

C2M Simulation

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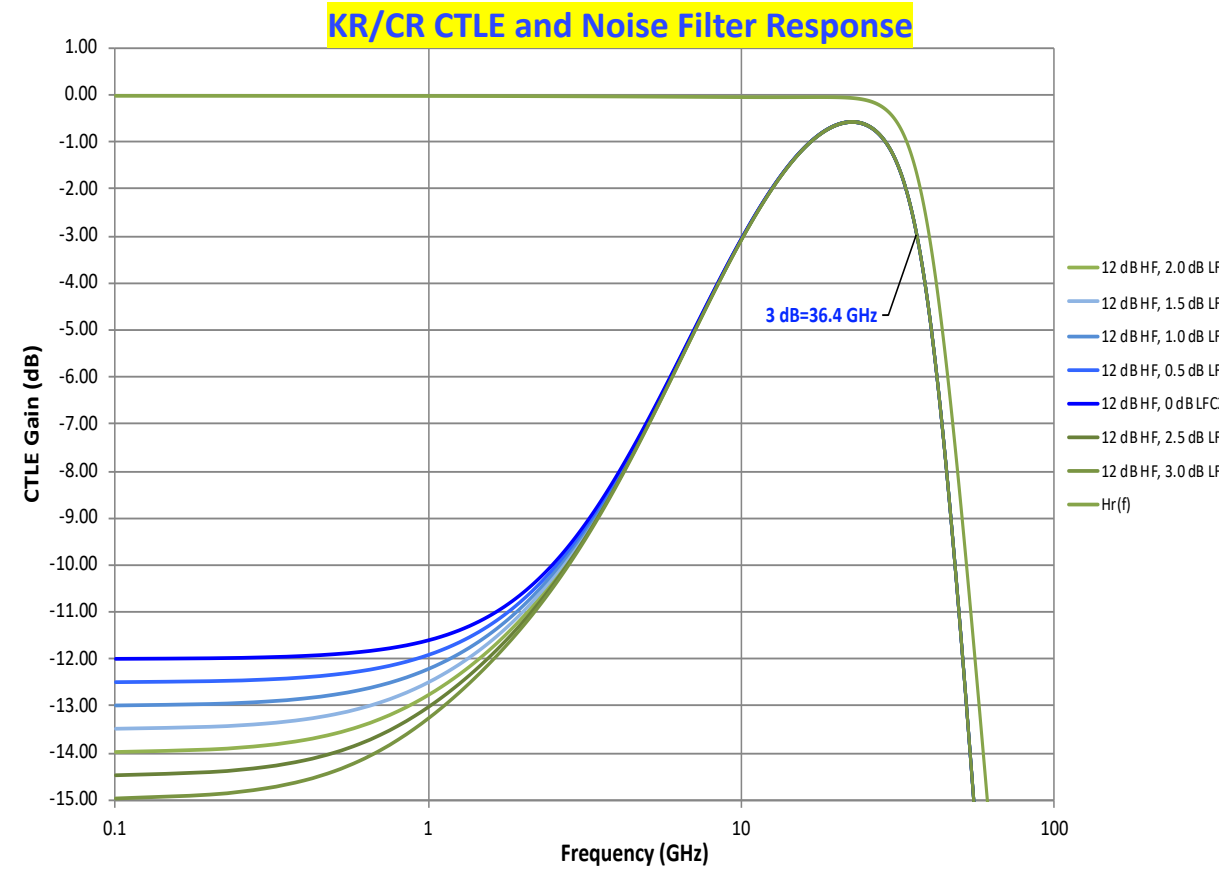
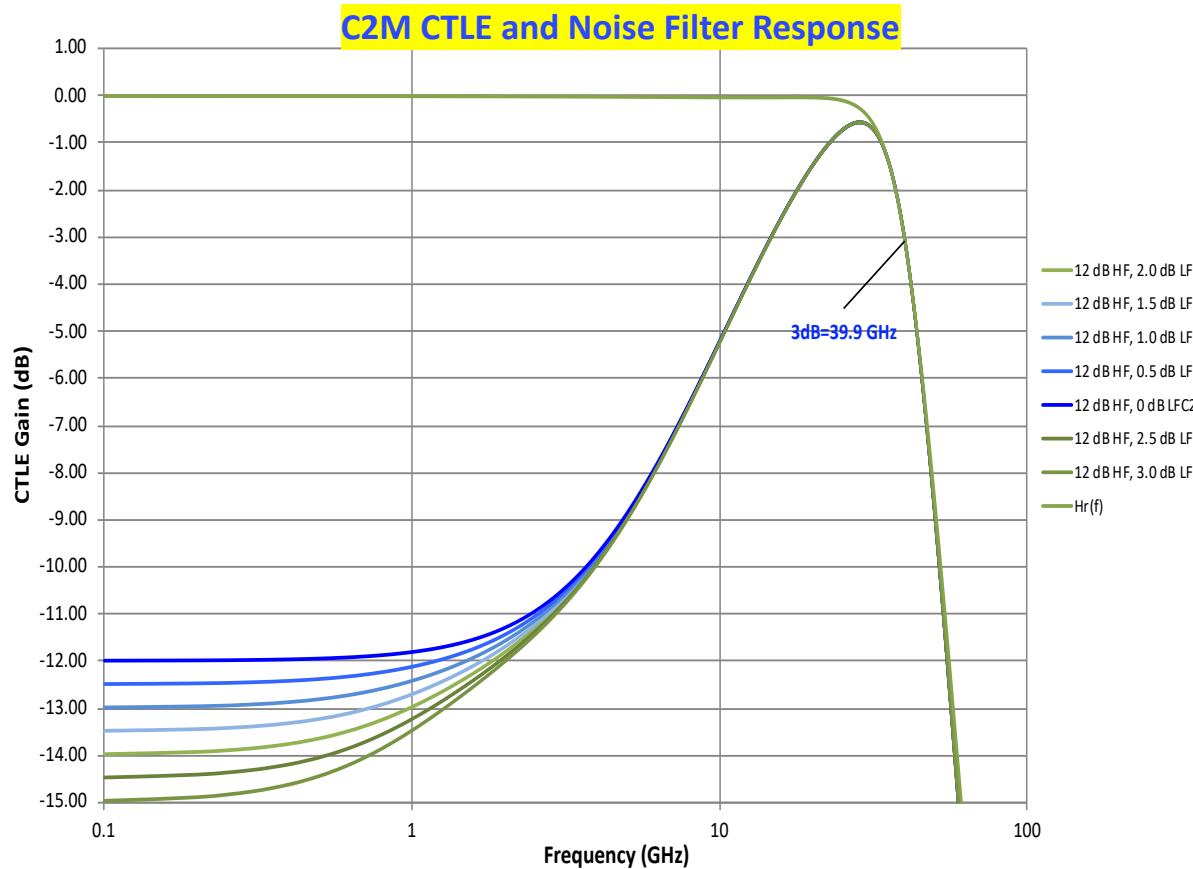
Overview

- ❑ Improved C2M/VSR CTLE response cascaded with noise filter response
- ❑ Results are with COM 2.5.8 with improved C2M CTLE with Butterworth 4th order LP post filter $fr=0.75$
- ❑ Channel investigated for C2M at TP1a and M2C simulation at TP4/TP5
 - Tracy OSFP micro-via channels exceed 3 dB COM with 5 T FFE
 - Tracy OSFP Long Barrel Via some channels do not meet 3 dB COM with 5 T FFE
 - Lim QSFP-dd channels do not pass 3 dB COM with 5T FFE after Cd increased from 90 ff to 110 ff
 - Both Tracy Lon Barrel via channels and Lim 16 dB previously passed 3 dB CON with Cd=90 ff
 - http://www.ieee802.org/3/ck/public/19_01/ghiasi_3ck_01c_0119.pdf
- ❑ The TP1a/TP5 is a weak generic equalizer to observe and sampler the signal
 - The actual equalizer may need additional capability to recover the signal at slicer.

Response of C2M and KR/CR CTLE and Noise Filters

□ Response of C2M and KR/CR CTLE with 12 dB and LF from 0 to 3 dB

- C2M CTLE has higher BW and designed to perform better with no DFE receiver
- Response below is noise filter and cascaded the CTLE+Hr(f) filters.



112G CTLE

IEEE Proposed 112G KR/CR CTLE Coefficients

- Low frequency gain sum of $g_{DC}+g_{DC2}$
- Low frequency zero/pole adjustable
- g_{DC} 0 to -15 dB in 1 dB step
- g_{DC2} 0 to -4 dB in 1 dB step
- $F_z=F_{\text{baud}}/4.25$
- $F_{p1}=F_b/1.8839$
- $F_{p2}=F_{\text{baud}}$
- $F_{IF}=F_{\text{baud}}/40$
- $f_r=0.75 \cdot F_{\text{baud}}$

Common CTLE Filter for KR/CR/C2M

$$H_{ctf}(f) = \frac{\left(10^{\frac{g_{DC}}{20}} + j\frac{f}{f_z}\right)\left(10^{\frac{g_{DC2}}{20}} + j\frac{f}{f_{LF}}\right)}{\left(1 + j\frac{f}{f_{p1}}\right)\left(1 + j\frac{f}{f_{p2}}\right)\left(1 + j\frac{f}{f_{LF}}\right)}$$

Proposed 112G C2M CTLE Coefficients are based on CL120E CTLE with enhance performance for non-DFE receiver

- Low frequency gain sum of $g_{DC}+g_{DC2}$
- Low frequency zero/pole adjustable
- g_{DC} 0 to -14 dB in 0.5 dB step
- g_{DC2} 0 to -3 dB in 0.5 dB step
- $F_z=F_{\text{baud}}/2.862$
- $F_{p1}=F_{\text{baud}}/1.8839$
- $F_{p2}=F_{\text{baud}}$
- $F_{IF}=F_{\text{baud}}/40$
- $f_r=0.75 \cdot F_{\text{baud}}$

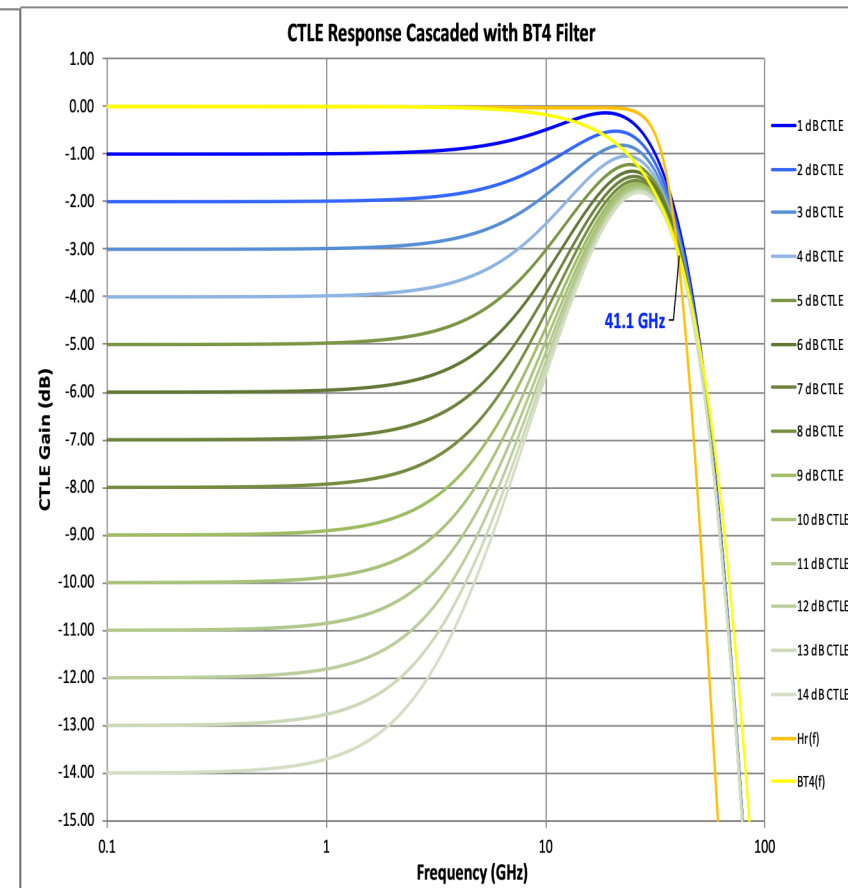
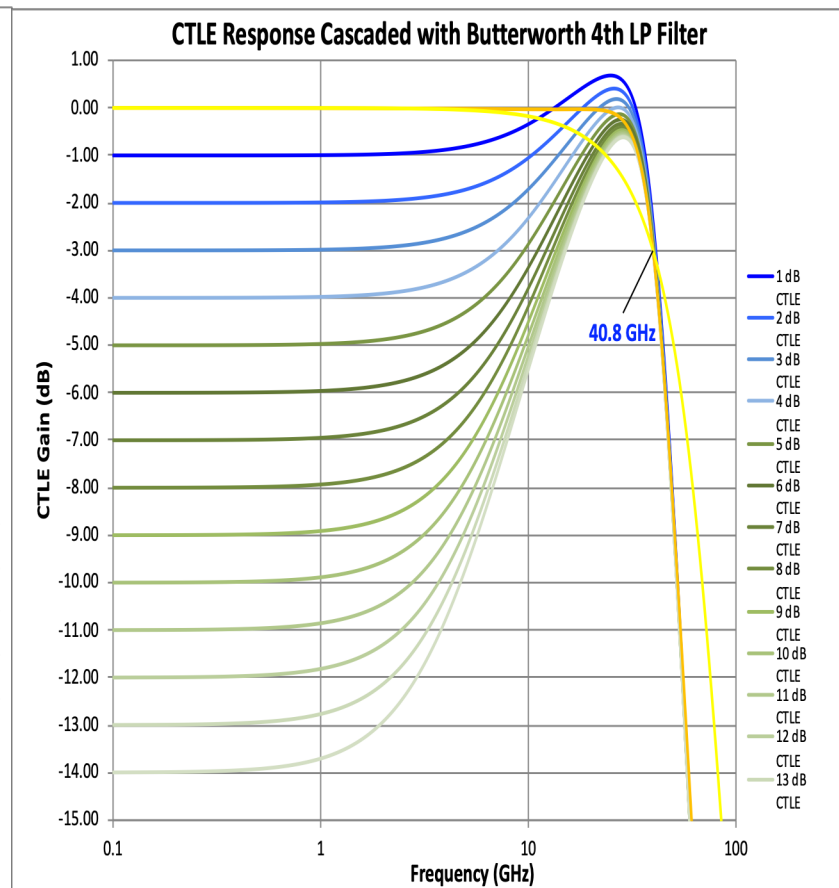
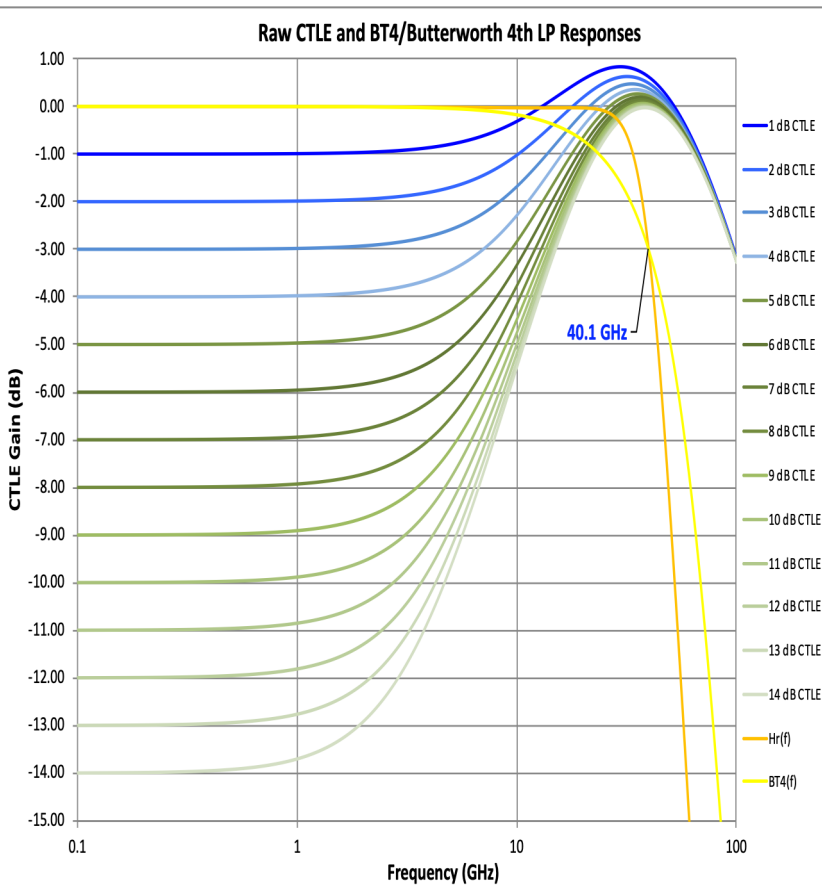
Post CTLE Noise/Technology 4th Order Butterworth Filter

$$H_r(f) = \frac{1}{1 - 3.414214(f/f_r)^2 + (f/f_r)^4 + j2.613126(f/f_r - (f/f_r)^3)}$$

Proposed C2M CTLE Response with Cascaded Butterworth and BT4 LP Filters

Raw CTLE response shown from 1-14 dB for LF=0 dB and cascaded with either Butterworth or BT4 with $fr=0.75$

- CTLE cascaded response with Butterworth LP filter gain varies from +0.68 to -0.57 dB
- CTLE cascaded response with BT4 LP filter gain varies from -0.38 to -0.1.8 dB
 - If we use $fr=1.0$ then BT4 gain varies from +0.18 to -1.0 dB but -3 dB point increases to 53 GHz a bit too high to avoid aliasing!



COM Code 2.5.8 Host-Module (2 Segments PKG 15-30 mm)

☐ Filter coefficient selected to have the improved CL120E response scaled for 53.1 GBd

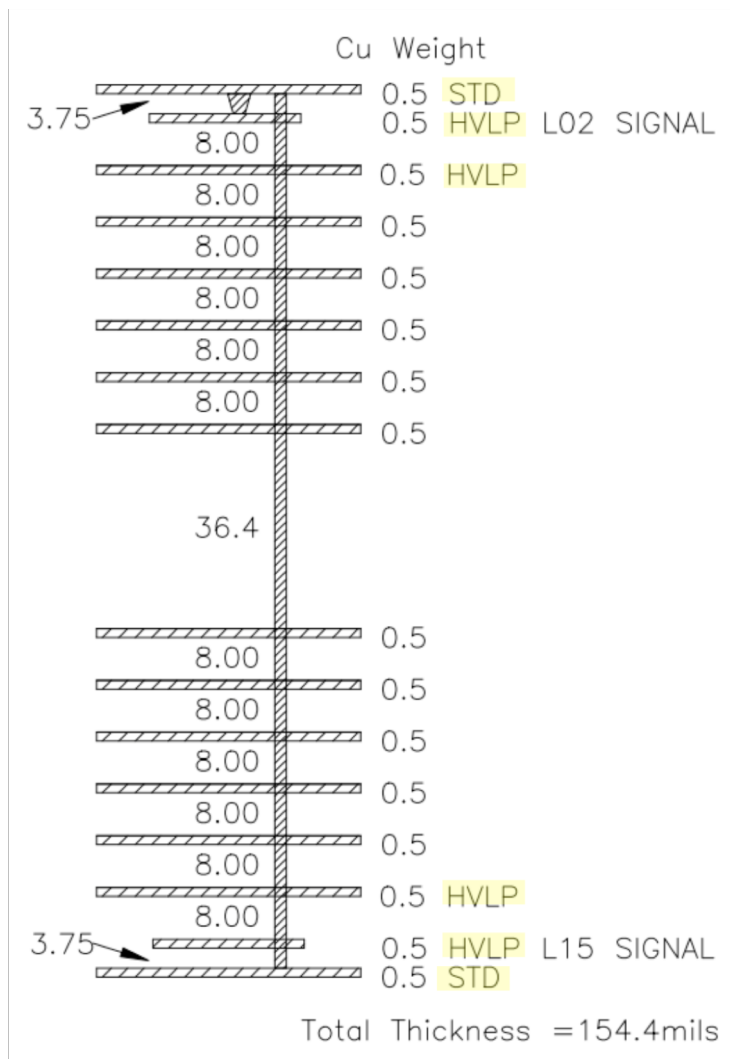
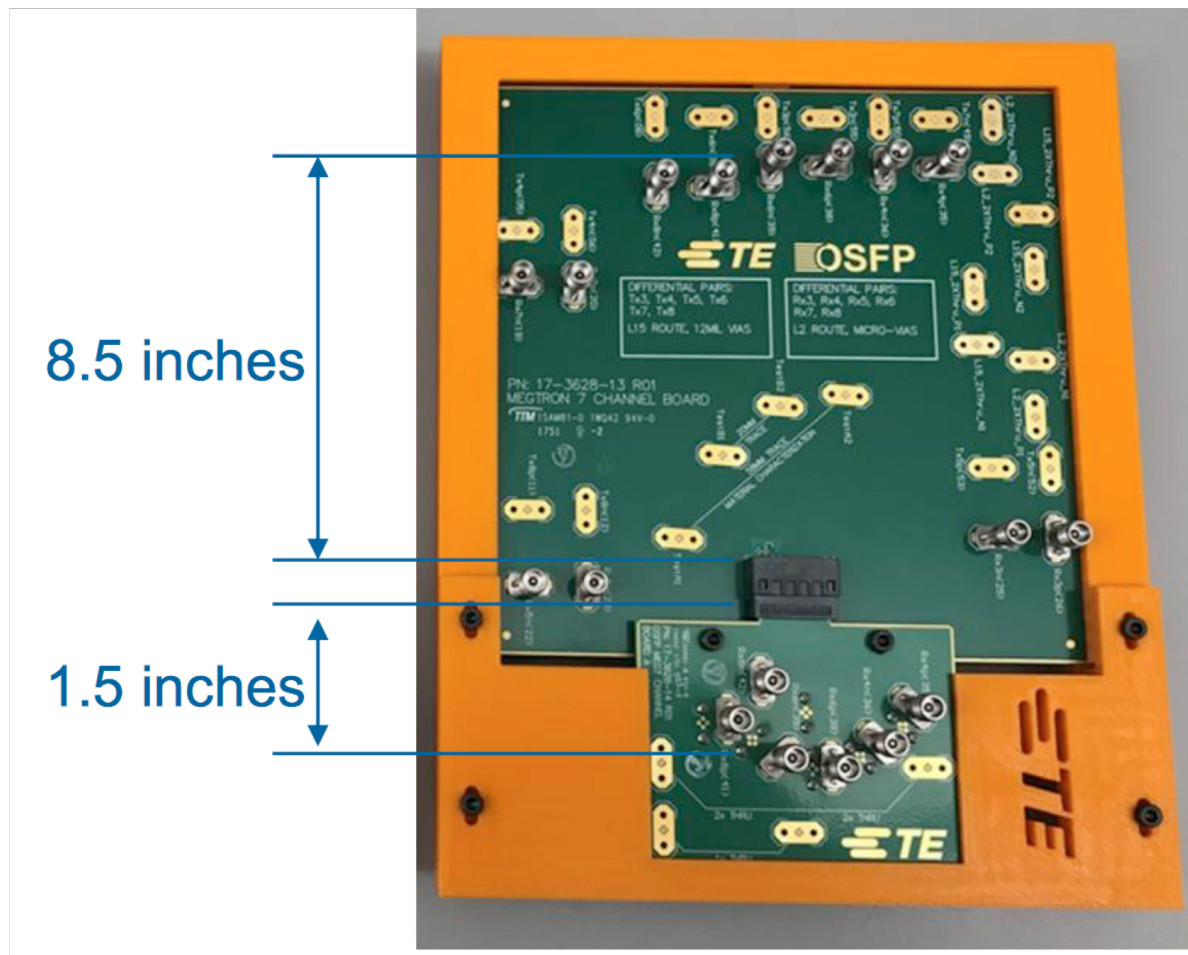
Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	53.1	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[1.1e-4 0]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[15 30; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[15 30; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[15 30; 1.8 1.8]	mm	[test cases]
z_p (RX)	[0 0; 0 0]	mm	[test cases]
C_p	[0.87e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 50]	Ohm	[TX RX]
A_v	0.41	V	
A_fe	0.41	V	
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.65		min
c(-1)	[-0.2:0.02:0]		[min:step:max]
c(-2)	[0:0.2:0.1]		[min:step:max]
c(1)	[-0.1:0.02:0]		[min:step:max]
N_b	0	UI	
b_max(1)	0.5		
b_max(2..N_b)	0.2		
g_DC	[-14:0.5:-4]	dB	[min:step:max]
f_z	18.55345912	GHz	
f_p1	53.1	GHz	
f_p2	28.2	GHz	
g_DC_HP	[-3:0.5:-1]		[min:step:max]
f_HP_PZ	1.3275	GHz	
ffe_pre_tap_len	0	UI	
ffe_post_tap_len	6	UI	
Include PCB	0	logical	
ffe_tap_step_size	0		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.3		
ffe_post_tap1_max	0.3		
ffe_tapn_max	0.125		
ffe_backoff	1		

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_WG_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	C2M_1218	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	1	dB
ERL Pass threshold	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	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	0.18	
fixture delay time	0	
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	8.20E-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	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm
Table 92-12 parameters		
board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	
board_tl_tau	6.200E-03	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	50	mm
z_bp (NEXT)	50	mm
z_bp (FEXT)	50	mm
z_bp (RX)	0	mm

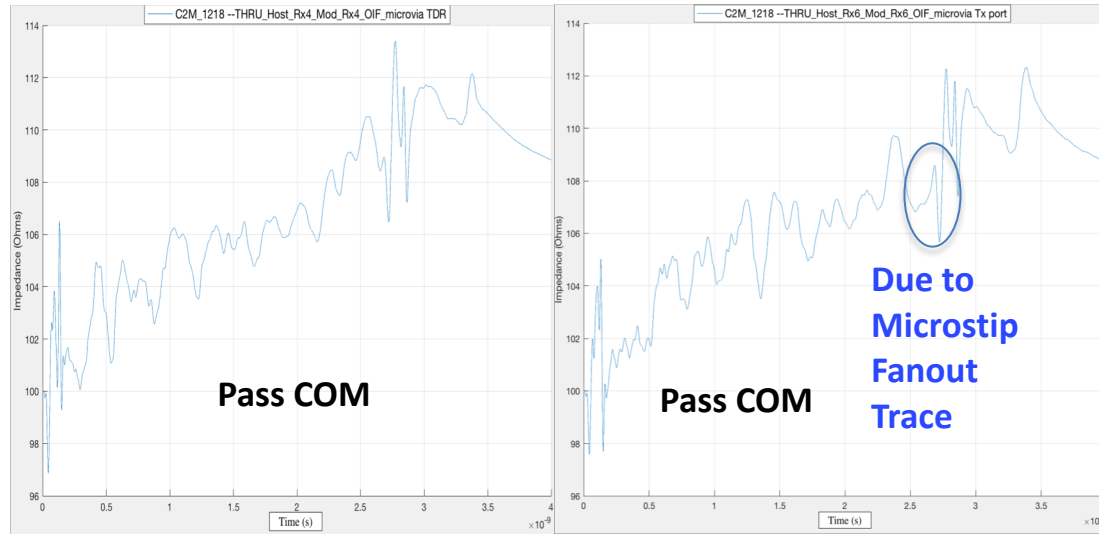
Tracy OSFP Board

- Board uses microvias as well as long barrel 154.4 mils vias with 3.75 mils stub.



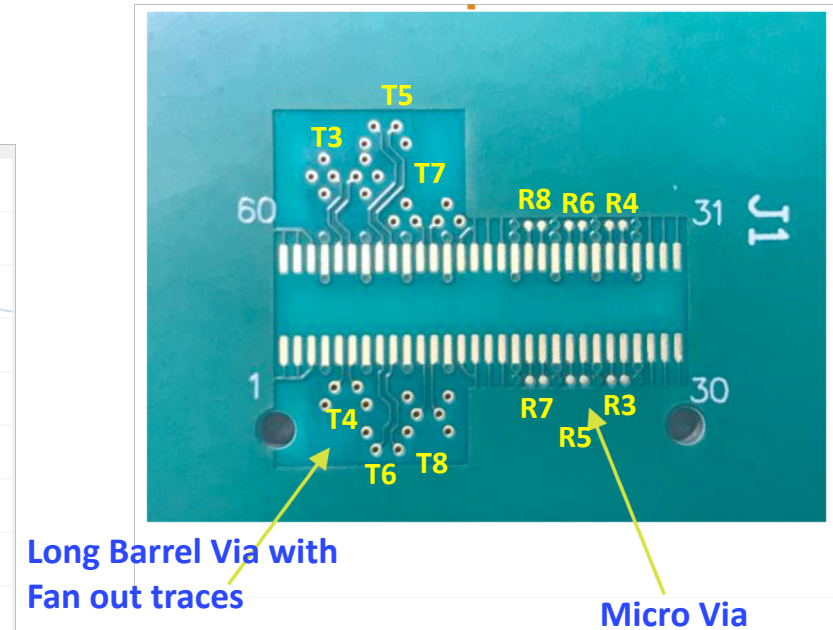
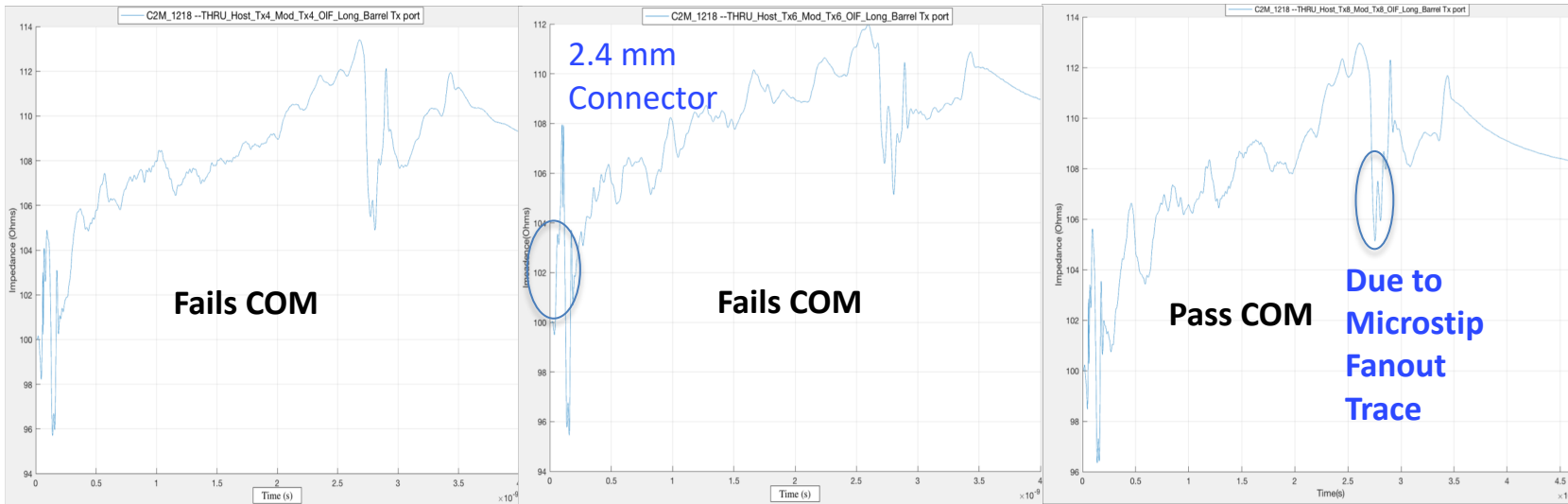
Tracy Microvia and Long Barrel Via Channels TDR T4 and T6

Microvia TE RX4 and RX6 Channels.



- 3.75 mils via stub is unlikely as the source of degradation.
- 154.4 mils long via likely one source of degradation.
- Microstrip fanout trace likely source of degradation
- 2.4 mm connector on T6 has 20 Ω swing.
- Tracy channels include connector and may double count Cp.

Microvia TE TX4, TX6, and TX8 Long barrel via channels.



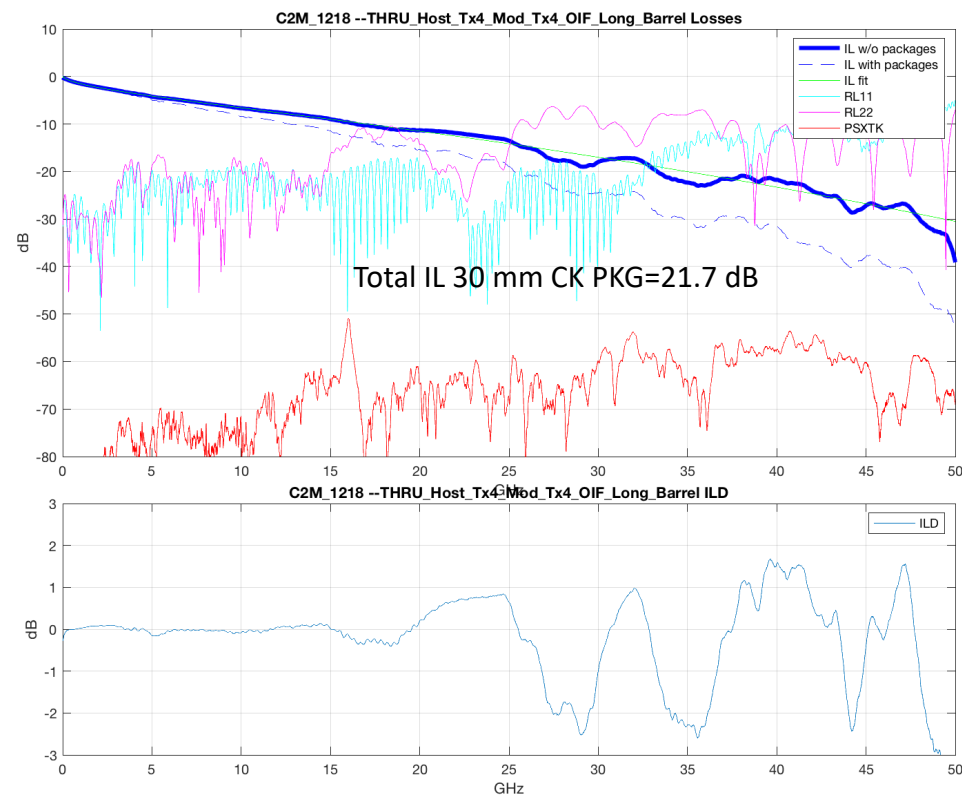
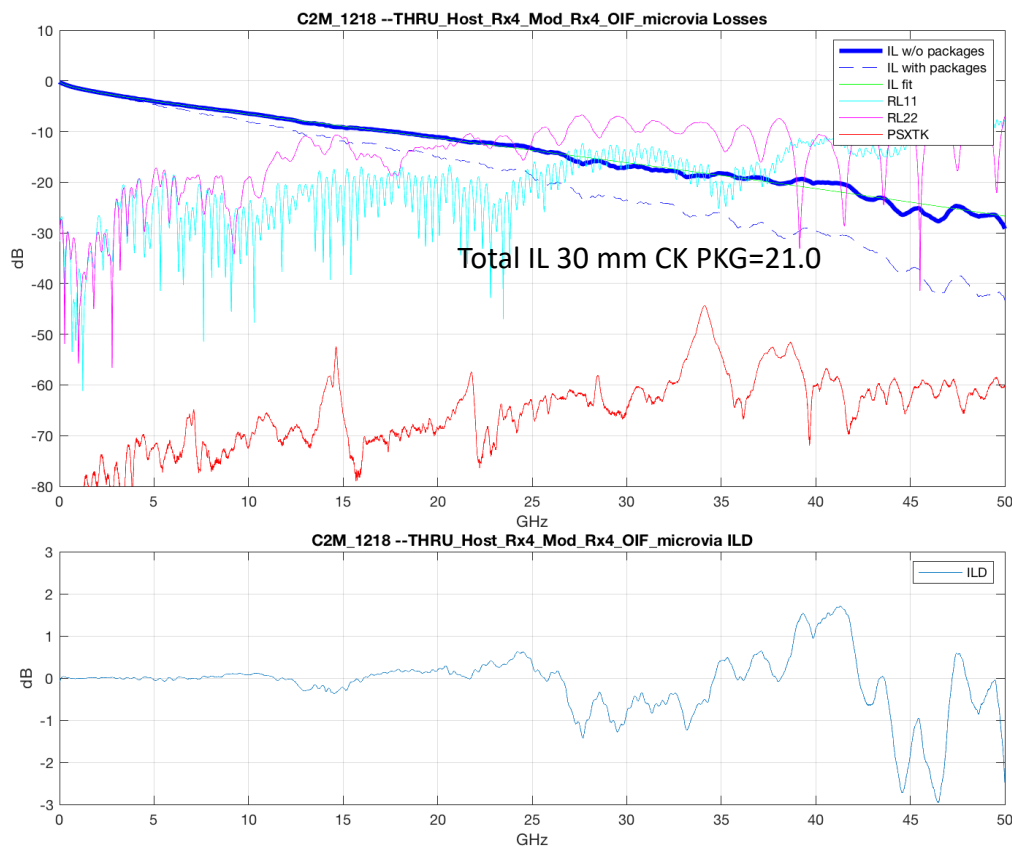
COM Analysis of Tracy Channels

8.5" OSFP (16 dB) channels, with 2 segment CK package with increased ILD and COM penalty!

- http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)
- http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

Tracy T4 MicroVia, FOM_ILD=0.20, ICN=0.62 mV, ICR=48, ERL11=14.1, ERL22=7.9 COM=4.18 (4.74) dB, EH=13.3 (11.8) mV, VEC=8.4 (7.5) dB

Tracy T4 LongBarrel, FOM_ILD=0.38, ICN=0.51 mV, ICR=46, ERL11=14.7, ERL22=8.9 COM=1.9 (2.8) dB, EH=6.3 (7.9) mV, VEC=14.1 (11.3) dB
 5T FFE - CK PKG: COM=1.9 (2.8) dB, EH=6.3 (7.9) mV, VEC=14.1 (11.3) dB
 7T FFE - CK PKG: COM=3.4 (4.1) dB, EH=10.3 (10.4) mV, VEC=9.8 (8.4) dB



Result in x(y) are for 15(30) mm PKG.

COM Analysis of Tracy Channels

8.5" OSFP (16 dB) channels, with 2 segment CK package with increased ILD and COM penalty!

http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)

http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

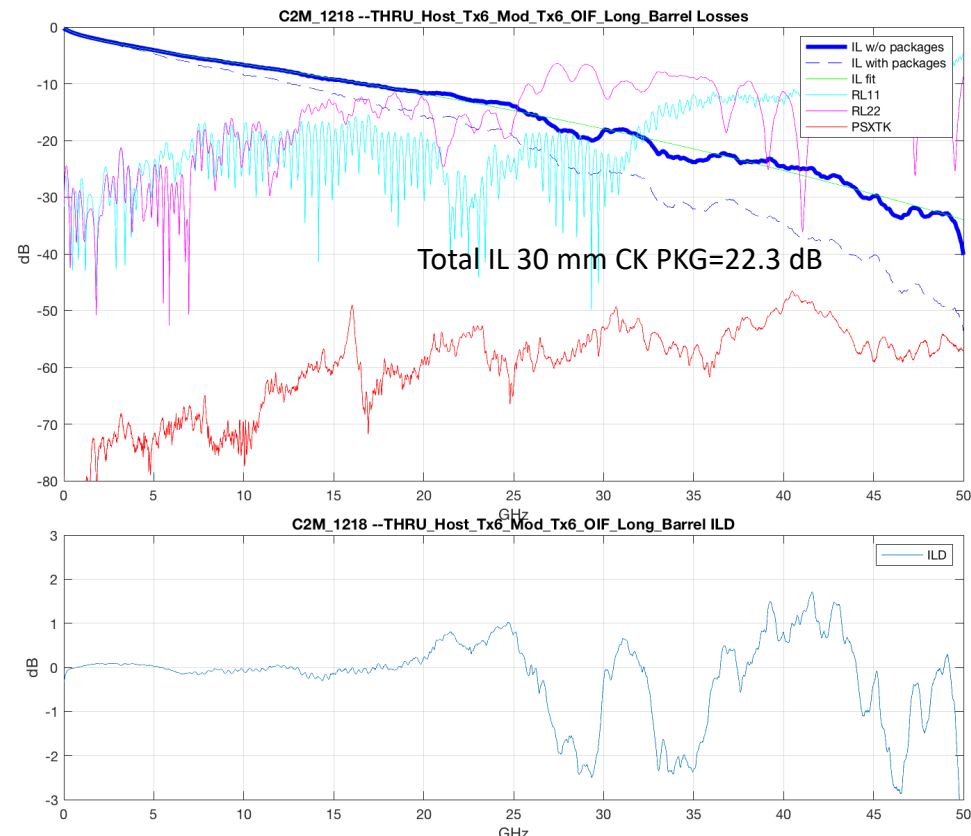
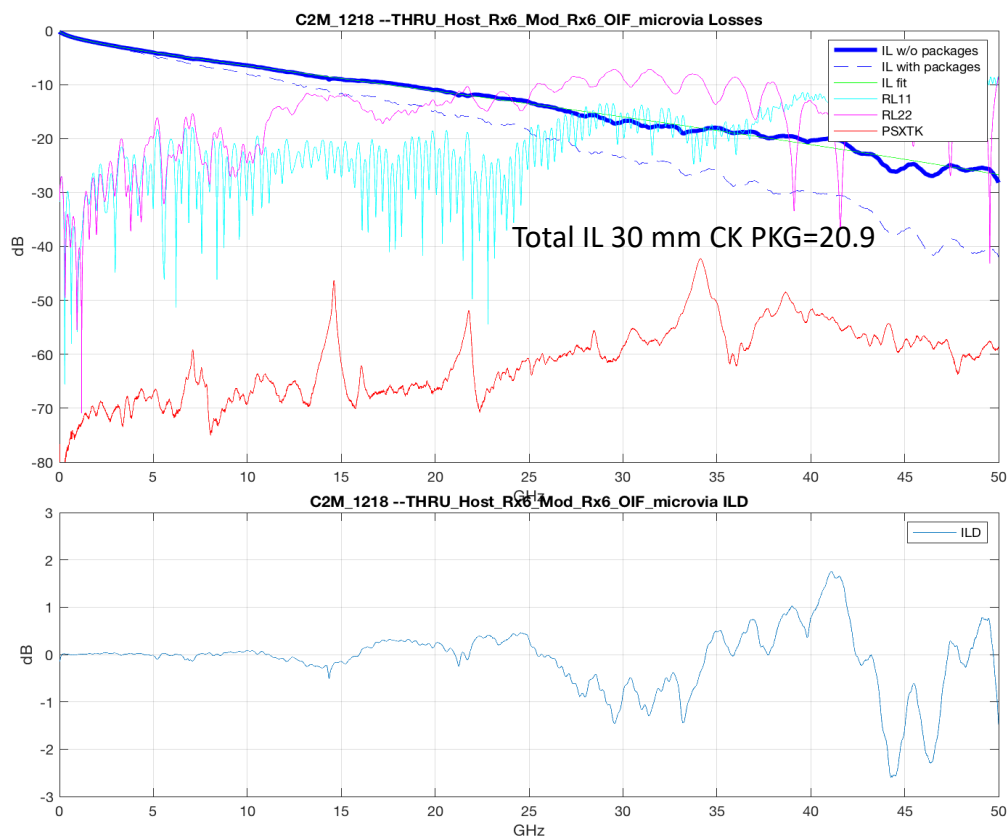
Tracy T6 MicroVia, FOM_ILD=0.21, ICN=0.91 mV, ICR=46, ERL11=15.4, ERL22=8.3 Tracy T6 LongBarrel, FOM_ILD=0.39, ICN=0.98 mV, ICR=40.2, ERL11=14.0, ERL22=9.3

5T FFE: COM=4.6 (5.7) dB, EH=16.7 (15.8) mV, VEC=7.6 (6.3) dB

7T FFE: COM=4.8 (5.8) dB, EH=18.1 (17.6) mV, VEC=7.5 (6.3) dB

5T FFE: COM=2.2 (3.0) dB, EH=7.4 (8.1) mV, VEC=12.9 (10.6) dB

7T FFE: COM=3.1 (3.9) dB, EH=9.8 (9.8) mV, VEC=10.5 (8.8) dB



Result in x(y) are for 15(30) mm PKG.

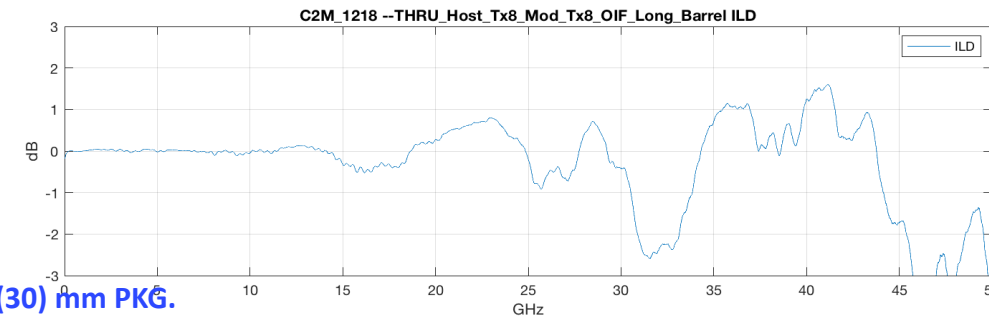
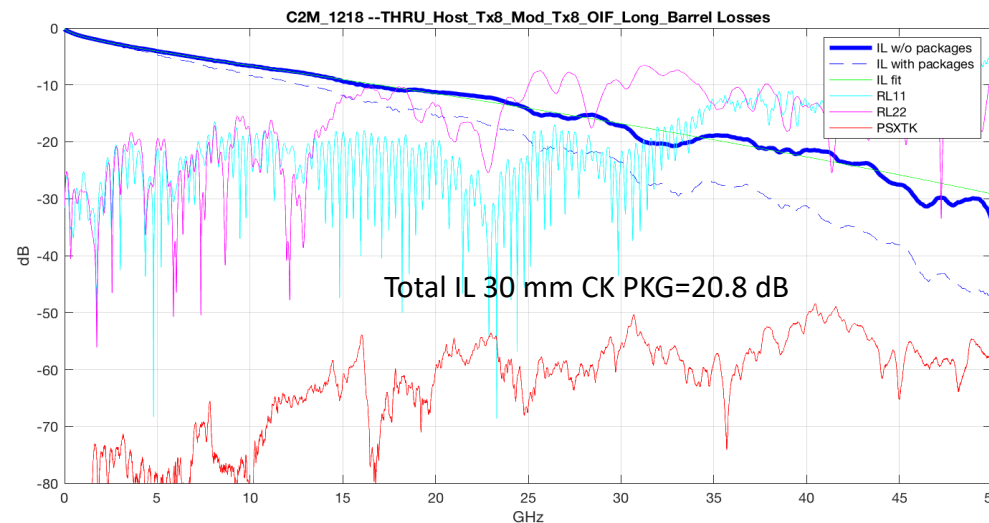
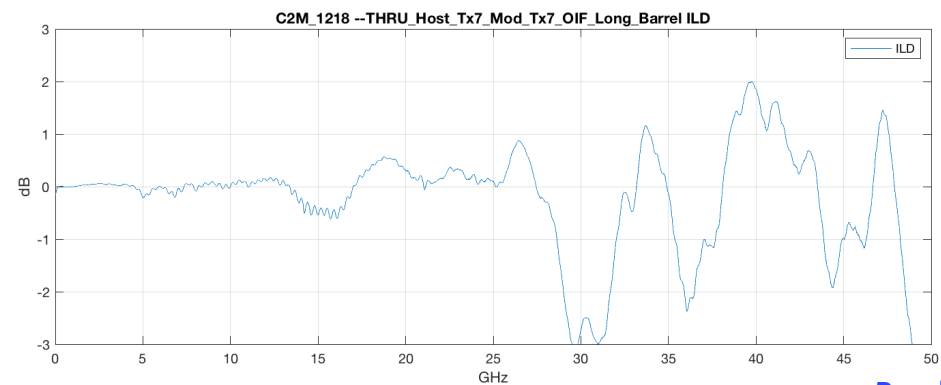
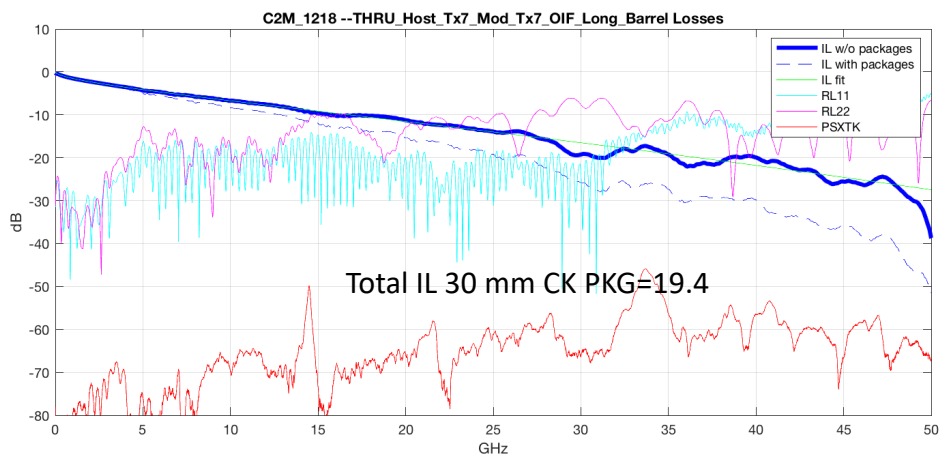
COM Analysis of Tracy Channels

8.5" OSFP (16 dB) channels, CK package reduces loss but increases ILD at significant COM penalty!

- http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)
- http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

Tracy T7 LongBarrel, FOM_ILD=0.39, ICN=0.66 mV, ICR=48, ERL11=13.0, ERL22=7.3
 5T FFE: COM=2.4 (3.5) dB, EH=8.6 (10.2) mV, VEC=12.3 (9.6) dB
 7T FFE: COM=2.6 (3.7) dB, EH=8.3 (9.7) mV, VEC=11.7 (9.2) dB

Tracy T8 LongBarrel, FOM_ILD=0.32, ICN=0.76 mV, ICR=43, ERL11=14.9, ERL22=8.7
 5T FFE: COM=4.6 (4.0) dB, EH=14.8 (11.2) mV, VEC=7.8 (8.6) dB



Result in x(y) are for 15(30) mm PKG.

COM Analysis on Lim Nov-18 Channels (Legacy Contacts)

- Lim Nov-2018 channel ICR still pretty low ~ 30 dB and with high ICN, with 2 segment CK package with increased ILD and COM penalty!

— http://www.ieee802.org/3/ck/public/tools/c2m/lim_3ck_01_0918_QDD_legacy_pairs.zip

Lim 14 dB FOM_ILD=0.11, ICN=2.72 mV, ICR=31.5, ERL11=9.1, ERL22=12.2

5T FFE: COM=2.6 (4.0) dB, EH=10.6 (13.2) mV, VEC=11.7 (8.7) dB

7T FFE(6 post): COM=2.6 (4.0) dB, EH=12.1 (12.0) mV, VEC=11.8 (8.7) dB

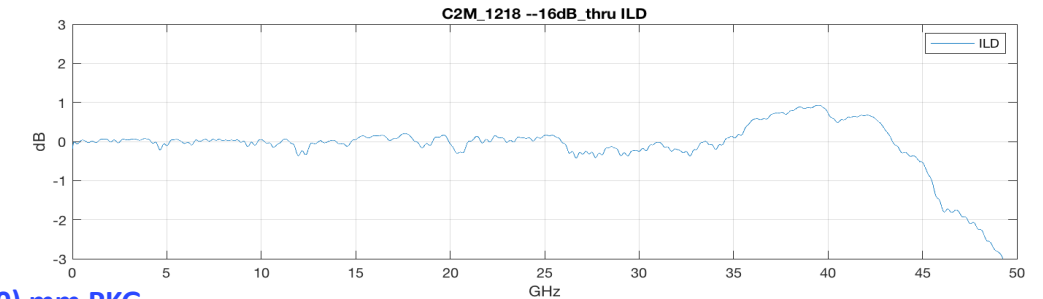
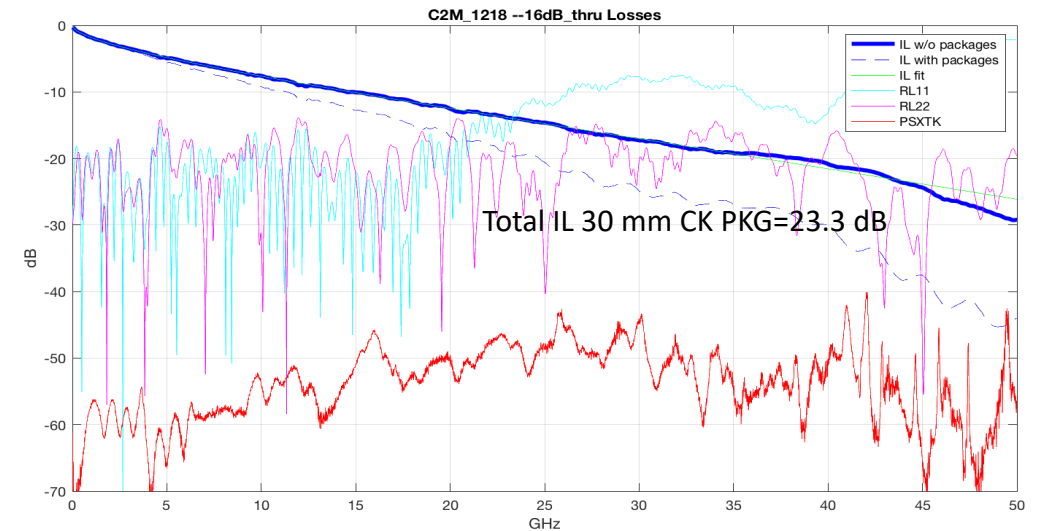
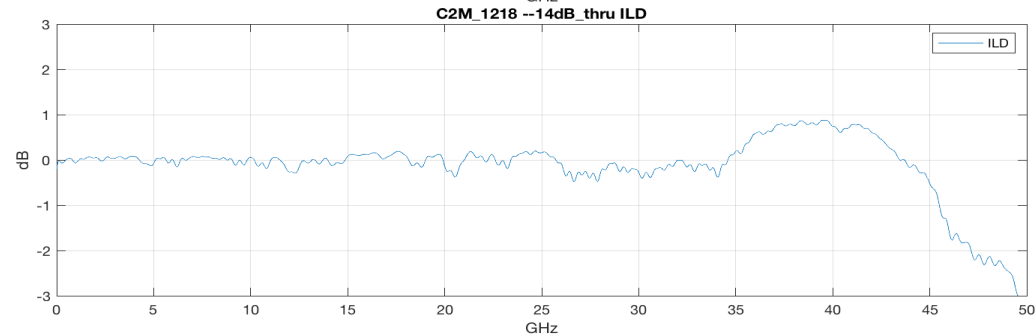
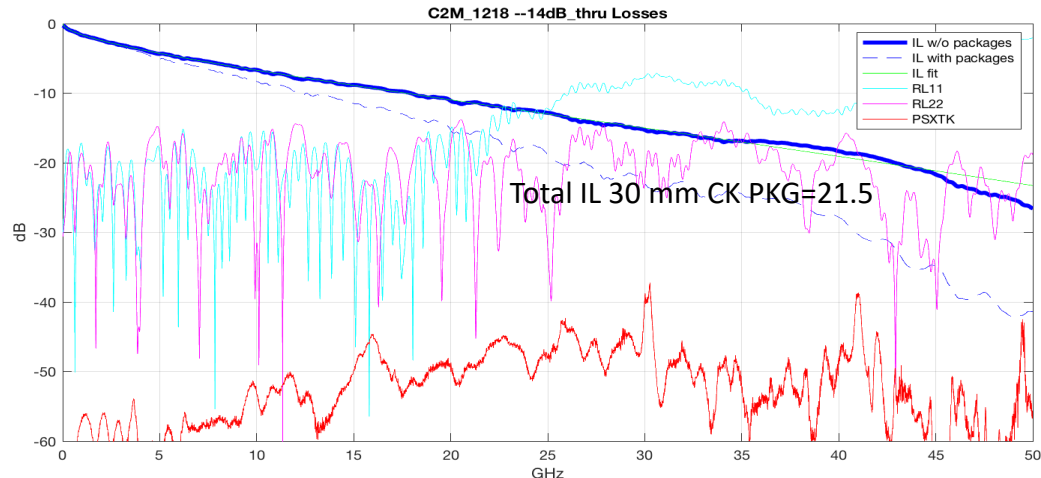
5T FFE(4 post)+1DFE: COM=4.4 (4.9) dB, EH=23.1 (21.5) mV, VEC=8.1 (7.3) dB

Lim 16 dB, FOM_ILD=0.10, ICN=2.14 mV, ICR=30.3 dB, ERL11=9.4, ERL22=12.3

5T FFE(4 post): COM=2.60 (4.4) dB, EH=9.5 (11.3) mV, VEC=11.8 (8.0) dB

7T FFE(6 post): COM=2.4 (4.4) dB, EH=9.2 (13.2) mV, VEC=12.4 (8.0) dB

5T FFE(4 post)+1DFE: COM=4.3 (5.3) dB, EH=18.5 (18.4) mV, VEC=8.2 (6.8) dB



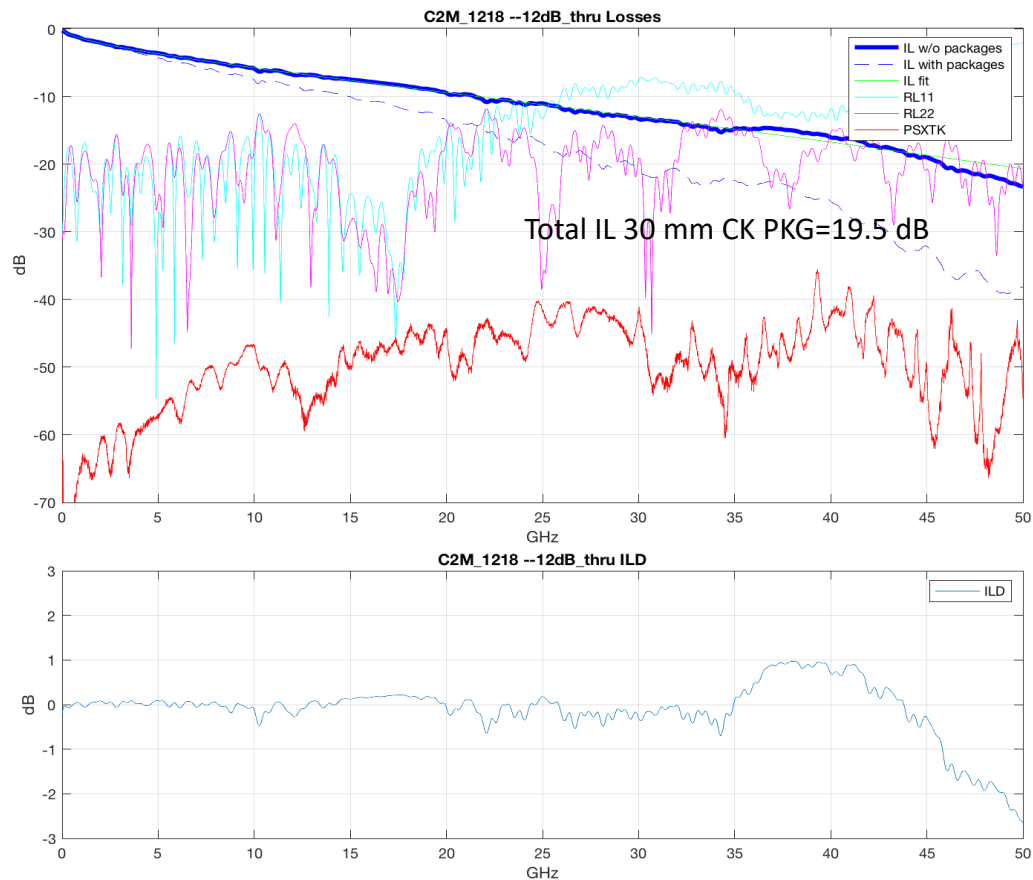
Result in x(y) are for 15(30) mm PKG.

COM Analysis on Lim Nov-18 Channels (new contacts)

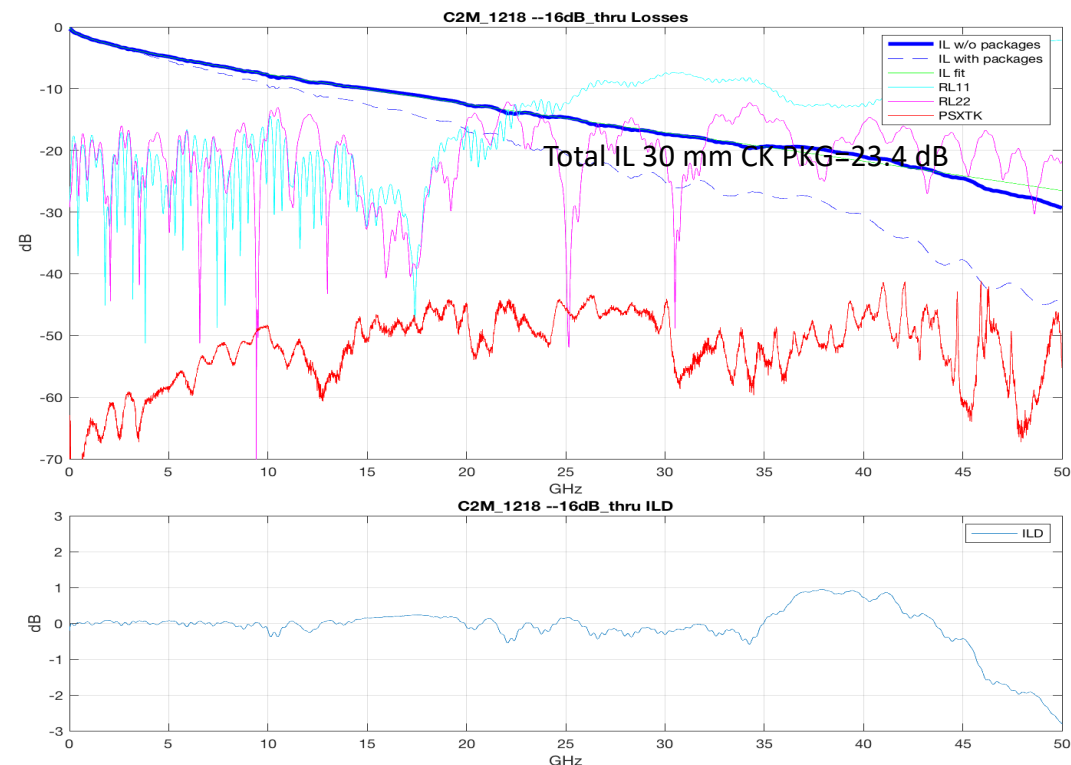
Lim Nov-2018 channel ICR still pretty low ~30 dB and with high ICN, with 2 segment CK package with increased ILD and COM penalty!

— http://www.ieee802.org/3/ck/public/tools/c2m/lim_3ck_01_0918_QDD_new_pairs.zip

Lim 12 dB, FOM_ILD=0.126, ICN=3.65 mV, ICR=30.2 dB, ERL11=8.7, ERL22=11.5
5T FFE: COM=3.2 (4.3) dB, EH=18.3 (17.7) mV, VEC=10.3 (8.2) dB



Lim 16 dB, FOM_ILD=0.122, ICN=2.85 mV, ICR=30.8 dB, ERL11=9.3, ERL22=11.6
5T FFE(4 post): COM=2.9 (4.0) dB, EH=10.9 (11.2) mV, VEC=11.1 (8.7) dB
7T FFE(6 post): COM=2.9 (4.0) dB, EH=11.0 (11.3) mV, VEC=10.9 (8.6) dB
5T FFE(4 post)+1DFE: COM=4.4 (4.8) dB, EH=18.8 (17.2) mV, VEC=8.0 (7.4) dB



Result in x(y) are for 15(30) mm PKG.

COM 2.5.8 Module-Host (Single Segment PKG 2-10 mm)

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	53.1	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.85e-4 0]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[2 10]	mm	[test cases]
z_p (NEXT)	[2 10]	mm	[test cases]
z_p (FEXT)	[2 10]	mm	[test cases]
z_p (RX)	[0 0]	mm	[test cases]
C_p	[0.87e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 50]	Ohm	[TX RX]
A_v	0.41	V	
A_fe	0.41	V	
A_ne	0.6	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.72		min
c(-1)	-0.2		[min:step:max]
c(-2)	57:36.0		[min:step:max]
c(1)	-0.04		[min:step:max]
N_b	∞	UI	
b_max(1)	0.5		
b_max(2..N_b)	0.2		
g_DC	[-14:0.5:-4]	dB	[min:step:max]
f_z	18.55345912	GHz	
f_p1	53.1	GHz	
f_p2	28.2	GHz	
g_DC_HP	[-3:0.5:-1]		[min:step:max]
f_HP_PZ	1.3275	GHz	
ffe_pre_tap_len	0	UI	
ffe_post_tap_len	4	UI	
Include PCB	0	logical	
ffe_tap_step_size	0		
ffe_main_cursor_min	0.7		
ffe_pre_tap1_max	0.3		
ffe_post_tap1_max	0.3		
ffe_tapn_max	0.125		
ffe_backoff			

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.results\100GEL_WG_{date}\	
SAVE_FIGURES	0	logical
Port Order	[2 4 1 3]	
RUNTAG	C2M_1218	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	1	dB
ERL Pass threshold	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	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	0.18	
fixture delay time	0	
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	8.20E-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	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5]	Ohm
Table 92-12 parameters		
board_tl_gamma0_a1_a2	[0 0.000599 0.0001022]	
board_tl_tau	6.200E-03	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	50	mm
z_bp (NEXT)	50	mm
z_bp (FEXT)	50	mm
z_bp (RX)	0	mm

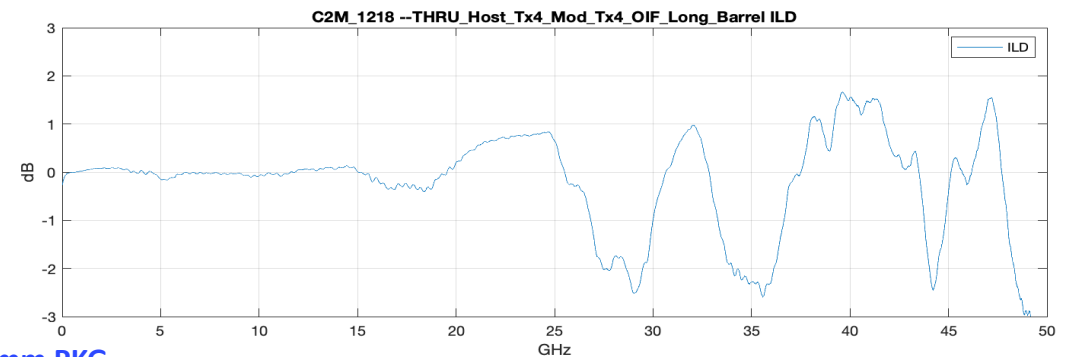
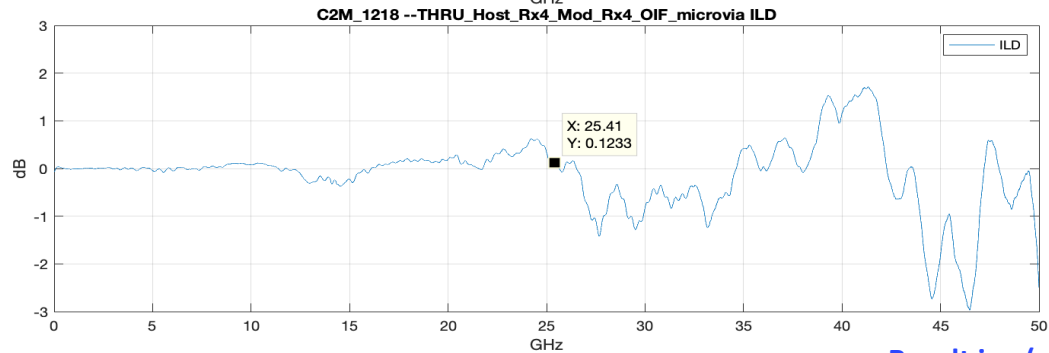
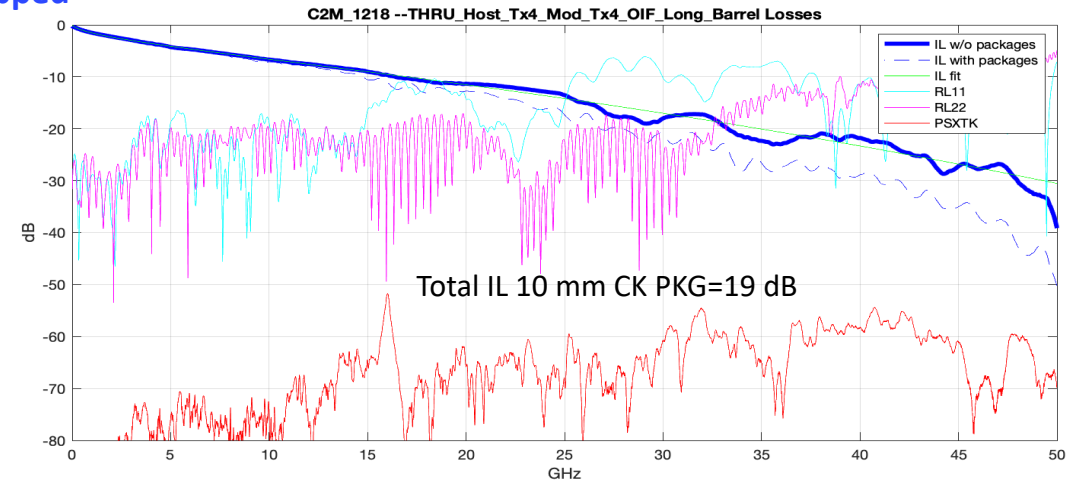
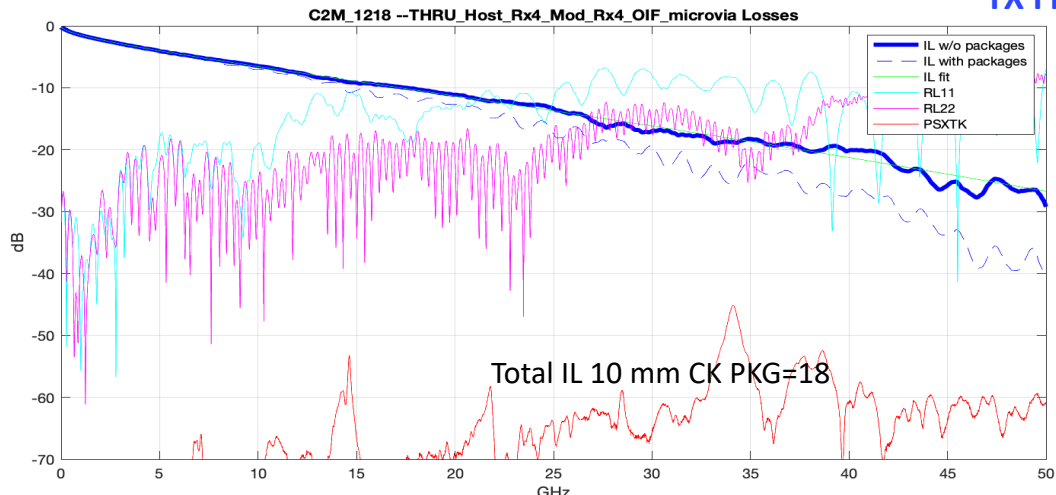
COM Analysis of Tracy Channels Module-ASIC (Single Segment PKG)

❑ Swapping optimum TX FFE for Tracy T4 microvia with long barrel channel there is as much as 1.3 dB COM penalty and 35% eye height reduction!

Tracy T4 MicroVia, FOM_ILD=0.20, ICN=0.57 mV, ICR=48, ERL11=7.9, ERL22=14.1
 COM=4.2 (4.6) dB, EH=15.8 (15.6) mV, VEC=8.4 (7.7) dB
 TX FFE[0.02, -0.14, 0.76,-0.08] Optimum
 COM=3.5 (3.9) dB, EH=14.2 (15.6) mV, VEC=9.6 (8.8) dB

Tracy T4 LongBarrel, FOM_ILD=0.38, ICN=0.47 mV, ICR=46, ERL11=8.9, ERL22=14.7
 5T FFE - CK PKG: COM=2.6 (3.1) dB, EH=9.9 (10.6) mV, VEC=11.8 (10.4) dB
 TX FFE[0.04, -0.2, 0.72,-0.04] Optimum
 5T FFE - CK PKG: COM=1.4 (2.5) dB, EH=6.4 (9.5) mV, VEC=16.4 (12) dB

TX FFE Taps Swapped



Result in x(y) are for 2(10) mm PKG.

COM Analysis of Tracy Channels Module-ASIC with Single Segment PKG

❑ Swapping optimum TX FFE for Tracy T6 microvia with long barrel channel there is as much as **0.7 dB COM penalty** and no eye height reduction!

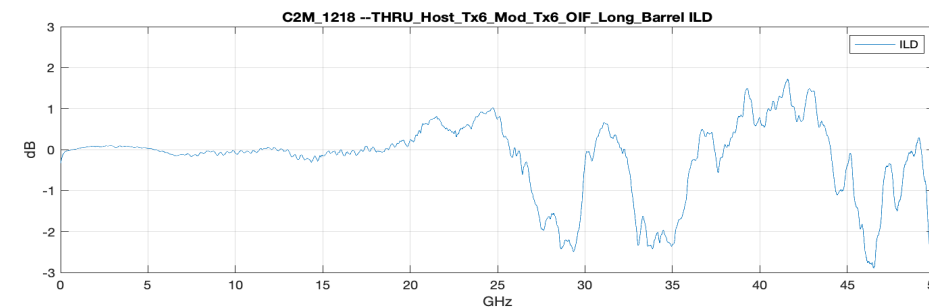
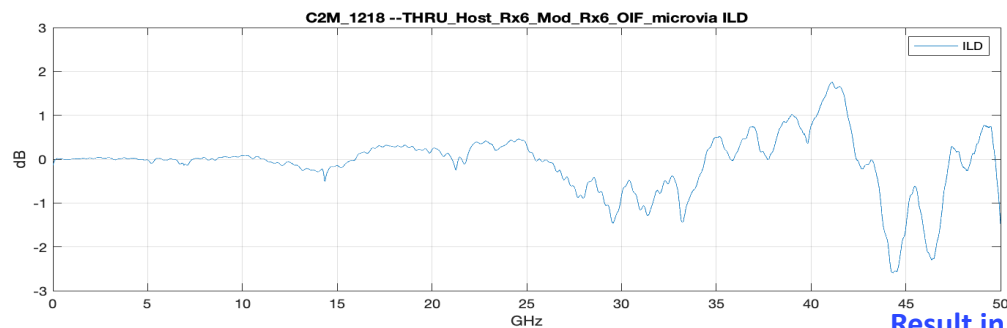
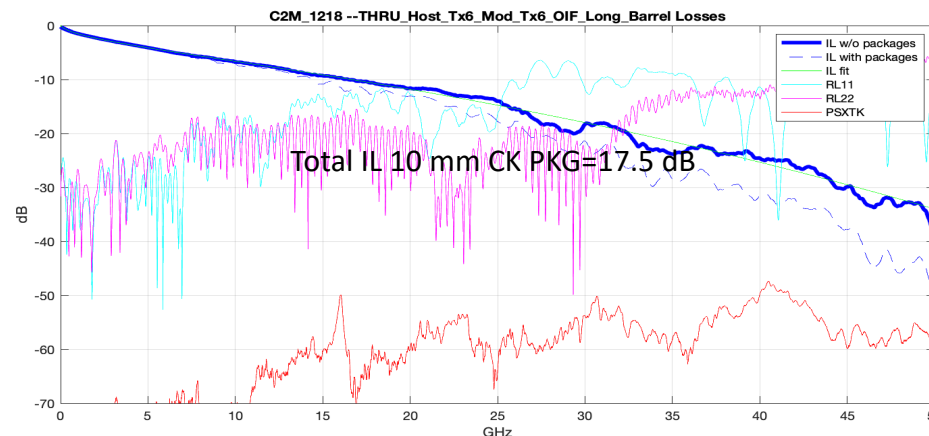
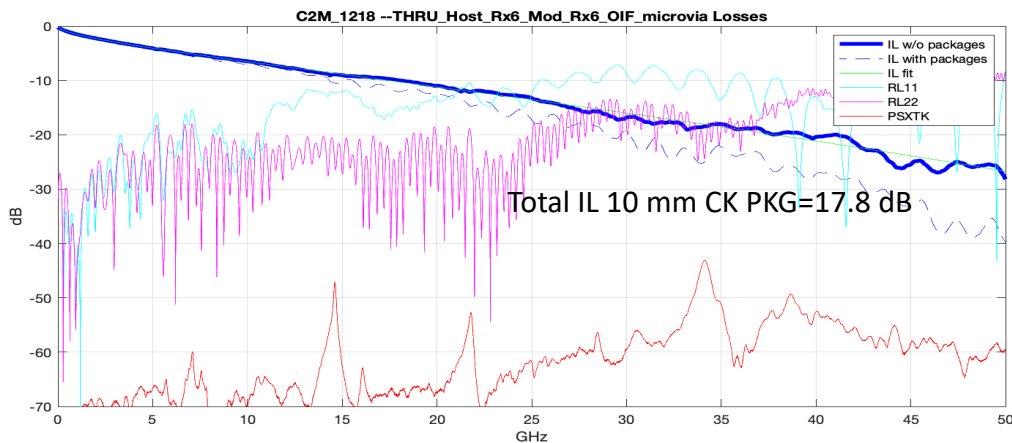
Tracy T6 MicroVia, FOM_ILD=0.21, ICN=0.83 mV, ICR=46, ERL11=8.3, ERL22=15.4 Tracy T6 LongBarrel, FOM_ILD=0.37, ICN=0.90 mV, ICR=40.2, ERL11=9.3, ERL22=14

5T FFE: COM=4.8 (4.7) dB, EH=19.0 (17.1) mV, VEC=7.5 (7.6) dB 5T FFE: COM=3.2 (3.7) dB, EH=10.8 (12.3) mV, VEC=10.3 (9.2) dB

TX FFE[0.04, -0.18, 0.76, -0.02] Optimum Setting TX FFE[0.04, -0.18, 0.68, -0.1] Optimum TX FFE

5T FFE: COM=4.1 (4.5) dB, EH=19.1 (14.3) mV, VEC=8.4 (7.9) dB 5T FFE: COM=**2.9** (3.6) dB, EH=11.8 (12.4) mV, VEC=11.0 (9.3) dB

TX FFE Taps Swapped



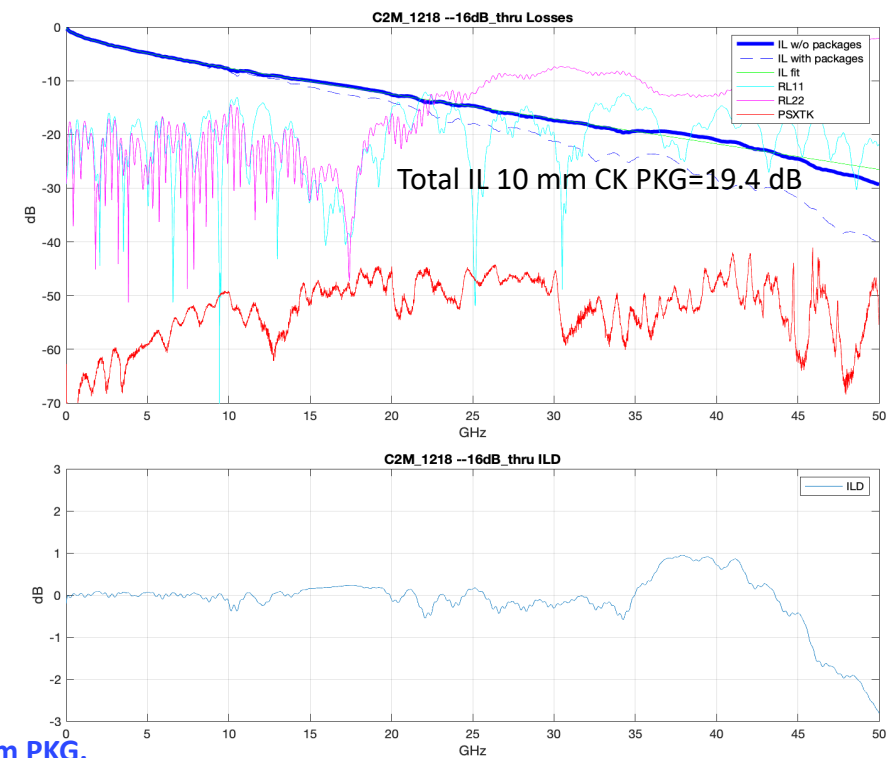
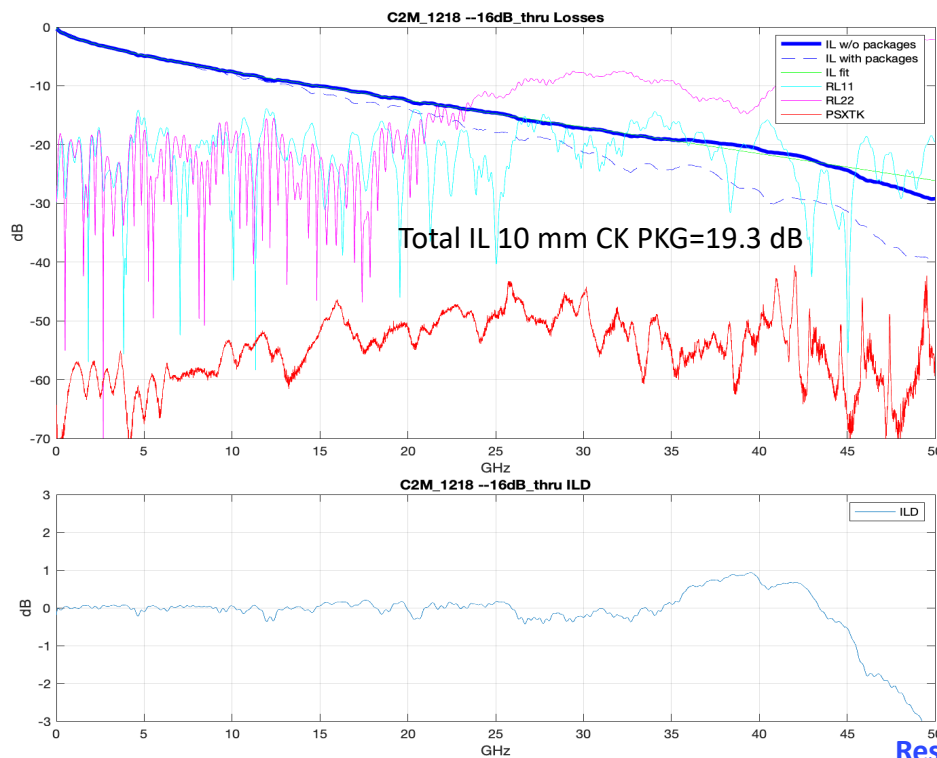
Result in x(y) are for 2(10) mm PKG.

COM Analysis on Lim Nov-18 Channels (new contacts) Module-ASIC with Single Segment PKG

Using TX FFE for TE T4 microvia for Lim channels there is as much as 1.0 dB COM penalty and 21% eye height reduction!

Lim 12 dB, FOM_ILD=0.105, ICN=2.1 mV, ICR=30.2 dB, , ERL11=12.3, ERL22=9.4
 5T FFE: COM=5.1 (5.5) dB, EH=21.7 (17.5) mV, VEC=6.6 (7.1) dB
 TX FFE [0.02, -0.14, 0.84, 0] Optimum
 5T FFE(4 post): COM=4.6 (4.3) dB, EH=19.9 (17.8) mV, VEC=7.7 (8.1) dB
 TX FFE[0.04, -0.2, 0.72,-0.04] with TE T4 Settings

Lim 16 dB, FOM_ILD=0.122, ICN=2.66 mV, ICR=30.8 dB, , ERL11=11.7, ERL22=9.3
 5T FFE(4 post): COM=5.2 (4.7) dB, EH=22.9 (17.3) mV, VEC=6.9 (7.6) dB
 TX FFE [0.02, -0.14, 0.82, -0.02] Optimum
 5T FFE(4 post): COM=4.1 (3.7) dB, EH=18.2 (15.7) mV, VEC=8.5 (9.1) dB
 TX FFE[0.04, -0.2, 0.72,-0.04] with TE T4 Settings



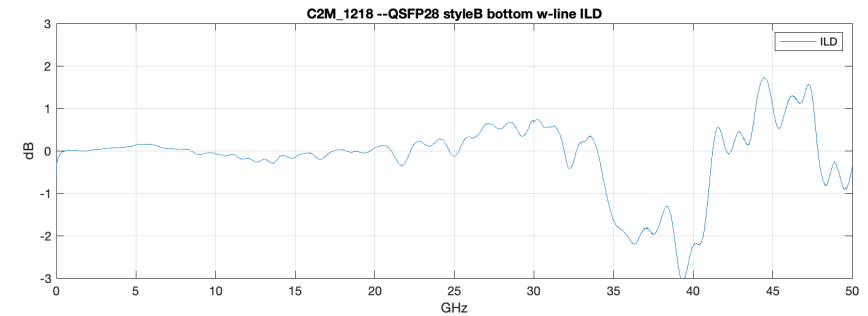
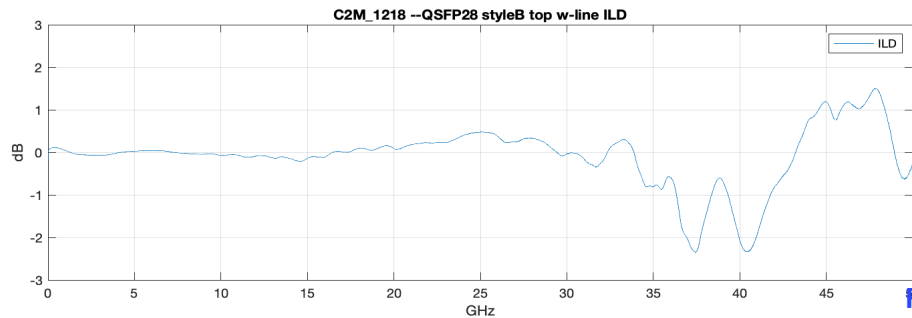
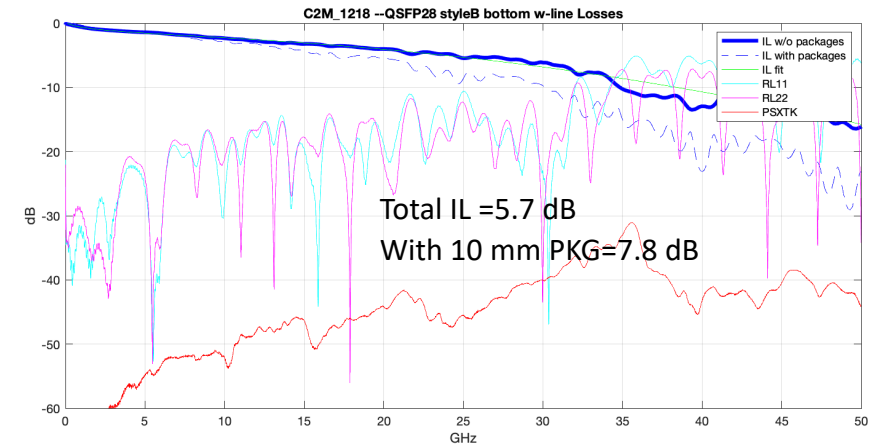
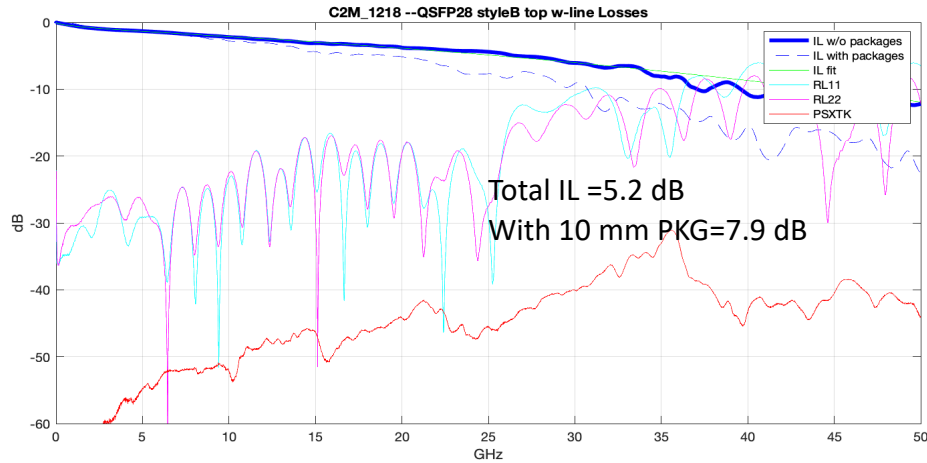
Result in x(y) are for 2(10) mm PKG.

Yamaichi QSFP28 MCB/HCB TP4 Simulations with Single Segment PKG

- Using TX FFE for TE T4 microvia for Yamichi MCB/HCB channels there is as much as 0.9 dB COM penalty and 20% eye height reduction at TP4!

Top, FOM_ILD=0.18, ICN=5.2 mV, ICR=40 dB, , ERL11=14.5, ERL22=14.4
 5T FFE: COM=5.4 (5.2) dB, EH=49.7 (43.8) mV, VEC=6.7(6.9) dB
 TX FFE [0.04, -0.18, 0.78, 0] Optimum
 5T FFE(4 post): COM=4.5 (4.4) dB, EH=42.3 (37.9) mV, VEC=7.9 (8.0) dB
 TX FFE[0.04, -0.2, 0.72,-0.04] with TE T4 Settings

Bottom, FOM_ILD=0.23, ICN=5.2 mV, ICR=39 dB, , ERL11=10.9, ERL22=11.9
 5T FFE(4 post): COM=5.8 (4.8) dB, EH=53.9 (38.9) mV, VEC=6.3 (7.4) dB
 TX FFE [0.04, -0.18, 0.78, 0] Optimum
 5T FFE(4 post): COM=4.8 (4.6) dB, EH=43.1 (38.1) mV, VEC=7.4 (7.7) dB
 TX FFE[0.04, -0.2, 0.72,-0.04] with TE T4 Settings



Result in x(y) are for 2(10) mm PKG.

Summary

- ❑ **COM results here are with improved C2M CTLE similar to CL 120E but with parametric definition**
 - All results are with Butterworth 4th order post filter with $f_r=0.75$
 - BT4 filter with $f_r=0.75$ may result in too much attenuation ~ 1.8 dB and $f_r=1.0$ may not provide good anti-aliasing filter
- ❑ **The 5 tap low power FFE equalizer can be sufficient if ILD, ICN, and channel reflections are better controlled**
 - The key source of problems are long barrel vias and connector fan-in/transitions traces
- ❑ **Updated results on Tracy and Lim channels are promising to assume 5T FFE for TP1a test point equalizer as the channels will improve with 112G generation of connectors**
 - Tracy OSFP micro-via channels all exceed 3 dB COM with 5 T FFE
 - Tracy OSFP Long Barrel Via some channels do not meet 3 dB COM with 5 T FFE but pass 3 dB COM with 7T FFE
 - Some of Lim QSFP-dd channels do not meet 3 dB COM with 5T FFE
 - But in every case Tracy Long Barrel and Lim channels which has long barrel via pass with 30 mm PKG
 - One option is to restrict connecting short package traces to long barrel vias
- ❑ **Limited simulation at TP4/TP5 using Tracy and Lim channels are promising with the assumed 2 and 10 mm single segment package**
 - One key observation is that fixed module TX FFE may result in as much as 1 dB of COM penalty at TP5 due to non optimum pre cursor setting
 - We may need to consider host receiver with 7 Tap FFE with 2 pre-cursor large penalty associated with fix module TX pre-cursor!