

# C2C Equalization Parameters for COM

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IEEE P802.3ck Task Force

March 2020

# Supporters

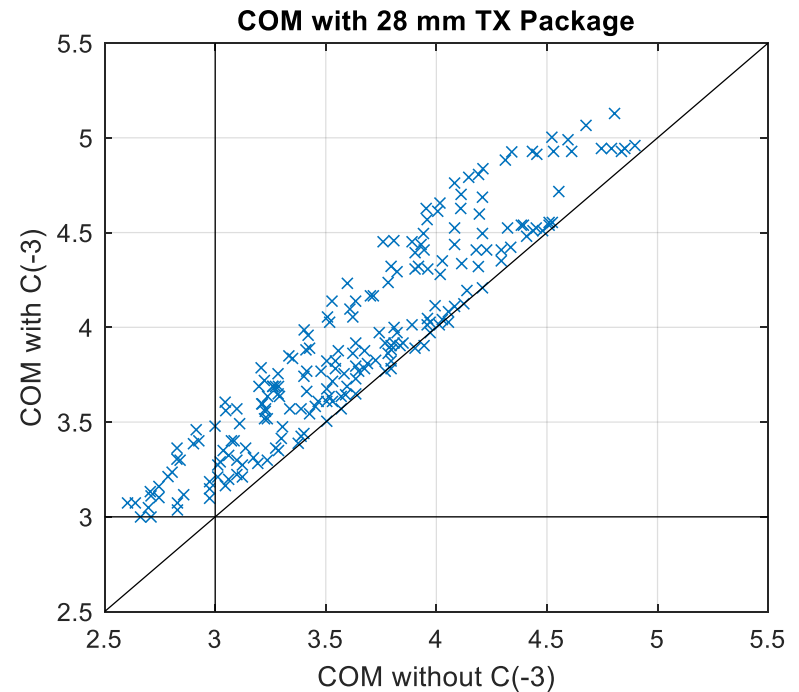
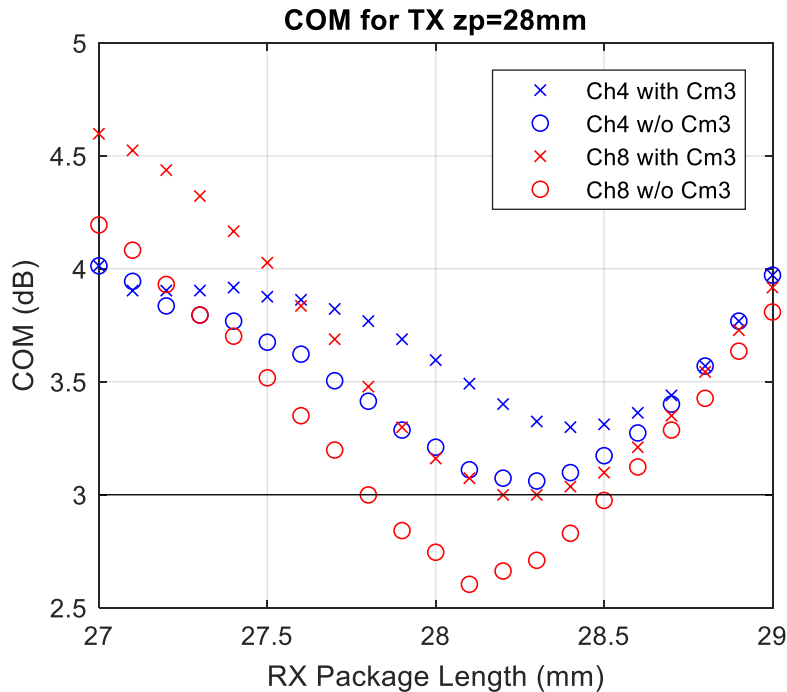
- ❖ Mike Dudek, Marvell
- ❖ Adee Ran, Intel
- ❖ Upen Kareti, Cisco
- ❖ Rich Mellitz, Samtec

# Introduction

- ❖ This is to analyze TX/RX COM parameters. C2C SERDES receiver costs a lot more power than TX. Reference receiver should be minimal performance
  - ❖ KR/CR reference receiver is an overkill
  - ❖ Ref RX for C2C is to qualify channels with certain package parameters
- ❖ [sun\\_3ck\\_adhoc\\_01\\_030420](#) shows 5-tap DFE with existing D1.1 TX can support all C2C channels, assuming 1 mm  $z_p$  searching grid and identical  $z_p$  for both TX and RX are too pessimistic
- ❖ This contribution adds the following:
  - ❖  $N_b$  is increased from 5 to 6 to cover  $z_p = 8$  mm tough cases (page 8 of [sun\\_3ck\\_adhoc\\_01\\_030420](#))
  - ❖ Finer grid  $z_p$  sensitivity @ tough package lengths
  - ❖ TX FIR functionality

# Package Length ( $z_p$ ) Sensitivity

- ❖ TX  $z_p=28$  mm as an example. RX  $z_p= [27:0.1:29]$



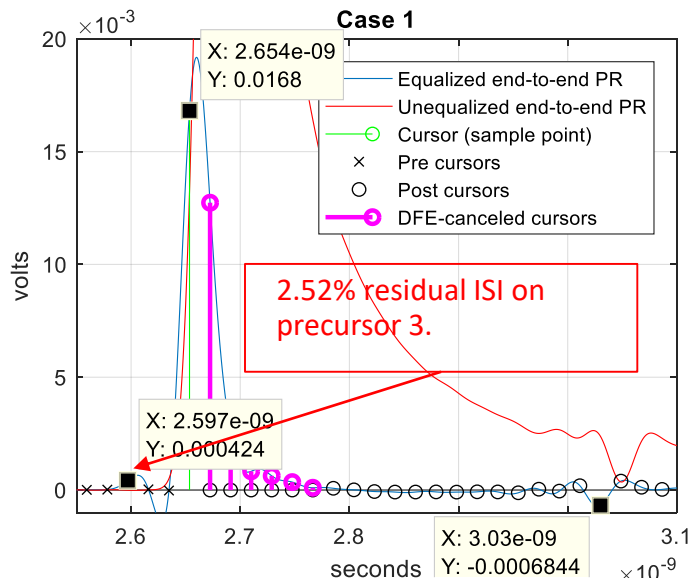
- ❖ COM degrades with smaller TX and RX  $z_p$  difference
- ❖ All cases pass 3dB COM with C(-3)
- ❖ W/o C(-3), around 20 DFE tap coverage is needed to cancel reflections from 28 mm package

# C(-3) Functionality

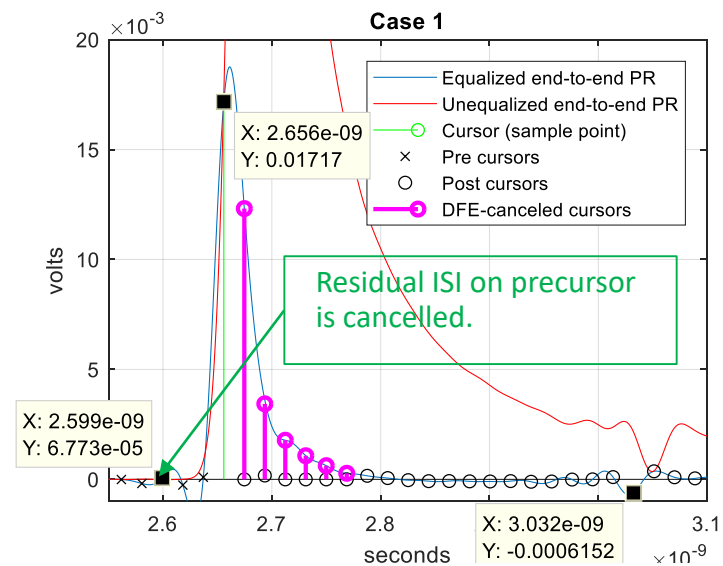
- ❖ healey\_3ck\_adhoc\_01\_031120 explains how C(-3) allows phase optimization
- ❖ More importantly C(-3) has other functions, e.g., precursor ISI cancellation
- ❖ Precursor ISI may be caused by factors not (fully) modeled in COM tool. For example:
  - ❖ TX/RX bandwidth limitation and imperfection
  - ❖ More dispersive channels not included in the contributed 3 channel sets
- ❖ C(-3) is often important for improving interoperability/performance while its cost is very small
  - ❖ Power of a digital TX FFE tap is only about a quarter of a RX FFE tap
  - ❖ No need to optimize if not needed in a particular link
  - ❖ Only couple steps of searching range

# C(-3) Functionality Cont.

- ❖ COM has high TX/RX bandwidth ( $T_r$  and CTLE). What happens to a slower more realistic system?
- ❖ Set  $T_r = 12$  ps (13 ps in Clause 120D) to illustrate the problem. Residual ISI on Precursor 3 is 2.52% without C(-3). For PAM4 signal, 2.52% ISI causes 7.56% eye closure.



Ch8, COM=2.6 dB w/o C(-3)



Ch8, COM=3.1 dB with C(-3)

Reflection problem may be exaggerated by existing COM parameters, while other challenges, e.g., bandwidth are underestimated

# Summary

- ❖ 6-tap DFE seems a good balance of power and performance for C2C
  - ❖ Sufficient for all 18 channels (excluding pessimistic zp)
  
- ❖ C(-3) has significant impact
  - ❖ Solves problems not (fully) modeled in COM tool, e.g., precursor cancellation
  - ❖ More channels can be supported without a heavy (20 tap coverage) RX
  - ❖ Improves COM by up to 0.8 dB at critical region
  - ❖ Improves interop
  
- ❖ **Proposals:**
  - ❖ RX parameters in Table 120F-5:
    - ❖  $N_b=6$ ,  $b_{\max(1)}=0.85$ ,  $b_{\max(2:N_b)}=0.2$
  - ❖ TX EQ parameters: same as in D1.1 Table 120F-5
    - ❖ Tap weight may be tightened after further investigation

# Backup Slides



# Channel Set

ID	Channel Description	IL (dB)	ERL11 (dB)	ERL22 (dB)	ICN (mV)	ILD (dB)
1	lim_3ck_04_0719\Asic_Mezz_Retimer_L10_Thru.s4p	16.56	21.06	19.26	1.88	0.06
2	lim_3ck_04_0719\Asic_Mezz_Retimer_L23_Thru.s4p	16.88	20.81	18.95	1.34	0.10
3	lim_3ck_04_0719\Asic_Deep_Mezz_Retimer_L10_Thru.s4p	17.35	19.14	16.40	1.81	0.11
4	lim_3ck_04_0719\Asic_Deep_Mezz_Retimer_L23_Thru.s4p	17.77	18.95	16.24	1.18	0.13
5	rabinovich_3ck_adhoc_01a_071019\Impaired_C2C_10dB_P1_to_P2_THRU_ExtPEC.s4p	10.20	23.31	23.93	4.58	0.17
6	rabinovich_3ck_adhoc_01a_071019\Impaired_C2C_16dB_P1_to_P2_THRU_ExtPEC.s4p	15.80	26.02	25.76	2.49	0.17
7	rabinovich_3ck_adhoc_01a_071019\Impaired_C2C_18dB_P1_to_P2_THRU_ExtPEC.s4p	18.18	26.69	26.04	1.97	0.17
8	rabinovich_3ck_adhoc_01a_071019\Impaired_C2C_20dB_P1_to_P2_THRU_ExtPEC.s4p	19.52	26.96	26.18	1.73	0.17
9	gore_3ck_01a_0519\C2C_PCB_SYSVIA_12dB_thru.s4p	12.17	22.81	17.83	0.98	0.11
10	gore_3ck_01a_0519\C2C_PCB_SYSVIA_14dB_thru.s4p	14.09	24.12	17.91	0.85	0.11
11	gore_3ck_01a_0519\C2C_PCB_SYSVIA_16dB_thru.s4p	16.03	25.04	17.98	0.75	0.11
12	gore_3ck_01a_0519\C2C_PCB_SYSVIA_18dB_thru.s4p	17.94	25.61	18.63	0.67	0.11
13	gore_3ck_01a_0519\C2C_PCB_SYSVIA_20dB_thru.s4p	20.08	26.21	19.40	0.61	0.12
14	gore_3ck_01a_0519\C2C_CA_CONN_SYSVIA_12dB_thru.s4p	11.54	16.71	16.66	1.37	0.12
15	gore_3ck_01a_0519\C2C_CA_CONN_SYSVIA_14dB_thru.s4p	13.82	17.30	17.23	1.13	0.12
16	gore_3ck_01a_0519\C2C_CA_CONN_SYSVIA_16dB_thru.s4p	15.93	17.71	17.66	0.93	0.12
17	gore_3ck_01a_0519\C2C_CA_CONN_SYSVIA_18dB_thru.s4p	17.98	18.32	18.39	0.80	0.13
18	gore_3ck_01a_0519\C2C_CA_CONN_SYSVIA_20dB_thru.s4p	19.86	19.10	18.94	0.69	0.13

For CH[1-4], 2 FEXT and 2 NEXT channels in the distribution were used as is.

For CH[5-8], single FEXT channel was replicated for 3 times.

For CH[9-18], 6 FEXT and 4 NEXT channels in the distribution were used as is.

# COM parameters

Nb=6 unless explicitly stated.

All combinations of TX zp = [6:16 28:31] (15 cases) and RX zp = [13 28:31] (5 cases) (total 15 \* 5 = 75 cases for each channel).

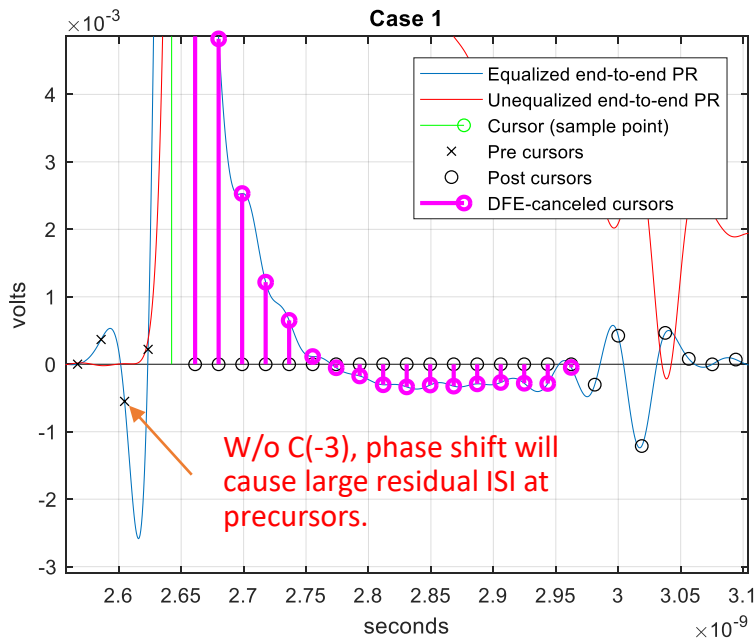
Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[13 31; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[11 29; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[13 31; 1.8 1.8]	mm	[test cases]
z_p (RX)	[11 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)	[-0.1:0.05:0]		[min:step:max]
N_b	6	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.2		
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	0	logical
DISPLAY_WINDOW	0	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\C2C_(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	10	dB
DER_0	1.00E-05	
T_r	6.16E-03	ns
FORCE_TR	1	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	3000	
beta_x	2.53E+09	
rho_x	0.25	
fixture delay time	[ 0 0 ]	[ port1 port2 ]
TDR_W_TXPKG	0	
N_bx	24	UI
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.2E-09	V^2/GHz
SNR_TX	33	dB
R_LM	0.95	

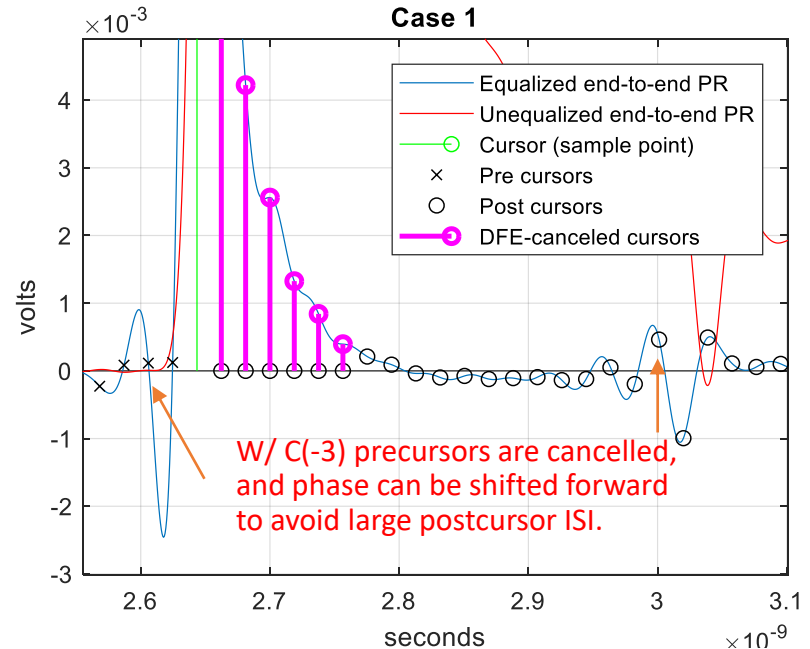
Table 93A-3 parameters		
Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.141E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5 ]	Ohm
benartsi_3ck_01_0119 & mellitz_3ck_01_0119		
Table 92-12 parameters		
Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
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	0.2	max DFE value for floating taps
B_float_RSS_MAX	0.03	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN parameters		
f_v	0.723	*Fb
f_f	0.723	*Fb
f_n	0.723	*Fb
f_2	39.844	GHz
A_ft	0.600	V
A_nt	0.600	V
heck_3ck_03b_0319	Adopted Mar 2019	kasapi_3ck_02_1119
walker_3ck_01d_0719	Adopted July 2019	Adopted Nov 2019
result of R_d=50		under consideration
benartsi_3ck_01a_0719	no used for KR	
mellitz_3ck_03_0919		

# C(-3) Functionality – Phase Optimization

- ❖ C(-3) allows phase optimization to avoid large postcursor ISI ([healey 3ck adhoc 01 031120](#))
- ❖ With C(-3), post 18 is avoided by shifting phase forward.
- ❖ W/o C(-3), this phase shift will cause large residual ISI at precursors.



Nb=17 w/o C(-3), COM=2.6 dB



Nb=6 with C(-3), COM=3.1 dB

W/o C(-3), around 20 DFE taps are needed to pass 3 dB COM by cancel postcursor ISI.

# Slide 8 of sun\_3ck\_adhoc\_01\_030420

- Re-simulated COM w/ vs w/o c(-3) with  $f_{LF}=f_b/40$  for tough zp values.
- $f_{LF}=f_b/40$  improves COM.
- C(-3) improves COM by up to 0.7 dB at critical region.

