C2C TX/RX COM Parameters

Yasuo Hidaka, Credo
Junqing (Phil) Sun, Credo

IEEE P802.3ck Task Force

Overview

- This is to analyze TX/RX COM parameters for C2C including:
  - Reference receiver DFE tap length and weight constraints
  - TX FIR number of taps

- C2C SERDES receiver costs a lot more power than TX. Reference receiver should be minimal performance.
  - KR/CR reference receiver is an overkill.

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

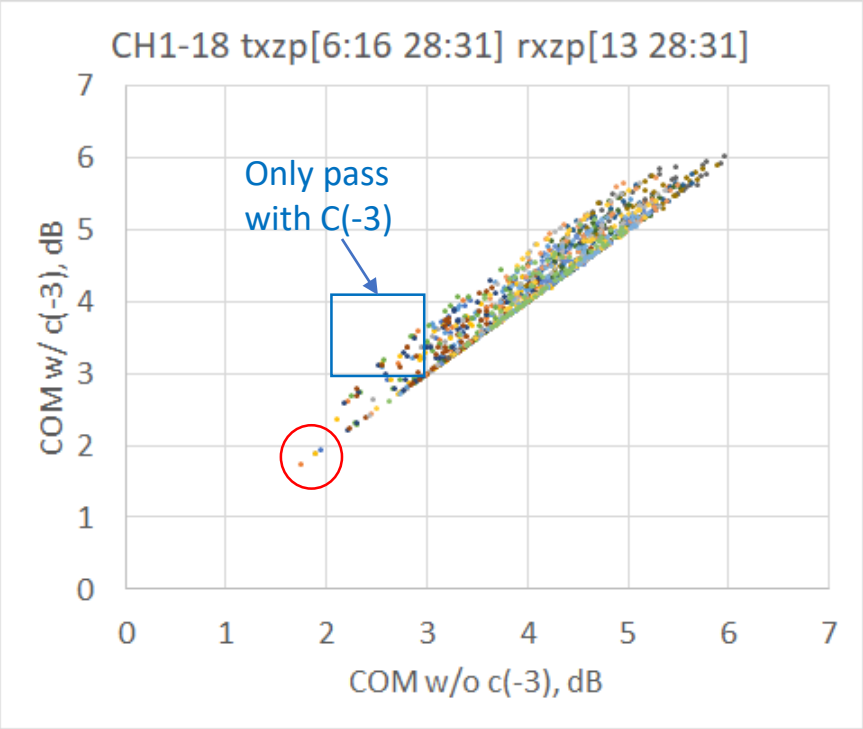
We assumed 5-tap DFE. No floating taps.
All combinations of TX zp = [6:16 28:31] (15 cases) and RX zp = [13 28:31] (5 cases) (total 15 * 5 = 75 cases for each channel).

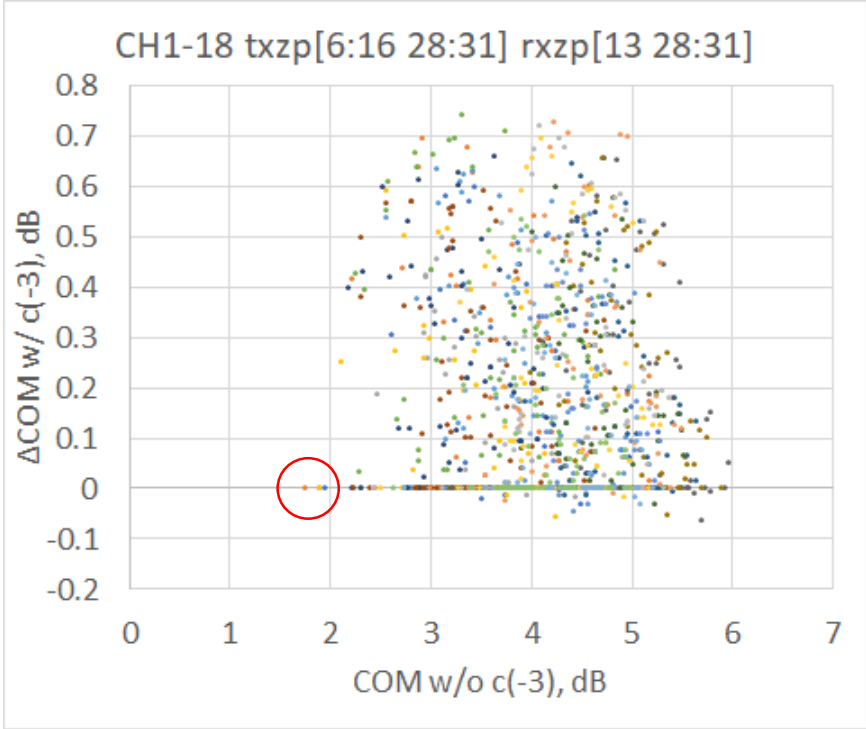
Table 93A-1 parameters			
Parameter	**Setting**	**Units**	**Information**
f_b	53.125	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.2e-4 1.2e-4]	nF	[TX RX]
L_s	[0.12, 0.12]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
z_p select	[1]		[test cases to run]
z_p (TX)	[13 31; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[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	0.4	V	
A_fe	0.4	V	
A_ne	0.6	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	5	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		

COM Results w/ Default COM Table





- Bad COM results in red circles are CH1-4 for both TX and RX zp are exactly 13mm.
- C(-3) improves COM by up to 0.8 dB at critical region.

Tough Tx & Rx zp values

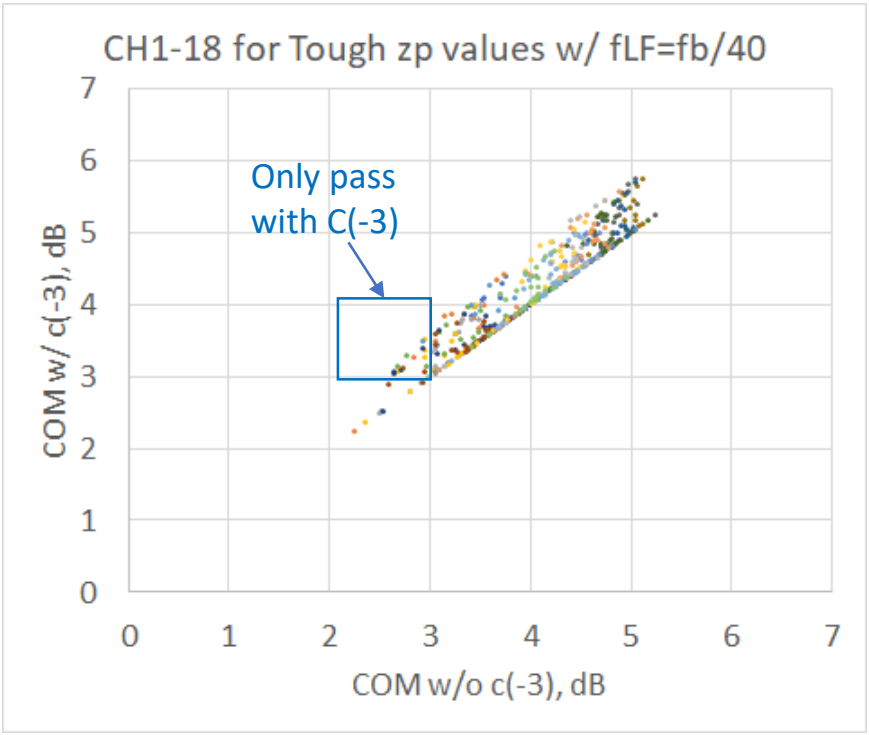
Tough Tx & Rx zp values were chosen based on CH1 COM w/o c(-3) < 3.5dB.

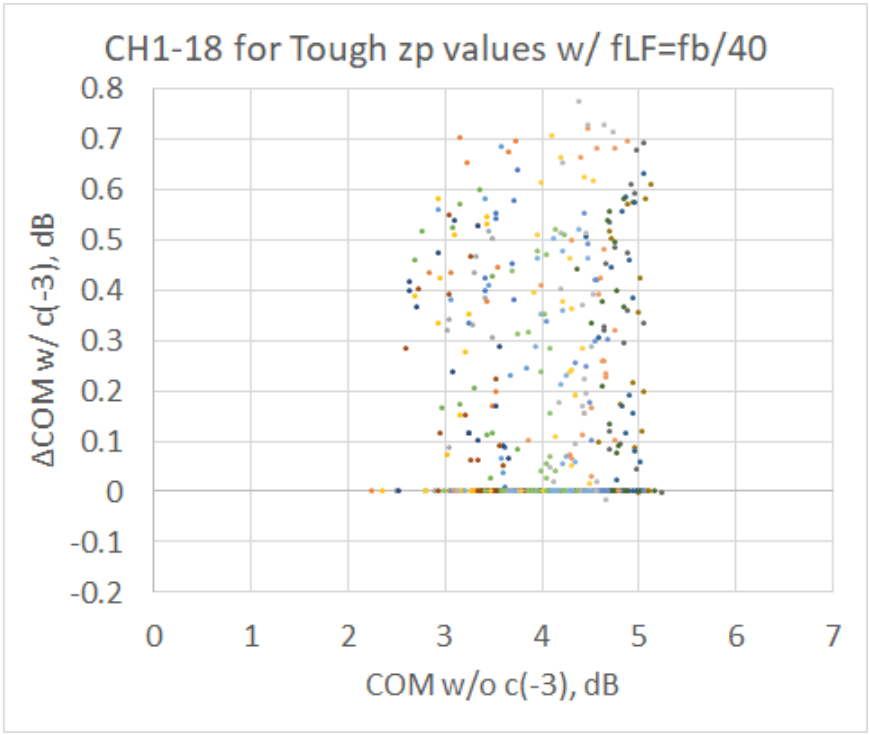
- Blank cells are easy Tx & Rx zp values where CH1 COM w/o c(-3) ≥ 3.5dB.
- Both Tx zp and Rx zp being 13mm is very tough.
  - As discussed for KR/CR, TX/RX with exactly the same Zp is too pessimistic.

	CH1 COM w/ c(-3) vs w/o c(-3) (dB)									
Rx zp (mm)	13		28		29		30		31	
Tx zp (mm)	w/ c(-3)	w/o c(-3)	w/ c(-3)	w/o c(-3)	w/ c(-3)	w/o c(-3)	w/ c(-3)	w/o c(-3)	w/ c(-3)	w/o c(-3)
6										
7	3.4258	3.4258								
8	2.9117	2.6067	3.7150	3.1353	3.6487	3.3371	3.4785	3.0833	3.7819	3.2230
9	3.4047	3.4047								
10	3.3284	3.3284	3.3882	3.3882					3.4397	3.4397
11			3.9445	3.3754			3.7284	3.3243	4.0270	3.4268
12										
13	1.9367	1.9367	3.3116	3.3116	3.3882	3.3882	3.2482	3.2482	3.3754	3.3754
14										
15										
16	3.3882	3.3882	3.2609	3.2609	3.4655	3.4655	3.3882	3.3882	3.3882	3.3371
28	3.3754	3.3754	3.5697	3.2356						
29										
30	3.2609	3.2609					3.1353	3.1353		
31	3.4011	3.4011								

COM with $f_{LF}=f_b/40$

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





CH# and zp values of COM failing with $f_{LF}=f_b/40$

- There are many cases in which 3dB COM passed only with c(-3).
- With C(-3), all channels pass unless TX/RX have identical package length which is unlikely in the field.
  - COM is close or better than 3dB unless TX/RX zp are both exactly 13 mm.

3dB COM passed only with c(-3)

	tx	rx	pass only		COM	COM	ΔCOM	TX FIR
ch	zp	zp	w/ c(-3)	Both fail	w/ c(-3)	w/o c(-3)	w/ c(-3)	c(-3)
ch002	8	13	TRUE	FALSE	3.2636	2.831	0.4326	-0.02
ch004	8	13	TRUE	FALSE	3.0722	2.6845	0.3877	-0.02
ch004	8	28	TRUE	FALSE	3.5175	2.9379	0.5796	-0.02
ch004	8	30	TRUE	FALSE	3.2735	2.94	0.3335	-0.02
ch004	28	28	TRUE	FALSE	3.3754	2.9504	0.425	-0.02
ch005	28	28	TRUE	FALSE	3.4911	2.9299	0.5612	-0.02
ch006	8	13	TRUE	FALSE	3.1306	2.9627	0.1679	-0.02
ch006	8	28	TRUE	FALSE	3.2788	2.7633	0.5155	-0.02
ch006	28	28	TRUE	FALSE	3.1407	2.6822	0.4585	-0.02
ch007	8	13	TRUE	FALSE	3.0775	2.7098	0.3677	-0.02
ch007	8	28	TRUE	FALSE	3.0609	2.6443	0.4166	-0.02
ch007	8	31	TRUE	FALSE	3.4011	2.9276	0.4735	-0.02
ch007	28	28	TRUE	FALSE	3.0362	2.6389	0.3973	-0.02
ch008	8	13	TRUE	FALSE	3.0628	2.9456	0.1172	-0.02
ch008	8	28	TRUE	FALSE	3.1229	2.7217	0.4012	-0.02

3dB COM failed regardless of c(-3)

	tx	rx	pass only		COM	COM	ΔCOM	TX FIR
ch	zp	zp	w/ c(-3)	Both fail	w/ c(-3)	w/o c(-3)	w/ c(-3)	c(-3)
ch001	13	13	FALSE	TRUE	2.5143	2.5143	0	0
ch002	13	13	FALSE	TRUE	2.2487	2.2487	0	0
ch003	13	13	FALSE	TRUE	2.4988	2.4988	0	0
ch003	30	30	FALSE	TRUE	2.9017	2.9017	0	0
ch004	13	13	FALSE	TRUE	2.3511	2.3511	0	0
ch004	30	30	FALSE	TRUE	2.7932	2.7932	0	0
ch006	13	13	FALSE	TRUE	2.8006	2.8006	0	0
ch007	13	13	FALSE	TRUE	2.5252	2.5252	0	0
ch008	13	13	FALSE	TRUE	2.926	2.926	0	0
ch008	28	28	FALSE	TRUE	2.8775	2.5919	0.2856	-0.02
ch016	13	13	FALSE	TRUE	2.7997	2.7997	0	0
ch018	13	13	FALSE	TRUE	2.9871	2.9871	0	0

Summary

- C(-3) improves COM significantly: up to 0.8 dB at critical region.

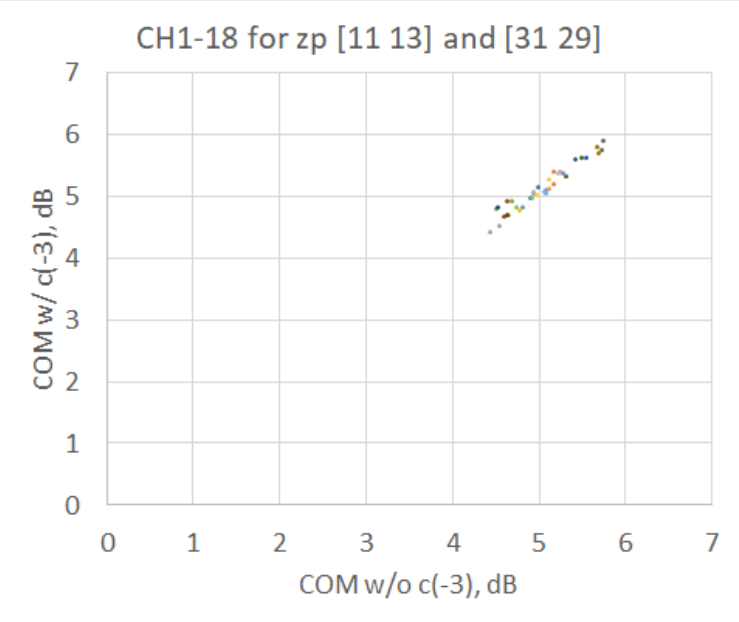
- 5-tap DFE is a good balance of power and performance for C2C.
  - Sufficient for all 18 channels.

- Proposals:
  - RX parameters in Table 120F-5: Nb=5, bmax(1)=0.85 and bmax(2:5)=0.2
  - TX parameters: remove editor's note regarding C(-3) in Clause 120F.3.1.3. Keep TX FIR C(-3) in table 120F-5 as it is.

Backup Slides

COM values for parameters in D1.0

- Plotted Tx 11mm / Rx 13mm and Tx 31mm / Rx 29mm
  - We did not simulate Tx 13mm / Rx 11mm as specified in D1.0
  - This result is for the default $f_{LF} = f_b/80$
- 5-tap DFE with COM parameters in D1.0 passes 3dB COM for all 18 channels



	tx	rx	COM	COM	ΔCOM	tx	rx	COM	COM	ΔCOM
ch	zp	zp	w/ c(-3)	w/o c(-3	w/ c(-3)	zp	zp	w/ c(-3)	w/o c(-3	w/ c(-3)
ch001	11	13	5.1455	4.9829	0.1626	31	29	4.9744	4.8978	0.0766
ch002	11	13	5.4005	5.177	0.2235	31	29	5.1927	5.177	0.0157
ch003	11	13	4.5243	4.5338	-0.0095	31	29	4.4225	4.437	-0.0145
ch004	11	13	4.7765	4.7765	0	31	29	4.6866	4.642	0.0446
ch005	11	13	5.0421	4.9414	0.1007	31	29	4.8128	4.8057	0.0071
ch006	11	13	4.7909	4.4998	0.2911	31	29	4.913	4.6866	0.2264
ch007	11	13	4.8066	4.5243	0.2823	31	29	4.7015	4.6272	0.0743
ch008	11	13	4.913	4.6272	0.2858	31	29	4.6717	4.5977	0.074
ch009	11	13	5.7326	5.7326	0	31	29	5.8828	5.747	0.1358
ch010	11	13	5.6955	5.6955	0	31	29	5.7977	5.6799	0.1178
ch011	11	13	5.619	5.5536	0.0654	31	29	5.5968	5.4167	0.1801
ch012	11	13	5.6134	5.4981	0.1153	31	29	5.32	5.32	0
ch013	11	13	5.3682	5.2721	0.0961	31	29	5.0829	5.0829	0
ch014	11	13	5.1208	5.1208	0	31	29	5.4005	5.2369	0.1636
ch015	11	13	5.0669	4.9387	0.1282	31	29	5.3682	5.2244	0.1438
ch016	11	13	5.0207	4.9668	0.0539	31	29	5.2561	5.1141	0.142
ch017	11	13	5.0673	5.0673	0	31	29	5.0518	5.0829	-0.0311
ch018	11	13	4.9744	4.913	0.0614	31	29	4.8218	4.7314	0.0904

Channels Only Pass with C(-3) when fLF=fb/80

	tx	rx	pass only	COM	COM	ΔCOM	TX FIR
ch	zp	zp	w/ c(-3)	w/ c(-3)	w/o c(-3)	w/ c(-3)	c(-3)
ch002	8	28	TRUE	3.5045	2.8654	0.6391	-0.02
ch002	8	30	TRUE	3.1478	2.7098	0.438	-0.02
ch002	8	31	TRUE	3.596	2.9017	0.6943	-0.02
ch003	8	28	TRUE	3.3626	2.9431	0.4195	-0.02
ch003	8	30	TRUE	3.2356	2.926	0.3096	-0.02
ch003	8	31	TRUE	3.3626	2.9382	0.4244	-0.02
ch003	28	28	TRUE	3.223	2.9626	0.2604	-0.02
ch004	8	28	TRUE	3.1353	2.5452	0.5901	-0.02
ch004	8	29	TRUE	3.1853	2.926	0.2593	-0.02
ch004	8	31	TRUE	3.2356	2.7335	0.5021	-0.02
ch004	11	30	TRUE	3.2862	2.9871	0.2991	-0.02
ch004	28	28	TRUE	3.2482	2.926	0.3222	-0.02
ch005	8	28	TRUE	3.2259	2.849	0.3769	-0.02
ch005	28	28	TRUE	3.0912	2.5523	0.5389	-0.02
ch006	8	31	TRUE	3.1105	2.5569	0.5536	-0.02
ch006	11	28	TRUE	3.1853	2.5773	0.608	-0.02
ch006	11	31	TRUE	3.5045	2.8379	0.6666	-0.02
ch006	14	28	TRUE	3.5045	2.8647	0.6398	-0.02
ch007	11	28	TRUE	3.1105	2.5104	0.6001	-0.02
ch007	11	29	TRUE	3.3626	2.9993	0.3633	-0.02
ch007	11	31	TRUE	3.2482	2.8052	0.443	-0.02
ch007	12	28	TRUE	3.3626	2.9871	0.3755	-0.02
ch007	14	28	TRUE	3.2989	2.7693	0.5296	-0.02
ch007	31	31	TRUE	3.4785	2.8654	0.6131	-0.02
ch008	8	29	TRUE	3.0116	2.9017	0.1099	-0.02
ch008	8	31	TRUE	3.098	2.7335	0.3645	-0.02
ch008	11	28	TRUE	3.1105	2.5452	0.5653	-0.02
ch008	11	31	TRUE	3.3754	2.8052	0.5702	-0.02
ch008	14	28	TRUE	3.3626	2.7932	0.5694	-0.02
ch008	31	31	TRUE	3.2482	2.8896	0.3586	-0.02