Revisit ISI_RES Specification for 100Gbase CR

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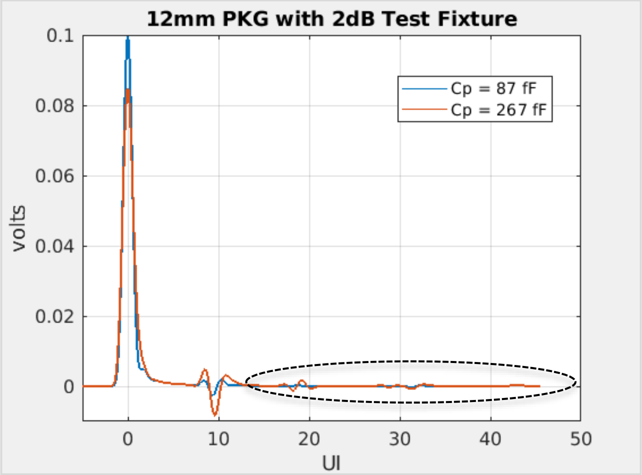
For IEEE 802.3ck Ad-Hoc

Outlines

- Background
- TX Specifications: KR vs CR
- Feasibility of Current Np & ISI_RES Values
- Conclusion & Proposal

Background

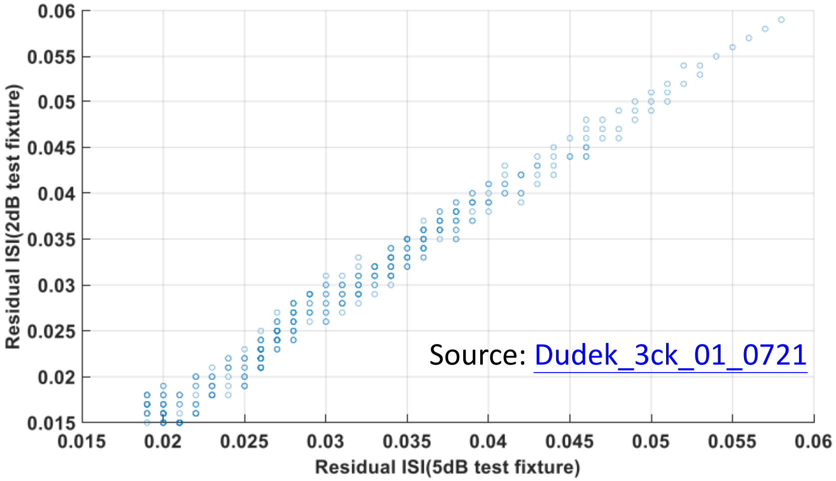
- Dudek_3ck_adhoc_01_0428 & Dudek_3ck_01_0521 showed that the transmitters with similar dERL, SNDR, dRpeak, and dVf have very different system performance
  - E.g., existing KR spec allowed a 12mm package with Cp=0.267pF to pass the TX specifications
- In Dudek_3ck_01_0721, it was shown that energy outside the main pulse can interact with reflections in the channel
  - For high Cp case, more DFE taps or banks of floating taps are required than the current KR reference RX has
  - Additional ISI_RES spec was proposed for 802.3ck KR to differentiate between these transmitters



Background

- According to draft 3.0 comment #237, ISI_RES with max value of -30dB was added to CR specification based on
  - Dudek_3ck_01_0721 showed that residual ISI won't affected by test fixture (TF) loss
  - 1 dB gap to distinguish Pmax difference between KR & CR

	TX SNDR spec (Np = 200)	RES_ISI spec (Np = 11)
KR	32.5	-31
CR	31.5	-30



Source: Dudek_3ck_01_0721

Necessity of ISI_RES Spec?

- Types of transmitter ERL spec
  - KR (TP0v): difference between measured and reference values
  - CR (TP2): specific ERL value
- Definitions of ERL & ISI_RES are kind of similar
  - Transmitter specifications at TP2

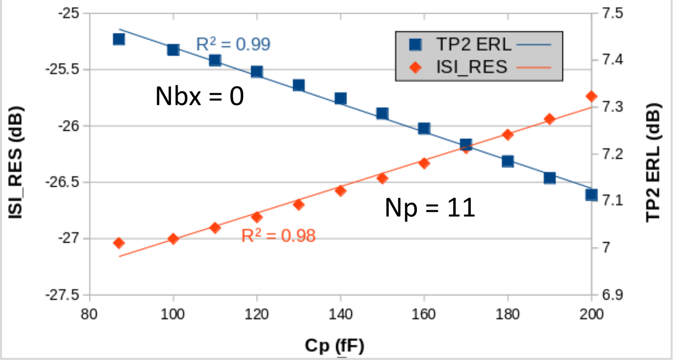
	Parameters
ERL	Nbx = 0
ISI_RES	Np = 11

- ERL under Nbx = 0 is sufficient to cover the reflection issue
  - Correlation between ERL and Cp is strong
    - Different Cp values represent different reflection levels

Table 162–13—Transmitter and receiver ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	T_r	0.01	ns
Incremental available signal loss factor	β_x	0	GHz
Permitted reflection from a transmission line external to the device under test	ρ_x	0.618	—
Length of the reflection signal	N	800	UI
Equalizer length associated with reflection signal	N_{bx}	0	UI
Tukey window flag	tw	1	—

Correlation between ERL/ISI_RES and Cp

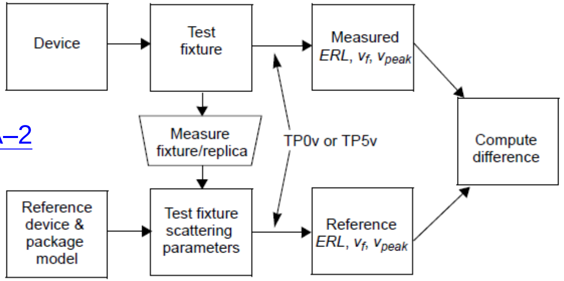


* *TP0-TP2: "C2M__Z100_IL12_WC-BOR_H_L_H_THRU.s4p", mellitz_3ck_01_0518_C2M*

TX specifications: KR vs CR (1/2)

- KR specification at TP0v mainly defines the difference between measured and reference values of transmitter
  - wu_3ck_adhoc_01_093020 & li_3ck_adhoc_01_063021 evaluated TP0v dERL value based on the variations of Z_p, Z_c, & R_d
  - Dudek_3ck_01_0721 proposed additional ISI_RES spec to guarantee the whole link performance
- Recall KR TX measurement method

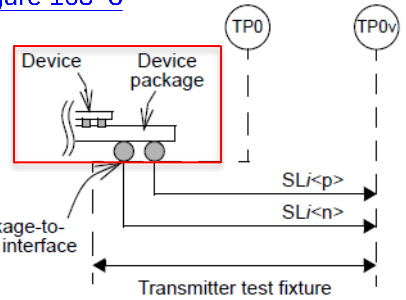
Draft 3.0 Figure 163A–2



KR TX TF & test points

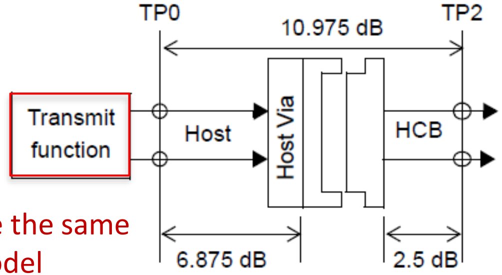
Draft 3.0 Figure 163–3

KR



Draft 3.0 Figure 162A–3

CR



KR & CR share the same ref. device model

TX specifications: KR vs CR (2/2)

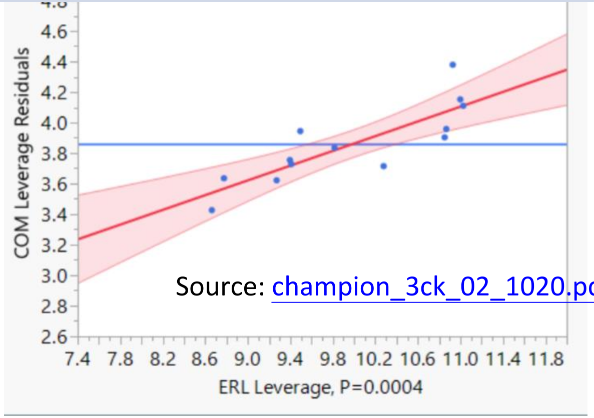
- TP2 ERL specifies the reflections from TX device to TP2
  - ERL calculated based on Nbx = 0 → ISI_RES spec & TX ERL spec overlapping
  - Unlike KR, the existence of transition vias & connector within TP0-TP2 makes large Cp relatively less dominated
- CR ERL value determined based on the comprehensive analysis of
  - Published channels that representative of 100G host designs
  - Relationship between ERL and COM
  - Please also refer to kochuparambil_3ck_03b_1020, champion_3ck_02_1020.pdf, and draft 1.3 Comment #3 & #114 for details

→ **ISI_RES spec is unnecessary for 802.3ck CR**

- ***Option A: Remove ISI_RES specification from 802.3ck CR (Table 162.10)***

	KR	CR
Effective return loss (dB)	dERL > -3	ERL > 7.3
Steady-state voltage (V)	dVf > 0	0.387 < Vf < 0.6
Linear fit pulse peak ratio	dRpeak > 0	Rpeak > 0.397

Relationship between ERL and COM is observed



Source: champion_3ck_02_1020.pdf

Feasibility of Current Np & ISI_RES Values

- Very different channel characteristics between TP0-TP0v & TP0-TP2

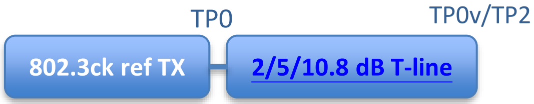
	TX SNDR spec (Np = 200)	RES_ISI spec (Np = 11)	TF loss (dB)	TX ERL spec (dB)
KR	32.5	-31	1.7-5	dERL > -3
CR	31.5	-30	< 10.975	ERL > 7.3

  – From the perspective of TF loss
    - For Np = 11, ~3.5 dB residual ISI caused by TF loss
    - Np > 11 & ISI_RES > -30 dB are required to distinguish residual ISI from TF loss & reflection

  – From the perspective of reflection
    - Channel characteristics of TP0-TP2 make ISI_RES more complicated to be specified
    - ISI_RES will be affected by not just TF loss but also impedance discontinuities within TF
    - Change Np = 11 → 18 & ISI_RES (max) = -30 → -29 dB

KR vs CR: from the Perspective of IL

- Experiments for evaluating TF loss impacts
  - Zp = 12 mm
  - Cp = [87 100:10:300] fF
  - Other parameters shown in appendix

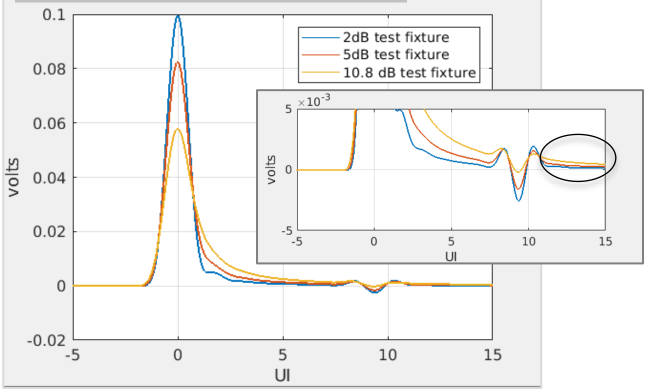


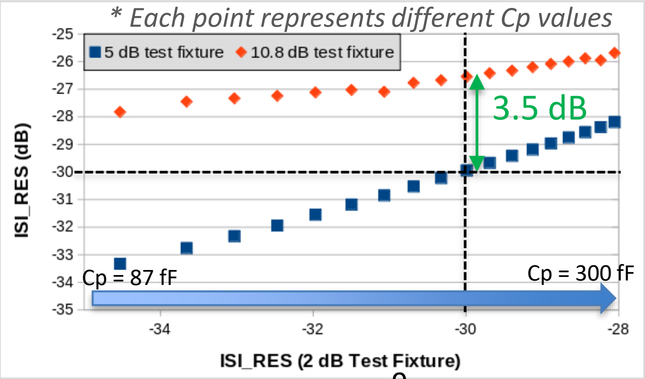
- Energy outside main cursor caused by TF loss will let CR suffer severe fitted error

	TX SNDR spec (Np = 200)	RES_ISI spec (Np = 11)	TF loss (dB)
KR	32.5	-31	1.7-5
CR	31.5	-30	< 10.975

  - Residual ISI will be affected by TF loss if channel tails > Np
  - Need to distinguish residual ISI from TF loss or reflection
- **Current values of Np & ISI_RES are unreasonable**

TP0v/TP2 SBR (Cp = 87 fF)



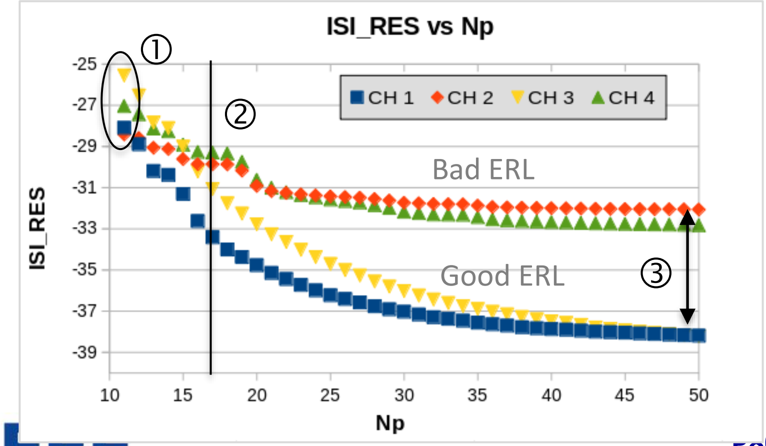


KR vs CR: from the Perspective of Reflection (1/2)

* 12mm PKG & Cp = 87 fF

	TF (TP0-TP2) loss	TP2 ERL
CH 1	9.07 dB	10.61 dB
CH 2	9.29 dB	7.05 dB
CH 3	11.15 dB	10.92 dB
CH 4	11.15 dB	7.44 dB
802.3ck CR	< 10.975 dB	> 7.3 dB

- Experiments for evaluating reflection impacts within TF
  - Choose 2 pairs of channels with similar IL but very different ERL
    - TF (TP0-TP2) information listed in appendix
    - COM spreadsheet shown in appendix
    - TX FIR set to Preset 1
- ISI_RES will be affected by not just TF loss but also impedance discontinuities within TF



① CH 1 & 3 with similar ERL but different TF loss contribute very different ISI_RES under Np = 11
→ **Np = 11 is insufficient to cover TF loss-induced ISI**

② Necessity to differentiate TFs with different ERL conditions
→ **Np = 17 at least**

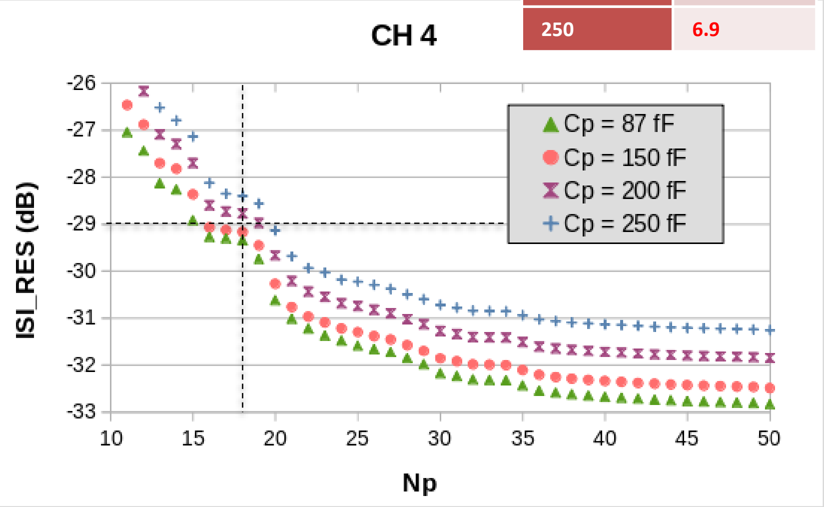
③ Though Np = 50 is long enough to cover channel tails, the impedance discontinuities within TP0-TP2 also make impacts on ISI_RES
→ **ISI_RES value at TP2 is more complicated to be specified**

KR vs CR: from the Perspective of Reflection (2/2)

- Criterions of determining Np & ISI_RES
  - CH 4 with more critical TF conditions is chosen for analysis
  - If Np too small, severe fitted error within channel tails is inevitable
  - If Np too large, the existence of ISI_RES spec is less significant
  - Np > 17 is required to differentiate TFs with different ERL conditions (from the result of P.10)
  - Ability to filter out bad ERL cases
- Proposed changes for Np & ISI_RES
  - Np = 11 → 18
  - ISI_RES = -30 → -29 dB
- ***Option B: Change Np from 11 → 18 & ISI_RES (max) from -30 dB → -29 dB***

	TF (TP0-TP2) loss	TP2 ERL
CH 1	9.07 dB	10.61 dB
CH 2	9.29 dB	7.05 dB
CH 3	11.15 dB	10.92 dB
CH 4	11.15 dB	7.44 dB
802.3ck CR	< 10.975 dB	> 7.3 dB

Cp (fF)	TP2 ERL
87	7.4
150	7.3
200	7.1
250	6.9



Conclusion & Proposal

- ERL specification at TP2 is sufficient to constrain reflections which may cause severe degradation on COM
- This presentation shows that the residual ISI at TP2 will be affected by both TF loss & impedance discontinuities within TP0-TP2
  - Need to change the values of Np & ISI_RES (max) to
    - Distinguish residual ISI from TF loss and reflection
    - Differentiate TFs with different levels of impedance discontinuity
- Proposals
  - **Option A (preferred)**: Remove ISI_RES specification from 802.3ck CR (Table 162.10)
  - **Option B**: Change Np from 11 → **18** & ISI_RES (max) from -30 dB → **-29 dB**

Option B	Np	RES_ISI (max)
CR	11	-30
Proposal	**18**	**-29**

Proposed Straw Poll

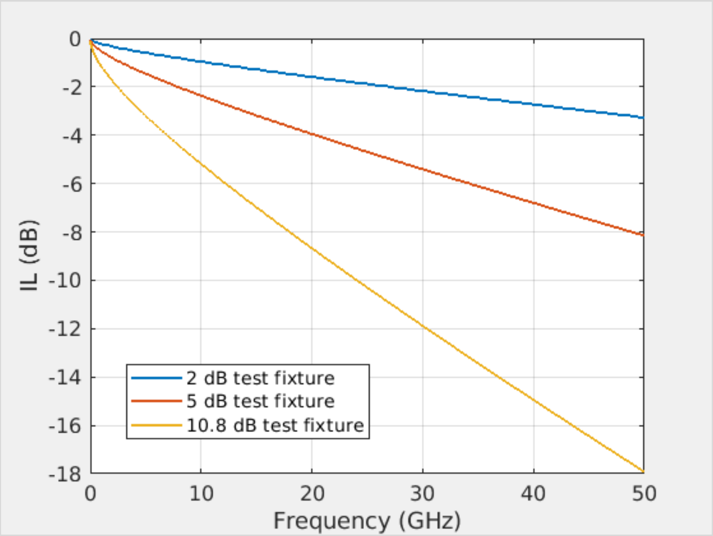
- I support the following direction for ISI_RES spec in 100Gbase CR
  - (A) Option A: Remove ISI_RES spec from 802.3ck CR (Table 162.10)
  - (B) Option B: Change Np from 11 to 18 & ISI_RES (max) from -30 dB to -29 dB
  - (C) The draft ISI_RES method and spec limit for CR need improvement

Appendix

2/5/10.8 dB Test Fixture

- TF generated based on reference PCB model
  - Impedance: 92.5 Ohm
  - 2/5/10.8 dB → 50/125/275 mm

Table 92–12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	92.5	Ohm



COM Spreadsheet for TP2 Impulse Response Generation

Table 93A-1 parameters				
Parameter	**Setting**	**Units**	**Information**	
f_b	53.125	GBd		
f_min	0.05	GHz		
Delta_f	0.01	GHz		
C_d	[1.2e-4 0]	nF	[TX RX]	
L_s	[0.12, 0]	nH	[TX RX]	
C_b	[0.3e-4 0]	nF	[TX RX]	
z_p select	[1 2]		[test cases to run]	
z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]	
z_p (NEXT)	[0 0; 0 0]	mm	[test cases]	
z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]	
z_p (RX)	[0 0; 0 0]	mm	[test cases]	
C_p	[0.87e-4 0]	nF	[TX RX]	
R_0	50	Ohm		
R_d	[50 50]	Ohm	[TX RX]	
A_v	0.413	V		
A_fe	0.413	V		
A_ne	0.608	V		
AC_CM_RMS	0	V	[test cases]	0.0235 0.0256
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)	[0:0.02:0.12]		[min:step:max]	
c(-3)	[-0.06:0.02: 0]		[min:step:max]	
c(1)	[-0.2:0.02:0]		[min:step:max]	
N_b	12	UI		
b_max(1)	0.85			
b_max(2..N_b)	[0.3 0.2*ones(1,5) 0.1*ones(1,5)]			
b_min(1)	0.3			
b_min(2..N_b)	[0.05 -0.03*ones(1,10)]			
g_DC	[-20:1:0]	dB	[min:step:max]	
f_z	21.25	GHz		
f_p1	21.25	GHz		
f_p2	53.125	GHz		
g_DC_HP	[-6:1:0]		[min:step:max]	
f_HP_PZ	0.6640625	GHz		

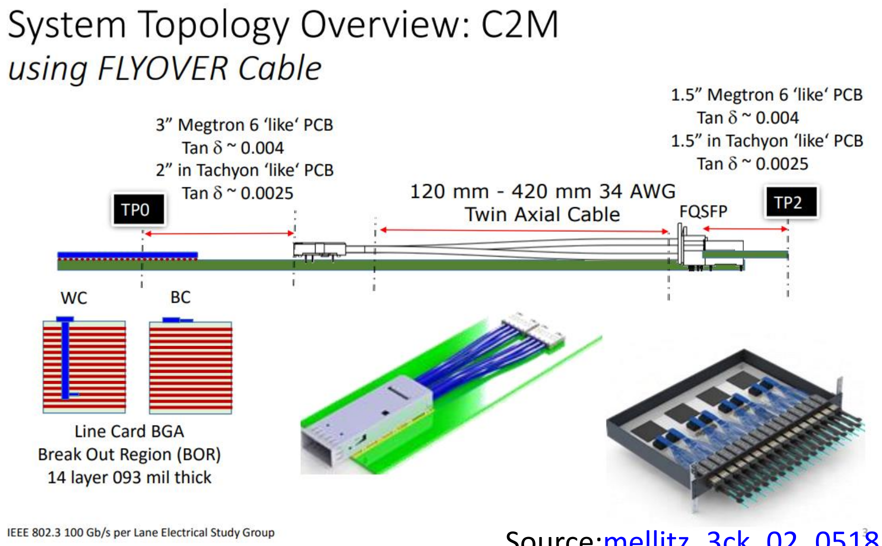
I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\100GEL_CR_CA_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	CR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8.25	dB
DER_0	0.0001	
T_r	0.0075	ns
FORCE_TR	1	logical
Local Search	2	
BREAD_CRUMBS	1	logical
SAVE_CONFIG2MAT	1	logical
PLOT_CM	0	
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	800	
beta_x	0	
rho_x	0.618	
fixture delay time	[.2e-9 0]	port1 port2]
TDR_W_TXPKG	1	
N_bx	0	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	9.00E-09	V^2/GHz
SNR_TX	32.5	dB
R_LM	0.95	

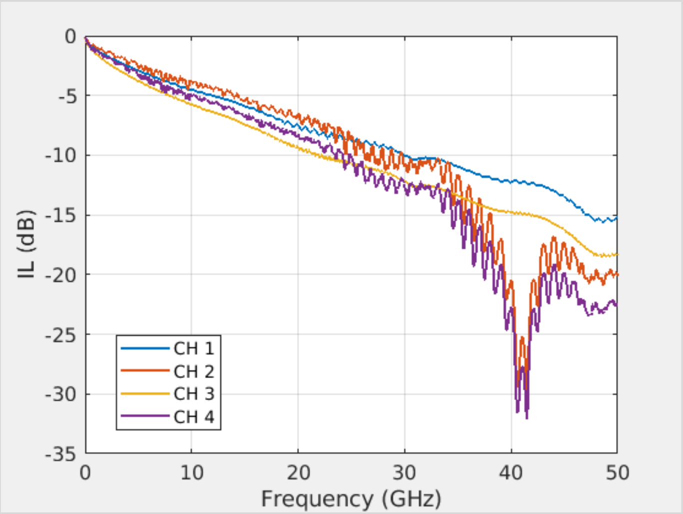
Table 93A-3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
Parameter	**Setting**	
board_tl_gamma0_a1_a2	*[0 3.8206e-04 9.5909e-05]*	
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	*100*	Ohm
z_bp (TX)	*110.3*	mm
z_bp (NEXT)	*110.3*	mm
z_bp (FEXT)	*110.3*	mm
z_bp (RX)	*110.3*	mm
C_0	[0.29e-4]	nF
C_1	[0.19e-4]	nF
Include PCB	**0**	**logical**
Floating Tap Control		
N_bg	3	0 1 2 or 3 groups
N_bf	3	taps per group
N_f	40	UI span for floating taps
bmaxg	0.05	max DFE value for floating taps
B_float_RSS_MAX	0.02	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN parameters		
f_v	0.594	*Fb
f_f	0.594	*Fb
f_n	0.594	*Fb
f_2	40.000	GHz
A_ft	0.600	V
A_nt	**0.600**	V
Receiver testing		
RX_CALIBRATION	0	logical
56GPAM4/matlab_m/112G	5.00E-03	V
CA		

P802.3ck

TP0-TP2 Channel List

Contribution	Company		s4p	Manufacturing Variations	TP0-TP2 (dB)	TP2 ERL (dB)
Presentation: 100 GEL C2M Flyover Host Files: Tp0 to Tp2, with and without manufacturing variations, for losses of 9, 10, 11, 12, 13, and 14 dB Losses **S-parameter files:** C2M channels and xtalk (all lengths and variations)	Samtec	**CH 1**	C2M__Z100_IL9_BC-BOR_N_N_N_THRU	Normal	9.07	10.61
		CH 2	C2M__Z100_IL10_WC-BOR_H_L_H_THRU	Worst case	9.29	7.05
		CH 3	C2M__Z100_IL11p2_BC-BOR_N_N_N_THRU	Normal	11.15	10.92
		CH 4	C2M__Z100_IL12_WC-BOR_H_L_H_THRU	Worst case	11.15	7.44
802.3ck CR					< 10.975	> 7.3





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