

The need for an additional Tx specification for 100Gbase-KR.

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Introduction

- In Dudek_3ck_adhoc_01_0428 it was shown that the existing backplane ulletspecification with Tx dERL specification of -3dB allowed a 12mm package with Cp=0.267pF to pass the Tx specifications.
- In Dudek_3ck_01_0521 it was shown that with this passing transmitter there • were multiple channels that passed the COM test that had poor system performance (COM less than 2dB). A proposal was made to tighten the dERL specification to fail the false passing transmitter.
- Li_3ck_adhoc_01_063021 confirmed this poor performance on more channels but also showed that if dERL were degraded by changing Rd or Zc instead of Cp the system performance was still adequate. i.e. tightening the dERL specification would lead to false fails for transmitters with low Cp and varying Rd and Zc.
- This presentation confirms the results in Li_3ck_adhoc_01_063021, \bullet evaluates a likely reason that the transmitters with similar dERL, dRpeak, and dVf have very different system performance, and proposes an additional specification that differentiates between these transmitters. It is in support of Draft 2.1 comment #75

Results from Degraded Kareti KR channel OAch1_t.s4p (Dudek_3ck_01_0521)



Results from Degraded Kareti KR channel OAch1_t.s4p with Rd adjusted instead of Cp



Performance on other channels slide 8 from Li_3ck_adhoc_01_063021

dCOM Sensitivity with TX dERL

• dCOM = COM - Reference COM (calculated based on the following TX parameters specified in D2p0)

R_d (Ohm)	C_p (nE)	C_b (nE)	Z_c (Ohm)	Z_p (mm)	ERL
50.00	0.87	0.30	87.50	31.00	18.60

- Normal case:
 - COM is not sensitive to R_d & Z_c variations
 - For critical channels with COM = [2.8 3.5], COM degradation <= 0.2 dB
- Extreme case:
 - It's apparently larger C_p & C_b cause worse dERL and hence degrade COM more
 - dCOM > 0.5 dB even we tighten TX dERL specification up to -1 dB

 \rightarrow Is it necessary to allocate dERL margin for C_p & C_b?







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System Performance conclusions.

- The system performance is very different between the transmitter where Cp was made large versus where Rd and other parameters were adjusted.
- To create an inter-operable specification the transmitters with the large Cp need to fail Tx specifications.
- What is the difference between these transmitters and how they meet the existing Transmitter specification?
 4dB test fixture and TxSNB=33dB

	Np	Rd(ohm)	Cp(pF)	Package(mm)	dRpeak	dERL(dB)	SNDR(dB)
Reference	29	50	0.087	30	0	0	32.89
High Cp	29	50	0.267	12	0.006	-2.69	32.98
High Rd	29	65	0.087	25	0.017	-2.97	32.93

• There is obviously a difference between the transmitters that is not being captured by the existing specifications.

Pulse responses from these transmitters.



 It is obvious that for the high Cp case there is much more energy outside the main pulse that can interact with reflections in the channel resulting in the need for many more DFE taps and or banks of DFE floating taps than the KR reference receiver has.

Proposed specification.

 Investigating a new parameter "Residual ISI" Defined as sigma_e/Pmax) with Np=11 using the same definitions as used for SNDR i.e. as defined in 162.9.3.3 with the exception that Np=11 instead of 29.

	Np	Rd(ohm)	Cp(pF)	Package(mm)	dRpeak	dERL(dB)	SNDR(dB)	Residual ISI
Reference	11	50	0.087	30	0	0	30.46	0.02
High Cp	11	50	0.267	12	0.006	-2.69	26.53	0.041
High Rd	11	65	0.087	25	0.017	-2.97	29.66	0.024

4dB test fixture and TxSNR=33dB

The pass fail criterion proposed is "Residual ISI (max) = 0.027

Values of Residual ISI for some other transmitters (4dB test fixture).

Np	Av(V)	Zpkg(ohm)	Lpkg(mm)	Rd(ohm)	Zvia(ohm)	Lvia(mm)	Cp(pF)	Vpeak(V)	Vf(V)	Rpeak	Sigmae(mV)	SNDR(dB)	Residual ISI
11	0.372	87.5	12	40	92.5	1.8	0.087	0.253	0.401	0.632	4.652	30.764	0.018
11	0.413	87.5	12	50	92.5	1.8	0.087	0.251	0.402	0.623	5.315	30.217	0.021
11	0.454	87.5	12	60	92.5	1.8	0.087	0.248	0.402	0.618	6.335	29.387	0.026
11	0.372	87.5	30	40	92.5	1.8	0.087	0.224	0.401	0.558	4.144	30.737	0.019
11	0.413	87.5	30	50	92.5	1.8	0.087	0.22	0.401	0.549	4.404	30.457	0.02
11	0.454	87.5	30	60	92.5	1.8	0.087	0.22	0.401	0.547	4.941	29.967	0.023
11	0.372	87.5	12	40	92.5	1.8	0.167	0.241	0.402	0.6	6.891	28.807	0.029
11	0.413	87.5	12	50	92.5	1.8	0.167	0.239	0.402	0.593	7.676	28.139	0.032
11	0.454	87.5	12	60	92.5	1.8	0.167	0.237	0.402	0.59	9.325	26.891	0.039
11	0.372	87.5	30	40	92.5	1.8	0.167	0.217	0.402	0.54	5.106	29.76	0.024
11	0.413	87.5	30	50	92.5	1.8	0.167	0.213	0.401	0.531	5.523	29.308	0.026
11	0.454	87.5	30	60	92.5	1.8	0.167	0.211	0.401	0.527	6.521	28.375	0.031
11	0.372	87.5	12	40	92.5	1.8	0.267	0.227	0.402	0.565	8.325	27.347	0.037
11	0.413	87.5	12	50	92.5	1.8	0.267	0.223	0.402	0.555	9.255	26.533	0.041
11	0.454	87.5	12	60	92.5	1.8	0.267	0.221	0.402	0.55	11.558	24.908	0.052
11	0.372	87.5	30	40	92.5	1.8	0.267	0.201	0.402	0.502	5.916	28.653	0.029
11	0.413	87.5	30	50	92.5	1.8	0.267	0.199	0.401	0.497	6.472	28.086	0.032
11	0.454	87.5	30	60	92.5	1.8	0.267	0.198	0.402	0.493	7.997	26.709	0.04

Check that residual ISI isn't affected by Test fixture loss.



Conclusion

- Residual ISI is reasonably invariant with the test fixture loss.
- Residual ISI does separate the transmitters with high values of Cp from those with similar poor ERL created by higher Zp.
- In order to not have false passing transmitters an additional specification is required. If this is not done the specification is not inter-operable.
- The task force should add an additional specification of Residual ISI (max) value of 0.027.

Backup. Slides from previous presentations

Degraded Kareti KR channel



163.10.3 Channel ERL

ERL of the channel at TP0 and at TP5 are computed using the procedure in 93A.5 with the values in Table 163-11. Parameters that do not appear in Table 163-11 take values from Table 163-10.

Channel ERL at TP0 and at TP5 shall be greater than or equal to 9.7 dB.

Table 163-11-Channel ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	Tr	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	3500	UI
Equalizer length associated with reflection signal	N _{bx}	21	UI
Time-gated propagation delay	T _{fx}	0	ns
Tukey window flag	tw	1	_











Conclusions

- There is a serious inter-operability issue with the existing backplane specification.
- For channels passing the COM specification, when the 12mm package with Cp of 0.267pF that passed the Tx specifications is used the COM of the signal going into the Rx is only approximately 1.5dB worst case.
- The following slides show what happens if the Tx dERL spec is tightened to -1dB.





Conclusions with dERL specification of -1dB.

 Tightening the Tx dERL specification to -1dB significantly improves inter-operability. The worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) for these channels has 2.5dB COM.

Results when a lower loss channel is degraded.

Modified Kareti KR channel



163.10.3 Channel ERL

ERL of the channel at TP0 and at TP5 are computed using the procedure in 93A.5 with the values in Table 163-11. Parameters that do not appear in Table 163-11 take values from Table 163-10.

Channel ERL at TP0 and at TP5 shall be greater than or equal to 9.7 dB.

Table 163-11-Channel ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	Tr	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	3500	UI
Equalizer length associated with reflection signal	N _{bx}	21	UI
Time-gated propagation delay	T _{fx}	0	ns
Tukey window flag	tw	1	_















Conclusions from the degraded lower loss chanels

- The inter-operability problem is even worse with the degraded lower loss channel.
- With the existing dERL specification of -3dB the worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) only has 1dB COM.
- Even with the dERL specification tightened to -1dB the worst combination of passing Tx (dRpeak and dERL) and passing channel (COM and ERL) only has 2dB COM.
- Further specification tightening is required. Either further tightening of Tx dERL or the Channel ERL (or a combination of the two is indicated.

$OAch1_t.s4p$ (IL=23.407dB, ERL11=13.706dB, ERL22=16.973dB) 9 FEXT and 9 NEXT included

тх тх		2dB TF	PO-TPOv	4dB TF	0-TP0v	5dB TP	0-TP0v	ll w/pkg/dP)	
Package(mm)	Cp(pF)	dERL(dB)	dRpeak(dB)	dERL(dB)	dRpeak(dB)	dERL(dB)	dRpeak(dB)	п w/ркg(ав)	COlvi(dB)
30	0.087	0	0	0	0	0	0	31.714	3.986
	<mark>0.107</mark>	<mark>-0.034</mark>	<mark>-0.006</mark>	<mark>-0.026</mark>	<mark>-0.002</mark>	<mark>-0.036</mark>	<mark>-0.004</mark>	<mark>31.921</mark>	<mark>3.849</mark>
	0.087	0.613	0.086	0.541	0.074	0.563	0.066	30.066	4.437
	0.107	-0.155	0.079	-0.065	0.068	0.037	0.06	30.381	4.265
	0.127	-0.649	0.068	-0.472	0.061	-0.325	0.054	30.734	4.194
	0.147	-1.009	0.059	-0.85	0.054	-0.686	0.047	31.114	4.082
	0.167	-1.341	0.05	-1.178	0.044	-1	0.038	31.513	3.836
10	0.187	-1.638	0.034	-1.489	0.036	-1.309	0.033	31.923	3.795
12	0.207	-1.983	0.028	-1.784	0.03	-1.626	0.026	32.338	3.622
	0.227	-2.239	0.019	-2.079	0.022	-1.938	0.019	32.754	3.388
	0.247	-2.489	0.01	-2.409	0.014	-2.279	0.011	33.167	3.173
	0.267	-2.781	0	-2.694	0.006	-2.563	0.004	33.575	3.135
	<mark>0.287</mark>	<mark>-3.029</mark>	<mark>-0.009</mark>	-2.965	<mark>-0.002</mark>	-2.843	<mark>-0.002</mark>	<mark>33.975</mark>	<mark>2.95</mark>
	<mark>0.299</mark>	<mark>-3.166</mark>	<mark>-0.015</mark>	<mark>-3.129</mark>	<mark>-0.006</mark>	<mark>-3.001</mark>	<mark>-0.007</mark>	<mark>34.212</mark>	<mark>2.793</mark>

Red results are transmitters that fail 802.3ck draft 2.0. All others pass with at least one Tp0 to Tp0v test fixture..

COM spreadsheet

Paraterie Netting Union Dia/s(0)116 1 10plicity Parameter Setting Ubins/ r_nin 0.05 64 DISMA/VMNOW 1 10plicity Packeg=1_gamma/s_0_0 0000000272 Image: 1_gamma/s_0_0000272 Image: 1_gamma/s_0_00000272 Image: 1_gamma/s_0_00000072 Image: 1_gamma/s_0_00000072 Image: 1_gamma/s_0_00000072 Image: 1_gamma/s_0_000000072 Image: 1_gamma/s_0_0000000072 Image: 1_gamma/s_0_0000000072 Image: 1_gamma/s_0_0000000072 Image: 1_gamma/s_0_0000000000000000000000000000000000	Table 93A-1 parameters				I/O control			Table 93A–3 parameters			
f_b 53.125 68d Isgan Is	Parameter	Setting	Units	Inform ation		DIAGNOSTICS	1	logical	Parameter	Setting	Units
t_{min} 0.05 6Hz CN_PEROR 1 logical package_tital 0.001/L mm $C.d$ L2e41.2e41 nf TXR0 SWE_UNDR YEUNSWOOTLUK Operating package_tital 0.001/L package_tital package_tital 0.001/L package_tital package_tit	f_b	53.125	GBd			DISPLAY_WINDOW	1	logical	package_tl_gamma0_a1_a	[0 0.0009909 0.0002772]	
	f_min	0.05	GHz			CSV_REPORT	1	logical	package_tl_tau	0.006141	ns/mm
C_{cd} $[12+412e+4]$ nf $[TKR]$ SNR_FIGURES 0 logical $[Decay]$ <td>Delta_f</td> <td>0.01</td> <td>GHz</td> <td></td> <td></td> <td>RESULT_DIR</td> <td>.\results\100GEL_</td> <td>KR_{date}</td> <td>package_Z_c</td> <td>[87.5 87.5 ; 92.5 92.5]</td> <td>Ohm</td>	Delta_f	0.01	GHz			RESULT_DIR	.\results\100GEL_	KR_{date}	package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
$(\downarrow_{5} \\ () () () () () () () () () ($	C_d	[1.2e-4 1.2e-4]	nF	[TX RX]		SAVE_FIGURES	0	logical			
C.b. [0] 8-4 0.38-4) Inf [TKR] RUMAG R.R.a. Parameter Setting (mt) z_p (NeT) [1233], 18.18] mm [test cases to model of the set caset to the set case to the set case to model of the set	L_s	[0.12, 0.12]	nH	[TX RX]		Port Order	[1324]			Table 92–12 parameters	5
12 prime (12) Text cases to run COM_CONTRIBUTION 0 logical bord_f_gamma0_g.2_2 03.8206-49.85096-49 sector 49.85096-49 sector 49.85096-49 <td>C_b</td> <td>[0.3e-4 0.3e-4]</td> <td>nF</td> <td>[TX RX]</td> <td></td> <td>RUNTAG</td> <td>KR_eval_</td> <td></td> <td>Parameter</td> <td>Setting</td> <td></td>	C_b	[0.3e-4 0.3e-4]	nF	[TX RX]		RUNTAG	KR_eval_		Parameter	Setting	
$L_p(TX)$ [123]; 13.18] mm Itest cases] OPeration bond, L_bau 5.796-03 n/mm $L_p(RY)$ [122]; 13.18] mm [test cases] ERLPass threshold 8 dB $L_p(RY)$ 1123; 13.18] mm [test cases] ERLPass threshold 8 dB $L_p(RY)$ 1103; 13.18] mm [test cases] DER_D 0.0001 $L_p(RY)$ 1103 mm $L_p(RY)$ [1229; 13.18] mm [test cases] DER_D 0.0001 $L_p(RY)$ 120.3 mm R_0 50 Ohm T,r 0.0075 ns $L_p(RY)$ 120.3 mm R.d [059] Ohm TXRN Local search 2 C_0 0.029e-41 nf A,r 0.413 V ERLPASS (DAMBS 1 logical C_0 0.029e-41 nf A,re 0.413 V ERLPASS (DAMBS 1 logical N_D 0.000 0 M 32 D	z_p select	[12]		[test cases to run]		COM_CONTRIBUTION	0	logical	board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
r_p (PKR) ID 229; 13.18] mm Itest cases] COM Pass threshold 3 dB board_2_c 100 Ohm L_p (PKN) ID 23; 13.18] mm Itest cases] DER_0 0.0001 2, b(PKN) 12.03 mm C_p (0.67+4.087+4) nf [TX RN] T_r 0.00075 ns 2, bp (PKN) 12.0.3 mm R_0 50 0 hm FORCE_TR 1 logical 2, bp (PKN) 12.0.3 mm R_0 5000 0 hm FORCE_TR 1 logical 2, bp (PKN) 12.0.3 mm A_v 0.413 V BREAD_GOMMS 1 logical C_0 (0.298+4) nf A_re 0.433 V Extender 1 logical C_0 (0.298+4) nf A_re 0.443 V Itest cases] ID 025500256] TDR and ERL eptions 0 logical M 32 0 10.202500256] TDR and ERL eptions N_f 40 UI span fording taps (0) 0.042 ERL	z_p (TX)	[12 31; 1.8 1.8]	mm	[test cases]			Operational		board_tl_tau	5.790E-03	ns/mm
Image: Problem (FER) [1233] (18.18) mm [test cases]	z_p (NEXT)	[12 29; 1.8 1.8]	mm	[test cases]		COM Pass threshold	3	dB	board_Z_c	100	Ohm
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	z_p (FEXT)	[12 31; 1.8 1.8]	mm	[test cases]		ERL Pass threshold	8	dB	$z_bp(TX)$	110.3	mm
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	z_p (RX)	[12 29; 1.8 1.8]	mm	[test cases]		DER_0	0.0001		z_bp (NEXT)	110.3	mm
R_0 S0 Dhm FORE_TR 1 logical Z_b(R3) 120.3 mm R_d [S9 50] Dhm [TX RX] bREAD_CRUMBS 1 logical C.0 [0.296+4] nf A_re 0.413 V SAVE_CONFIGURANT 1 logical C_2 [0.19e+4] nf A_re 0.413 V SAVE_CONFIGURANT 1 logical C_2 [0.19e+4] nf A_re 0.413 V SAVE_CONFIGURANT 1 logical Indue PCB 0 logical A_re 0.608 V PUT_CM 1 logical N_tf 3 0.12.073 groups L 4 C TDR 1 logical N_tf 40 UI span for logitag tap M 32 ERL 1 logical N_tf 40 UI span for logitag tap f.r 0.75 *fb TR_TDR 0.01 ns B_totsparstap max DR totspare group	C_p	[0.87e-4 0.87e-4]	nF	[TX RX]		T_r	0.0075	ns	z_bp (FEXT)	110.3	mm
R.d [50:50] Ohm TTX RXJ Local search 2 C 0 $029-4$] nF A.y 0.413 V SAVE_CONFIG2MAT 1 logical 0.2 $0.19e-4$] nF A.re 0.608 V SAVE_CONFIG2MAT 1 logical Indue PIB 0 logical A.re 0.608 V PLOT_CM 1 logical Indue PIB 0 logical A.C.M.RMS 0 V Itest cases] $(0.235 0.0256)$ TTR and ER logical N_bg 3 taps per group L 4 TTR 1 logical N_bf 3 taps per group f.r 0.75 #fb TR_TDR 0.01 ns 8_float_RSS_MAX 0.02 rs tait tap limit c(-1) f0.340.02.01 Iminstep:max] fst.x 0 N_ts N_ts 0.12 or 390 N_ts 0.12 or 390 N_ts 0.12 or 390 N_ts 0.12 or 390 N_ts	R_0	50	Ohm			FORCE_TR	1	logical	z_bp (RX)	110.3	mm
A_v 0.413 V BREA_CRUMBS 1 logical C_2 (0.19e-4) nF A_re 0.413 V SAVE_CONFIG2MAT 1 logical 0 logical A_re 0.608 V PLOT_CM 1 logical N_bd 0 logical A_CMMRMS 0 V [test cases] [0.0295 0.0256] TOR and ERL options N_bg 3 012 or 3 porps L 4 TOR 1 logical N_bf 3 taps per groups f.t 4 TOR 1 logical N_bf 3 taps per groups f.t 0.75 *fb TR_TDR 0.01 ns B_float_RSS_MAX 0.02 rss tail tap limit c(-1) [-0.340.02.0] [min:step:max] fixture delay time 0.01 ns f_stat rd 25 (U) star of tail taps limit c(-2) [0.02.02.012] [min:step:max] fixture delay time 0.01 ns f_st 0.594 *Fb	R_d	[50 50]	Ohm	[TX RX]		Local Search	2		<u>C_</u> 0	[0.29e-4]	nF
A_fe 0.41s V SAVE_COMP(62MAT 1 logical Include PCB 0 logical A_ne 0.608 V restance PLOT_GO 1 logical Include PCB 0 logical ACMLRMS 0 V (rest cases) [002550 0250 025 025] TDR 1 logical N_bg 3 0.12 or 3 groups L 4 0 1 logical N_bf 3 0.12 or 3 groups M 32 1 IDR 1 logical N_f 40 UI span for loating taps f_r 0.75 *fb ERI_ONLV 0 logical N_maxg 0.02 rs tail tap limit d(0) 0.54 min N 3500 N N_tail_start 225 (UI) start of tait aps limit d(1) [-034.0202] [min:step:max] mbx 0.618 CM f_r 0.594 #fb d(1) [-02.05.01] [min:step:max] fbkure delay time [A_v	0.413	V			BREAD_CRUMBS	1	logical	C_1	[0.19e-4]	nF
A_ne0.608VVImage: control independence in the indepen	A_fe	0.413	V			SAVE_CONFIG2MAT	1	logical	Include PCB	0	logical
AC_CM_RMS 0 V [test cases] [0.0235 0.0256] TDR and ERL options N_bg 3 0.12 or 3 groups L 4 TDR 1 logical N_bf 3 taps per group M 32 Image: Sigma BA ERL 1 logical N_f 40 Ull span for floating taps. filter and Eq min FR_TDR 0.01 ns b_float_RSS_MAX 0.02 rss tail tap limit. c(1) Imin:step:max] beta_X 0 Imin:step:max] fixture delay time [0.01] port_port_port_port_port_port_port_port_	A_ne	0.608	V			PLOT_CM	1		Floating Tap Control		
L4FDR1logical $N_{c}hf$ 3taps per groupM32ERL1logicalN_ff40Ul span foltating tapsminerFL1logicalN_f40Ul span foltating tapsf_r0.75*fbTR_TDR0.01nsB_float_RSS_MAX0.02rss tail tap limitc(0)0.54minN3500N_tail_start0.5(Ul) start of tail taps limitc(1)[0.302012][min:step:max]beta_x0N_tail_start0.54(Ul) start of tail taps limitc(-2)[0.002012][min:step:max]fntxure delay time[0.0]port1 port2f_f0.594*Fbc(-3)[-0.60.02:0][min:step:max]fntxure delay time[0.0]port2f_f0.594*Fbc(1)[-0.20.050][min:step:max]TDR_W_TXPK60f_n0.594*Fbc(1)[-0.20.050][min:step:max]Tukey_Window1logicalA_ft0.600Vb_max[1)0.85Iministep:max]Tukey_Window1logicalA_ft0.600Vb_max[2,N_b)[0.30.2*ones(1,10)]Iministep:max]sigma_R0.01UlIministep:max]A_DD0.02Ulb_min(2,N_b)[0.50-03*ones(1,10)]Iministep:max]Sigma_R0.01UlIministep:max]Sigma_R0.01Ulf_p121.25GHzSNR_TX33dBSigma_BN stepSOL6-03	AC_CM_RMS	0	V	[test cases]	[0.0235 0.0256]	TDR	and ERL options		N_bg	3	012 or 3 groups
M32IERL1logicalN_f40UI span for floating taps. $fiter and Eq.$ $fiter and Eq.$ $fiter and Eq.$ RL_ONLY 0 $logical$ $bmaxg$ 0.05 $nax DF value for floating taps.$ f_r 0.75*fbmin RL_ONLY 0.01 ns $b_float_RSS_MAX$ 0.02rss tail tap limit. $c(0)$ 0.54minN3500 $N_t tail_start$ 25(UI) start of tail tap limit. $c(-1)$ $[-0.340.02.0]$ [min:step:max] $beta_x$ 0 $N_t tail_start$ 25(UI) start of tail tap limit. $c(-2)$ $[0.002.012]$ [min:step:max] $fixure delay time[0.0]portl port2f_f0.594*Fbc(-3)[-0.60.02:0][min:step:max]TDR_VTMKG0f_r0.594*Fbc(1)[-0.20.05,0][min:step:max]TDR_VTMKG0f_r0.594*Fbc(1)[-0.20.05,0][min:step:max]TDR_VTMKG0f_r0.594*Fbb_max(1)0.85UTMe_VTMKG0f_r0.594*Fbb_max(2.N.b)[0.30.2*nes(1,01)]UN_bx21UIf_r0.600Vb_min(2.N.b)[0.5-0.3*nesf,1.01]A_rA_r0.600VVg_rC_rSNR_TX33dBSigma BNSole-03Vf_r21.25GHzR_LM0.95A_$	L	4				TDR	1	logical	N_bf	3	taps per group
Image: state and Eq. ERL_ONLY 0 logical bmaxg 0.05 hax DFE value for floating tape f_{-r} 0.75 *fb TR_TOR 0.01 ns B_{1} foat_RSS_MAX 0.02 rss tail tap limit $c(0)$ 0.54 imin N 3500 N B_{1} foat_RSS_MAX 0.02 rss tail tap limit $c(1)$ $[0.34.02.012]$ Imin:step:max 0 N B_{1} foat_RSS_MAX 0.02 rss tail tap limit $c(-2)$ $[0.002.012]$ Imin:step:max 0 N B_{1} foat_RSS_MAX 0.594 *Fb $c(-3)$ $[-0.60.02:0]$ Imin:step:max TDR_W_TXPKG 0 Imin:step:max 0 Imin:step:max 0.01 N_t $h_max(1)$ 0.85 Imin:step:max TDR_WTXPKG 0 Imin:step:max 0.01 N_t $h_max(2.N_b)$ $[0.30.2^*ones(1,10)]$ Imin:step:max N_b 21 UI Imin:step:max 0.01 UI $h_min(1)$ 0.3 Imin:step:max	м	32				ERL	1	logical	N_f	40	UI span for floating taps
f_r 0.75 *fb v TR_TDR 0.01 ns b_float_RSS_MAX 0.02 rsstall tap limit c(0) 0.54 min N 3500 N N_tail_start 25 (U) start of ail taps limit c(-1) [-0.34.0020] [min:step:max] beta_X 0 ICN & FOM_ID paramet/ c(-2) [0.002.012] [min:step:max] ho_X 0.618 f_v 0.594 *fb c(-3) [-0.06.002:0] [min:step:max] fixture delay time [0.01] port_port2] f_f 0.594 *fb c(-1) [-0.20050] [min:step:max] fixture delay time [0.01] port_port2] f_f 0.594 *fb 0.1) [-0.20050] [min:step:max] TDR_W_TNPKG 0 f_f.n 0.594 *fb 0.10 0.85 I Tukey_Window 1 log(al A_ft 0.600 V b_max[1) 0.8 Iministep:max] A_DD 0.01 UI A_ft 0.600		filter and Eq				ERL_ONLY	0	logical	bmaxg	0.05	nax DFE value for floating tap:
$c(0)$ 0.54 minN 3500 N_{tail_start} 25 (U) start of tail taps limit $c(-1)$ $[0.30.02.012]$ $[min:step:max]$ $beta_x$ 0 f f_v 0.594 $*Fb$ $c(-2)$ $[0.002.012]$ $[min:step:max]$ fno_x 0.618 r_v f_v 0.594 $*Fb$ $c(-3)$ $[-0.06.002:0]$ $[min:step:max]$ $fixture delay time$ $[0.0]$ $port_1 port_2$ f_f 0.594 $*Fb$ $c(-1)$ $[-0.20.050]$ $[min:step:max]$ $fixture delay time$ $[0.0]$ $port_1 port_2$ f_f 0.594 $*Fb$ $c(1)$ $[-0.20.050]$ $[min:step:max]$ $fixture delay time$ $[0.0]$ $port_1 port_2$ f_f 0.594 $*Fb$ $c(1)$ $[-0.20.050]$ $[min:step:max]$ $N_b bx$ 21 UI f_f 0.594 $*Fb$ $n_b max[1)$ 0.85 I $Imin:step:max]$ $N_b bx$ 21 UI $f_f n$ 0.594 $*Fb$ $b_max[2, N_b)$ $[0.3.02^* ones(1,01)]$ I $Imin:step:max]$ $N_b bx$ 21 UI $Imin:step:max]$ 0.02 $Imin:step:max]$ 0.02 $Imin:step:max]$ 0.02 $Imin:step:max]$ $Imin:step:max]$ 0.02 $Imin:step:max]$	f_r	0.75	*fb			TR_TDR	0.01	ns	B_float_RSS_MAX	0.02	rss tail tap limit
(-1) $[-0.340.02.0]$ $[min:step:max]$ $beta_x$ 0 (-1)	c(0)	0.54		min		N	3500		N_tail_start	25	(UI) start of tail taps limit
(-2) $[0.020.12]$ $[min:step:max]$ nb_x 0.618 f_v f_v 0.594 $*Fb$ (-3) $[-0.06.02:0]$ $[min:step:max]$ $fixture delay time[0.0]port1 port2f_{_1}f0.594*Fb(-1)[-0.20.05.0][min:step:max]TDR_W_TXPKG0f_{_1}n0.594*FbN_b12UImin:step:max]TDR_W_TXPKG0f_{_1}n0.594*Fbh_m12UIUIf_240.000GH2GH2h_mx(1)0.85IIN_bx21UIf_240.000GH2h_mx(2)0.85IIItkey.Window1IogicalA_ft0.600Vh_mx(2)0.30.2^{\circ}noes(1,10)IIItkey.WindowIIogicalA_ft0.600Vh_mx(2)0.3IIItkey.WindowIIogicalA_ft0.600Vh_mx(2)I_03.02^{\circ}noes(1,10)IIA_DD0.02UIA_Int0.600Vh_mn(2)I_05.003^{\circ}noes(1,10)IIA_DD0.02UIRX_CALIBRATION0Iogicalf_2I_12.5GH2IIIIIIIIIf_2I_12.5GH2IIII$	c(-1)	[-0.34:0.02:0]		[min:step:max]		beta_x	0			ICN & FOM_ILD paramete	215
(-3) $[-0.06.0.22.0]$ $[min:step:max]$ fixture delay time $[0.0]$ $port_1 port_2$ f_f 0.594 *Fb (-1) $[-0.2.0.5.0]$ $[min:step:max]$ TDR_W_TXPKG 0 f_n 0.594 *Fb N_b 12 UI M_b 21 UI f_2 40.000 $GH2$ $b_max(1)$ 0.85 I I N_bx 21 UI f_2 40.000 $GH2$ $b_max(1)$ 0.85 I I N_bx 21 UI f_2 40.000 $GH2$ $b_max(1)$ 0.85 I $Imm(step:max)$	c(-2)	[0:0.02:0.12]		[min:step:max]		rho_x	0.618		f_v	0.594	*Fb
(1) $[-0.20.50]$ $[min:step:max]$ TDR_W_TXPKG 0 f_n 0.594 *Fb N_b 12 UI N_bx 21 UI f_2 40.000 $GH2$ b_max(1) 0.85 Imax Tukey_Window 1 logical A_ft 0.600 V b_max(2.N_b) $[0.30.2*ones(1,10)]$ Imax Imax $Misey_Window$ 1 logical A_ft 0.600 V b_max(2.N_b) $[0.30.2*ones(1,10)]$ Imax Imax $Misey_Window$ Imax $Misey_Window$ $Misey_Wind$	c(-3)	[-0.06:0.02: 0]		[min:step:max]		fixture delay time	[00]	port1 port2]	f_f	0.594	*Fb
N_b 12 UI N_bx 21 UI f_2 40.000 GHz b_max(1) 0.85 Image: Constraint of the symptotic of the symptot of the symptot of the symptotic of the symptotic	c(1)	[-0.2:0.05:0]		[min:step:max]		TDR_W_TXPKG	0		f_n	0.594	*Fb
b_max(1) 0.85 Image: max (2N_b) 0.85 Image: max (2N_b) 0.30.2*ones(1,10)] Image: max (2N_b) 1mage: max (2N_	N_b	12	UI			N_bx	21	UI	f_2	40.000	GHz
b_max(2N_b) [0.3.0_2*ones(1,10)] Image: Constraint of the symbol of	b_max(1)	0.85				Tukey_Window	1	logical	A_ft	0.600	V
b_min(1) 0.3 Image: sigma_RJ 0.01 UI b_min(2N_b) [0.05+0.03*ones(1,10)] A_DD 0.02 UI Receiver testing g_DC [-201.0] dB [min:step:max] eta_0 8.20E-09 V^2/GHz RX_CALIBRATION 0 logical f_z 21.25 GHz SNR_TX 33 dB Sigma_BBN step 5.00E-03 V f_p1 21.25 GHz R_LM 0.95 Image: sigma_BBN step 5.00E-03 V f_p2 53.125 GHz R_LM 0.95 Image: sigma_BBN step 5.00E-03 V g_DC_HP [-61.0] [min:step:max] Eta_H Eta_H Eta_H Eta_H f_HP_PZ 0.6640625 GHz Eta_H Eta_H Eta_H Eta_H Eta_H Eta_H	b_max(2N_b)	[0.3 0.2*ones(1,10)]					Noise, jitter		A_nt	0.600	V
b_min(2N_b) [0.05 -0.03*ones(1,10)] A_DD 0.02 UI Receiver testing g_DC [-201.0] dB [min:step:max] eta_0 8.20E-09 V^2/GHz RX_CALIBRATION 0 logical f_z 21.25 GHz SNR_TX 33 dB Sigma BBN step 5.00E-03 V f_p1 21.25 GHz R_LM 0.95 Image: Comparison of the	b_min(1)	0.3				sigma_RJ	0.01	UI			
g_DC [-201:0] dB [min:step:max] eta_0 8.20E-09 V^2/GHz RX_CALIBRATION 0 logical f_z 21.25 GHz GM SNR_TX 33 dB Sigma BBN step 5.00E-03 V f_p1 21.25 GHz GM R_LM 0.95 Image: Sigma BBN step 5.00E-03 V f_p2 53.125 GHz Image: Sigma BBN step Image: Sigma BBN step Sigma BBN s	b_min(2N_b)	[0.05 -0.03*ones(1,10)]				A_DD	0.02	UI		Receiver testing	
f_z 21.25 GHz SNR_TX 33 dB Sigma BBN step 5.00E-03 V f_p1 21.25 GHz R_LM 0.95 Image: Sigma BBN step 5.00E-03 V f_p2 53.125 GHz R_LM 0.95 Image: Sigma BBN step 5.00E-03 V g_DC_HP [-61:0] [min:step:max] Image: Sigma BBN step Sigma BBN step 1mage: Sigma BBN step	g_DC	[-20:1:0]	dB	[min:step:max]		eta_0	8.20E-09	V^2/GHz	RX_CALIBRATION	0	logical
f_p1 21.25 GHz R_LM 0.95 f_p2 53.125 GHz new g_DC_HP [-61:0] [min:step:max] new f_HP_PZ 0.6640625 GHz GHz	f_z	21.25	GHz			SNR_TX	33	dB	Sigma BBN step	5.00E-03	V
f_p2 53.125 GHz new g_DC_HP [-61:0] [min:step:max]	f_p1	21.25	GHz			R_LM	0.95				
g_DC_HP [-6:1:0] [min:step:max] f_HP_PZ 0.6640625 GHz	f_p2	53.125	GHz						new		
f_HP_PZ 0.6640625 GHz	g_DC_HP	[-6:1:0]		[min:step:max]							
	f_HP_PZ	0.6640625	GHz								

RX: 30mm package and 0.087pF Cp