

COM Impact Assessment: RxFFE Quantization Index Bug Fix (Commit Request 4p14_3)

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IEEE 802.3 Channel Operating Margin (COM) Open Source Project Ad Hoc

List of supporters

- Richard Mellitz, Samtec.
- Adam Gregory, Samtec.
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History

Revision	Date	Comment
0.5	20-Apr-2026	<ul style="list-style-type: none">▪ Initial Draft.
1.0	21-Apr-2026	<ul style="list-style-type: none">▪ Revises the title.▪ Added a summary slide.▪ Revise text on slide 4, 5, 6 and 7.▪ Revised plot on slide 7.
1.5	24-Apr-2026	<ul style="list-style-type: none">▪ Revised the summary slide.▪ Added a slide titled 'Results- Impact of sigma_X2' and 'Results- Impact of RxFFE Quant. Index Bug Fix'.

1. Summary

- Results “support approval” of Commit Request 4p14_3.
 - The fix for the RxFFE Quantization Index bug results in as much as 0.53 dB improvement in COM “without sigma_X2” and as much as 0.6 dB improvement “with sigma_X2”.
- “Without sigma_X2”, the COM value degrades by as much as 0.56 dB.
- Evaluation covered 171 CR and KR channels from the IEEE 802.3dj Public Area for Class A and Class B package models (171x4= 684 total cases).

2. Purpose for this Presentation

- Assess the COM impact given the RxFFE Quantization Index Bug Fix.
 - An indexing bug in `adjust_Rx_Noise_for_quantization()` caused the main tap to be included twice while omitting the first pre-tap. As a result, the first pre-tap was effectively replaced by an additional main tap.
 - https://www.ieee802.org/3/ad_hoc/COM/public/telecon/260324/gregory_COM_01_260324.pdf
- Bug exists in v4p14p0 and earlier versions when ADC quantization noise was introduced.
- Merge request: https://opensource.ieee.org/802-com/com_code/-/merge_requests/35/diffs
- Branch: RxFFE_Quantization_Index_Bug.
https://opensource.ieee.org/adam.gregory/com_code/-/branches
- Git branch file pointer:
https://opensource.ieee.org/adam.gregory/com_code/-/tree/RxFFE_Quantization_Index_Bug/src?ref_type=heads

3. Summary of code changes page 1

```
src/adjust_Rx_noise_for_quantization.m  +2 -1 ⋮
↑ @@ -61,8 +61,9 @@ quantization_noise_pdf.y = zeros(size(quantization_noise_pdf.x));
61 quantization_noise_pdf.y(ind_center) = 1;
62 % Calculate quantization noise PDF after RxFFE
63 h_rxffe = fom_result.RxFFE(find(fom_result.RxFFE ~= 0));
64 for irxffe = 1:length(h_rxffe)
65 - if irxffe ~= param.ffe_pre_tap_len
66     quantization_noise_in_pdf_scale = scalePDF(quantization_noise_in_pdf,
abs(h_rxffe(irxffe)));
67     quantization_noise_pdf = conv_fct(quantization_noise_pdf,
quantization_noise_in_pdf_scale);
68     end
↓

↑ @@ -61,8 +61,9 @@ quantization_noise_pdf.y = zeros(size(quantization_noise_pdf.x));
61 quantization_noise_pdf.y(ind_center) = 1;
62 % Calculate quantization noise PDF after RxFFE
63 h_rxffe = fom_result.RxFFE(find(fom_result.RxFFE ~= 0));
64 + cursor_tap = param.ffe_pre_tap_len+1;
65 for irxffe = 1:length(h_rxffe)
66 + if irxffe ~= cursor_tap
67     quantization_noise_in_pdf_scale = scalePDF(quantization_noise_in_pdf,
abs(h_rxffe(irxffe)));
68     quantization_noise_pdf = conv_fct(quantization_noise_pdf,
quantization_noise_in_pdf_scale);
69     end
↓
```

- In `adjust_Rx_Noise_for_quantization()`, an indexing bug caused the first pre-tap to be excluded while the main tap was included twice in the FFE output noise PDF calculation. As a result, the effective behavior was the replacement of the first pre-tap contribution with an additional main tap, rather than a simple double counting of the main tap alone.

4. List of CR and KR Channels on 802.3dj Public Area

- Below are the 200 Gb/s CR and KR channel data (TP0 to TP5)- with crosstalk.

1. akinwale_3dj_01_2311: x4
2. weaver_3dj_02_2311: x12
3. akinwale_3dj_01_2310: x7
4. lim_3dj_07_2309: x1
5. lim_3dj_04_230629: x1
6. lim_3dj_03_230629: x1
7. weaver_3dj_elec_01_230622: x8
8. shanbhag_3dj_01_2305: x6
9. shanbhag_3dj_02_2305: x4
10. kocsis_3dj_02_2305: x5
11. weaver_3dj_02_2305: x36
12. mellitz_3dj_02_elec_230504: x27
13. weaver_3dj_02_2303: x5
14. mellitz_3dj_02_2303: x54

Table 178–14—Device termination and package model parameters

Parameter	Symbol	Value	Units
Device termination model			
Single-ended device capacitance for stage 1	$C_d^{(1)}$	40×10^{-6}	nF
Single-ended device capacitance for stage 2	$C_d^{(2)}$	90×10^{-6}	nF
Single-ended device capacitance for stage 3	$C_d^{(3)}$	110×10^{-6}	nF
Single-ended device series inductance for stage 1	$L_s^{(1)}$	0.13	nH
Single-ended device series inductance for stage 2	$L_s^{(2)}$	0.15	nH
Single-ended device series inductance for stage 3	$L_s^{(3)}$	0.14	nH
Single-ended bump capacitance	C_b	30×10^{-6}	nF
Device package model, class A			
Transmission line parameter γ_0	γ_0	5×10^{-4}	1/mm
Transmission line parameter a_1	a_1	8.9×10^{-4}	ns ^{1/2} /mm
Transmission line parameter a_2	a_2	2×10^{-4}	ns/mm
Transmission line parameter r	r	6.141×10^{-3}	ns/mm
Transmission line 1 length, Test 1	$z_p^{(1)}$	33	mm
Transmission line 1 length, Test 2	$z_p^{(1)}$	12	mm
Transmission line 1 characteristic impedance	$Z_c^{(1)}$	87.5	Ω
Transmission line 2 length	$z_p^{(2)}$	1.8	mm
Transmission line 2 characteristic impedance	$Z_c^{(2)}$	92.5	Ω
Device package model, class B			
Transmission line parameter γ_0	γ_0	5×10^{-4}	1/mm
Transmission line parameter a_1	a_1	6.5×10^{-4}	ns ^{1/2} /mm
Transmission line parameter a_2	a_2	2.93×10^{-4}	ns/mm
Transmission line parameter r	r	6.141×10^{-3}	ns/mm
Transmission line 1 length, Test 1, Tx / Rx	$z_p^{(1)}$	45 / 44	mm
Transmission line 1 length, Test 2, Tx / Rx	$z_p^{(1)}$	30 / 29	mm
Transmission line 1 characteristic impedance	$Z_c^{(1)}$	87.5	Ω
Transmission line 2 length	$z_p^{(2)}$	2	mm
Transmission line 2 characteristic impedance	$Z_c^{(2)}$	95	Ω
Transmission line 3 length	$z_p^{(3)}$	1.3	mm
Transmission line 3 characteristic impedance	$Z_c^{(3)}$	100	Ω
Transmission line 4 length	$z_p^{(4)}$	1.5	mm
Transmission line 4 characteristic impedance	$Z_c^{(4)}$	78	Ω

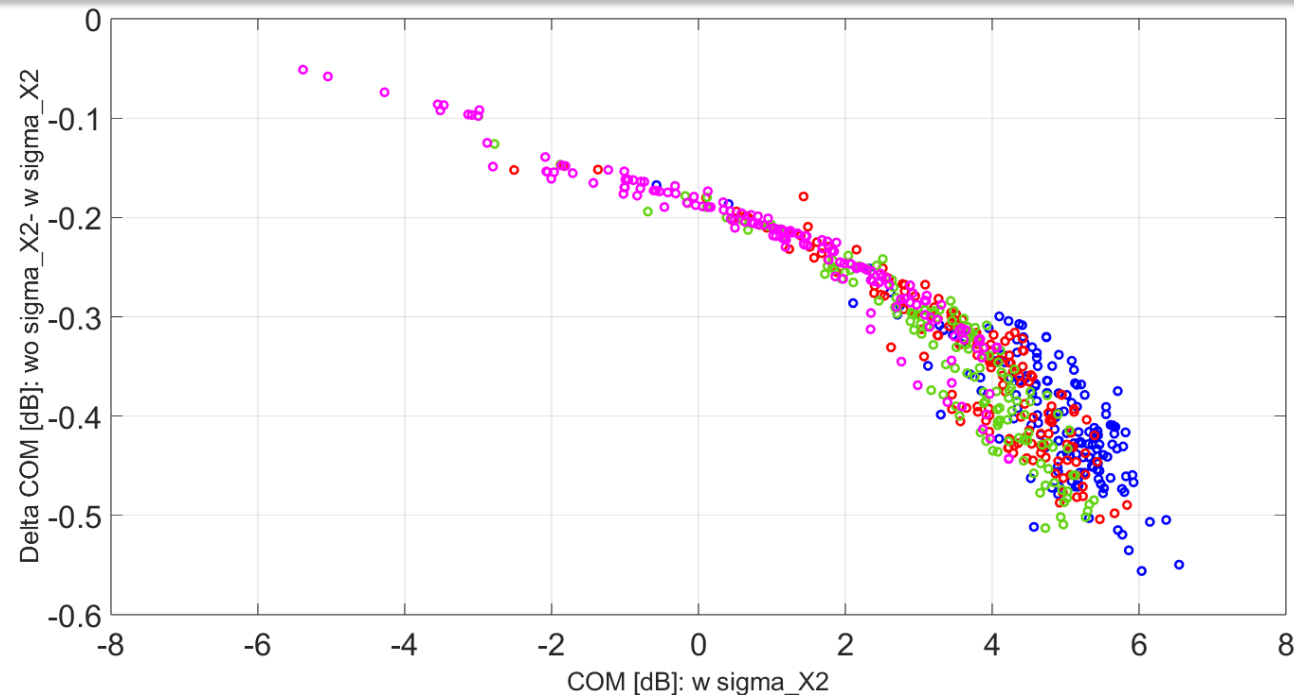
- Total of 171 channels from the IEEE 802.3dj Public Area are evaluated against the class A and class B package models.
 - Total cases= 171x4= 684 cases.

5. Results- Impact of sigma_X2

Device pkg model, class A with 12 mm
Device pkg model, class A with 33 mm
Device pkg model, class B with 30/ 29 mm
Device pkg model, class B with 45/ 44 mm

171 x 4 = 684 cases

“Delta COM [dB]: without sigma_X2- with sigma_X2” vs. “COM [dB]- with sigma_X2”



- “Without sigma_X2”, the COM value degrades by as much as 0.56 dB.
 - sigma_X2 is toggled using S_tn_w_AM= 1 (with sigma_X2) while S_tn_w_AM= 0 (without sigma_X2).
- Please refer to https://www.ieee802.org/3/ad_hoc/COM/public/telecon/260203/lusted_COM_01a_250203.pdf for more information on sigma_X2.

6. Results- Impact of RxFFE Quant. Index Bug Fix

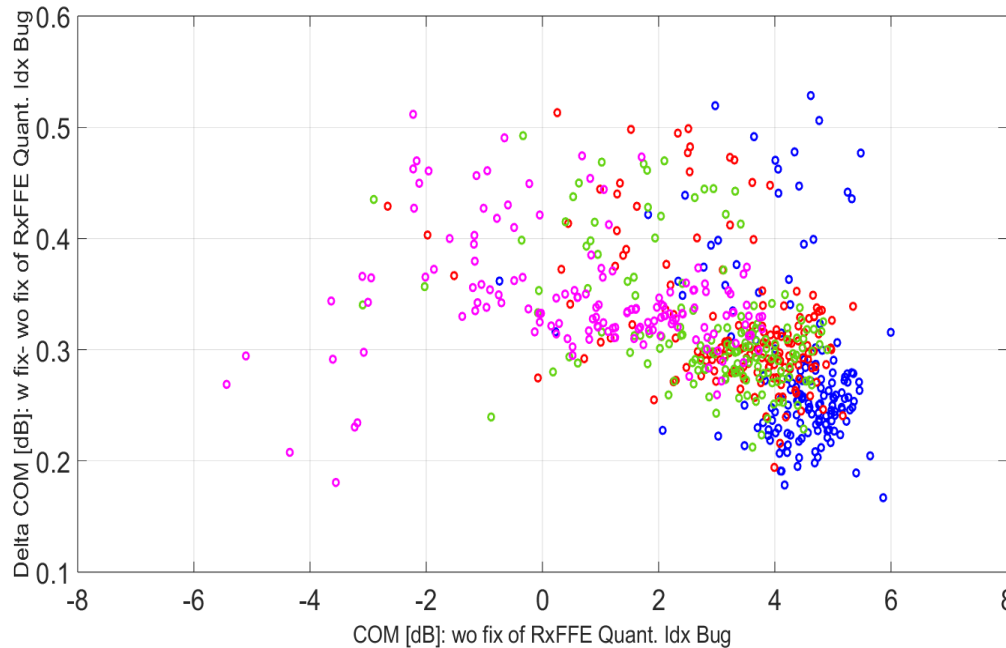
Device pkg model, class A with 12 mm
Device pkg model, class A with 33 mm
Device pkg model, class B with 30/ 29 mm
Device pkg model, class B with 45/ 44 mm

171 x 4 = 684 cases

1.

Without sigma_X2

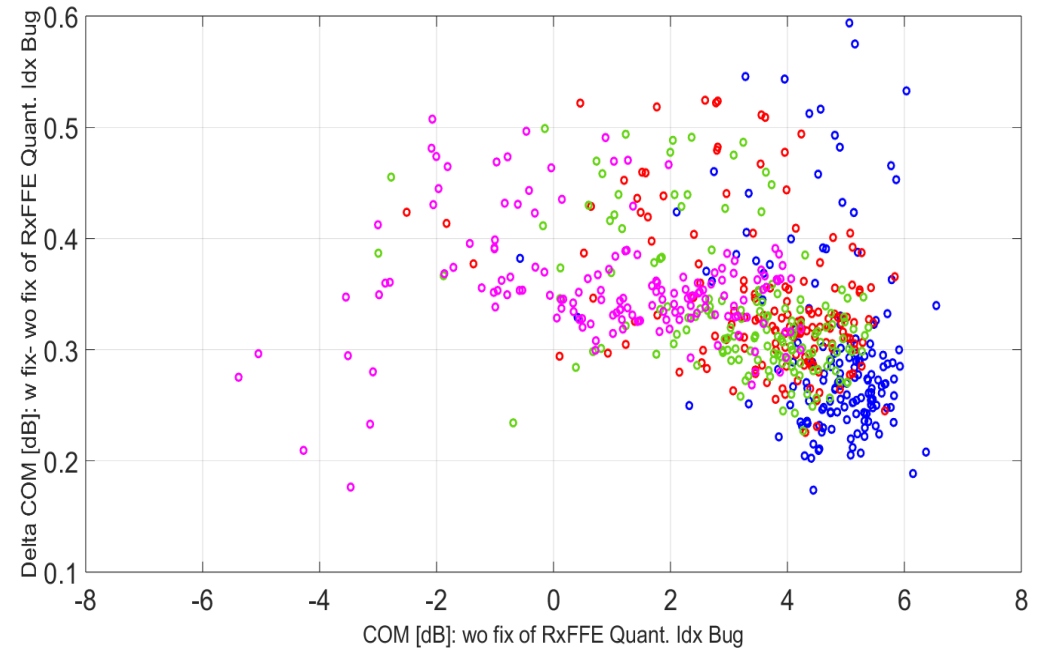
“Delta COM [dB]: with fix- without fix” vs. “COM [dB]- without fix”



2.

With sigma_X2

“Delta COM [dB]: with fix- without fix” vs. “COM [dB]- without fix”



- The fix for the RxFFE Quantization Index bug results in as much as 0.53 dB improvement in COM “without sigma_X2” and as much as 0.6 dB improvement “with sigma_X2”.

Thank you

COM_Spreadsheet_PKG_A

data rate, die load, ref impedance				I/O control			Operational			SAVE_CONFIG2MAT	0			
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	ERL Pass threshold	11	dB		Receiver testing			
f_b	106.25	Gbd		DISPLAY_WINDOW	1	logical	COM Pass threshold	3	db		0			
f_min	0.05	GHz		CSV_REPORT	0	logical	DER_0	2.00E-04			logical			
Delta_f	0.01	GHz		RESULT_DIR	.\results\CAKR_{date}\		T_r	0.00400	ns					
C_d	[0.4e-4 0.9e-4 1.1e-4; 0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]	SAVE_FIGURES	0	logical	FORCE_TR	1	logical	for legacy but required				
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	Port Order	[1 3 2 4]		PMD_type	C2C	for MMSE use C2C only		ICN parameters			
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	RUNTAG	KR_pkgA		EW	1			T_t	6.000	ps	
R_0	46.25	Ohm		COM_CONTRIBUTION	0	logical	MLSE	1	logical		f_v	0.371	39.42	
PKG_NAME	PKG_LowR_CLASSA PKG_LowR_CLASSA		TX RX				sample_adjustment	[-24 24]			T_ft	4.250	ps	
z_p select	[1 2]			TDR and ERL options			Local Search	0			T_nt	4.250	ps	
L	4			TDR	1	logical	flim	6.70E+10	Hz		f_f	0.524	55.65	
M	32			ERL_ONLY	0	ns	zero_pad	1	logical	Filter: Rx FFE	f_n	0.524	55.65	
filter and Eq				TR_TDR	0.005							f_1	0.010	GHz
f_r	0.55	*fb		N	7000	logical	ffe_pre_tap_len	6	UI		f_2	67.000	GHz	
c(0)	0.55	min		TDR_Butterworth	1		d_w				A_ft	0.600	V	
c(-1)	0	[-0.34; 02:0]	[min:step:max]	beta_x	0		N_fix-d_w				A_nt	0.600	V	
c(-2)	0	[0.14; 02:0]	[min:step:max]	rho_x	0.618		w_max(d_w) and -w_min(d_w)				Parameter		Setting	
c(-3)	0		[min:step:max]	TDR_W_TXPKG	0	UI	w_max(d_w+2) and -w_min(d_w+2)				board_tl_gamma0_a1_a2	[0.5 95e-4 2.6e-05]	1.4 db/in @ 53.125G	
c(-4)	0		[min:step:max]	N_bx	16	??	all other fixed w_max and w_min				board_tl_tau	5.790E-03	ns/mm	
c(1)	0	[-0.2; 02:0]	[min:step:max]	fixture delay time	[00]						board_Z_c	92.5	Ohm	
N_b	1	UI		Tukey_Window	1						z_bp (TX)	9	mm	
b_max(1)	0.85	As/dffe1		Z_t	[46.25]						z_bp (NEXT)	9	mm	
b_max(2..N_b)	0	not used		Noise, jitter							z_bp (FEXT)	9	mm	
b_min(1)	0	As/dffe1		sigma_RJ	0.01	UI					z_bp (RX)	9	mm	
b_min(2..N_b)	0	not used		A_DD	0.02	V ² /GHz					C_0	[00]	nF	
g_DC	[-20; 1:0]	dB	[min:step:max]	eta_0	1.00E-08	dB					C_1	[00]	nF	
f_z	42.50	GHz		SNR_TX	33.5						Include PCB	0	logical	
f_p1	42.50	GHz		R_LM	0.95									
f_p2	106.25	GHz		N_qb	6									
g_DC_HP	[-6; 1:0]		[min:step:max]	P_qc	1.00E-07									
f_HP_PZ	1.328125	GHz												

Parameter	Setting	Units	Information
package_tl_gamma0_a1_a2	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[46.25 46.25]	Ohm	[TX RX]
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]
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]
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]
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]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	0.385	V	Vf=0.400
A_fe	0.385	V	Vf=0.399
A_ne	0.481	V	Vf=0.400
.END			

COM_Spreadsheet_PKG_B

data rate, die load, ref impedance				I/O control			Operational			SAVE_CONFIG2MAT	0		
Parameter	Setting	Units	Information	DIAGNOSTICS	1	logical	ERL Pass threshold	11	dB				
f_b	106.25	Gbd		DISPLAY_WINDOW	1	logical	COM Pass threshold	3	db		Receiver testing		
f_min	0.05	GHz		CSV_REPORT	1	logical	DER_0	2.00E-04			0	logical	
Delta_f	0.01	GHz		RESULT_DIR	.\results\CAKR_{date}\		T_r	0.00400	ns		Sigma BBN step	5.00E-03	V
C_d	[0.4e-4 0.9e-4 1.1e-4; 0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]	SAVE_FIGURES	0	logical	FORCE_TR	1	logical		ICN parameters		
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]	Port Order	[1 3 2 4]		PMD_type	C2C			T_t	6.000	ps
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]	RUNTAG	KR_pkgB		EW	1			f_v	0.371	39.42
R_0	46.25	Ohm		COM_CONTRIBUTION	0	logical	MLSE	1	logical		T_ft	4.250	ps
PKG_NAME	PKG_HIR_CLASSB PKG_HIR_CLASSB		TX RX				ts_anchor	1			T_nt	4.250	ps
z_pselect	[3 4]			TDR and ERL options			sample_adjustment	[-24 24]			f_f	0.524	55.65
L	4			TDR	1	logical	Local Search	0			f_n	0.524	55.65
M	32			ERL	1	logical	flim	6.70E+10	Hz		f_1	0.010	6.65
filter and Eq				ERL_ONLY	0	ns	zero_pad	1	logical		f_2	67.000	GHz
f_r	0.55	*fb		TR_TDR	0.005		Filter: Rx FFE				A_ft	0.600	V
c(0)	0.55		min	N	7000	logical	ffe_pre_tap_len	6	UI		A_nt	0.600	V
c(-1)	0	[-0.34; 0.20]	[min:step:max]	TDR_Butterworth	1		ffe_post_tap_len	8	UI	d_w			
c(-2)	0	[0.14; 0.20]	[min:step:max]	beta_x	0		N_fix-d_w			w_max(d_w) and -w_min(d_w)			
c(-3)	0		[min:step:max]	rho_x	0.618		ffe_pre_tap1_max	0.7	(normalized)	w_max(d_w+2) and -w_min(d_w+2)			
c(-4)	0		[min:step:max]	TDR_W_TXPKG	0	UI	ffe_post_tap1_max	0.7	(normalized)	all other fixed w_max and w_min			
c(1)	0	[-0.2; 0.20]	[min:step:max]	N_bx	15	??	ffe_tapn_max	0.7	(normalized)				
N_b	1	UI		fixture delay time	[0 0]		num_ui_RXFF_noise	4096					
b_max(1)	0.85		As/dffe1	Tukey_Window	1		Floating Tap Control						
b_max(2..N_b)	0		not used	Z_t	[46.25]		N_bg	2	0 1 2 or 3 groups	N_wg			
b_min(1)	0		As/dffe1	Noise, jitter			N_bf	4	taps per group	N_wf			
b_min(2..N_b)	0	S	not used	sigma_RJ	0.01	UI	N_f	80	UI span for floating taps	Nmax-d_w-1			
g_DC	[-20; 1.0]	dB	[min:step:max]	A_DD	0.02	V^2/GHz	bmaxg	0.05	max FFE value for floating taps	all floating w_max and w_min			
f_z	42.50	GHz		eta_0	1.00E-08	dB	N_tail_start	9	(UI) start of tail taps limit	not supposed to be used but untested			
f_p1	42.50	GHz		SNR_TX	33.5		S_tn_w_AM	1					
f_p2	106.25	GHz		R_LM	0.95								
g_DC_HP	[-6; 1.0]		[min:step:max]	N_qb	6								
f_HP_PZ	1.328125	GHz		P_qc	1.00E-07								

Parameter	Setting	Units	Information
board_tl_gamma0_a1_a2	[0.595e-4 2.6e-05]		1.4 db/in @ 53.125G
board_tl_tau	5.790E-03		ns/mm
board_Z_c	92.5		Ohm
z_bp(TX)	60		mm
z_bp(NEXT)	60		mm
z_bp(FEXT)	60		mm
z_bp(RX)	60		mm
C_0	[0 0]		nF
C_1	[0 0]		nF
Include PCB	0		logical

Parameter	Setting	Units	Information
package_tl_gamma0_a1_a2	[0.0005 0.00065 0.000293]		
package_tl_tau	0.006141		ns/mm
package_Z_c	[87.5 87.5; 95 95; 100 100; 78 78]		Ohm
R_d	[46.25 46.25]		Ohm [TX RX]
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]
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]
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]
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]
C_p	[0.4e-4 0.4e-4]		nF [TX RX]
A_v	0.385		V Vf=0.400
A_fe	0.385		V Vf=0.399
A_ne	0.481		V Vf=0.400
.END			