

C2C Channel Equalization Options

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Overview

❑ C2C COM analysis

- 4 Lim channels between 16.5 to 17.5 dB loss
- 1 Gore PCB channel with 20 dB loss
- 1 Gore cabled channel with 20 dB loss

❑ Equalizer considered

- 5 tap DFE, 12 tap DFE, and 3 tap FFE + 2T floating DFE with 12 UI span

❑ Key consideration for C2C link are:

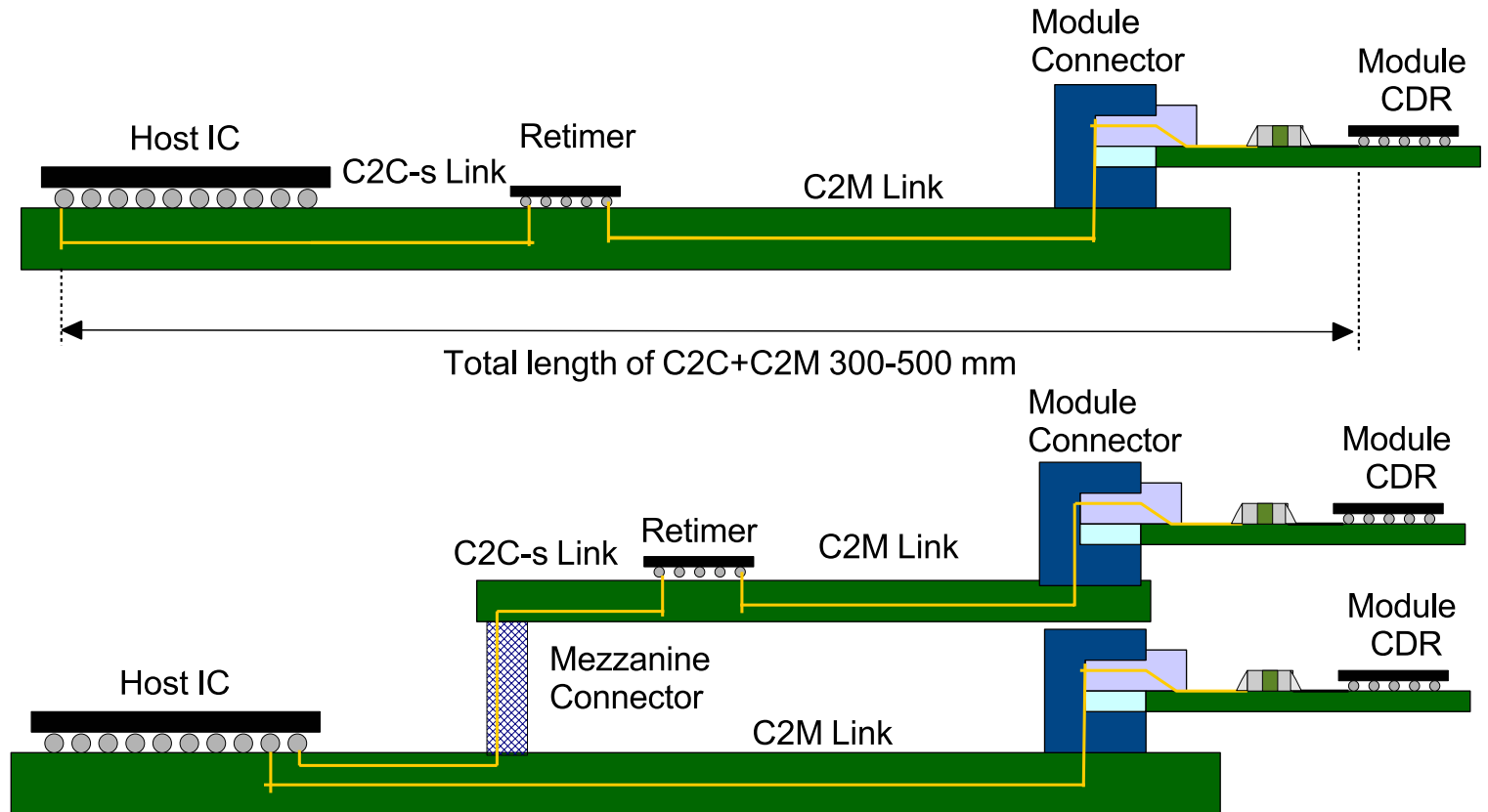
- Operation with end-end FEC where link must operate with acceptable burst error rate
- Given that key application of C2C links are retimers/inverse-gearbox
- Low power is a key consideration

❑ Addressing comment 133 and 134.

Two Common C2C-S Applications

□ These two common C2C applications can be satisfied with ~300 mm trace and by repurposing 16 dB C2M budget

- Connecting to far-side of the ASIC IO may require retimer
- Modules mounted on mezzanine card.



COM 2.7.6 Table for C2C

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 3 4 5]		[test cases to run]
z_p (TX)	[13 13 13 31 31; 1.8 1.8 1.8 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[13 13 13 31 31; 1.8 1.8 1.8 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[13 13 13 31 31; 1.8 1.8 1.8 1.8 1.8]	mm	[test cases]
z_p (RX)	[7 11 13 13 29; 1.8 1.8 1.8 1.8 1.8]	mm	[test cases]
C_p	[0.87e-4 0.87e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 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	5	UI	
b_max(1)	0.75		
b_max(2..N_b)	0.1		
g_DC	[-16:1:0]	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	

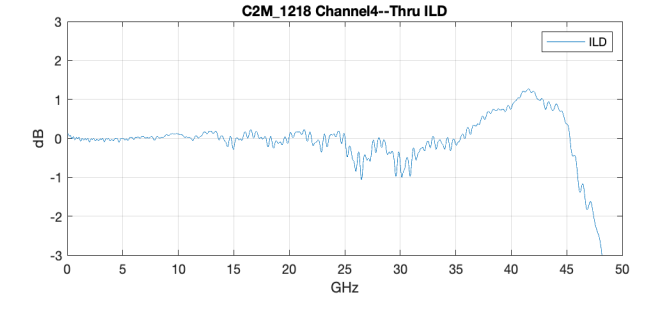
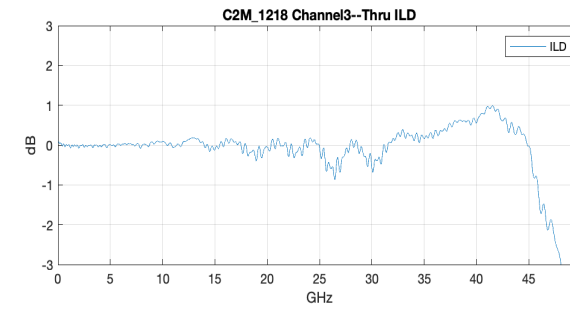
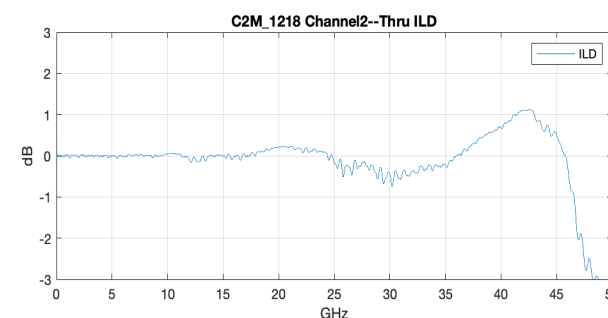
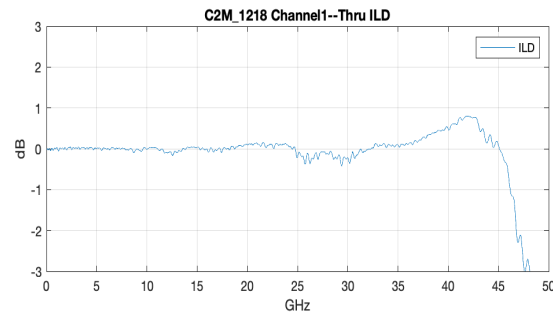
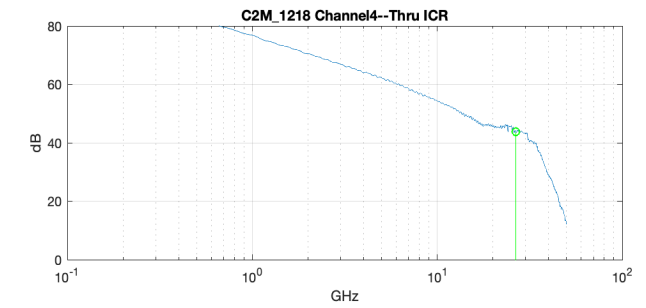
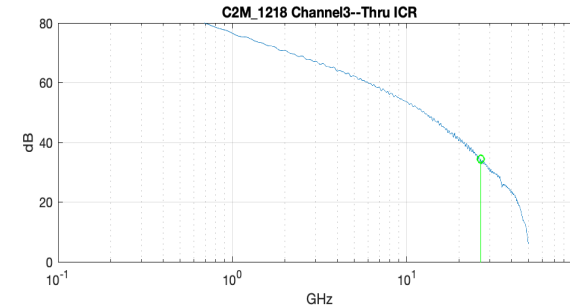
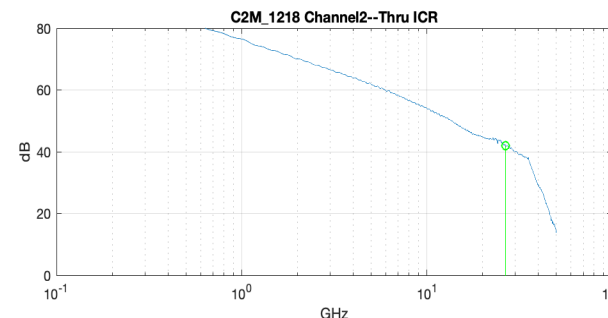
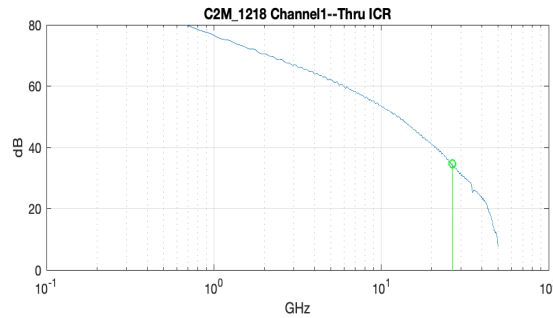
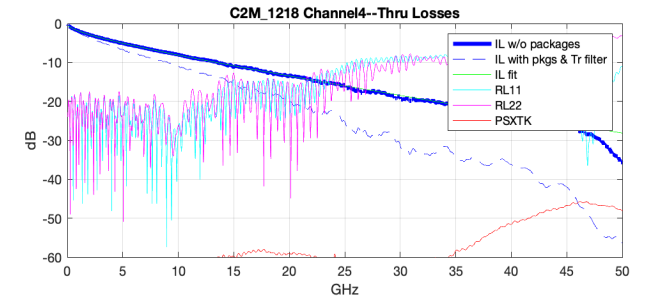
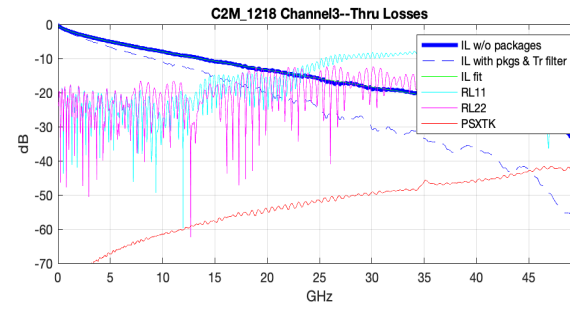
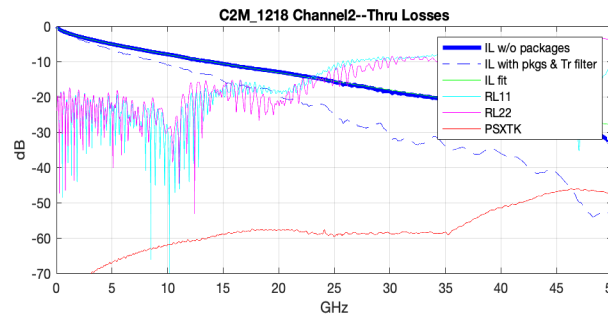
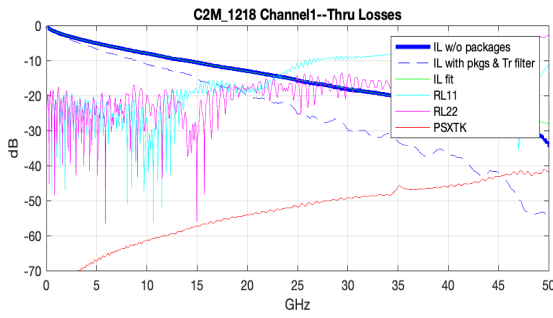
I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_KR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	KR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-05	
T_r	6.16E-03	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	300	
beta_x	2.3407E+09	
rho_x	0.19	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	5	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	2	taps per group
N_f	12	UI span for floating taps
bmaxg	0.1	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		

Lim C2C Channels

- **Total of 4 channels were built with optimized host ASIC, retimer & mezzanine connector footprint (shallow via breakout). Both shallow and long via are considered at connector and retimer footprint.**
 - Channel 1: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (shallow via breakout) + daughtercard trace 4” + Retimer footprint (shallow via) ; including 2 FEXT & 2 NEXT
 - Channel 2: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (shallow via breakout) + daughtercard trace 4” + Retimer footprint (long via); including 2 FEXT & 2 NEXT
 - Channel 3: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (long via breakout) + daughtercard trace 4” + Retimer footprint (shallow via) ; including 2 FEXT & 2 NEXT
 - Channel 4: ASIC BGA footprint (mid via – L17) TX + host trace 7” + Mezzanine footprint & connector (long via breakout) + daughtercard trace 4” + Retimer footprint (long via) ; including 2 FEXT & 2 NEXT
 - http://www.ieee802.org/3/ck/public/tools/c2c/lim_3ck_05_0719_c2c.zip.

Lim C2C Channels



COM Summary Lim C2C Channel 1

❑ Reducing B1max to 0.5 has no material impact on COM but for [13,13] mm PKG with 5T DFE 0.1 dB penalty.

Lim C2C Channel 1	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	16.6	24.7	18.4/17.4	0.06	1.87	3.9	3.5
Package [13,11] mm	5T	16.6	24.0	18.4/17.4	0.06	1.87	4.9	4.4
Package [13,13] mm	5T	16.6	25.4	18.4/17.4	0.06	1.87	2.3	1.9
Package [13,29] mm	5T	16.6	26.7	18.4/17.4	0.06	1.87	3.8	3.7
Package [31,29] mm	5T	16.6	27.9	18.4/17.4	0.06	1.87	5.2	5.0
Package [13,7] mm	12T	16.6	24.7	18.4/17.4	0.06	1.87	6.4	6.4
Package [13,11] mm	12T	16.6	24.0	18.4/17.4	0.06	1.87	6.5	6.3
Package [13,13] mm	12T	16.6	25.4	18.4/17.4	0.06	1.87	6.2	6.1
Package [13,29] mm	12T	16.6	26.7	18.4/17.4	0.06	1.87	5.9	5.7
Package [31,29] mm	12T	16.6	27.9	18.4/17.4	0.06	1.87	5.6	5.4
Package [13,7] mm	3T+2T Float 12 UI	16.6	24.7	18.4/17.4	0.06	1.87	4.1	3.7
Package [13,11] mm	3T+2T Float 12 UI	16.6	24.0	18.4/17.4	0.06	1.87	5.6	5.4
Package [13,13] mm	3T+2T Float 12 UI	16.6	25.4	18.4/17.4	0.06	1.87	4.1	4.0
Package [13,29] mm	3T+2T Float 12 UI	16.6	26.7	18.4/17.4	0.06	1.87	4.6	4.5
Package [31,29] mm	3T+2T Float 12 UI	16.6	27.9	18.4/17.4	0.06	1.87	5.2	5.0

COM Summary Lim C2C Channel 2

☐ Reducing B1max to 0.5 has no material impact on COM but for [13,13] mm PKG with 5T DFE 0.3 dB penalty.

Lim C2C Channel 2	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	16.9	26.5	18.4/16.2	0.095	1.34	3.9	3.3
Package [13,11] mm	5T	16.9	25.1	18.4/16.2	0.095	1.34	5.6	5.1
Package [13,13] mm	5T	16.9	27.1	18.4/16.2	0.095	1.34	2.2	1.8
Package [13,29] mm	5T	16.9	28.4	18.4/16.2	0.095	1.34	3.5	3.4
Package [31,29] mm	5T	16.9	29.4	18.4/16.2	0.095	1.34	5.4	5.2
Package [13,7] mm	12T	16.9	26.5	18.4/16.2	0.095	1.34	6.8	6.4
Package [13,11] mm	12T	16.9	25.1	18.4/16.2	0.095	1.34	6.8	6.9
Package [13,13] mm	12T	16.9	27.1	18.4/16.2	0.095	1.34	6.5	6.3
Package [13,29] mm	12T	16.9	28.4	18.4/16.2	0.095	1.34	6.1	5.9
Package [31,29] mm	12T	16.9	29.4	18.4/16.2	0.095	1.34	5.8	5.6
Package [13,7] mm	3T+2T Float 12 UI	16.9	26.5	18.4/16.2	0.095	1.34	3.9	3.6
Package [13,11] mm	3T+2T Float 12 UI	16.9	25.1	18.4/16.2	0.095	1.34	5.8	5.7
Package [13,13] mm	3T+2T Float 12 UI	16.9	27.1	18.4/16.2	0.095	1.34	4.1	4.0
Package [13,29] mm	3T+2T Float 12 UI	16.9	28.4	18.4/16.2	0.095	1.34	4.6	4.5
Package [31,29] mm	3T+2T Float 12 UI	16.9	29.4	18.4/16.2	0.095	1.34	5.3	5.3

COM Summary Lim C2C Channel 3

❑ Reducing B1max to 0.5 has no material impact on COM but for [13,13] mm PKG with 5T DFE 0.3 dB penalty.

Lim C2C Channel 3	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	16.7	25.9	17.3/15.4	0.108	1.81	3.6	3.3
Package [13,11] mm	5T	16.6	25.3	17.3/15.4	0.108	1.87	4.2	3.9
Package [13,13] mm	5T	16.6	26.6	17.3/15.4	0.108	1.87	2.3	2.0
Package [13,29] mm	5T	16.6	27.7	17.3/15.4	0.108	1.87	3.4	3.4
Package [31,29] mm	5T	16.6	29.0	17.3/15.4	0.108	1.87	4.7	4.5
Package [13,7] mm	12T	16.6	24.7	17.3/15.4	0.108	1.87	5.7	5.6
Package [13,11] mm	12T	16.6	24.0	17.3/15.4	0.108	1.87	5.5	5.4
Package [13,13] mm	12T	16.6	25.4	17.3/15.4	0.108	1.87	5.5	5.4
Package [13,29] mm	12T	16.6	26.7	17.3/15.4	0.108	1.87	5.1	5.0
Package [31,29] mm	12T	16.6	27.9	17.3/15.4	0.108	1.87	5.0	4.8
Package [13,7] mm	3T+2T Float 12 UI	16.6	24.7	17.3/15.4	0.108	1.87	3.7	3.3
Package [13,11] mm	3T+2T Float 12 UI	16.6	24.0	17.3/15.4	0.108	1.87	4.6	4.5
Package [13,13] mm	3T+2T Float 12 UI	16.6	25.4	17.3/15.4	0.108	1.87	3.9	2.6
Package [13,29] mm	3T+2T Float 12 UI	16.6	26.7	17.3/15.4	0.108	1.87	4.9	4.0
Package [31,29] mm	3T+2T Float 12 UI	16.6	27.9	17.3/15.4	0.108	1.87	4.7	4.5

COM Summary Lim C2C Channel 4

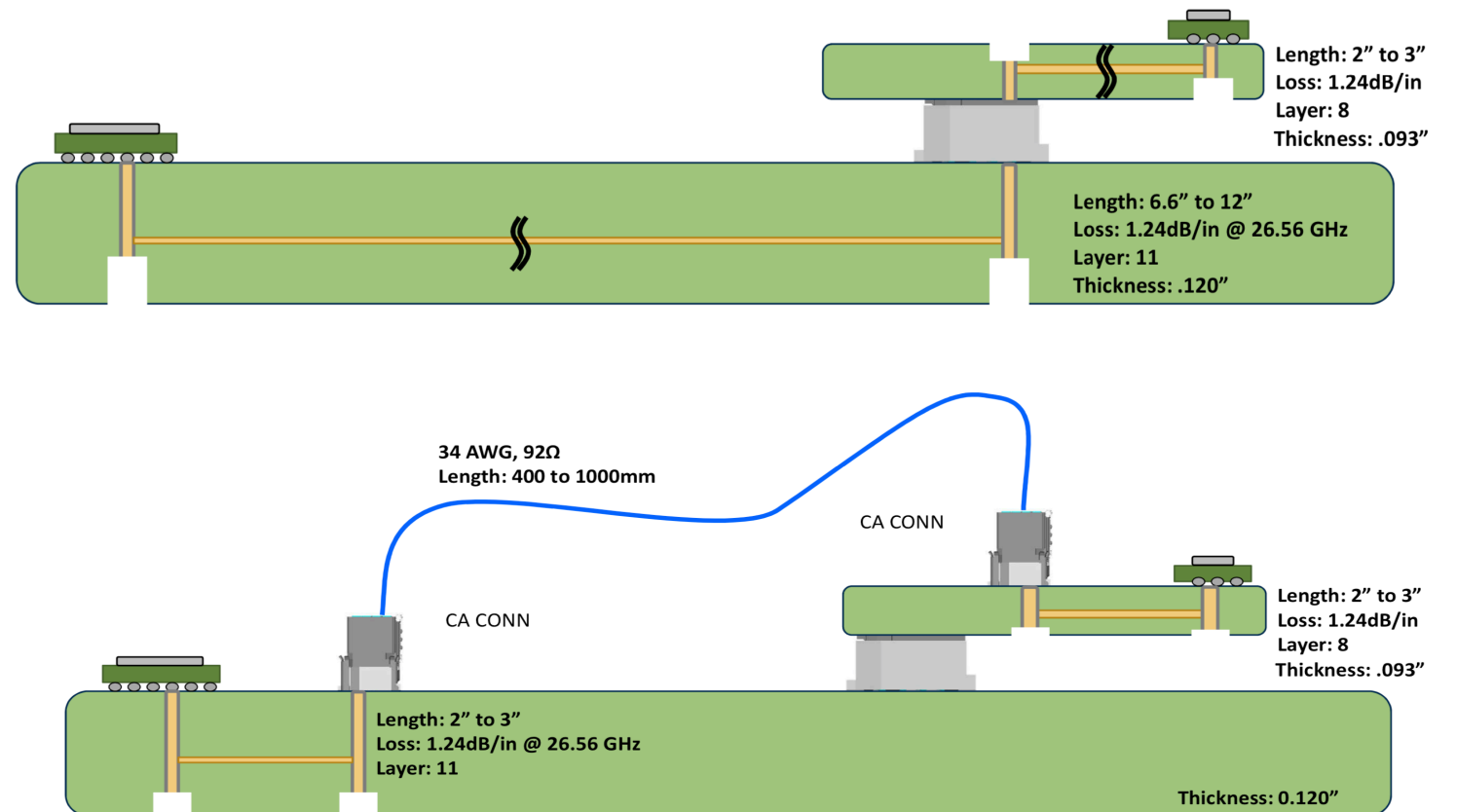
❑ Reducing B1max to 0.5 with 5T DFE there is up to 0.3 dB penalty.

Lim C2C Channel 4	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	17.8	28.2	17.1/14.4	0.125	1.18	3.8	3.3
Package [13,11] mm	5T	17.8	26.6	17.1/14.4	0.125	1.18	5.0	4.3
Package [13,13] mm	5T	17.8	28.8	17.1/14.4	0.125	1.18	2.3	1.8
Package [13,29] mm	5T	17.8	30.0	17.1/14.4	0.125	1.18	3.4	3.2
Package [31,29] mm	5T	17.8	30.9	17.1/14.4	0.125	1.18	4.9	4.3
Package [13,7] mm	12T	17.8	28.2	17.1/14.4	0.125	1.18	6.1	6.0
Package [13,11] mm	12T	17.8	26.6	17.1/14.4	0.125	1.18	6.0	5.9
Package [13,13] mm	12T	17.8	28.8	17.1/14.4	0.125	1.18	5.8	5.7
Package [13,29] mm	12T	17.8	30.0	17.1/14.4	0.125	1.18	5.3	5.2
Package [31,29] mm	12T	17.8	30.9	17.1/14.4	0.125	1.18	5.1	4.9
Package [13,7] mm	3T+2T Float 12 UI	17.8	28.2	17.1/14.4	0.125	1.18	3.9	3.4
Package [13,11] mm	3T+2T Float 12 UI	17.8	26.6	17.1/14.4	0.125	1.18	5.1	4.9
Package [13,13] mm	3T+2T Float 12 UI	17.8	28.8	17.1/14.4	0.125	1.18	3.8	3.7
Package [13,29] mm	3T+2T Float 12 UI	17.8	30.0	17.1/14.4	0.125	1.18	4.0	3.9
Package [31,29] mm	3T+2T Float 12 UI	17.8	30.9	17.1/14.4	0.125	1.18	4.9	4.7

Gore C2C Channels

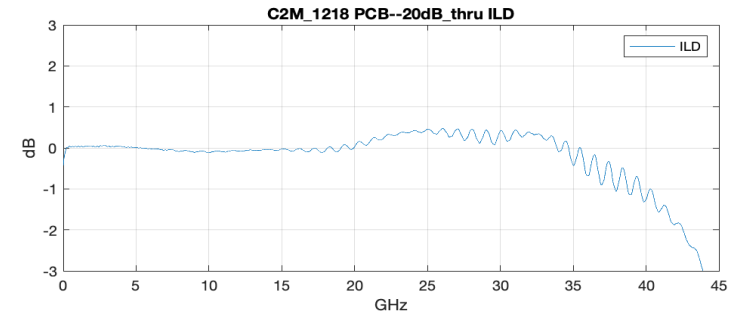
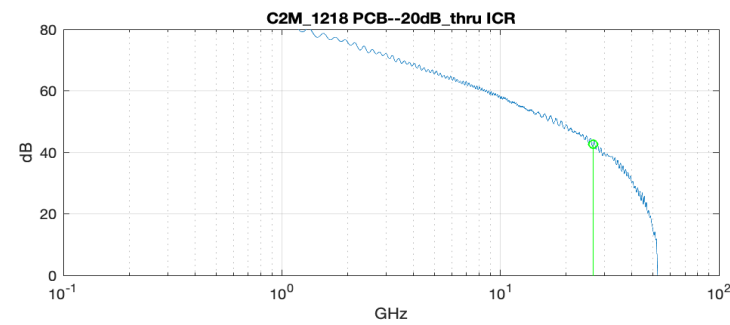
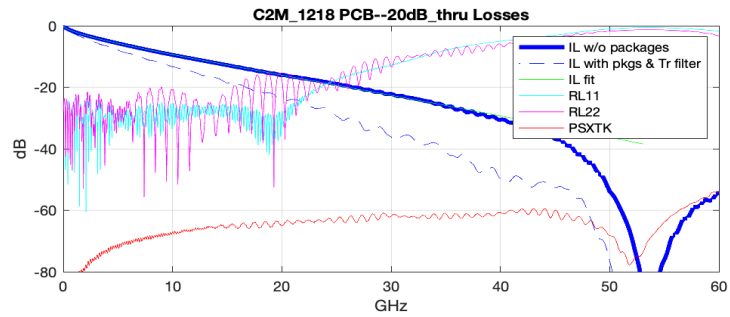
Construction of C2C channels based on PCB and cable construction provided by Brandon Gore

– http://www.ieee802.org/3/ck/public/19_05/gore_3ck_01a_0519.pdf

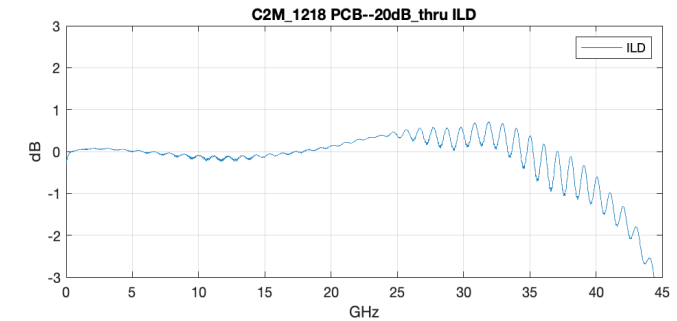
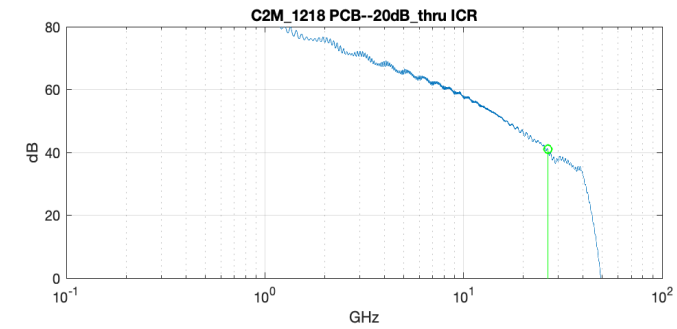
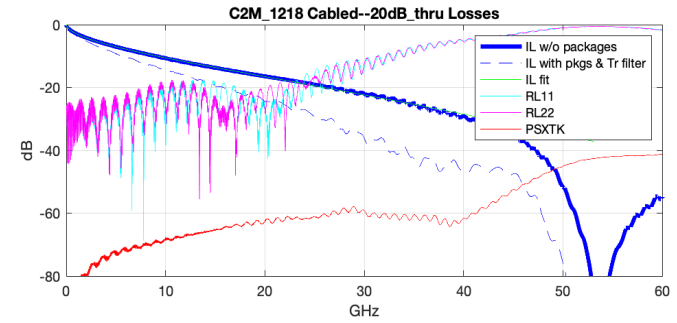


Gore C2C 20 dB Channels

PCB Channel



Cabled Channel



COM Summary Gore C2C Channels

20 dB PCB Channel	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	20.1	28.6	22.8/15.8	0.118	0.61	4.2	3.7
Package [13,11] mm	5T	20.1	27.5	22.8/15.8	0.118	0.61	5.5	5.3
Package [13,13] mm	5T	20.1	29.1	22.8/15.8	0.118	0.61	3.6	3.2
Package [13,29] mm	5T	20.1	30.5	22.8/15.8	0.118	0.61	4.4	4.3
Package [31,29] mm	5T	20.1	31.7	22.8/15.8	0.118	0.61	5.4	5.2

20 dB Cabled Channel	DFE Type	Fitted IL at 26.55 GHz (dB)	Total IL w PKG at 26.55 GHz (dB)	ERL (dB)	FOM ILD	ICN (mV)	COM RD=45 Ω	COM RD=50 Ω
Package [13,7] mm	5T	20.2	28.6	22.8/15.8	0.118	0.69	4.0	3.6
Package [13,11] mm	5T	20.2	27.7	22.8/15.8	0.118	0.69	5.4	5.0
Package [13,13] mm	5T	20.2	29.1	22.8/15.8	0.118	0.69	3.0	2.7
Package [13,29] mm	5T	20.2	30.4	22.8/15.8	0.118	0.69	4.0	3.9
Package [31,29] mm	5T	20.2	31.7	22.8/15.8	0.118	0.69	5.0	4.8

Options for C2C Reference Receiver

□ CTLE(14 dB HF, 4 dB LF) + 5T DFE

- Sufficient for 20 dB channels but can't support two pathological worst case [13,13] mm packages
- DFE $B1(\max) \leq 0.75$, $B[2-5] \leq 0.1$
 - Require pre-coder
- DFE $B1(\max) \leq 0.5$, $B[2-5] \leq 0.1$
 - Pre-coder not required but there could be up to 0.3 dB COM penalty
- Offers lowest power solution but it will not work on pathological [13,13] mm package combinations

□ CTLE(14 dB HF, 4 dB LF) + 12T DFE

- Can support 20 dB including pathological [13,13] mm packages combinations
- DFE $B1(\max) \leq 0.5$, $B[2-12] \leq 0.1$
 - Doesn't require pre-coder and works on all package combinations
- 12T DFE power will result in significant added power and overkill for the channel

□ CTLE(14 dB HF, 4 dB LF) + 3T DFE+2T floating DFE with 12 U span

- Can support 20 dB including pathological [13,13] mm packages combinations
- DFE $B1(\max) \leq 0.5$, $B[2-5] \leq 0.1$
 - Doesn't require pre-coder and works on all package combinations
- Will have lower power than 12T DFE and will work on pathological [13,13] mm package combination

□ To keep C2C power low total IL with PKG/Tr filter should be limited to 28 dB.