200Gbps/Lane AUI C2C Considerations

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IEEE P802.3dj Task Force

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Outline

- AUI BER Status Recap
- C2C Technical Considerations
- Example of COM Parameters
- Proposed Straw Poll

Introduction

- **Current focus of AUI BER targets**
  - **Trade-off between AUI BER limit and PMD BER limit**
  - **Relationships among C2M BER realistic, C2M channel characteristics, and the C2M TX/RX complexity**
- **Requirement of compatible host BER budgets for both optic and DAC to support "universal switch port"**
- **This presentation will discuss the work and decisions needed to progress C2C interface type towards a baseline proposal**

Straw Poll #1 and 2 -- directional

At this time, I prefer the 200 Gbps/lane AUI BER target option per brown_3dj_elec_01_230420 slide 18:

a. Option A: C2M and C2C AUI BER 1E-5
b. Option B: C2M and C2C AUI BER 2E-5
c. Option C: C2M and C2C AUI BER 5E-5
d. Option D: C2M and C2C AUI BER 1E-4
e. Option E: C2M AUI BER 8E-5 and C2C AUI BER 2E-5

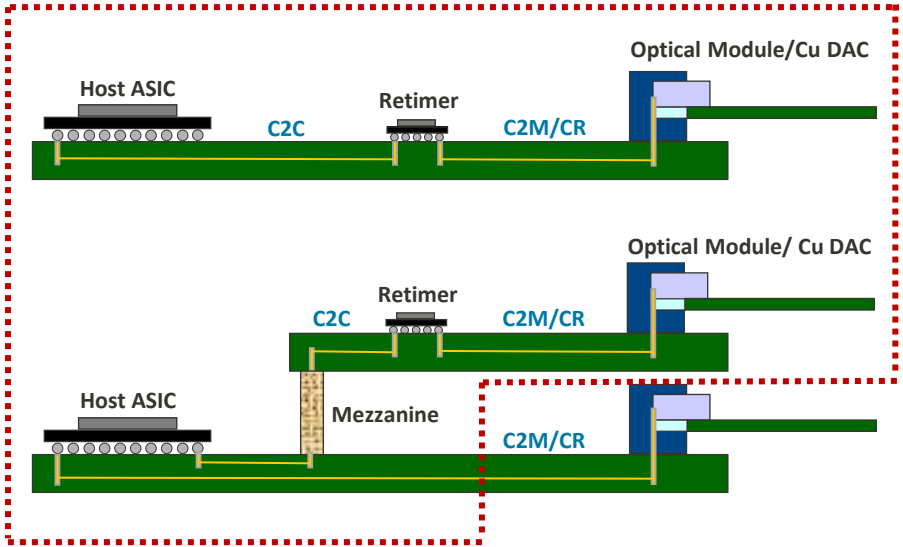
SP#1 Results (Chicago rules): A: 29 B: 19 C: 25 D: 8 E: 24

SP#2 Results (Choose one): A: 12 B: 4 C: 17 D: 0 E: 12 NMI: 11

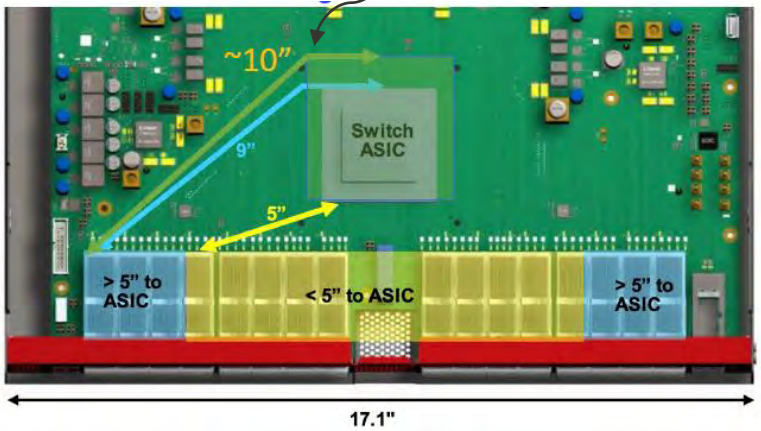
https://www.ieee802.org/3/dj/public/adhoc/electrical/23_0420/straw_polls_3df_elec_adhoc_230420.pdf

Common C2C Applications

- **Extend pluggable module range**
  - Requirement of up to 10” electrical trace for 51.2T switch with ~90x90 package per recommendation [ghiasi_3df_01_2211]
- **Support mezzanine card**



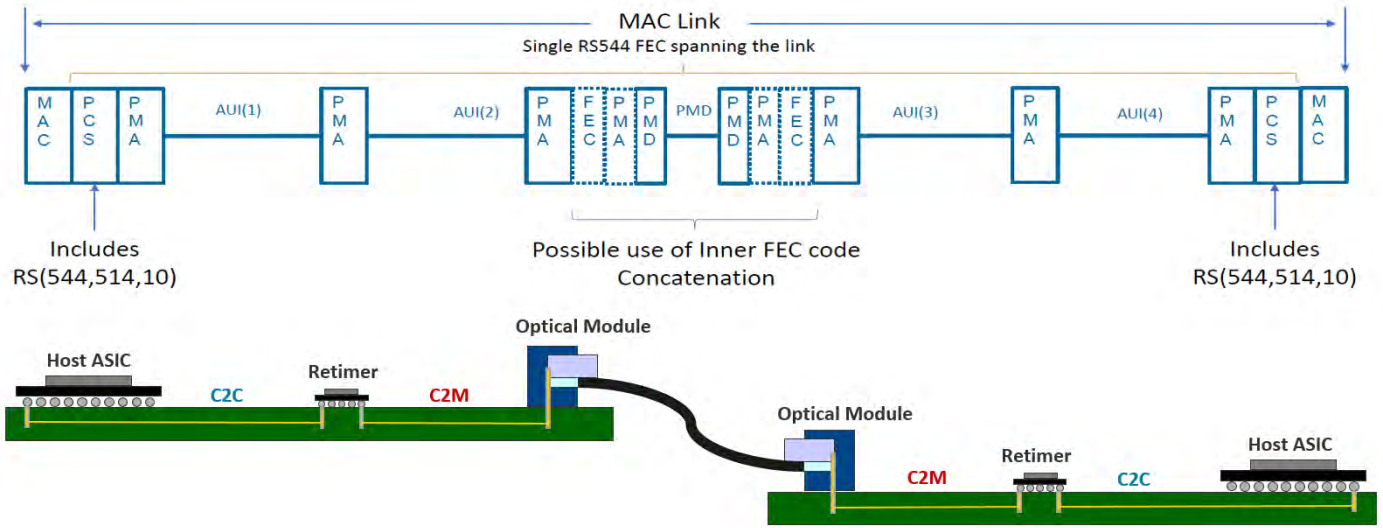
Require either intermediate retimers or intra-box cabling



Retimer in the path for
- **Optical ports: At least two AUIs (C2C+C2M) required**
- **Copper ports: At least one AUI C2C required**

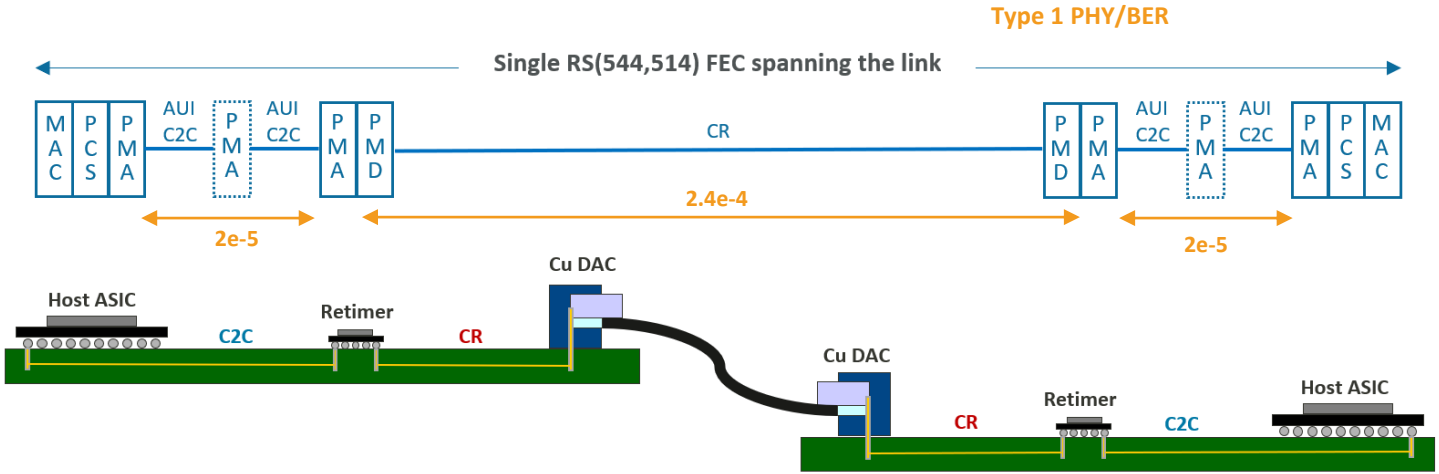
C2C BER Consideration: ASIC-CDR Interconnection

Source: gustlin_3dj_01_2303



- Trade-off between AUI BER limit and PMD BER limit have been illustrated in he_3df_01_2211 and ran_3dj_elec_01_230420
- MAC link latency in according to the choice of FEC architecture have been compared in brown_3dj_optx_01b_230413
- C2C AUI BER > 1E-5 should be supported by Type 2 or Type 3 PHY
  - AUI BER target (per segment) <= 2E-5 can only allow up to 1 AUI per Type 1 PHY → Retimerless!!

C2C BER Consideration: ASIC-ASIC Interconnection

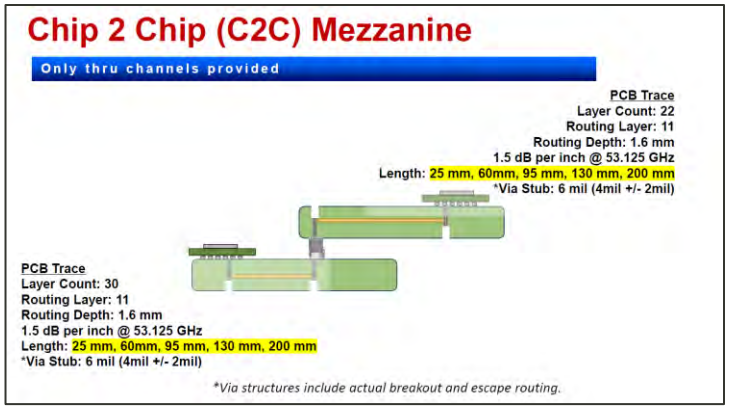


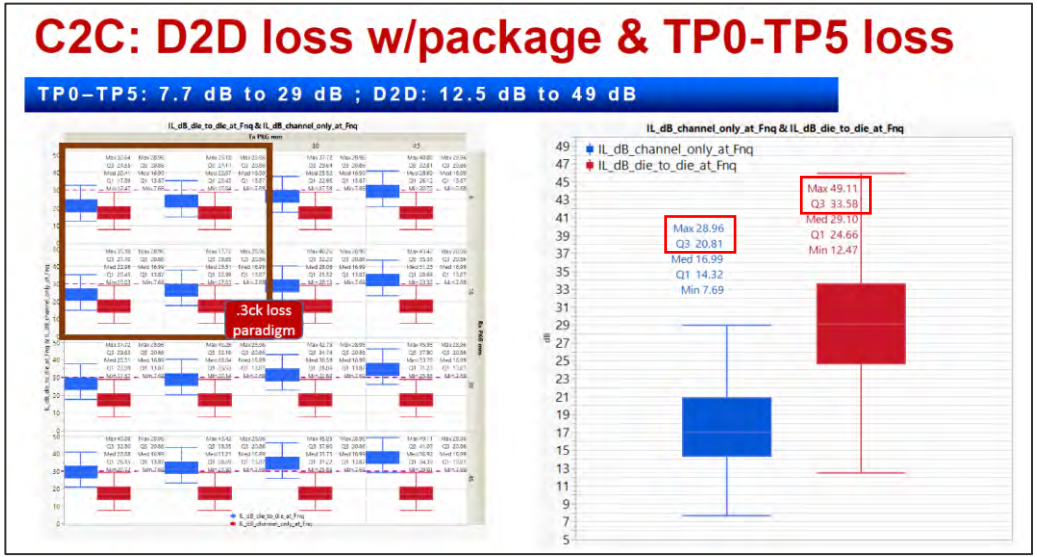
- **C2C AUI BER <= 2E-5 can be supported by Type 1 FEC**
  - BER target <= 1E-5: Up to 2 AUI C2C per Type 1
  - BER target <= 2E-5: Up to 1 AUI C2C per Type 1
- **Implement inner FEC at retimer may not be helpful**
  - Increasing coding gain will accelerate data-rate requirement, especially for electrical interfaces

C2C AUI BER <= 1E-5 is recommended to support "universal port“, otherwise FEC termination required

C2C Mezzanine Channel Topology

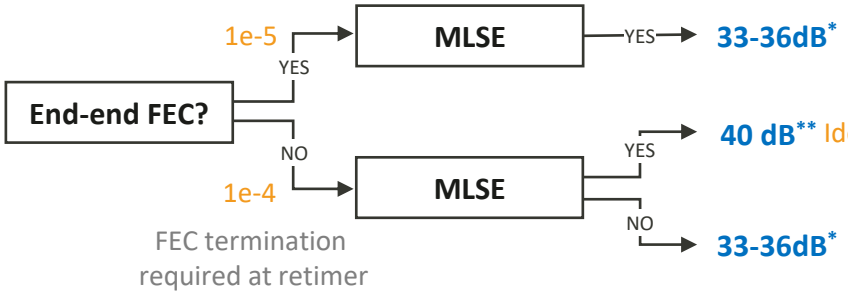
- C2C construction based on PCB and one Mezzanine connector taken from mellitz_3dj_04_2303 and mellitz_3dj_elec_01_230504
  - Electrical interconnect up to 400mm
  - TP0-TP5 loss ~20.x dB with a total length of 260mm
- 802.3ck: TP0-TP5 loss 20 dB with a total length of 250mm





C2C Loss Consideration

- **TP0-TP5 IL range from 7.7 to 29 dB with 50-400mm reach shown in mellitz_3dj_elec_01_230504**
- **Package loss assumptions for 200G high radix applications**
  - **benartsi_3df_01a_2211 uses best ABF conventional construction to lower package loss to 8+ dB**
  - **ghiasi_3df_01_220927 suggests using wider traces to give us the path to 6 dB package loss**
  - **li_3dj_02_2305 extracts a reference package model from the test package with ~6 dB loss**
- **C2C interface complexity will be somewhere between C2M and KR/CR**
- **C2C die-die loss and equalization complexity would probably like…**



** Bump-Bump IL estimated based on li_3dj_01a_2303*
*** Bump-Bump IL estimated based on mellitz_3dj_elec_04a_230504*

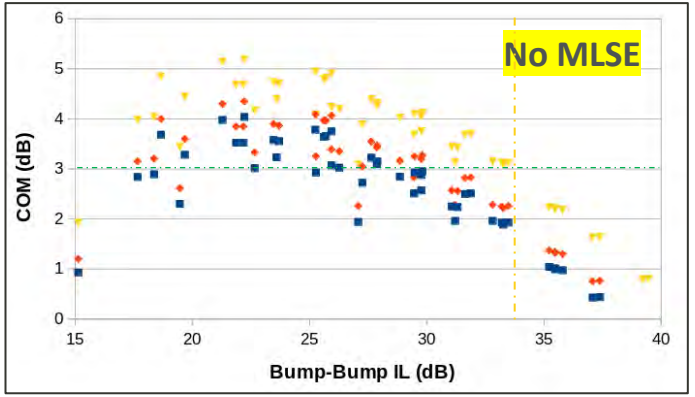
COM Simulation

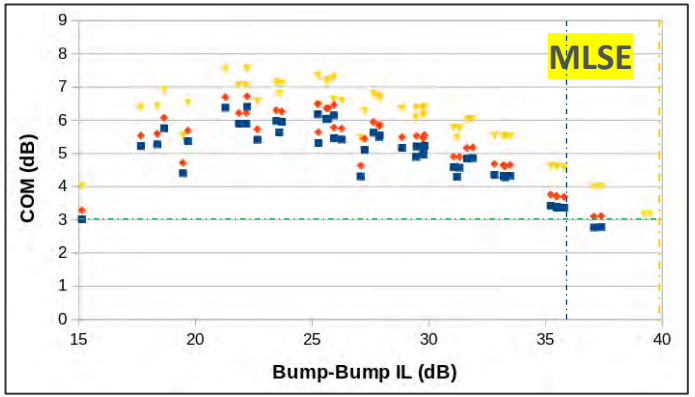
- Test channels (25x): mellitz_3dj_elec_01_230504
- COM 4.0 used, COM spreadsheet in appendix

Parameter	802.3ck C2C	802.3ck KR	Exploratory of 802.3dj C2C
DER_0	1E-5	1E-4	1E-5/2E-5/1E-4
SNR_TX	33	33	33
R_LM	0.95	0.95	0.95
TxFIR Length	5 (3 pre)	5 (3 pre)	6 (4 pre)
eta_0	2E-08	8.2E-09	8.2E-09
N_b	6	12	24
N_bg	0	3	6
N_bf	-	3	3
N_f	-	40	80
MLSE	0	0	0, 1

** Changes from 802.3ck C2C are marked in green*

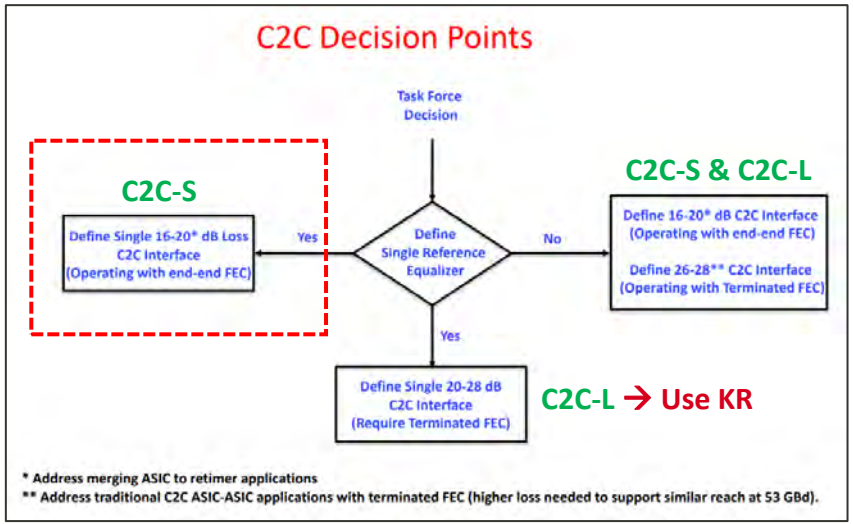
- This is NOT parameters proposal
  - Example parameters give > 3dB COM for direction finding





How to Proceed

- **802.3ck C2C direction recap**
  - **ghiasi_3ck_01_0719 addressed C2C applications with 2 classes of BER, Loss, and equalizer complexity**
  - **Straw Poll #5 secured direction on the proposed C2C baseline without exceeding "end-end FEC" capability, see lusted_3ck_02_0719**



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

https://www.ieee802.org/3/ck/public/19_07/minutes_3ck_0719.pdf

Proposed Straw Poll

- **I would support a C2C baseline operating without FEC termination, as illustrated in lit_3dj_01a_2305, slide 7 as the initial target for investigation**
- **Y/N/A**

Appendix

Example COM Configuration for 200G/L C2C

Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ;0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1, 2]		[test cases to run]
z_p (TX)	[13 31; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (NEXT)	[11 29; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (FEXT)	[13 31; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
z_p (RX)	[11 29; 1 1 ; 1 1 ; 0.5 0.5]	mm	[test cases]
PKG_Tx_FFE_preset	0		
C_p	[0.5e-4 0.5e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.413	V	vp/vf=
A_fe	0.413	V	vp/vf=
A_ne	0.45	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.54		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:.02:0.12]		[min:step:max]
c(-3)	[-0.06:.02:0]		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	[-0.12:0.02:0.1]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		As/dffe1
b_max(2..N_b)	[0.5 0.3 0.3 0.2*ones(1,20)]		As/dfe2..N_b
b_min(1)	0.3		As/dffe1
b_min(2..N_b)	[0.2 0.05 0.05 -0.05*ones(1,20)]		As/dfe2..N_b
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr
Raised_Cosine	0	logical	include in fr
RC_Start	6.70E+10	Hz	start freq for RCos
RC_end	7.97E+10	Hz	end freq for RCos

I/O control		
DIAGNOSTICS	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\CAKR_[date]\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CAKR_RCos_eval_	
COM_CONTRIBUTION	0	logical
Operational		
ERL Pass threshold	9.7	dB
COM Pass threshold	3	db
DER_0	1.00E-05	
T_r	3.75E-03	ns
FORCE_TR	1	logical
PMD_type	C2C	
EW	1	
TDR and ERL options		logical
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	ns
TR_TDR	0.01	
N	2000	logical
TDR_Butterworth	1	
beta_x	0	
rho_x	0.618	
TDR_W_TXPKG	0	UI
N_bx	12	
fixture delay time	[0 0]	
Tukey_Window	1	
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	8.20E-09	dB
SNR_TX	33	
R_LM	0.95	
Enforce Causality	1	
S-parameter magnitude extrapolation policy	trend_to_DC	
Filter: RxFFE		
ffe_pre_tap_len	0	UI
ffe_post_tap_len	0	UI
ffe_tap_step_size	0	
ffe_main_cursor_min	0.7	
ffe_pre_tap1_max	0.7	
ffe_post_tap1_max	0.7	
ffe_tapn_max	0.7	
ffe_backoff	0	

Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0008455 0.000340225]	
package_tl_tau	0.00644805	ns/mm
package_Z_c	[92 92 ; 70 70; 80 80; 100 100]	Ohm
Parameter	**Setting**	
board_tl_gamma0_a1_a2	[0 6.44084e-4 3.6036e-05]	1.5 db/in @ 56G
board_tl_tau	5.790E-03	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	125	mm
z_bp (NEXT)	0	mm
z_bp (FEXT)	125	mm
z_bp (RX)	0	mm
C_0	[0.2e-4 0]	nF
C_1	[0.2e-4 0]	nF
Include PCB	**0**	**logical**
Selections (rectangle, gaussian,dual_rayleigh,triangle		
Histogram_Window_Weight	gaussian	selection
Qr	0.02	UI
ICN parameters		
f_v	0.594	Fb
f_f	0.594	Fb
f_n	0.594	Fb
f_2	79.688	GHz
A_ft	0.450	V
A_nt	0.450	V
Floating Tap Control		
N_bg	6	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	80	UI span for floating taps
bmaxg	0.2	max DFE value for floating taps
MLSE	1	logical
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V

Thank you

Questions and Discussions