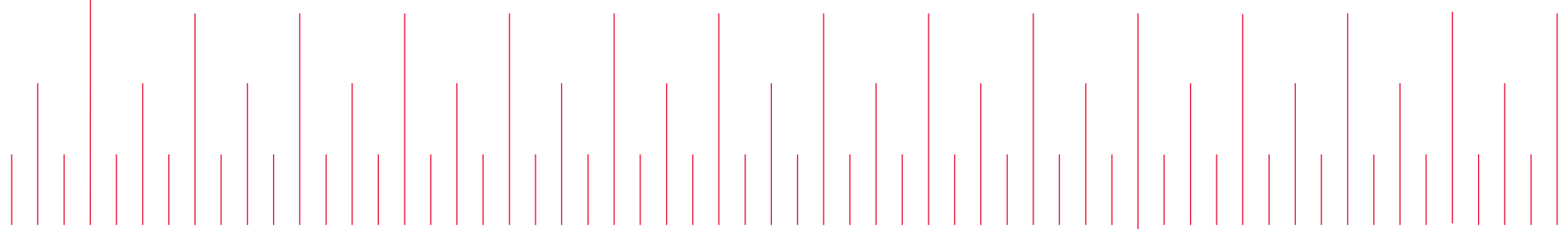


Examples of C2C Channels With Impairments

10dB 16dB 18dB 20dB Test Cases

August 28th, 2019



Rick Rabinovich

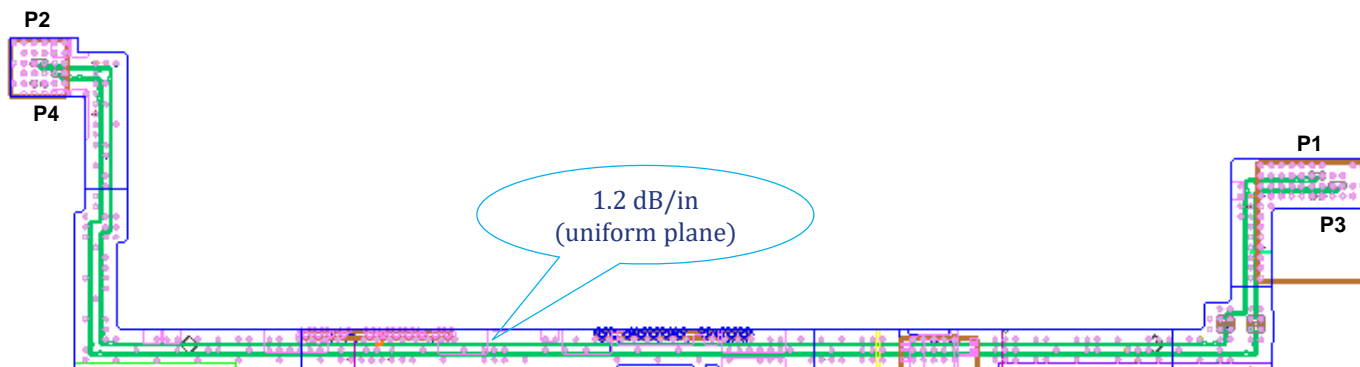
C2C Channels With Impairments

Examples of Channels with Impairments (Obstacles)

Perfect routing ideal scenario example vs. “actual” optimum routing

Set the specification based on a real “engineered (optimized)” channel rather than on an “ideal” channel

- Two-channel adaptation with AC coupling (~ connector)
- Dielectric similar to Megtron 7
- “Engineered Channel”
- Impairments:
 - Impedance tolerance
 - $Z_{nom} \sim 94$ ohms
 - Complex chip breakouts
 - Long and short via stripline mix
 - 105 mils (0.5 dB/via)
 - 22 mils (0.4 dB/via)
 - Six 90° turns
 - Routing on grid
 - Asymmetric via distribution along the route



C2C Channels With Impairments

Introduction

Analyze four test IL cases:

10dB 16dB 18dB 20dB

Myth: “FEXT increases with trace length”

- Yes, **ONLY** if the traces coupled, otherwise
- Coupling occurs **MOSTLY** at the destination

Verify: “NEXT is independent of trace length (and IL)”

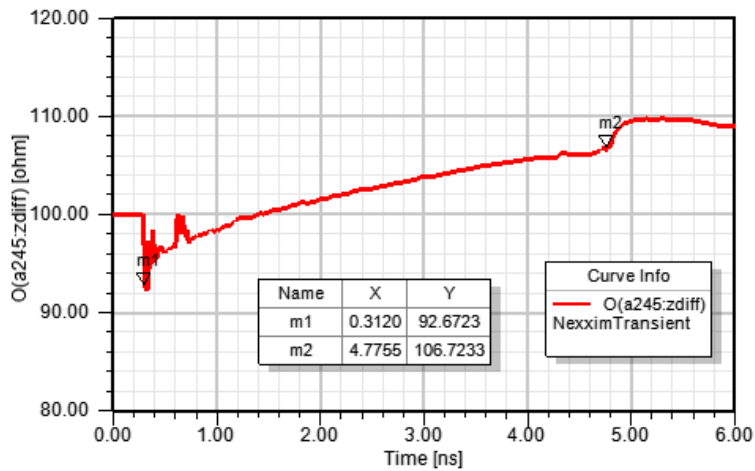
Observation: “RL is not too sensitive to channel length on long channels (> 7”)

C2C Channels With Impairments

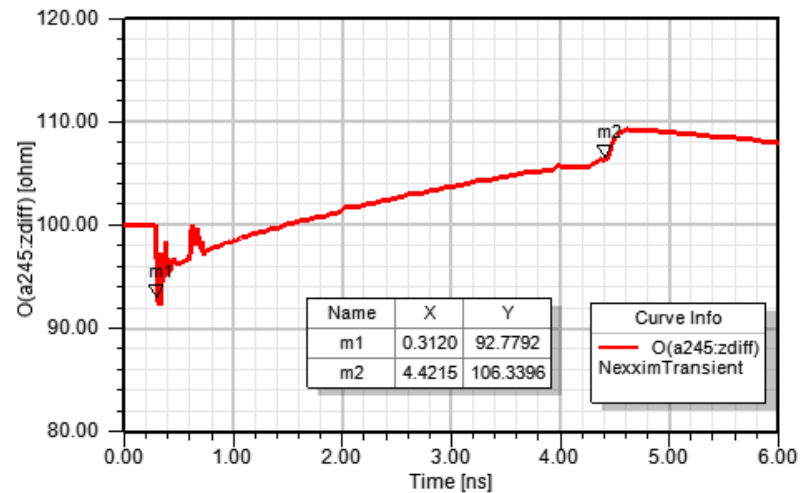
TDR – “Engineered Channel”

P2 _____ P1
P4 _____ P3

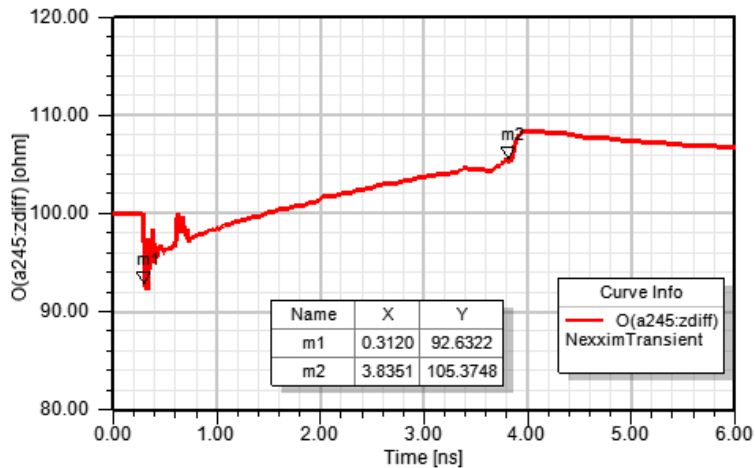
TDR P 20dB



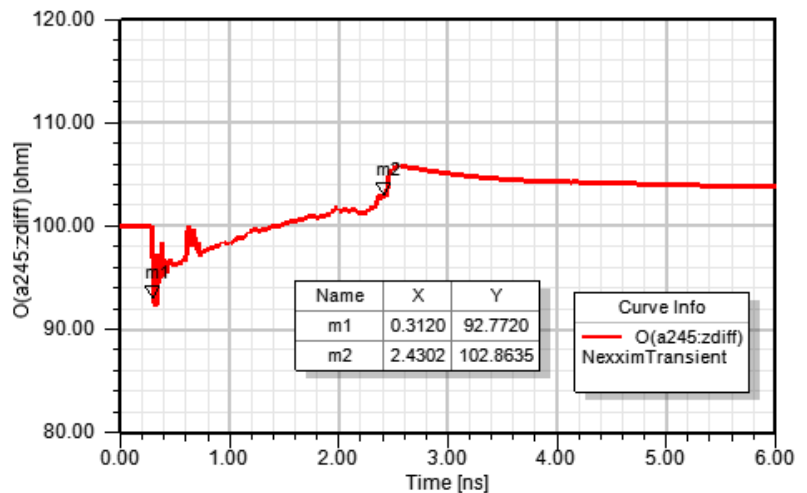
TDR P 18dB



TDR P 16dB



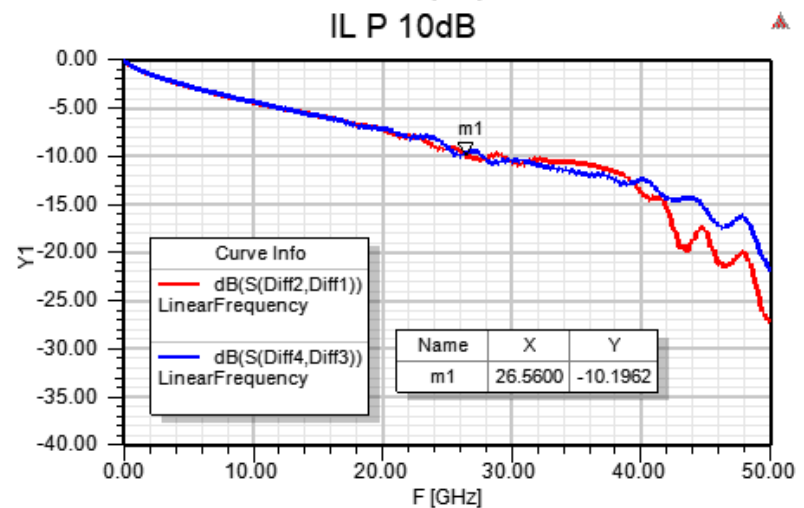
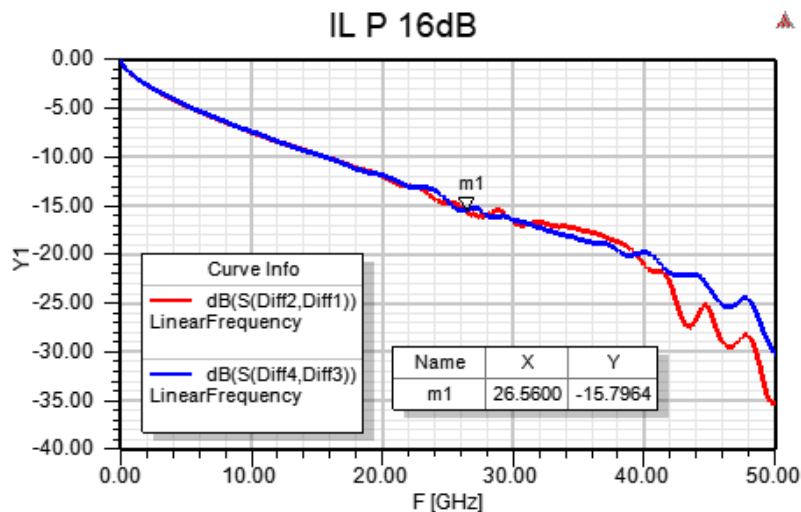
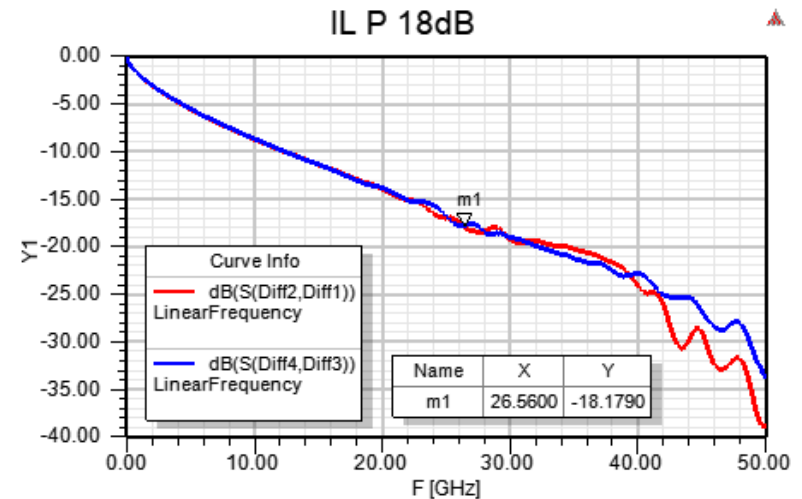
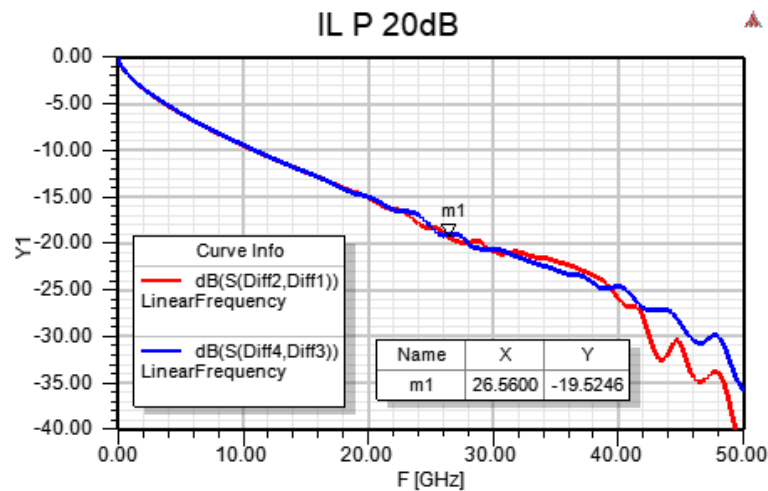
TDR P 10dB



C2C Channels With Impairments

IL – “Engineered Channel”

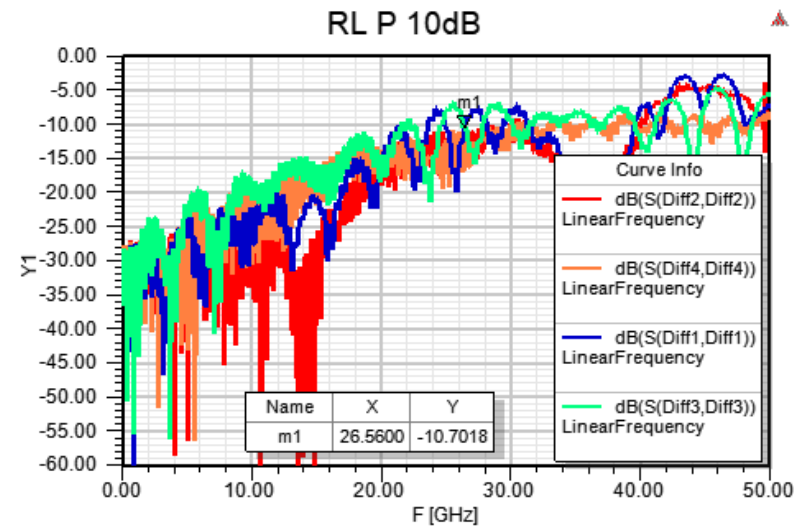
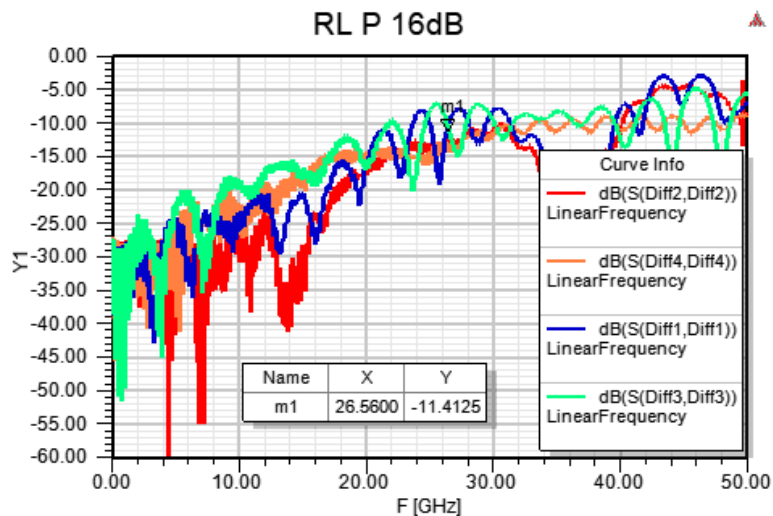
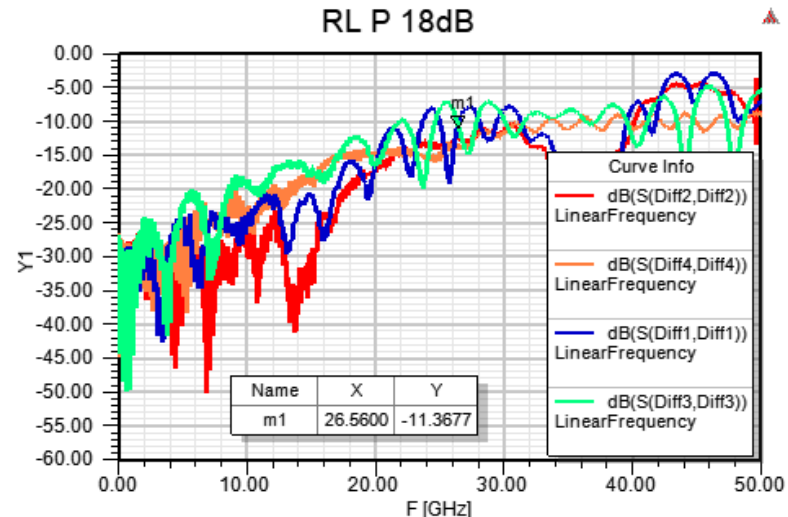
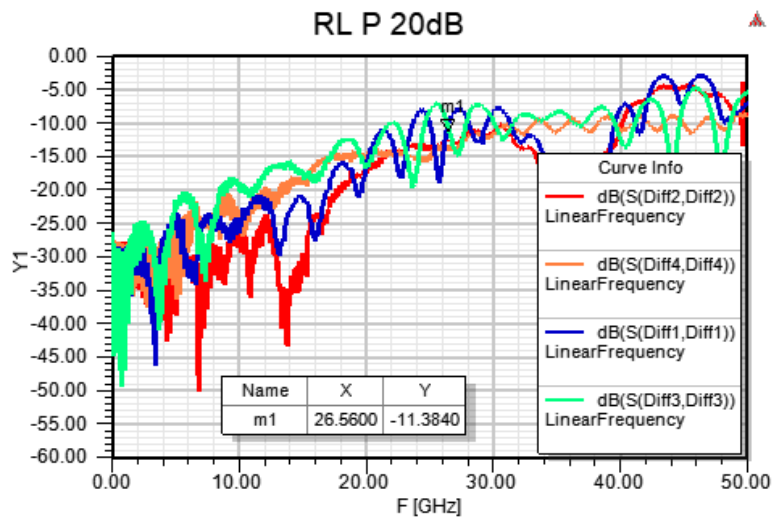
P2 _____ P1
 P4 _____ P3



C2C Channel With Impairments

RL

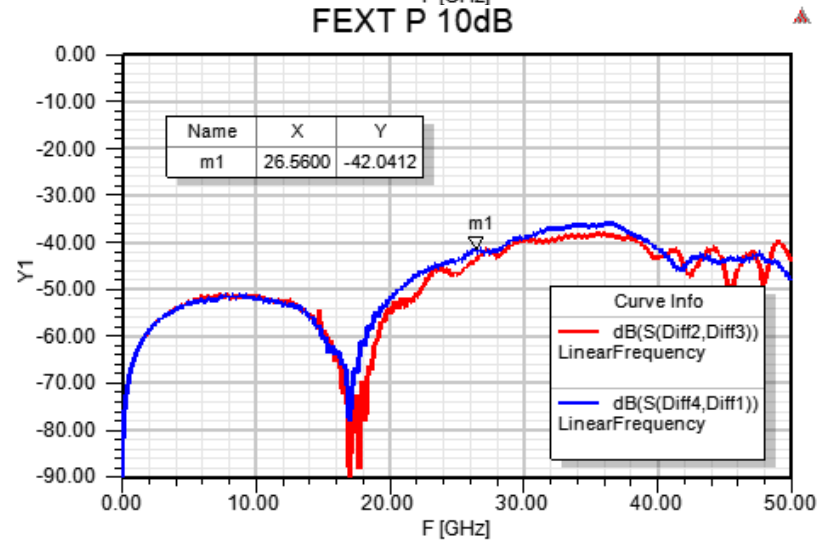
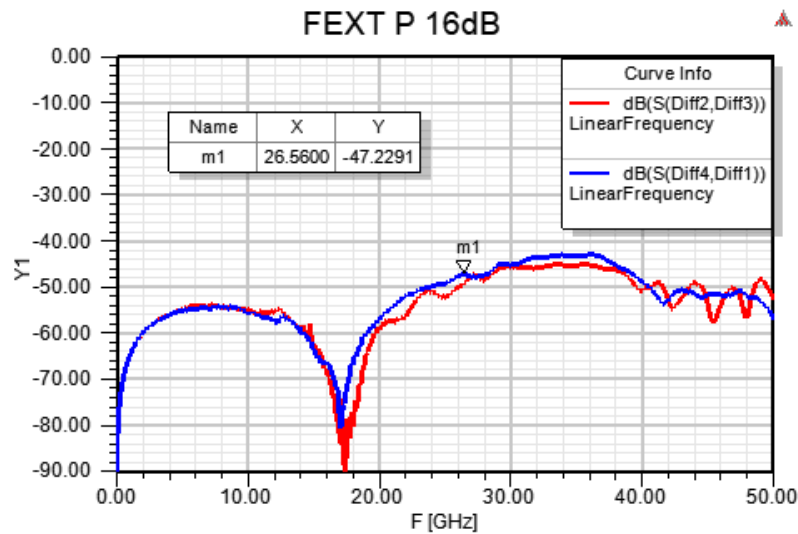
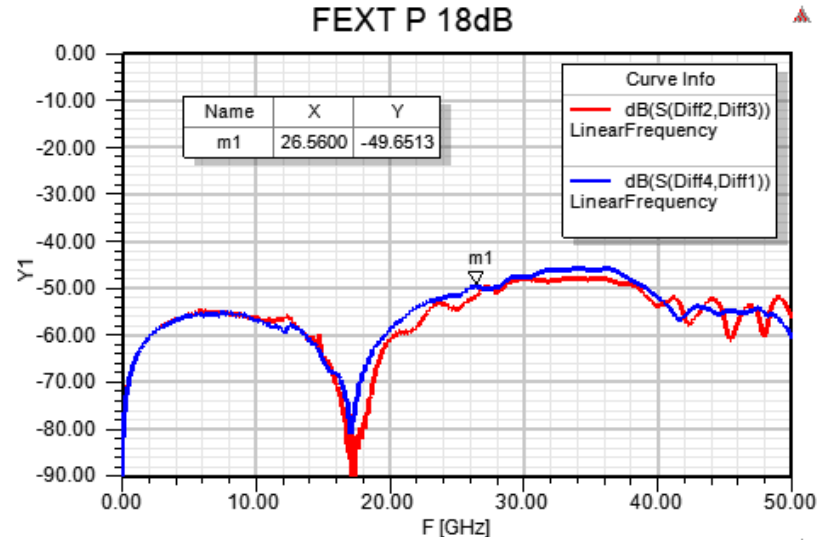
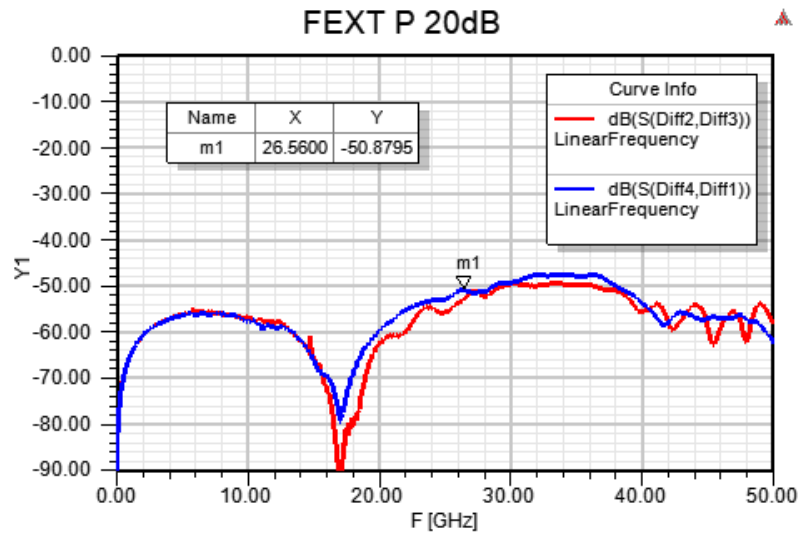
P2 _____ P1
P4 _____ P3



C2C Channels With Impairments

FEXT

P2 _____ P1
 P4 _____ P3

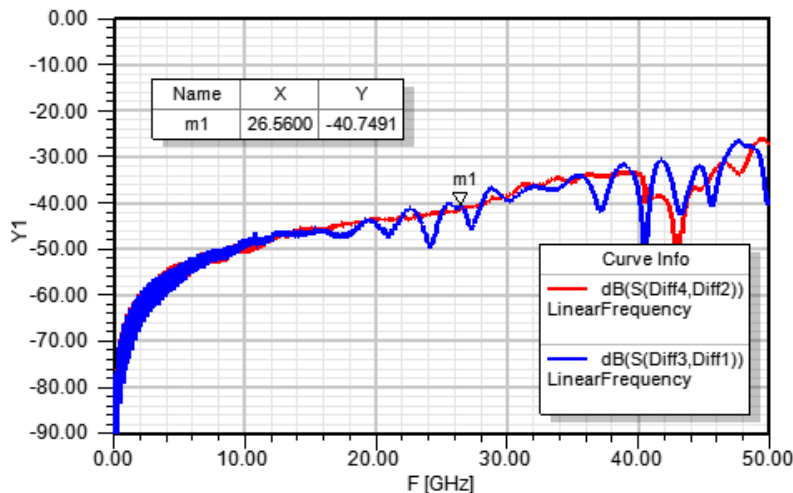


C2C Channels With Impairments

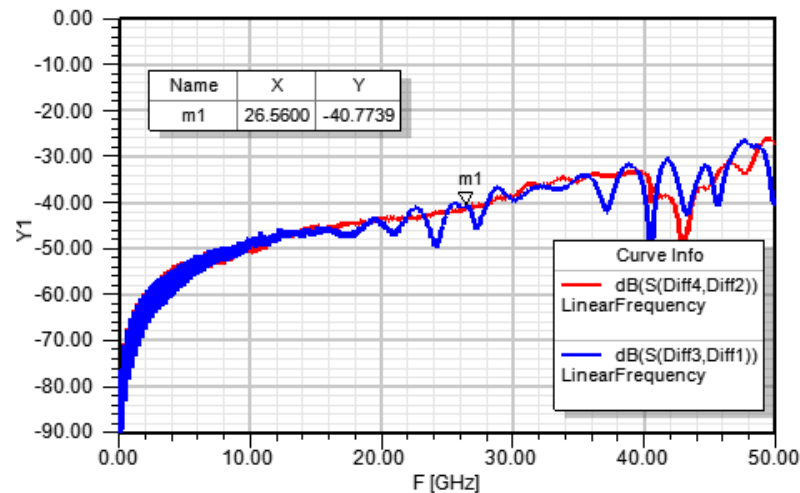
NEXT

P2 _____ P1
P4 _____ P3

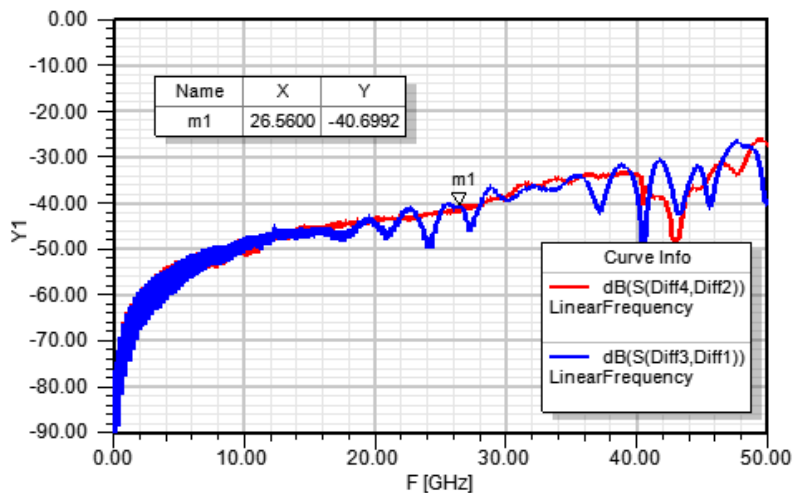
NEXT P 20dB



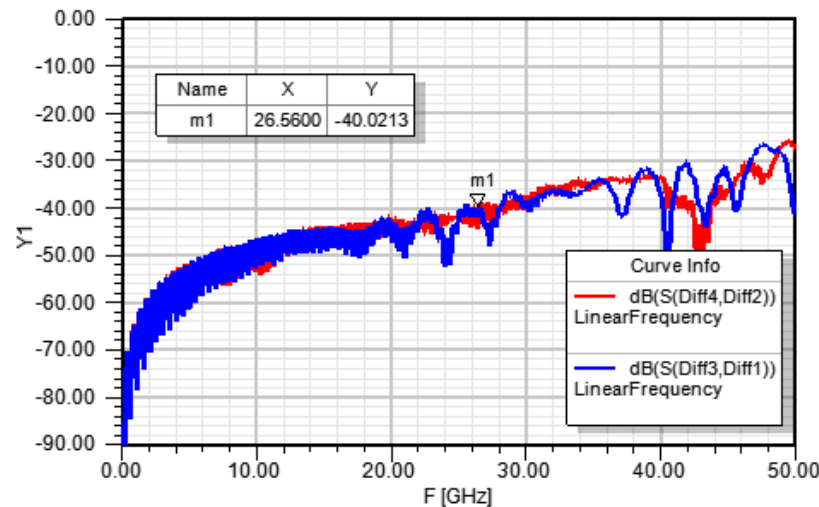
NEXT P 18dB



NEXT P 16dB



NEXT P 10dB



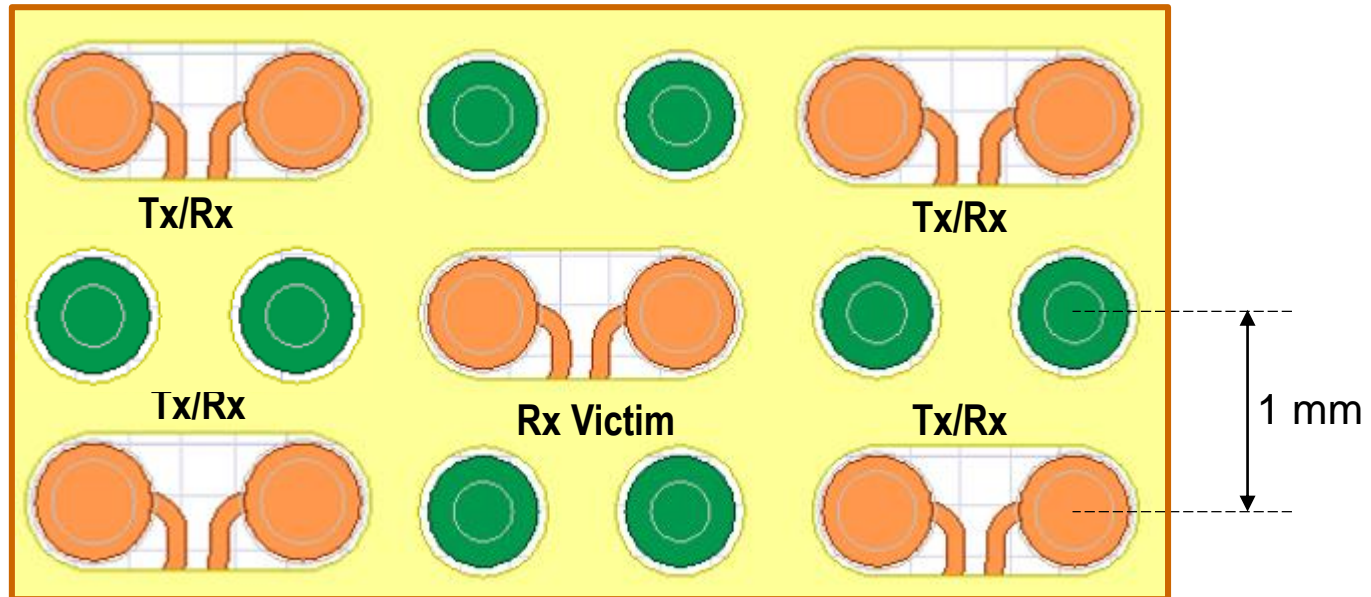
C2C Channels With Impairments

Observations:

1. FEXT decay tracks IL (uncoupled differential pairs)
 1. COM (S/N) insensitive to FEXT for variable trace length
 1. Signal and FEXT decreased at about the same rate
2. NEXT is independent of IL
 1. Signal decay with invariable NEXT => COM very sensitive to NEXT for variable trace length
3. Return Loss is independent of IL (statement valid up to minimum length of 6.75")

C2C Channels With Impairments

Chip Footprint



FEXT: Rx → Rx Victim

NEXT: Tx → Rx Victim

C2C Channels With Impairments

COM Results & Analysis

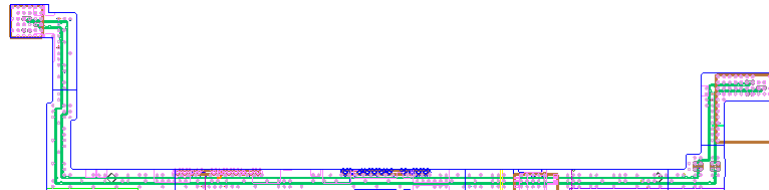
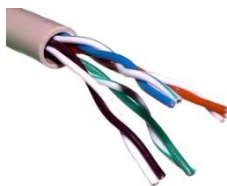
P2 ————— P1

COM									
		N_b = 12		b_max(1) = 0.85		b_max(2..N_b) = 0.3			
Nominal	10 dB		16 dB		18 dB		20 dB		
(1) Length	6.76 in (172 mm)		11.5 in (292 mm)		13.48 in (342 mm)		14.68 in (373 mm)		
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB		
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	
0/0	6.13	6.15	6.62	6.14	6.41	5.65	6.21	5.58	
3/0	5.70	5.85	6.27	5.87	6.10	5.42	5.92	5.37	
3/1	5.12	5.26	4.95	4.63	4.24	3.85	3.75	3.52	
2/2	4.74	4.82	3.96	3.73	2.96	2.76	2.35	2.26	
3/2	4.66	4.82	3.91	3.68	2.92	2.71	2.31	2.21	
3/3	4.24	4.44	3.12	2.91	1.93	1.84	1.17	1.19	
3/4	3.85	4.09	2.46	2.26	1.10	1.07	0.36	0.34	

(1) Glass weave and manufacturing variability are not included in simulation and could cause degradation of the reach

FEXT/NEXT (3/4) Ratio Precedence:

- 2006 - IEEE802.3an (aka 10 GBASE-T)
- Ratio applied to 100m 4-pair twisted cable



Is the (3/4) ratio applicable for C2C (and other .ck objectives)? Too conservative?

C2C Channels With Impairments

COM & ICN Results

P2 ————— P1

COM								
N_b = 5		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	3.91	5.42	3.51	5.32	3.41	5.16	3.41	4.97
3/0	3.66	5.00	3.25	4.99	3.17	4.87	3.17	4.72
4/0	3.58	4.87	3.16	4.88	3.10	4.78	3.10	4.66
3/1	3.25	4.39	2.16	3.62	1.63	3.11	1.37	2.84
N_b = 5		b_max(1) = 0.85		b_max(2..N_b) = 0.3				
3/1	3.25	4.39	2.16	3.62	1.63	3.11	1.37	2.84
N_b = 5		b_max(1) = 0.75		b_max(2..N_b) = 0.2				
4/0	3.58	4.87	3.16	4.88	3.10	4.78	3.10	4.67

ICN								
N_b = 5		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/0	3.02	3.02	1.59	1.59	1.24	1.24	1.08	1.08
4/0	3.48	3.48	1.83	1.83	1.43	1.43	1.25	1.25
3/1	4.52	4.52	3.68	3.68	3.54	3.54	3.48	3.48
N_b = 5		b_max(1) = 0.85		b_max(2..N_b) = 0.3				
3/1	4.52	4.52	3.68	3.68	3.54	3.54	3.48	3.48
N_b = 5		b_max(1) = 0.75		b_max(2..N_b) = 0.2				
4/0	3.48	3.48	1.83	1.83	1.43	1.43	1.25	1.25

COM								
N_b = 7		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	4.10	5.78	4.01	5.42	3.78	5.19	3.72	5.05
3/0	3.84	5.46	3.77	5.10	3.55	4.90	3.49	4.79
4/0	3.76	5.36	3.69	4.99	3.47	4.81	3.41	4.72
3/1	3.41	4.86	2.72	3.80	2.10	3.24	1.76	2.89
N_b = 7		b_max(1) = 0.85		b_max(2..N_b) = 0.3				
3/1	3.41	4.96	2.68	3.80	2.29	3.24	1.88	2.89

ICN								
N_b = 7		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/0	3.02	3.02	1.59	1.59	1.24	1.24	1.08	1.08
4/0	3.48	3.48	1.83	1.83	1.43	1.43	1.25	1.25
3/1	4.52	4.52	3.68	3.68	3.54	3.54	3.48	3.48
N_b = 7		b_max(1) = 0.85		b_max(2..N_b) = 0.3				
3/1	4.52	4.52	3.68	3.68	3.54	3.54	3.48	3.48

COM								
N_b = 4		b_max(1) = 0.75		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	3.46	5.16	3.38	5.24	3.30	5.16	3.36	4.97
3/0	3.18	4.71	3.07	4.93	3.05	4.87	3.11	4.72
4/0	3.10	4.57	2.98	4.82	2.96	4.76	3.02	4.66
3/1	2.76	4.05	1.93	3.53	1.48	3.07	1.24	2.83
N_b = 4		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
4/0	3.10	4.57	2.98	4.82	2.96	4.76	3.02	4.66

ICN								
N_b = 4		b_max(1) = 0.75		b_max(2..N_b) = 0.2				
Nominal	10 dB	16 dB	18 dB	20 dB				
Length	6.76 in (172 mm)	11.5 in (292 mm)	13.48 in (342 mm)	14.68 in (373 mm)				
IL (measured)	10.20 dB		15.80 dB		18.18 dB		19.52 dB	
FEXT/NEXT	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
0/0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3/0	3.02	3.02	1.59	1.59	1.24	1.24	1.08	1.08
4/0	3.48	3.48	1.83	1.83	1.43	1.43	1.25	1.25
3/1	4.52	4.52	3.68	3.68	3.54	3.54	3.48	3.48
N_b = 4		b_max(1) = 0.85		b_max(2..N_b) = 0.2				
4/0	3.48	3.48	1.83	1.83	1.43	1.43	1.25	1.25

C2C Channels With Impairments

Rx Configuration Summary and Polls

Keep Tx isolated from Rx ←

✓ Passing COM for up to IL=20dB with 4 FEXTs

- $N_b = 5$
- $b_{\max}(1) = 0.75$
- $b_{\max}(2..N_b) = 0.2$

From the unapproved minutes P802.3ck Task Force July 16-18 2019, Vienna

Straw Poll #5:

I would support the proposed C2C “no FEC termination” parameters in lusted_3ck_02_0719, slide 10 as an initial target for investigation

Y: 43 , N: 0 , A: 5

Straw Poll #6:

I would support continuing to explore another C2C case (appx 26-28 dB IL and segmented FEC) in addition to the C2C “no FEC termination” from Straw Poll #5

Y: 6 , N: 22 , A: 12

C2C Channels With Impairments

Summary

To reach a broad market potential we need:

1. Good Engineering Practices:

- Engineer the channel, i.e., trace geometries, material selection, stackup definition, antipads, via diameter, stubs, breakouts, etc.
- Engineer the connector including footprint
- [Engineer the chip footprint](#) ←

2. TF Straw Poll Guidance:

- Support for C2C with “no FEC termination”
- No support for IL ~ 26-28 dB and segmented FEC

3. Define the C2C channel to cover the highest percentage of applications.

4. It has been shown that a **20 dB channel** with impairments satisfies a 3 dB COM

Recommendation:

[Support a single C2C reach of up to at least 20 dB @ 26.56 GHz with no FEC termination.](#)

Q & A

C2C Channels With Impairments

COM Configuration Table

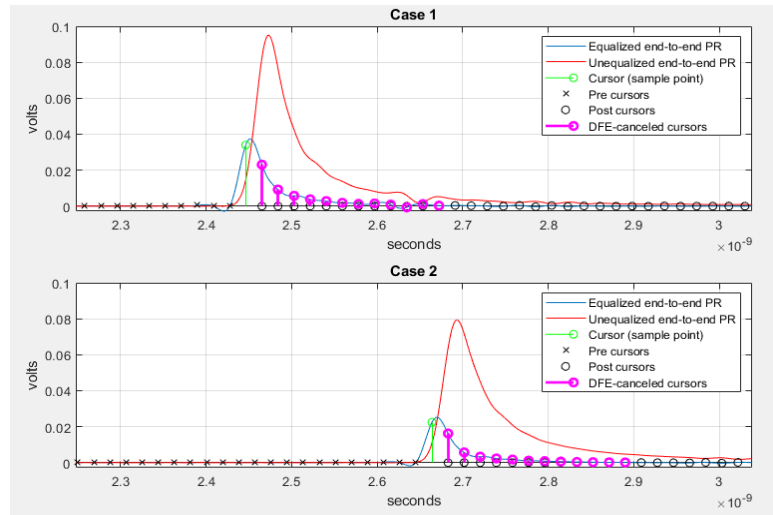
Table 93A-1 parameters				I/O control			Table 93A-3 parameters		
Parameter	Setting	Units	Information				Parameter	Setting	Units
f_b	53.125	GBd		DIAGNOSTICS	1	logical	package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
f_min	0.05	GHz		DISPLAY_WINDOW	1	logical	package_tl_tau	6.141E-03	ns/mm
Delta f	0.01	GHz		CSV_REPORT	1	logical	package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]	RESULT_DIR	.\results\100GEL_KR_{date}\		Table 92-12 parameters 5.2dB at 26.56GHz		
L_s	[0.12, 0.12]	nH	[TX RX]	SAVE_FIGURES	1	logical	board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	1.286 dB/in or 0.0506 dB/mm at 100 ohms
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	Port Order	[2 1 4 3]		board_tl_tau	6.200E-03	ns/mm
z_p select	[1 2]		[test cases to run]	RUNTAG	KR_eval_		board_Z_c	90	Ohm
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]	COM_CONTRIBUTION	0	logical	z_bp (TX)	102.7	mm
z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]	Operational			z_bp (NEXT)	102.7	mm
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]	COM Pass threshold	3	dB	z_bp (FEXT)	102.7	mm
z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]	ERL Pass threshold	10	dB	z_bp (RX)	102.7	mm
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]	DER_0	1.00E-05		Floating Tap Control		
R_0	50	Ohm		T_r	6.16E-03	ns	N_bg	0	0 1 2 or 3 groups
R_d	[45 45]	Ohm	[TX RX]	FORCE_TR	1	logical	N_bf	4	taps per group
A_v	0.39	V	vp/vf=.694	Include PCB	0	logical	N_f	40	UI span for floating taps
A_fe	0.39	V	vp/vf=.694	TDR and ERL options			bmaxg	0.1	max DFE value for floating taps
A_ne	0.578	V		TDR	1	logical			
L	4			ERL	1	logical			
M	32			ERL_ONLY	0	logical			
filter and Eq				TR_TDR	0.01	ns			
f_r	0.75	*fb		N	3000				
c(0)	0.5		min	beta_x	2.53E+09				
c(-1)	[-0.3:0.02:0]		[min:step:max]	rho_x	0.25				
c(-2)	[0.02:0.12]		[min:step:max]	fixture delay time	0	s			
c(-3)	[-0.06:0.02: 0]		[min:step:max]	TDR_W_TXPKG	0				
c(1)	[-0.2:0.05:0]		[min:step:max]	N_bx	24	UI	yellow indicates WIP		
N_b	5	UI		Receiver testing					
b_max(1)	0.75			RX_CALIBRATION	0	logical			
b_max(2..N_b)	0.2			Sigma BBN step	5.00E-03	V			
g_DC	[-20:1:0]	dB	[min:step:max]	Noise, jitter					
f_z	21.25	GHz		sigma_RJ	0.01	UI			
f_p1	21.25	GHz		A_DD	0.02	UI			
f_p2	53.125	GHz		eta_0	8.20E-09	V^2/GHz			
g_DC_HP	[-6:1:0]		[min:step:max]	SNR_TX	33	dB			
f_HP_PZ	0.6640625	GHz		R_LM	0.95				

C2C Channels With Impairments

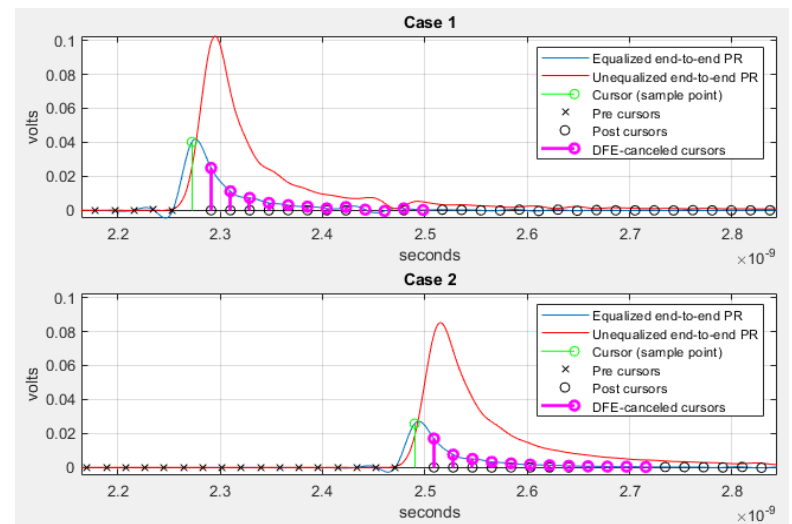
Pulse Responses (1)

P2 ————— P1

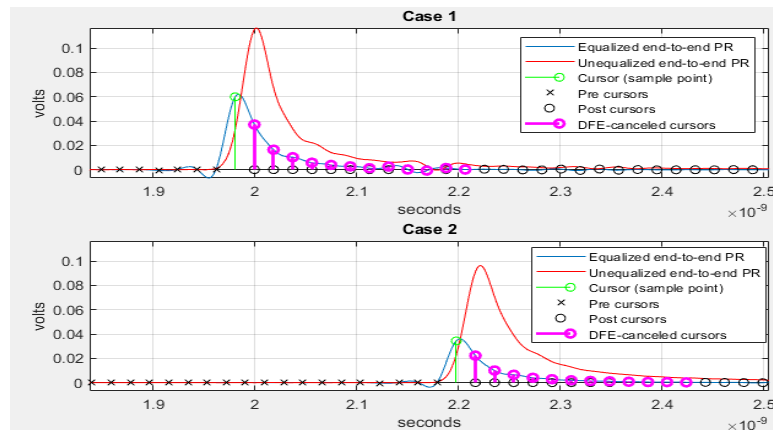
20 dB - 3/1 - $N_b = 12$ - $b_{\max}(2..N_b) = 0.3$



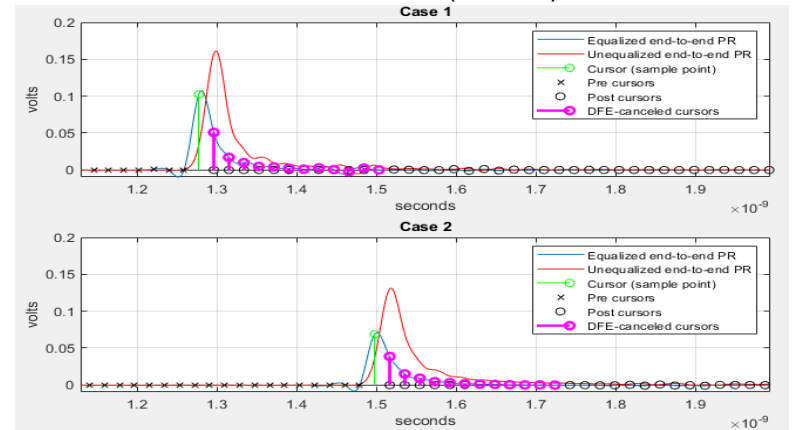
18 dB - 3/1 - $N_b = 12$ - $b_{\max}(2..N_b) = 0.3$



16 dB - 3/1 - $N_b = 12$ - $b_{\max}(2..N_b) = 0.3$



10 dB - 3/1 - $N_b = 12$ - $b_{\max}(2..N_b) = 0.3$

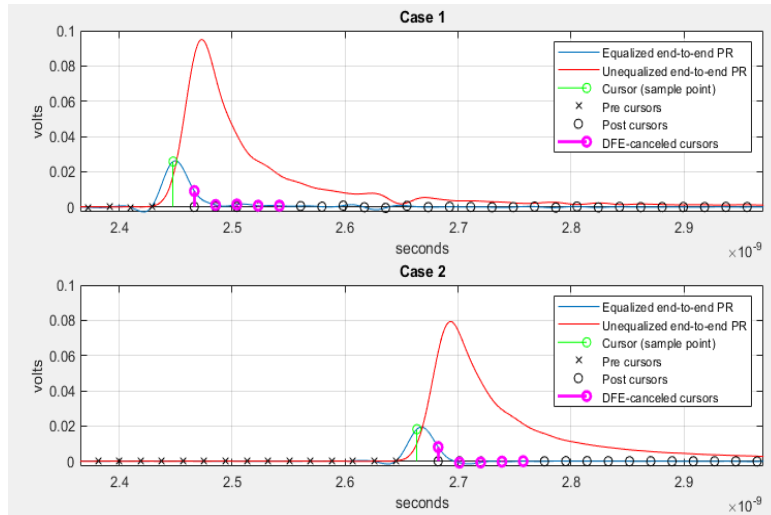


C2C Channels With Impairments

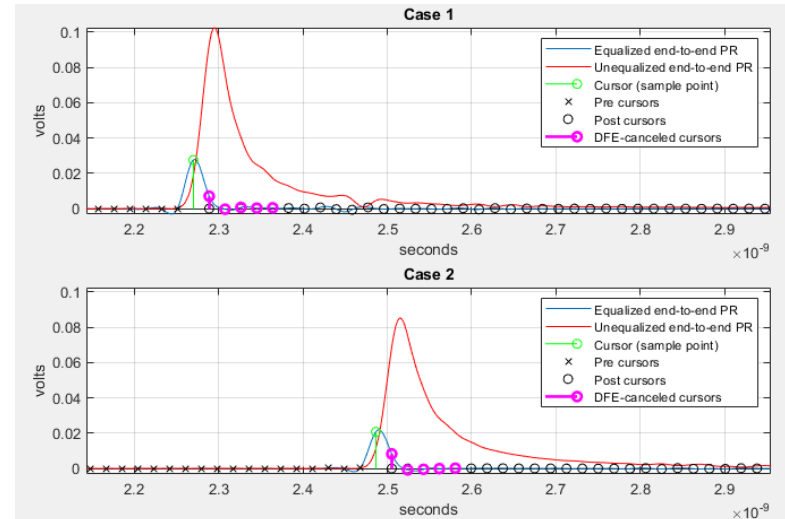
Pulse Responses (2)

P2 ————— P1

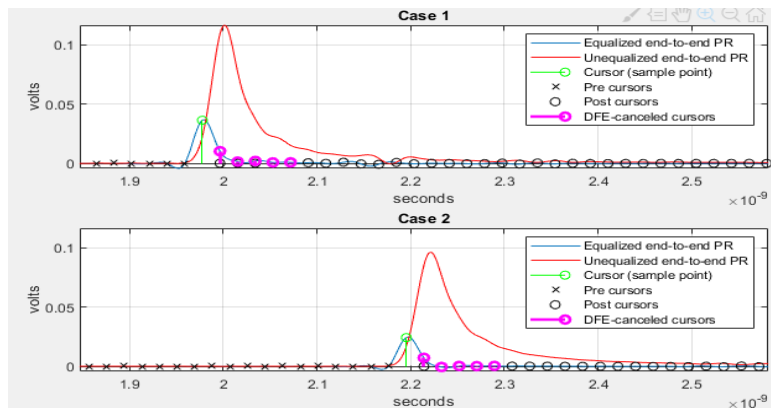
20 dB - 3/1 - $N_b = 5$ - $b_{\max}(2..N_b) = 0.2$



18 dB - 3/1 - $N_b = 5$ - $b_{\max}(2..N_b) = 0.2$



16 dB - 3/1 - $N_b = 5$ - $b_{\max}(2..N_b) = 0.2$



10 dB - 3/1 - $N_b = 5$ - $b_{\max}(2..N_b) = 0.2$

