ERL Discussion for KR and C2C

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For IEEE 802.3ck Ad-Hoc

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Outlines

- Background
- Example TP0a
- COM parameters
- dERL value
- Straw polls

Background

- Within the small group discussion, we can't get consensus of KR/C2C TX/RX ERL specs at this moment
  - Put several options on the table to facilitate the discussion at Task Force level
- Based on Matt's contribution on Sept. 16th, '20 (brown_3ck_adhoc_01_091620.pdf) & straw poll followed
  - Removal of "Example TX test fixture, TP0a" in D1p3 → nearly tied (10 for yes, 11 for no)
  - Replacing Rx test fixture spec with TP5v, similar to TP0v → strong support (14 for yes, 7 for no)
- The purposes of this contribution
  - Explore on some details related to TP0v calculation
  - Help the Task Force facilitate discussions for next step

Discussions in the small group

- The intuitive ideas **(not consensus!)**
  - Reference test points are TP0v (TX) and TP5V (RX)
  - Start from the R1.3 COM table for reference die+pkg for TX and RX
  - REF ERLs will be derived from it
  - dERL limits are >= 0 dB for TX and RX
- Let's discuss more after detailed explorations in this contribution
  - Followed by straw poll to get sense from the Task Force

Example TX test fixture, TP0a (informative)

- Debating of the necessity of TP0a in ad-hoc on Sept. 16th, ’20
  - Some raised concerns about the complexity of TP0v methodology
- Q: What if we just relaxed TP0a IL spec (to say 2.4 +/- 0.4 dB) & keep the original TP0a methodology?
  - Call to action: check the sensitivity of ERL, v_f, & v_{peak} for TP0a test fixture with IL from 2.0 to 2.8 dB
- Take straw poll #1

When measured using this test fixture, the reference values determined according to the methodology in 163A.3 take values listed in Table 163–7.

Table 163–7—Summary of transmitter reference values at TP0a

Parameter	Reference	Value	Units
Effective return loss	163.9.2.3	TBD	dB
Transmitter steady-state voltage, v_f	162.9.3.1.2	TBD	V
Transmitter linear fit pulse peak, v_{peak}	162.9.3.1.2	TBD	V

KR/C2C ERL – test fixture, parameters, & specs

- TP0v
  - **IL < 5 dB** @ 26.56 GHz
  - ILD <= 0.2 dB from 0.05 to 26.56 GHz
  - Common-mode RL >= 10 dB from 0.05 to 26.56 GHz
- Reference device & package model
  - By COM parameters
    - Q: **Rd = 50**?
      - It's too optimistic from return loss point-of-view
      - Check ERL sensitivity of Rd → later in this contribution
    - Q: Shall we set different Rd for ERL calculation?
  - We need to decide ***dERL*** value
    - Q: >=0 vs. <0

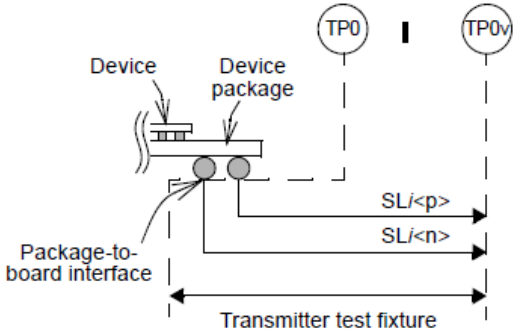

Figure 163–3—Transmitter test fixture and test points

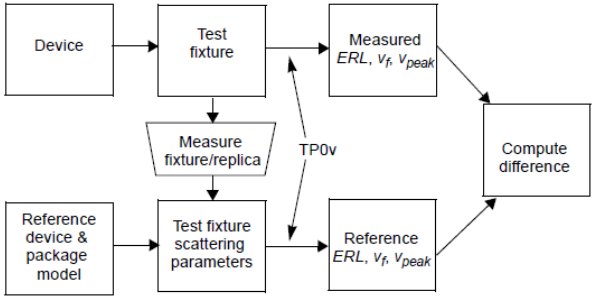

Figure 163A–1—Measurement method for transmitter reference steady-state voltage, pulse peak and ERL

TX ERL reference values – Sweeping Rd

- An example TP0 to TP0v test fixture
  - IL = 2.12 dB @ 26.56 GHz
- Sweep Rd to check ERL sensitivity
  - Shall at least consider Rd = 50 +/- 10%
  - 1.1 ~ 1.5 dB ERL difference for Rd = 50 vs. Rd = 55
- COM spread sheet
  - In appendix

Clause	C137 (50G-KR)	
	TX ERL	RX ERL
ERL (dB)	15	15

- ERL (min) for 50G-KR is 15 dB
  - Expect 100G-KR to be similar to that
- Straw poll (#2)
  - Calculate ERL reference value by Rd = 55, while keep Rd = 50 for channel COM calculation

Parameters	Conditions	Values					
Rd (Ohm)		30	35	40	45	50	55
TX ERL ref. values (dB)	KR (N_{bx} = 21)	14.76	17.84	19.67	19.20	18.42	17.35
	C2C (N_{bx} = 6)	13.89	16.87	18.51	18.11	17.50	15.97

TP0v – dERL & ERL reference value

- TX ERL
  - dERL, instead of ERL
- Q: Does 0 dB make sense?
  - Reserve margins not covered in ERL calculation?
  - Give the flexibility of Serdes design
- Straw poll #3

163.9.2 Transmitter characteristics

The transmitter shall meet the specifications given in Table 163–5. A test system with a fourth-order Bessel-Thomson low-pass response with 40 GHz 3 dB bandwidth is to be used for all transmitter signal measurements, unless otherwise specified.

Table 163–5—Summary of transmitter specifications at TP0v

Parameter	Reference	Value	Units
Signaling rate		53.125 ± 100 ppm	GBd
Differential pk-pk voltage (max)[a] Transmitter disabled Transmitter enabled	93.8.1.3	 30 1200	 mV mV
DC common-mode voltage (max)[a]	93.8.1.3	1.0	V
DC common-mode voltage (min)[a]	93.8.1.3	0.2	V
AC common-mode RMS voltage (max)[a]	93.8.1.3	30	mV
Difference between measured and reference effective return loss (min), *dERL*	163A.3.2.2	TBD	dB

163A.3.1.2 Effective return loss reference value

Effective return loss (ERL) is defined in 93A.5. The ERL reference value is determined as follows. Obtain the pulse time-domain reflection (PTDR) response from $S^{(0)}$ using Equation (93A–58) and Equation (93A–59). Determine the ERL reference value from the PTDR response using the method in 93A.5.2.

163A.3.2.2 Effective return loss

Measure the effective return loss using the method defined in 93A.5.

The difference between the measured and reference ERL, *dERL*, is calculated using Equation (163A–6).

$$dERL = ERL^{(meas)} - ERL^{(ref)} \quad (163A–6)$$

Alternative Ideas

- The intuitive ideas **(not consensus!)**
  - Reference test points are ~~TP0v (TX) and TP5V (RX)~~
    - **TP0a/TP5a with relaxed IL/ILD specs**
  - Start from the ~~R1.3 COM~~ table for reference die+pkg for TX and RX
    - **R1.3 COM except Rd = 55**
  - REF ERLs will be derived from it
  - dERL limits are >= 0 dB for TX and RX
    - **Other possible values, such as < 0**

Straw Polls

- #1. I support TP0a test fixture with relaxed IL & ILD specs
  - Y vs. N
- #2. I support adopt COM parameter, Rd=55, in the “reference package & device model” in Figure 163A-1
  - Y vs. N
- #3. (Chicago rule) I support dERL in Table 163-5 as
  - > 0
  - 0
  - < 0

Thank You

COM spread sheet – IEEE KR

- ERL22 for TX ERL
- ERL11 for RX 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)	[31 31; 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	[3 4 1 2]	
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	[2.40e-9 2.14e-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_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
Sigma BBN step	5.00E-03	V

COM spread sheet – IEEE C2C

- ERL22 for TX ERL
- ERL11 for RX 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)	[31 31; 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)	[-0.28:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.1]		[min:step:max]
c(-3)	[-0.04:0.02: 0]		[min:step:max]
c(1)	[-0.1:0.05:0]		[min:step:max]
N_b	6	UI	
b_max(1)	0.65		
b_max(2..N_b)	[0.15 0.1*ones(1,4)]		
b_min(1)	0.3		
b_min(2..N_b)	[0.05 -0.04*ones(1,4)]		
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	[-4:1:0]		[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	[3 4 1 2]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	8	dB
DER_0	1.00E-05	
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	[2.40e-9 2.14e-9]		[port1 port2]
TDR_W_TXPKG	1		
N_bx	6	UI	
Tukey_Window	1	logical	
Noise, jitter			
sigma_RJ	0.01	UI	
A_DD	0.02	UI	
eta_0	2.00E-08	V^2/GHz	
SNR_TX	33	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	0	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

ERL Parameters Comparison

163 (100G-KR)

Table 163–8—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	200	UI
Equalizer length associated with reflection signal	N_{bx}	21	UI
Tukey window flag	*tw*	1	—

137 (50G-KR)

Table 137–5—Transmitter and receiver ERL parameter values

Parameter	Symbol	Value	Units
Transition time associated with a pulse	T_r	0.0189	ns
Incremental available signal loss factor	β_x	1.7	GHz
Permitted reflection from a transmission line external to the device under test	ρ_x	0.32	—
Length of the reflection signal	N	100	UI

120F

Table 120F–2—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	200	UI
Equalizer length associated with reflection signal	N_{bx}	6	UI
Tukey window flag	*tw*	1	—

COM Parameters Comparison

163

Table 163–11—COM parameter values

Parameter	Symbol	Value	Units
Signaling rate	f_b	53.125	GBd
Maximum start frequency	f_{min}	0.05	GHz
Maximum frequency step	Δf	0.01	GHz
Device package model			
Single-ended device pad capacitance	C_d	1.2×10^{-4}	nF
Single-ended device series inductance	L_s	0.12	nH
Single-ended device bump capacitance	C_b	3×10^{-5}	nF
Transmission line length, Test 1	z_p	12	mm
Transmission line length, Tx Test 2	z_p	31	mm
Transmission line length, Rx Test 2	z_p	29	mm
Transmission line parameter, a_1	a_1	9.909×10^{-4}	$ns^{1/2}$/mm
Transmission line parameter, a_2	a_2	2.772×10^{-4}	ns/mm
Single-ended package capacitance at package-to-board interface	C_p	8.7×10^{-5}	nF
Transmission line characteristic impedance	Z_c	87.5	Ω
Transmission line 2 length	z_{p2}	1.8	mm
Transmission line 2 characteristic impedance	Z_{c2}	92.5	Ω
Single-ended reference resistance	R_0	50	Ω
Single-ended termination resistance	R_d	50	Ω

120F

Table 120F–7—COM parameter values

Parameter	Symbol	Value	Units
Signaling rate	f_b	53.125	GBd
Maximum start frequency	f_{min}	0.05	GHz
Maximum frequency step	Δf	0.01	GHz
Device package model			
Single-ended device pad capacitance	C_d	1.2e–4	nF
Single-ended device series inductance	L_s	0.12	nH
Single-ended device capacitance at device-to-package interface	C_b	3×10^{-5}	nF
Transmission line length, Tx Test 1	z_p	13	mm
Transmission line length, Rx Test 1	z_p	11	mm
Transmission line length, Tx Test 2	z_p	31	mm
Transmission line length, Rx Test 2	z_p	29	mm
Transmission line 2 length	z_{p2}	1.8	mm
Transmission line parameter, a_1	a_1	9.909×10^{-4}	$ns^{1/2}$/mm
Transmission line parameter, a_2	a_2	2.772×10^{-4}	ns/mm
Single-ended package capacitance at package-to-board interface	C_p	8.7×10^{-5}	nF
Package transmission line nominal characteristic impedance	Z_c	87.5	Ω
Package transmission line 2 nominal characteristic impedance	Z_{c2}	92.5	Ω
Single-ended reference resistance	R_0	50	Ω
Single-ended termination resistance	R_d	50	Ω