Further Analysis of Transmitter dERL (Comment #189)

Mau-Lin Wu, Tobey P.-R. Li

MediaTek

For IEEE 802.3ck

Outlines

- Background
- Recap Previous Analysis
- dCOM vs. dERL analysis – sweeping R_d
- Test Fixture Variations
- Summary

Background & Summary

- TX dERL & RX dERL were set as **-3 dB** based on the analysis in wu_3ck_02_1020
  - Based on ERL sensitivity analysis of R_d, z_p, Z_c, C_p, C_b
  - By considering z_p, Z_c, R_d valid range & test fixture variation, dERL = -3 dB was proposed & accepted in D2.0
- In dudek_3ck_adhoc_01_042821, **TX dERL = -1 dB** was proposed (also in Comment #189 in D2.0)
  - Based on dERL vs. COM analysis by sweep C_p with one KR channel (OAch1_t.s4p)
- In this contribution, we swept R_d with 9 KR channels (OAch1_t.s4p + 8 baseline KR channels)
  - By considering reasonable COM impact, dERL = -2.0 dB was selected
  - By adding 1 dB for text fixture measurement variation, propose to keep -3 dB for TX dERL

Recap ERL Sensitivity Analysis in wu_3ck_02_1020 – KR

ERL Sensitivity Analysis – Summary of KR

- By considering ERL variation due to z_p, Z_c, & R_d,
  - dERL shall be at least = -1.56
- By considering Z_c = 80 & R_d = 55
  - dERL is -2.13
- Take -1 dB for test fixture variation
- Proposal
  - dERL = -3 dB
- Q: What's the COM impact due to these device/package variations?

KR case (N_bx = 21)		Min calculated ERL by sweeping parameters			
Parameter settings	D1p3 *1	z_p	Z_c	R_d	Z_c=80, R_d=55 *2
z_p (mm)	31	**23**	31	31	31
C_p (fF)	87	87	87	87	87
C_b (fF)	30	30	30	30	30
Z_c (Ohm)	87.5	87.5	**80**	87.5	**80**
R_d (Ohm)	50	50	50	**55**	**55**
ERL (dB)	18.60	18.37	18.12	17.04	16.47
dERL (dB)		-0.23	-0.48	-1.56	-2.13

*1. This is "Case 1" for COM analysis in next slide
*2. This is "Case 2" for COM analysis in next slide

Recap COM Analysis in wu_3ck_02_1020 – KR

COM Analysis of 8 KR baseline Channels – Sweeping Device/Package Parameters

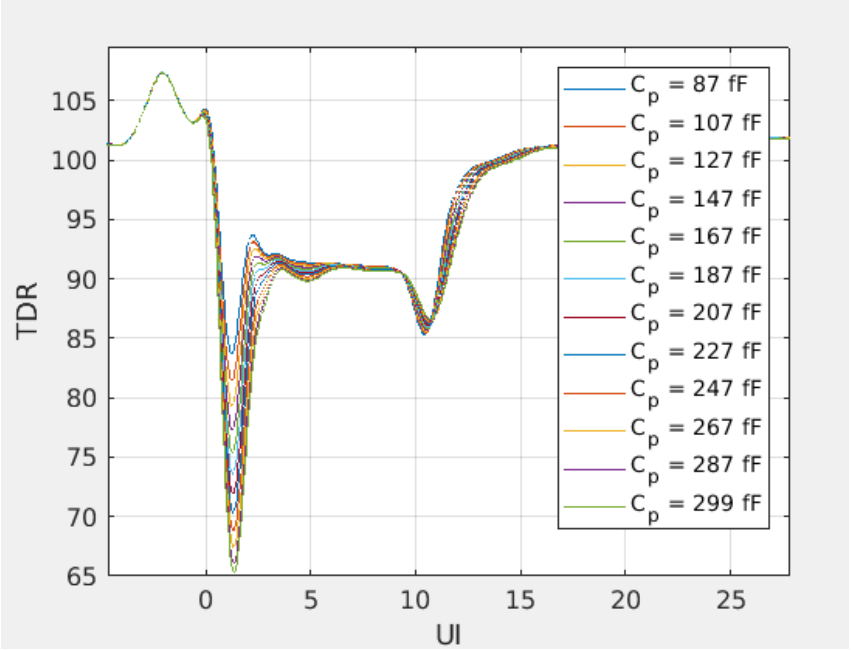
- 8 KR baseline channels
  - List in slide 6 of heck_3ck_01_0519.pdf
  - COM 2.95 excel sheet in appendix (D1p3)
- Observations
  - COM is not sensitive to R_d, Z_c variations
    - <= 0.33 dB for critical channels with COM ~= 3.0 dB
  - Could be included in 3 dB COM margin
- Proposal
  - No touch to COM parameters, such as R_d, Z_c, z_p
  - ERL variation due to R_d & Z_c variation could be covered by dERL = -3 dB

Channel	Case 1	Case 2	dCOM (dB)
Cable_BKP_28dB_0p575m_more_isi	2.85	2.93	0.08
Cable_BKP_16dB_0p575m_more_isi	5.75	4.85	-0.9
CaBP_BGAVia_Opt2_28dB	4.69	4.54	-0.15
Std_BP_12inch_Meg7	4.08	3.53	-0.55
DPO_IL_12dB	6.55	5.65	-0.9
OAch4	2.88	2.82	-0.06
CAch3_b2	3.90	3.86	-0.04
Bch2_b7p5_7	2.84	2.51	-0.33

PS: For COM calculation, A_v, A_ne, & A_fe are scaled by (R0+R_d)/(2*R_d) to make sure TX swing keeps the same as R_d varies

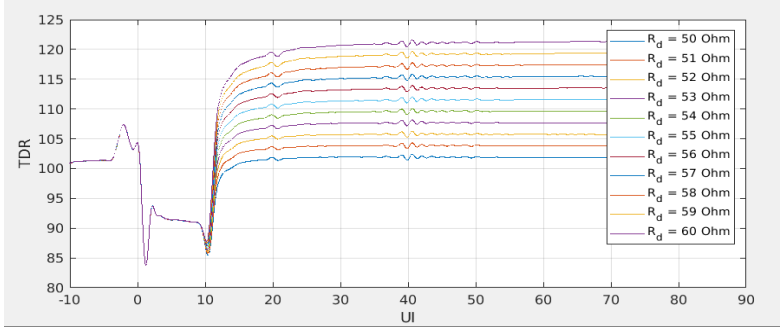
COM (dB) vs. dERL (dB) – Sweeping C_p

- In dudek_3ck_adhoc_01_042821, C_p (fF) was swept from 87 to 299, which may be too large a value to be representative
  - Impedance was as low as 65 Ohm, which is too low
  - Only one channel analyzed
- Based on that, we swept R_d instead & by 8 (baseline) + 1 KR channels

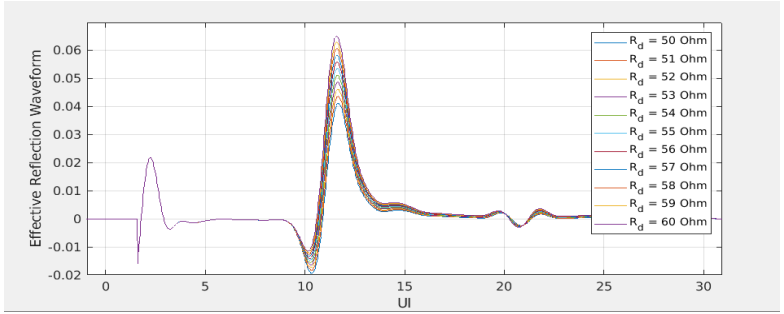


TX TDR and ERW with Sweeping R_d

- TDR with sweeping R_d (Ohm)



- Effective reflection waveform (ERW) with sweeping R_d (Ohm) – N_bx = 21



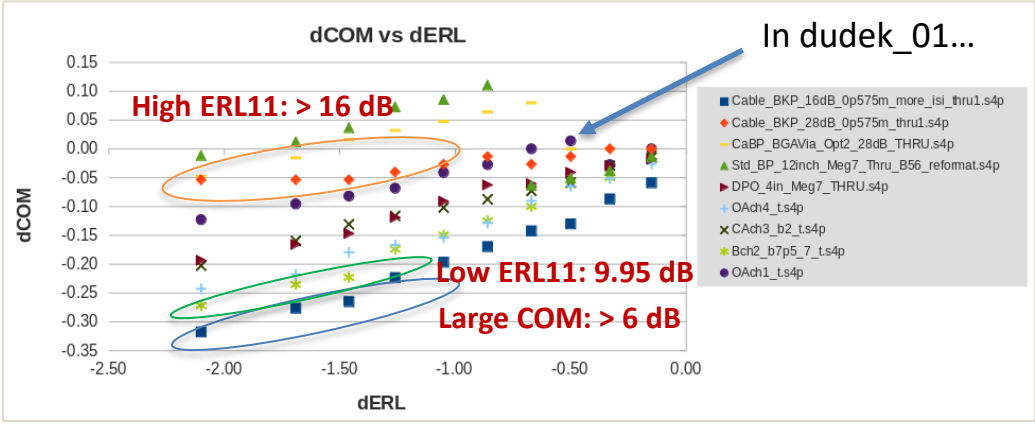
- COM analysis of 8 KR baseline channels & 1 KR channel
  - 8 KR baseline channels listed in slide 6 of heck_3ck_01_0519.pdf
  - COM 3.10 excel sheet in appendix

dCOM (dB)	IL	ERL11	ERL22
Cable_BKP_16dB_0p575m_more_isi_thru1.s4p	16.31	12.23	11.35
Cable_BKP_28dB_0p575m_thru1.s4p	29.61	16.14	15.59
CaBP_BGAVia_Opt2_28dB_THRU.s4p	26.61	17.56	17.56
Std_BP_12inch_Meg7_Thru_B56_reformat.s4p	16.54	13.59	13.59
DPO_4in_Meg7_THRU.s4p	13.04	13.69	14.09
OAch4_t.s4p	28.36	13.70	17.95
CAch3_b2_t.s4p	27.82	12.16	16.37
Bch2_b7p5_7_t.s4p	27.02	9.95	16.97
OAch1_t.s4p	24.27	13.81	17.19

Note
ERL11: RX + channel
ERL22: TX + channel

dCOM (dB) vs. dERL (dB) Analysis – Sweeping R_d

- dCOM = COM degradation due to lower ERL
  - Skip 'large COM'
- If dERL = -2.0 dB ➔ dCOM >= -0.3 dB
- If dERL = -1.0 dB ➔ dCOM >= -0.15 dB



COM Table

PKG = 12 mm, with FEXT/NEXT

R_d (Ohm)	50	51	52	53	54	55	56	57	58	59	60
ERL (dB)	19.37	19.22	19.04	18.87	18.70	18.51	18.32	18.11	17.91	17.68	17.27
dERL (dB)		-0.15	-0.33	-0.50	-0.67	-0.86	-1.05	-1.26	-1.46	-1.69	-2.10
Cable_BKP_16dB_0p575m_more_isi_thru1.s4p	6.21	6.15	6.12	6.08	6.07	6.04	6.01	5.99	5.95	5.93	5.89
Cable_BKP_28dB_0p575m_thru1.s4p	3.81	3.81	3.81	3.80	3.78	3.80	3.78	3.77	3.76	3.76	3.76
CaBP_BGAVia_Opt2_28dB_THRU.s4p	5.24	5.24	5.24	5.24	5.32	5.30	5.29	5.27	5.26	5.22	5.19
Std_BP_12inch_Meg7_Thru_B56_reformat.s4p	4.71	4.69	4.67	4.66	4.64	4.82	4.79	4.78	4.74	4.72	4.70
DPO_4in_Meg7_THRU.s4p	6.44	6.43	6.41	6.40	6.38	6.38	6.35	6.32	6.30	6.28	6.25
OAch4_t.s4p	3.48	3.45	3.43	3.41	3.39	3.35	3.32	3.31	3.30	3.26	3.24
CAch3_b2_t.s4p	4.54	4.52	4.51	4.48	4.47	4.45	4.44	4.42	4.41	4.38	4.34
Bch2_b7p5_7_t.s4p	3.20	3.19	3.15	3.14	3.10	3.07	3.05	3.02	2.97	2.96	2.93
OAch1_t.s4p	3.99	3.99	3.96	4.00	3.99	3.96	3.94	3.92	3.90	3.89	3.86

Take -1 dB for Test Fixture Variation

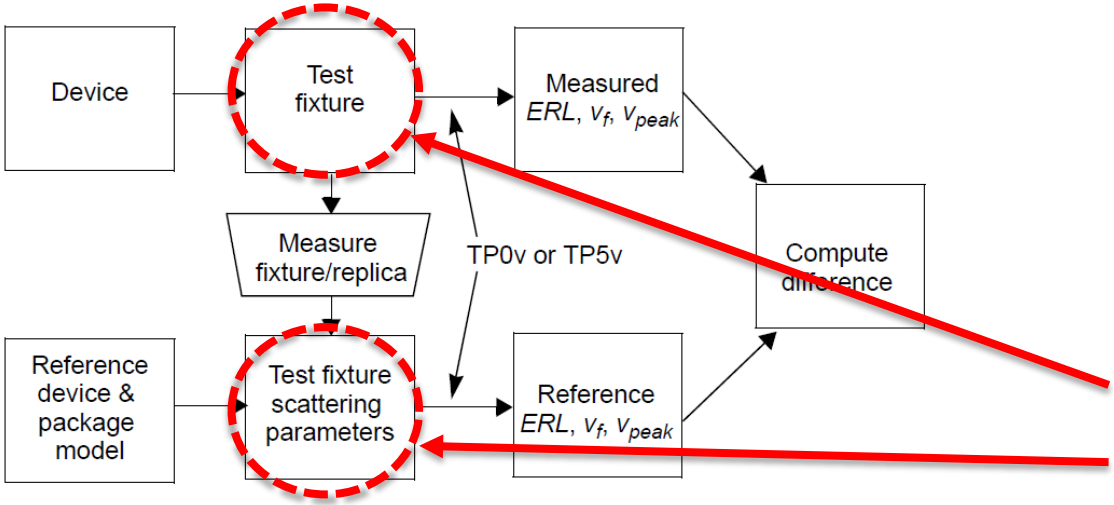


Figure 163A–1—Measurement method for transmitter reference steady-state voltage, pulse peak and ERL

Test fixture variation: measurement vs. s4p model

Summary

- It shall be reasonable to take TX dERL as -3 dB

Thank You

COM spread sheet – COM Calculation for KR

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 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	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)	[12 12;1.8 1.8]	mm	[test cases]
z_p (NEXT)	[29 29;1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 12;1.8 1.8]	mm	[test cases]
z_p (RX)	[29 29;1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	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	
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)	[-0.2:0.05:0]		[min:step:max]
N_b	12	UI	
b_max(1)	0.85		
b_max(2..N_b)	[0.3 0.2*ones(1,10)]		
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	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	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

TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3500	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	port1 port2]
TDR_W_TXPKG	0	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a	[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
Sigma BBN step	5.00E-03	V

COM spread sheet – IEEE KR for ERL

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 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	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)	[12 12;1.8 1.8]	mm	[test cases]
z_p (NEXT)	[0 0;0 0]	mm	[test cases]
z_p (FEXT)	[0 0;0 0]	mm	[test cases]
z_p (RX)	[29 29;1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	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	
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)	[-0.2:0.05:0]		[min:step:max]
N_b	12	UI	
b_max(1)	0.85		
b_max(2..N_b)	[0.3 0.2*ones(1,10)]		
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	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 2 3 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	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
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	1	logical
TR_TDR	0.01	ns
N	200	
beta_x	0	
rho_x	0.618	
fixture delay time	2.158e-9 2.158e-9	port1 port2]
TDR_W_TXPKG	1	
N_bx	21	UI
Tukey_Window	1	logical
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.20E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a	[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 te		
RX_CALIBRATION	0	
Sigma BBN step	5.00E-03	

- ERL22 for TX ERL
- ERL11 for RX ERL