 09/16/2024

Associated comments: 175,176, 178, 179

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Based on draft release of IEEE P802.3dj™/D1.0/1.1/1.1 Comments

Abstract: Performing 802.3dj clause 179.9.4.7 jitter operations have advanced with new measurement capabilities. This contribution summarizes jitter operations near 33dB through a conformant MTF and High Host loss serial configuration.

Supporters/Collaborators (Version 1.4)

Mike Dudek

Useful References:

IEEE 05/24 Contribution: https://www.ieee802.org/3/dj/public/24_05/calvin_3dj_01b_2405.pdf
IEEE 07/15 Contribution: https://www.ieee802.org/3/dj/public/24_07/calvin_3dj_01b_2407.pdf
IEEE 07/15 Contribution: https://www.ieee802.org/3/dj/public/24_07/calvin_3dj_02a_2407.pdf
RAN: https://www.ieee802.org/3/dj/public/24_07/ran_3dj_01b_2407.pdf
Diminico: https://www.ieee802.org/3/dj/public/23_11/diminico_3dj_01_2311.pdf

Instrumentation used in this contribution

- M8042A/M8050A PG
  - 5 Tap Tx de-emphasis (-.004, .013, -.056,.843, -.082, -.002, 0)
  - 1000mV Tx differential amplitude
- M8067A-005/003-Trace (1mm)
  - 31.1dB @53.125GHz – (35mm + 185mm Traces)
  - 2X pair of 1mm 8” phase matched cables (1.2dB each)
  - Net TP1a test channel loss 33.5dB
- UXR 1104B Real-Time scope
  - DSP/SW Clock Recovery
  - ~SIRC: 60GHz 4th order Bessel Thomson rolling off to -9dB @ 90GHZ
- N1000A+N1046A Sampling scope
  - Prototype Clock Recovery
  - SIRC: 60GHz 4th order Butterworth

Overview

May 2024 (P802.3dj D1.0) reviewed Jitter and VEC operations at TP2 (~27dB)

Instrument grade ISI structures.. SDD22 < -15dB

12Edge Jitter operations (instrument grade ISI structures.. SDD22 < -15dB)

- ✓ Physical CDR
- ✓ Oversampled/DSP CDR

VEC operations

× 1E-5 VEC ✓ 1E-3 VEC

July 2024 (P802.3dj D1.1) we repeated the above operations at TP1a (~33dB)

Instrument grade ISI structures.. SDD22 < -15dB

12Edge Jitter operations (instrument grade ISI structures.. SDD22 < -15dB)

- ✓ Physical CDR
- ✓ Oversampled/DSP CDR

VEC operations, not so successful (~12dB).

× 1E-5 VEC × 1E-3 VEC ✓ 1E-2VEC

September 2024 (Objectives) << This presentation

Examine Jitter operations with a MTF in the higher TP1a loss profile

Discuss Return Loss implications and degrees of Jitter decomposition failure

IEEE 802.3dj D1.1 TP0d->TP1a loss

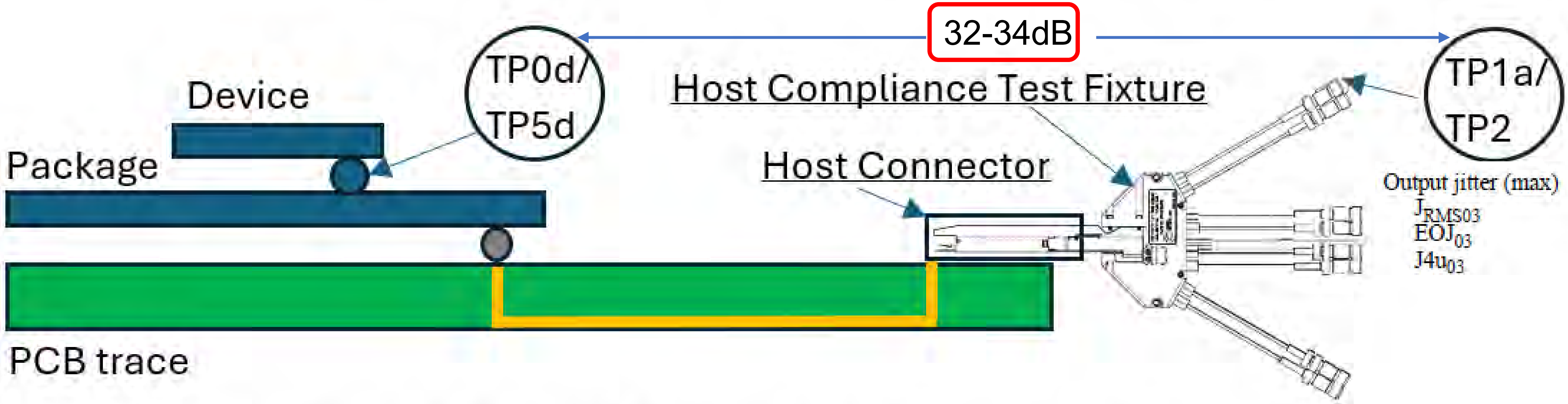
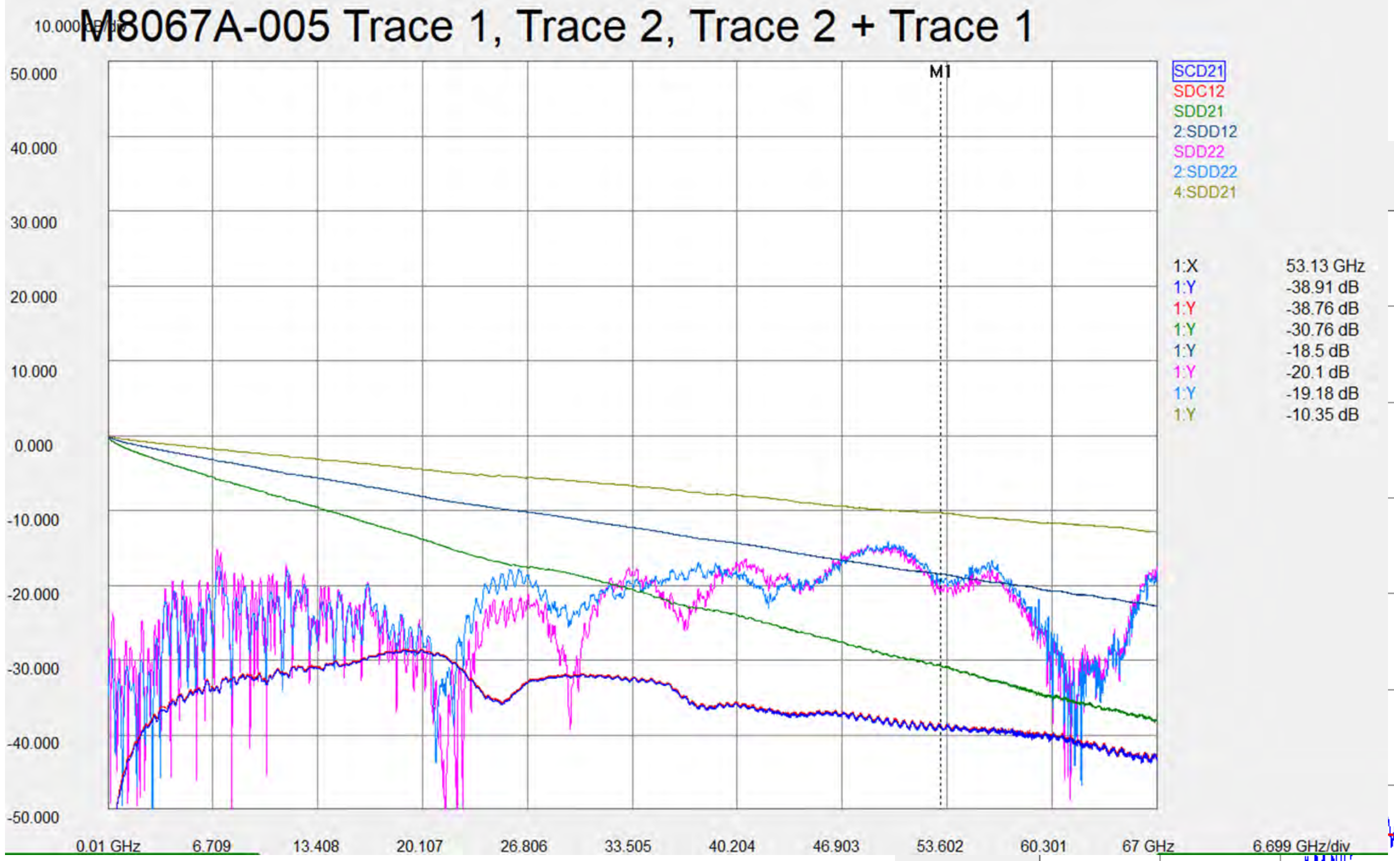
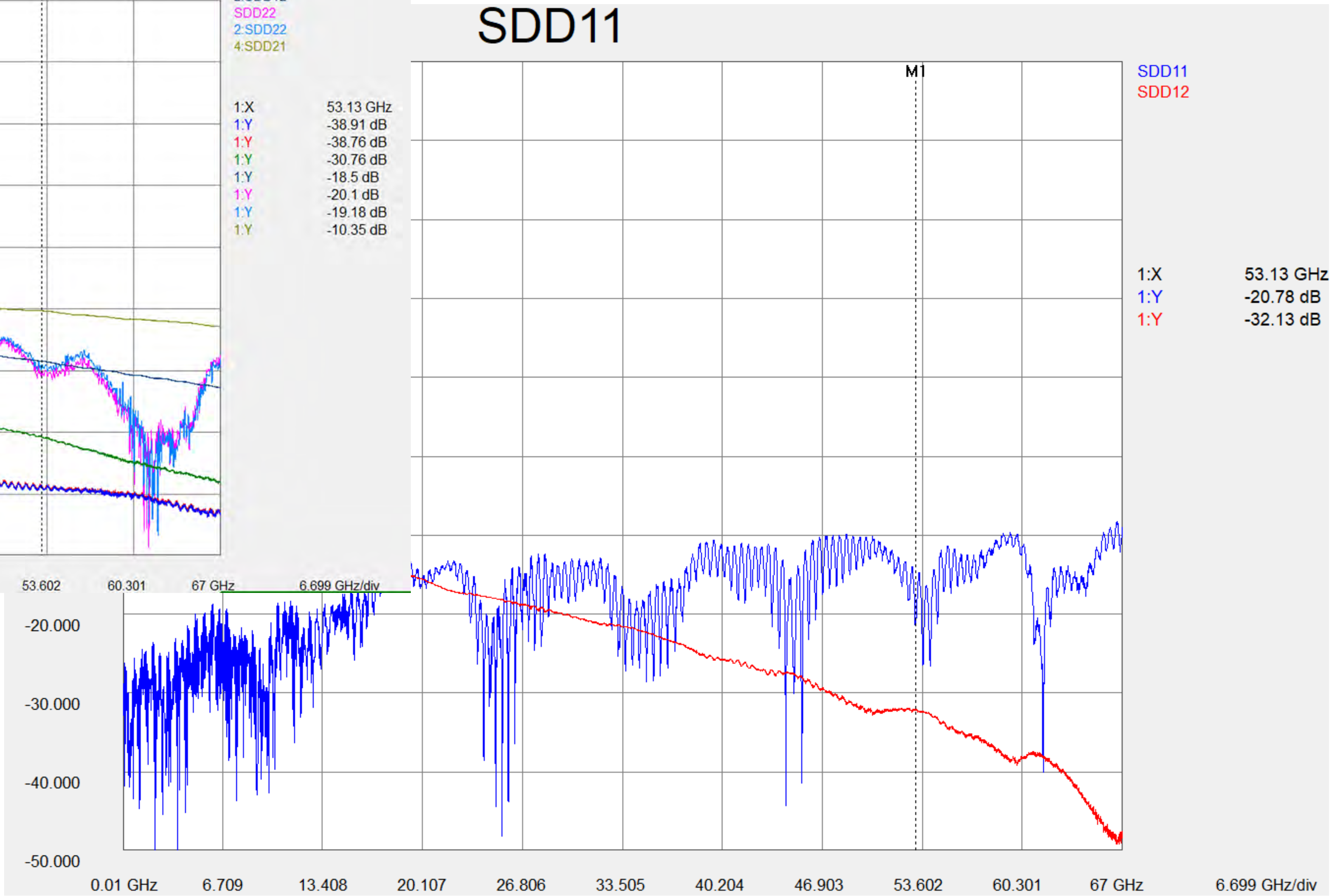


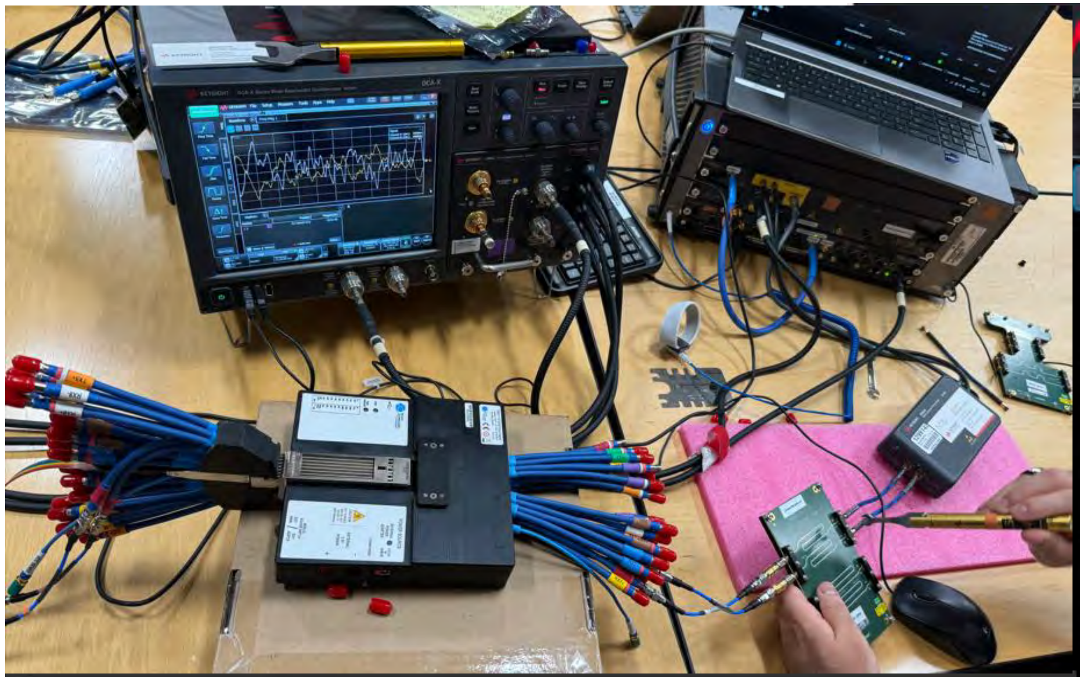
Figure 1: Typical 802.3dj host test point model

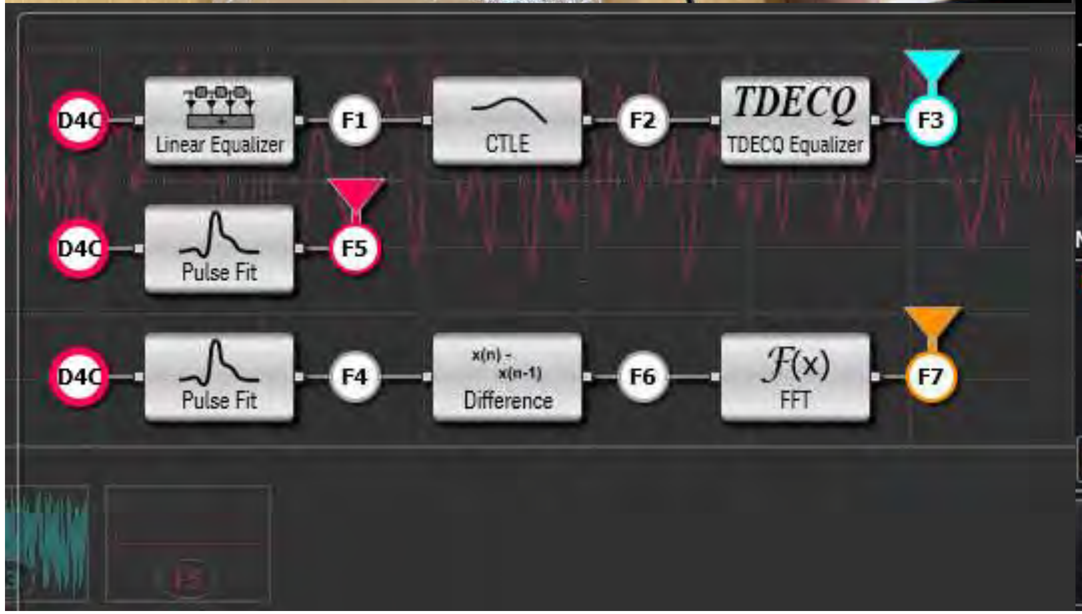
https://www.ieee802.org/3/dj/public/23_11/lusted_3dj_04_2311.pdf pg 5 (32dB)
https://www.ieee802.org/3/dj/public/24_07/ran_3dj_01b_2407.pdf pg 10 (34dB)

Laboratory grade ISI structures compared to MTF based structure









P8023dj: D3: V1.4 Jitter operations (179.9.4.7) at TP1a (33dB) 2024

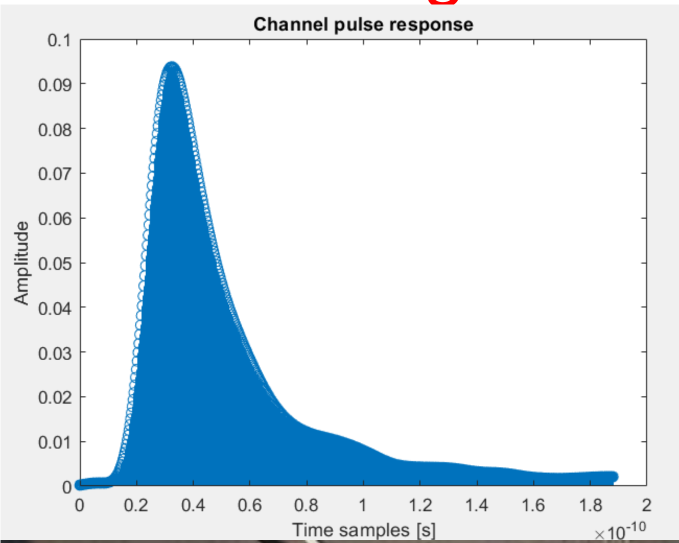
ET Jitter (4BT-60GHz , Explicit Clock*, 33dB/MTF)

*Phase detection after 33dB is still under development.

Name	Source	To L0	Status	To L1	Status	To L2	Status	To L3	Status
J3u (All)	D4C	230 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
J3u (R03/F	D4C	91 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
From L3	D4C	93 mUI	Correct	125 mUI	Correct	250 mUI	Correct	(n/a)	(n/a)
From L2	D4C	127 mUI	Correct	248 mUI	Correct	(n/a)	(n/a)	260 mUI	Correct
From L1	D4C	242 mUI	Correct	(n/a)	(n/a)	242 mUI	Correct	120 mUI	Correct
From L0	D4C	(n/a)	(n/a)	198 mUI	Correct	118 mUI	Correct	89 mUI	Correct
Jrms (All)	D4C	27.5 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
Jrms (R03/	D4C	14.0 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
From L3	D4C	14.3 mUI	Correct	19.0 mUI	Correct	37.5 mUI	Correct	(n/a)	(n/a)
From L2	D4C	19.8 mUI	Correct	37.0 mUI	Correct	(n/a)	(n/a)	39.0 mUI	Correct
From L1	D4C	36.5 mUI	Correct	(n/a)	(n/a)	37.0 mUI	Correct	18.2 mUI	Correct
From L0	D4C	(n/a)	(n/a)	30.5 mUI	Correct	18.2 mUI	Correct	13.7 mUI	Correct
EOJ (All)	D4C	17 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
EOJ (R03/F	D4C	7 mUI	Correct	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)	(n/a)
From L3	D4C	1 mUI	Correct	4 mUI	Correct	4 mUI	Correct	(n/a)	(n/a)
From L2	D4C	16 mUI	Correct	6 mUI	Correct	(n/a)	(n/a)	8 mUI	Correct
From L1	D4C	6 mUI	Correct	(n/a)	(n/a)	17 mUI	Correct	5 mUI	Correct
From L0	D4C	(n/a)	(n/a)	1 mUI	Correct	9 mUI	Correct	7 mUI	Correct

Precision 12Edge, TP1a Jitter decomposition is working well here.

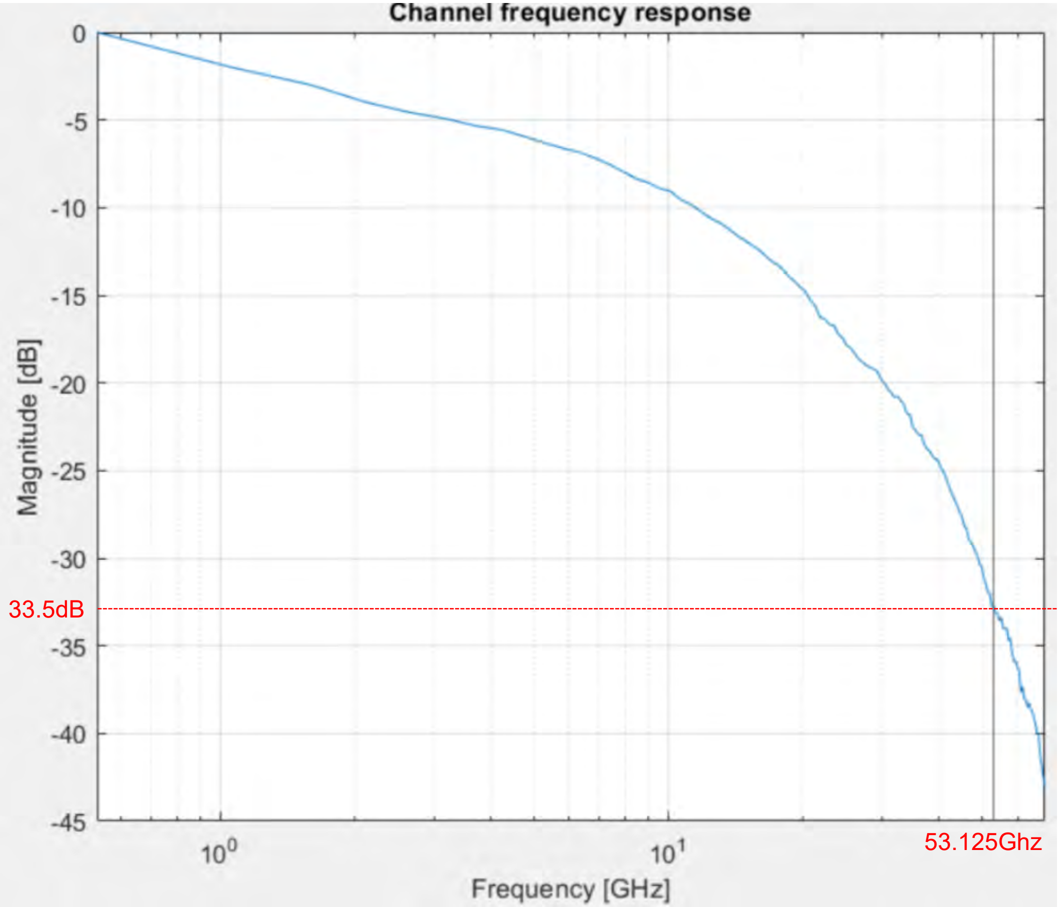
Channel configuration and Real-Time instrument used in this study:



Closest attainable physical proxies for (35mm + 185mm) C2M/TP1a targeting (HL-HL) ~33dB

Reference : https://www.ieee802.org/3/dj/public/23_11/lusted_3dj_04_2311.pdf pg 5

PR ->SR ->IR->(FFT) =>



RT Jitter (4BT 60GHz BW , 1’st order PLL)

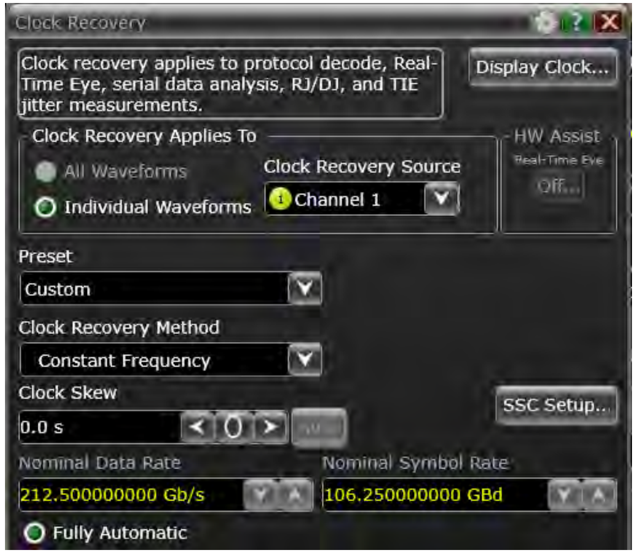
Instrument grade
SDD11 < -15dB
SDD21 33.5dB

✓

RT Jitter (4BT 60GHz BW , Constant Rate Clock)

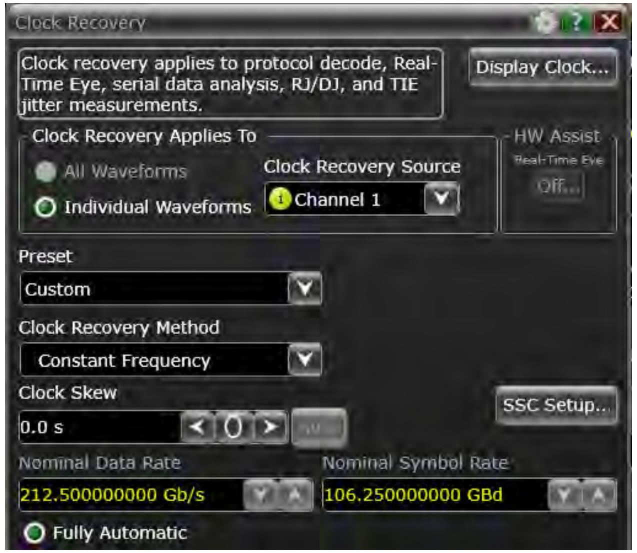
Actual MTF + ISI (1mm)
SDD11 < -10dB
SDD21 33.5dB
Generator set to 1200mV

✘



RT Jitter (4BT 60GHz BW , PLL)

Actual MTF + ISI (1mm)
SDD11 < -10dB
SDD21 33.5dB
Generator set to 1200mV



Output jitter (max) analysis/ Possible ERL connection (

Tfx set to 0, Only applicable to C2M Nbx is the effect of the equalizer.

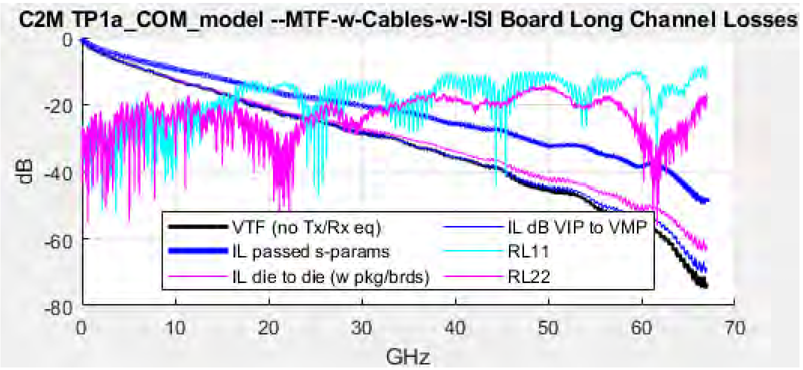
Effective return loss, ERL (min)	176E.6.2	TBD	dB	50
				51

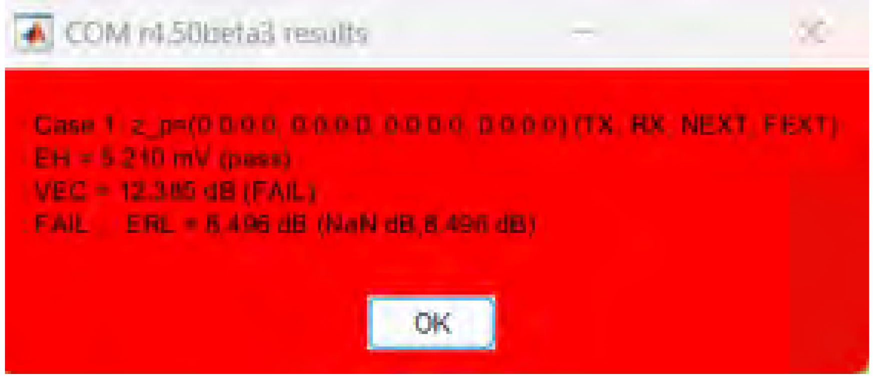
The OSFP MCB/HCB assembly has a SDD11 of nominally -10dB and an ERL of 8.49dB.

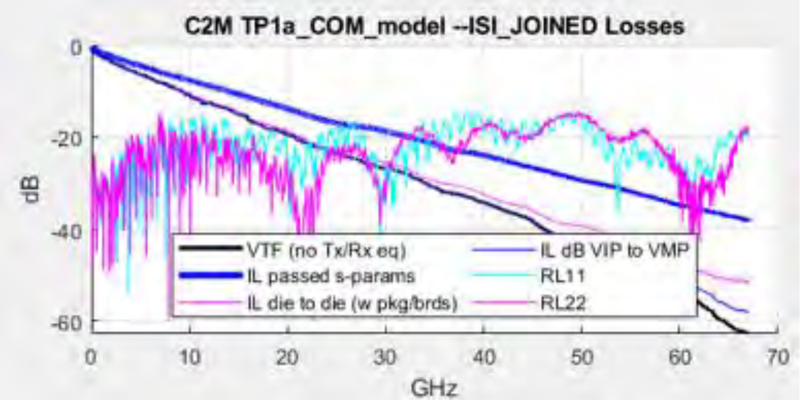
Is this low enough? There is an existence proof of Jitter decomposition running well when it's < -16dB.

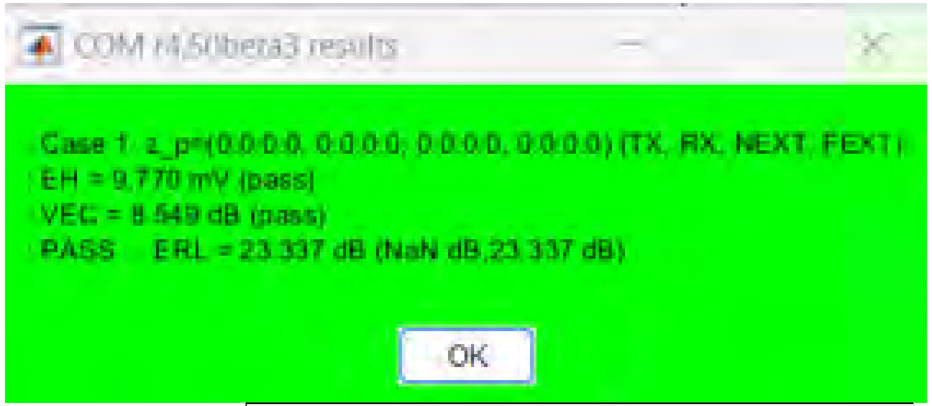
RT Instrument CDR's "should" and will eventually work under these conditions, but it's not ready today.

ET CDR is also work in progress









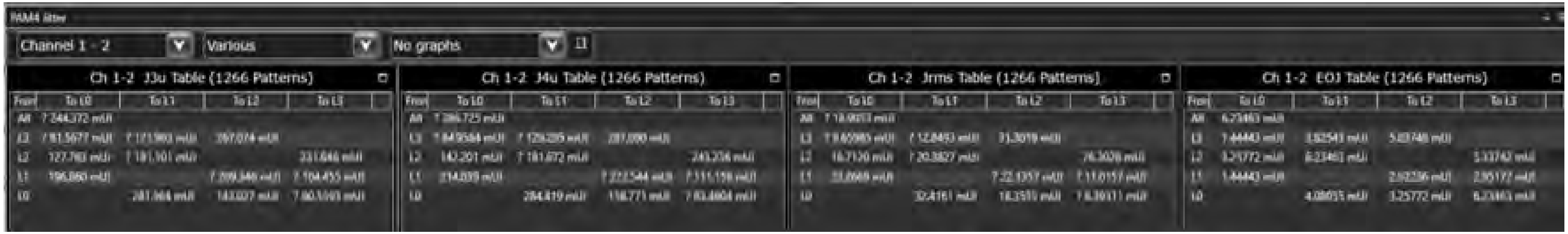
COM: New Entries

TDR_W_TXPKG	1	UI	ERL computed at TP1a
N_bx	0	UI	d1.0

	Operational
ERL Pass threshold	10
COM Pass threshold	3
DER_0	2.00E-05
T_r	0.00400
FORCE_TR	1
PMD_type	C2M

Summary

- The high-loss TP1a channel condition presents instrumentation with a few jitter decomposition challenges.   While the final maximum ERL for a TP1a is still a TBD, the results suggest a sensitivity to this value being 8.49 (< 10dB).   It's unclear where this problem clears, but it does not exist at 23dB
- With a 23dB ERL and a SDD11 of < -15dB 1'st order PLL operation and subsequent jitter decomposition work well (Page-10)

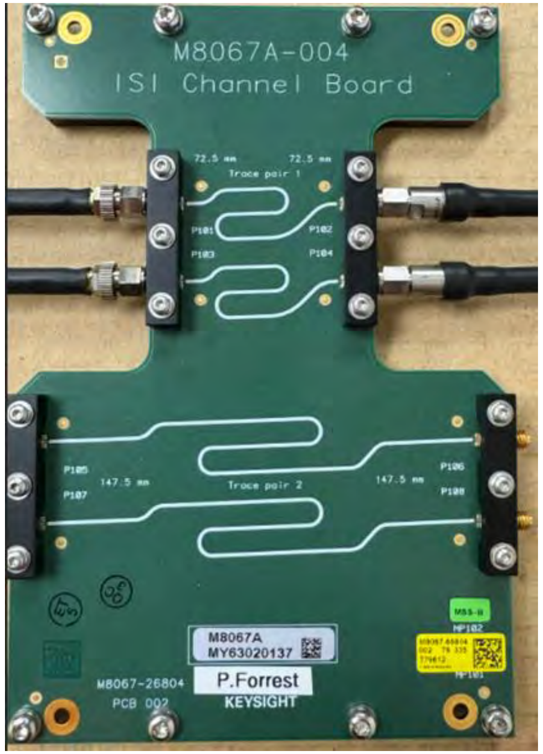


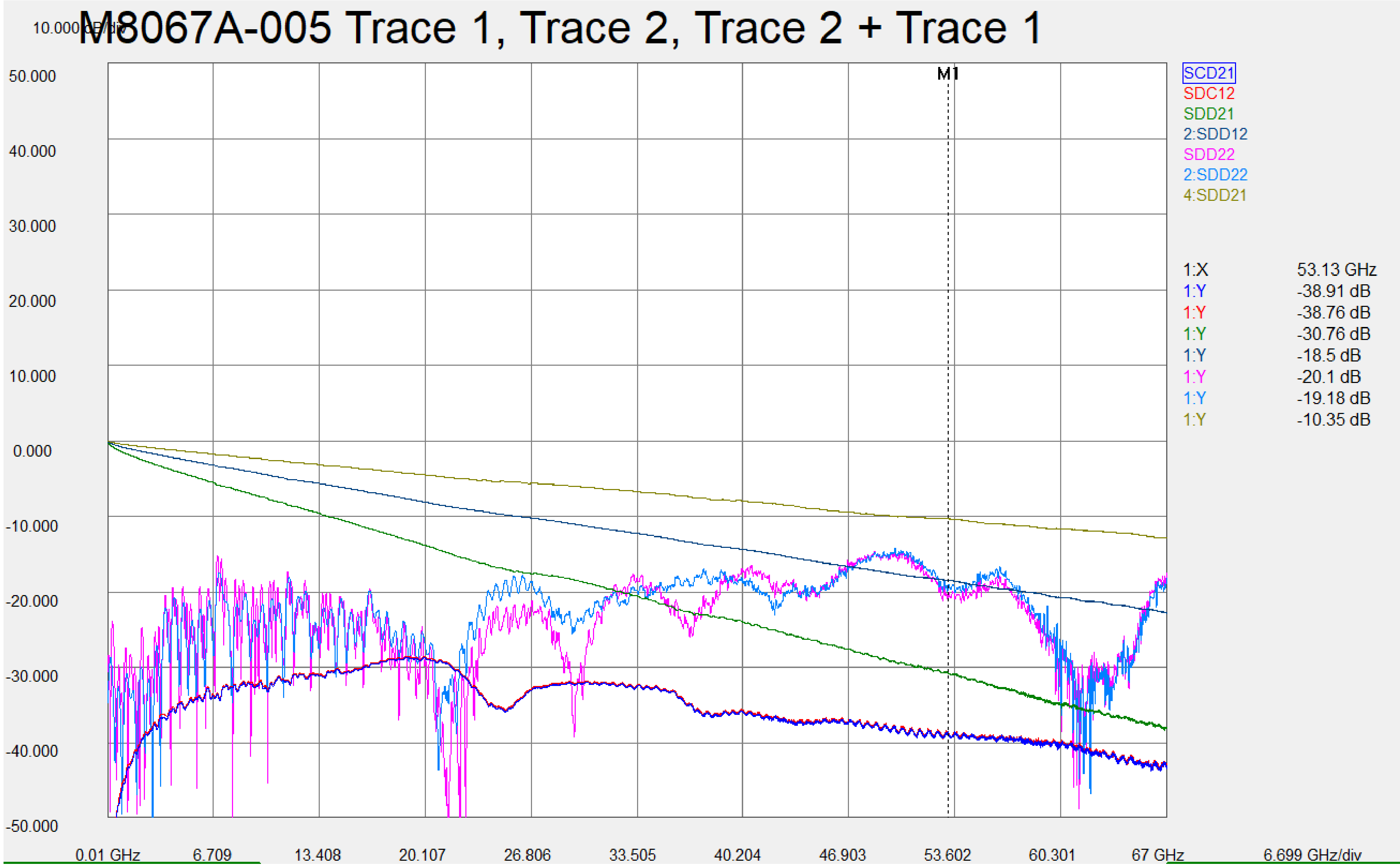
An analysis and planned improvements to the PLL/CDR system are underway, as this 5dB difference SDD11 should not trigger a jitter decomposition failure.   The fact that changing from a 1'st order PLL to a constant-rate recovery method indicates the failure is not in the jitter, rather it's the PLL system.

Thank you

Backup

- M8067A-005 ISI trace Performance





Backup “Support of 178.9.2 Transmitter characteristics”

Unless otherwise specified, transmitter signal measurements are made for each lane separately using a fourth-order Bessel-Thomson low-pass response with a 3 dB bandwidth of 60 GHz, with AC-coupled connection from TP0v to the test equipment.

- Tx: 300 mV SE amplitude. 106.25GHz clock recovery. PRBS13Q (IEEE/PRBS13Q_Lane0_bit). 4PAM Gray coded. No de-emphasis. No impairments.
- Channel: 35 mm ISI board (approx.. 6.5 dB channel loss at 53 GHz counting cables).
- Real-Time instrumentation test case.

Test case	VEC [dB]	J3u all [mUI]	Jrms all [mUI]
No BW limit (113 GHz brick)	7.79	153	18.3
70 GHz brick	6.94	160.6	17.4
60 GHz Butter. 75 GHz brick	6.06	137.8	15.4
60 GHz Bessel. 90 GHz brick	5.67	125.2	15.2

27dB


File Control Setup Display Trigger Measure Math Analyze Utilities Help
12:00 PM
8/12/2024
KEYSIGHT TECHNOLOGIES
Offline
104 mV
Time Meas
Vertical Meas
Real-Time Eye
1.76014 MUI
1 Wfms
-10.6 ps
-8.47 ps
-6.35 ps
-4.24 ps
-2.12 ps
0.0 s
2.12 ps
4.24 ps
6.35 ps
8.47 ps
10.6 ps
PAM4 Jitter
Channel 1
Various
No graphs
Ch 1 J4u Table (211 Patterns)
From To L0 To L1 To L2 To L3
All 97.3328 mUI
L3 92.1533 mUI 172.216 mUI 332.564 mUI
L2 127.237 mUI 321.454 mUI 332.555 mUI
L1 302.398 mUI 274.261 mUI 156.882 mUI
L0 184.394 mUI 152.146 mUI 102.191 mUI
Ch 1 Jrms Table (211 Patterns)
From To L0 To L1 To L2 To L3
All 14.3023 mUI
L3 13.6770 mUI 21.3265 mUI 43.6720 mUI
L2 19.9056 mUI 41.1484 mUI 45.6129 mUI
L1 44.4066 mUI 39.4035 mUI 20.4631 mUI
L0 40.7605 mUI 23.7361 mUI 14.8996 mUI
Ch 1 EOJ Table (211 Patterns)
From To L0 To L1 To L2 To L3
All 13.0678 mUI
L3 792.762 µUI 3.14140 mUI 11.4783 mUI
L2 6.53361 mUI 12.7884 mUI 6.08881 mUI
L1 792.762 µUI 457.750 µUI 13.0678 mUI
L0 3.89695 mUI 6.53361 mUI 12.7884 mUI
Results (Measure All Edges)
Measurements
Measurement Current Mean Min Max Range (Max-Min) Std Dev Count
Eye 2/3 Width(eq2) 165.2 mUI 165.2 mUI 165.2 mUI 165.2 mUI 0.0 UI 0.0 UI 1
Eye 1/2 Width(eq2) 198.6 mUI 198.6 mUI 198.6 mUI 198.6 mUI 0.0 UI 0.0 UI 1
Eye 0/1 Width(eq2) 167.0 mUI 167.0 mUI 167.0 mUI 167.0 mUI 0.0 UI 0.0 UI 1
Eye 2/3 Height(eq2) 11.8 mV 11.8 mV 11.8 mV 11.8 mV 0.0 V 0.0 V 1
Eye 1/2 Height(eq2) 13.0 mV 13.0 mV 13.0 mV 13.0 mV 0.0 V 0.0 V 1
Eye 0/1 Height(eq2) 11.2 mV 11.2 mV 11.2 mV 11.2 mV 0.0 V 0.0 V 1
VEC(eq2) 10.29 dB 10.29 dB 10.29 dB 10.29 dB 0.0 dB 0.0 dB 1
SER, cumulative(eq2) 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1760136
Color Grade
1 - 53
54 - 106
107 - 213
214 - 427
428 - 855
856 - 1710
1711 - 3420

27dB Jitter detail

Ch 1 J4u Table (211 Patterns)

Fron	To L0	To L1	To L2	To L3
All	97.3328 mUI			
L3	92.1533 mUI	172.216 mUI	332.564 mUI	
L2	127.237 mUI	321.454 mUI		332.555 mUI
L1	302.398 mUI		274.261 mUI	156.882 mUI
L0		184.394 mUI	152.146 mUI	102.191 mUI

Ch 1 Jrms Table (211 Patterns)

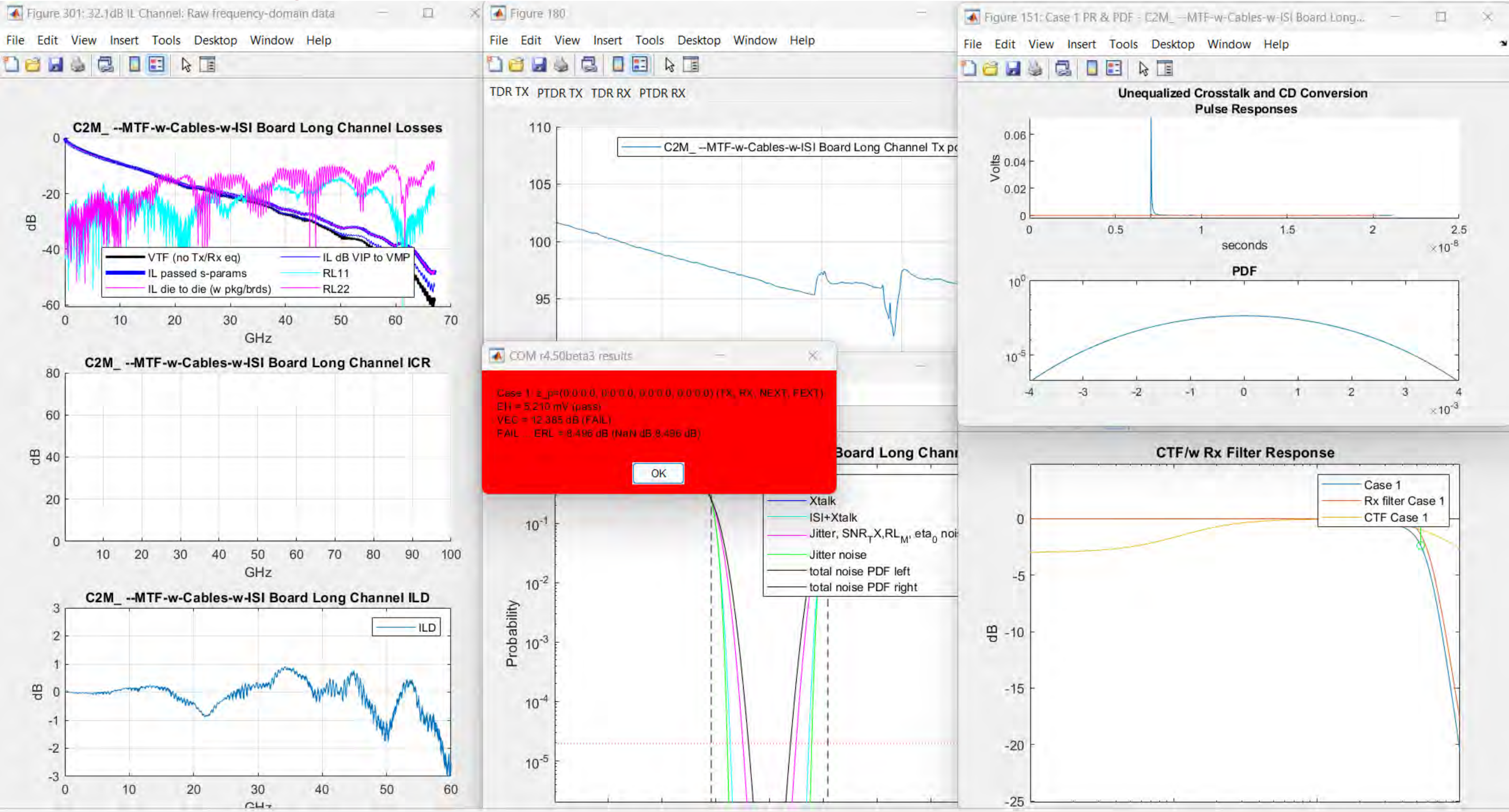
Fron	To L0	To L1	To L2	To L3
All	14.3023 mUI			
L3	13.6770 mUI	21.3265 mUI	43.6720 mUI	
L2	19.9056 mUI	41.1484 mUI		45.6129 mUI
L1	44.4066 mUI		39.4035 mUI	20.4631 mUI
L0		40.7605 mUI	23.7361 mUI	14.8996 mUI

Ch 1 EOJ Table (211 Patterns)

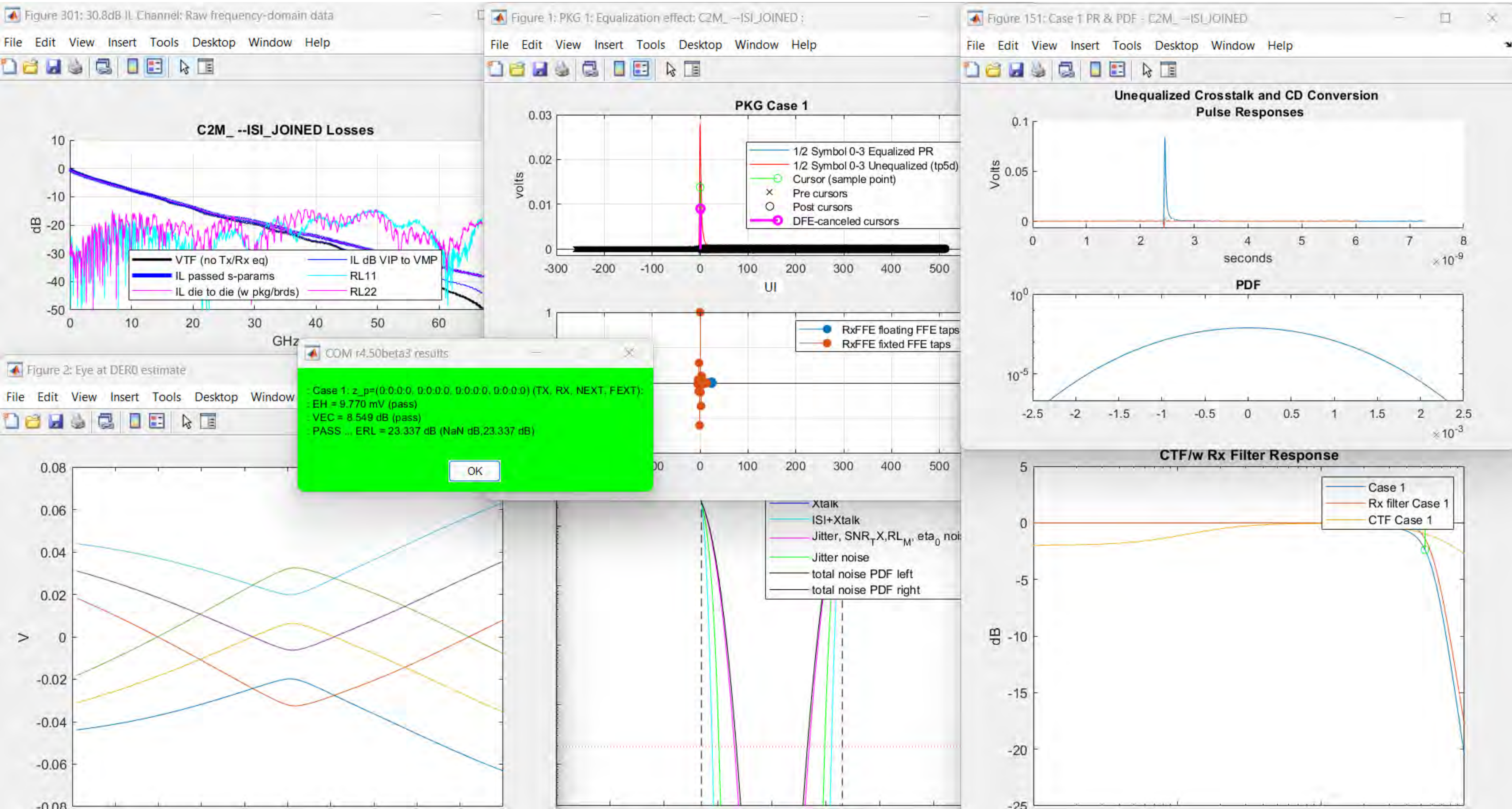
Fron	To L0	To L1	To L2	To L3
All	13.0678 mUI			
L3	792.762 µUI	3.14140 mUI	11.4783 mUI	
L2	6.53361 mUI	12.7884 mUI		6.08881 mUI
L1	792.762 µUI		457.750 µUI	13.0678 mUI
L0		3.89695 mUI	6.53361 mUI	12.7884 mUI

A typical physical layer validation screen shot is presented in this screen shot illustrated above, as the Jitter decomposition traditionally emphasizes all 12 of the available PAM4 transitions. For P802.3dj the draft specifications emphasize a limited set of 0 to 3 and 3 to 0 transitions. In this example the $J4u_{03}$ reported value is 97mUI against a typical spec limit of nominally 135mUI. $JRMS_{03}$ is reporting 14.3mUI against a nominal limit of 23mUI and the EOJ_{03} value of 13mUI against a nominal limit of 25mUI.

COM 4.5b3 analysis of MTF + ISI = 33.5dB. ERL 8.496dB



COM 4.5b3 analysis of ISI + ISI = 33.5dB. ERL 23.337dB



C2M COM Spreadsheet (1/2)

	A	B	C	D	E
1	Table 93A-1 parameters				stds ref.
2	Parameter	Setting	Units	Information	
3	f_b	106.25	GBd		
4	f_min	0.05	GHz		
5	Delta_f	0.01	GHz		
6	C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]	d1.0
7	L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	d1.0
8	C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	d1.0
9	R_0	50	Ohm	[TX RX]	d1.0 cmt 396
10	R_d	[46.25 46.25]	Ohm	[TX RX]	
11	PKG_NAME	_CLASSB_TST_EQUIP	PKG_Module_TST_EQUIP	TX RX	module is really TBD
12	A_v	0.413	V		
13	A_fe	0.413	V		
14	A_ne	0.45	V		
15	z_p select	[1]			
16	L	4			
17	M	32			
18	filter and Eq				
19	f_r	0.565	*fb		d1.0 cmt 60 (60 GHz)
20	c(0)	0.54		min	d1.0 cmt 37
21	c(-1)	0	-0.34:0.02:	[min:step:max]	d1.0 cmt 37
22	c(-2)	0	[0:.02:0.14	[min:step:max]	d1.0 cmt 37
23	c(-3)	0	0	[min:step:max]	
24	c(-4)	0	0	[min:step:max]	
25	c(1)	0	-0.2:0.02:(	[min:step:max]	d1.0 cmt 37
26	N_b	1	UI		d1.0
27	b_max(1)	0.85		As/dfe1	d1.0 cmt 279
28	b_max(2..N_b)	0		As/dfe2..N_b	
29	b_min(1)	0		As/dfe1	d1.0 cmt 279
30	b_min(2..N_b)	-0.15	UI	NA if Nb=1	
31	g_DC	0	dB	[-20:1:0]	d1.0
32	f_z	42.50	GHz		d1.0
33	f_p1	42.50	GHz		d1.0
34	f_p2	106.25	GHz		d1.0
35	g_DC_HP	[-6:1:0]		[min:step:max]	d1.0
36	f_HP_PZ	1.328125	GHz		d1.0
37	Butterworth	1	logical	include in fr	
38					
39					

	F	G	H	I
1	I/O control			stds ref.
2	DIAGNOSTICS	1	logical	
3	DISPLAY_WINDOW	1	logical	
4	CSV_REPORT	0	logical	
5	RESULT_DIR	.\results\C2M_{date}\		
6	SAVE_FIGURES	0	logical	
7	Port Order	[2 4 1 3]	input fi	
8	RUNTAG	C2M_		
9	COM_CONTRIBUTION	0	logical	
10		0		
11	TDR and ERL options			
12	TDR	1	logical	
13	ERL	1	logical	
14	ERL_ONLY	0	logical	
15	TR_TDR	0.005	ns	d1.0 cmt 48
16	N	1600	UI	
17	TDR_Butterworth	1		
18	beta_x	0		d1.0 cmt 48
19	rho_x	0.618		d1.0 cmt 48
20	TDR_W_TXPKG	1	UI	ERL computed at TP1a
21	N_bx	0	UI	d1.0
22	fixture delay time	[0 1.7e-9]	S	
23	Tukey_Window	1		
24	Noise, jitter			
25	sigma_RJ	0.01	UI	d1.0 cmt 271
26	A_DD	0.02	UI	d1.0 cmt 271
27	eta_0	1.00E-08	V^2/GHz	d1.0 cmt 269 straw poll
28	SNR_TX	33	dB	d1.0 cmt 45
29	R_LM	0.95		d1.0 cmt 273
30				
31				
32	Host chip to Module (AUI)			
33				
34	VEC Pass threshold	12		
35	EH_min	1		

	J	K	L	M	N
1	Table 93A–3 parameters				stds ref.
2	Parameter	Setting	Units	Information	
3	package_tl_gamma0_a1_a2	5e-4 0.00065 0.0003]			
4	package_tl_tau	0.006141	ns/mm		
5	package_Z_c	92 ; 70 70; 80 80; 100	Ohm		
6	z_p (TX)	; 1 1 11; 11 1 1; 0.5 0	mm	[test cases to run]	
7	z_p (NEXT)	; 1 1 11; 11 1 1; 0.5 0	mm	[test cases]	
8	z_p (FEXT)	; 1 1 11; 11 1 1; 0.5 0	mm	[test cases]	
9	z_p (RX)	; 1 1 11; 11 1 1; 0.5 0	mm	[test cases]	
10	C_p	[0.4e-4 0.4e-4]	nF	[test cases]	
11	Operational				
12	ERL Pass threshold	10	dB		
13	COM Pass threshold	3	db		d1.0 cmt 250
14	DER_0	2.00E-05			
15	T_r	0.00400	ns		d1.0 176E.4.2
16	FORCE_TR	1	logical	required for backward compatability	
17	PMD_type	C2M			d1.0 176E.4.2
18	samples_for_C2M	100			
19	T_O	50			
20	EW	1			
21	MLSE	0	logical		
22	ts_anchor	1			
23	sample_adjustment	[-12 12]			
24	Local Search	0		if set to 2 validate resuults	
25	Filter: Rx FFE				
26	ffe_pre_tap_len	5	UI		d1.0 cmt 72
27	ffe_post_tap_len	14	UI		d1.0 cmt 72
28	ffe_pre_tap1_max	0.7	interpreted as +/-	COM to change to V	d1.0 cmt 279
29	ffe_post_tap1_max	0.7	interpreted as +/-	COM to change to V	d1.0 cmt 279
30	ffe_tapn_max	0.7	interpreted as +/-	COM to change to V	d1.0 cmt 279
31	FFE_OPT_METHOD	MMSE		FV-LMS or MMSE	
32	num_ui_RXFF_noise	1024			
33	Floating Tap Control				
34	N_bg	2	0 1 2 or 3 groups		d1.0 cmt 72
35	N_bf	4	taps per group		d1.0 cmt 72
36	N_f	50	UI span for floating taps		d1.0 cmt 72
37	bmaxg	0.2	max DFE value for floating taps		
38	B_float_RSS_MAX	1	rss tail tap limit		
39	N_tail_start	15	(UI) start of tail taps limit		d1.0 cmt 72

	O	P	Q
1	SAVE_CONFIG2MAT	0	
2	Receiver testing		
3	RX_CALIBRATION	0	logical
4	Sigma BBN step	5.00E-03	V
5	ICN parameters		
6	f_v	0.278	Fb
7	f_f	0.278	Fb
8	f_n	0.278	Fb
9	f_2	60.000	GHz
10	A_ft	0.450	V
11	**A_nt**	0.450	V
12			
13	Parameter	Setting	
14	board_tl_gamma0_a1_a2	*2.7784e-04 4.7955e-0*	1.0 db/in @ 53.125G
15	board_tl_tau	*5.790E-03*	ns/mm
16	board_Z_c	100	Ohm
17	z_bp (TX)	*32*	mm
18	z_bp (NEXT)	*32*	mm
19	z_bp (FEXT)	*32*	mm
20	z_bp (RX)	*32*	mm
21	C_0	[0 0.2e-4]	nF
22	C_1	[0 0.2e-4]	nF
23	**Include PCB**	**0**	**logical**
24	Seletions (rectangle, gaussian,dual_rayleigh,triangle		
25	Histogram_Window_Weigl	gaussian	selection
26	Qr	*0.02*	UI

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41					
42	.START	PKG_LowR_CLASSA	[2.44 5.7] db		
43	Table 93A–3 parameters				
44	Parameter	Setting	Units	Information	
45	package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]			d1.0
46	package_tl_tau	0.006141	ns/mm		d1.0
47	package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm		d1.0
48	R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
49	z_p (TX)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
50	z_p (NEXT)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
51	z_p (FEXT)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
52	z_p (RX)	[12 33 33 33 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
53	C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
54	A_v	0.413	V	Vf=0.400	d1.0 cmt 434
55	A_fe	0.413	V	Vf=0.399	d1.0 cmt 434
56	A_ne	0.45	V	Vf=0.400	d1.0 cmt 434
57	.END				
58					
59	.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db		
60	Table 93A–3 parameters				
61	Parameter	Setting	Units	Information	
62	package_tl_gamma0_a1_a2	[0.0005 0.00065 0.000293]			d1.0
63	package_tl_tau	0.006141	ns/mm		d1.0
64	package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm		d1.0
65	R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
66	z_p (TX)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
67	z_p (NEXT)	[8 24 29 44 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
68	z_p (FEXT)	[8 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
69	z_p (RX)	[8 24 29 44 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]	d1.0
70	C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
71	A_v	0.413	V	Vf=0.400	d1.0 cmt 434
72	A_fe	0.413	V	Vf=0.399	d1.0 cmt 434
73	A_ne	0.45	V	Vf=0.400	d1.0 cmt 434
74	.END				
75					
76	.START	PKG_HiR_CLASSB_TST_EQUIP	[2.8 5.6 6.7 9.4] db		
77	Table 93A–3 parameters				
78	Parameter	Setting	Units	Information	
79	package_tl_gamma0_a1_a2	[0.0005 0.00065 0.000293]			d1.0
80	package_tl_tau	0.006141	ns/mm		d1.0
81	package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm		d1.0
82	R_d	[46.25 46.25]	Ohm	[TX RX]	d1.0 cmt 396
83	z_p (TX)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
84	z_p (NEXT)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
85	z_p (FEXT)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
86	z_p (RX)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]	d1.0
87	C_p	[0 0]	nF	[TX RX]	d1.0
88	A_v	0.413	V	Vf=0.400	d1.0 cmt 434
89	A_fe	0.413	V	Vf=0.399	d1.0 cmt 434
90	A_ne	0.45	V	Vf=0.400	d1.0 cmt 434
91	.END				

92	.START	PKG_Module_TST_EQUIP		
93	Table 93A–3 parameters			
94	Parameter	Setting	Units	Information
95	package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
96	package_tl_tau	0.006141	ns/mm	
97	package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
98	C_b	[0.3e-4 0.6e-4]	nF	[TX RX]
99	R_d	[50 50]	Ohm	[TX RX]
100	z_p (TX)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
101	z_p (NEXT)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
102	z_p (FEXT)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
103	z_p (RX)	[0 0 0 0 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
104	C_p	[0 0]	nF	[TX RX]
105	A_v	0.413	V	Vf=0.400
106	A_fe	0.413	V	Vf=0.399
107	A_ne	0.45	V	Vf=0.400
108	.END			
109				
110	.START	PKG_Module		
111	Table 93A–3 parameters			
112	Parameter	Setting	Units	Information
113	package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
114	package_tl_tau	0.006141	ns/mm	
115	package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
116	R_d	[50 50]	Ohm	[TX RX]
117	z_p (TX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
118	z_p (NEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
119	z_p (FEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
120	z_p (RX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
121	C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
122	A_v	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
123	A_fe	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
124	A_ne	[0.600 0.600 0.600 0.600]	V	Vf=0.400
125	.END			
126				
127	.START	PKG_Null		
128	Table 93A–3 parameters			
129	Parameter	Setting	Units	Information
130	package_tl_gamma0_a1_a2	[5e-4 0.001 0.03]		
131	package_tl_tau	0.006141	ns/mm	
132	package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm	
133	R_d	[50 50]	Ohm	[TX RX]
134	z_p (TX)	[0 0 0 0;0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
135	z_p (NEXT)	[0 0 0 0;0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
136	z_p (FEXT)	[0 0 0 0;0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
137	z_p (RX)	[0 0 0 0;0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
138	C_p	[0 0]	nF	[TX RX]
139	A_v	0.5	V	Vf=0.400
140	A_fe	0.5	V	Vf=0.400
141	A_ne	0.61	V	
142	.END			