Updated C2M COM Simulations

Ali Ghiasi

IEEE 802.3ck Adhoc Meeting

Feb 12, 2019

Overview

- **COM 2.5.8 generally produces improved results compare to COM 2.5.7**
  - COM results are now with fr=0.75 and does improve results on high ICN channels
  - Other changes from Long Beach presentation are
    - Low frequency Fz adjusted to Baudrate/40
    - TP1a termination adjusted to 50 Ω
- **Channel investigated**
  - TE/Tracy OSFP micro-via channels exceed 3 dB COM with 5 T FFE
  - TE/Tracy OSFP Long Barrel Via some channels do not meet 3 dB COM with 5 T FFE
  - Cisco/Lim QSFP-dd channels exceed 3 dB COM with 5T FFE
- **The TP1a/TP5 are observed with weak generic equalizer**
  - The actual equalizer may need additional capability to recover the signal at slicer.

COM Code 2.5.8

- **Filter coefficient selected to have the improved CL120E response scaled for 53.1 GBd**
  - http://www.ieee802.org/3/ck/public/tools/tools/mellitz_3ck_01_0119_COM2p58.zip

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	[0.9e-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	[0.9e-4 0]	nF	[TX RX]
R_0	50	Ohm	
R_d	[45 50]	Ohm	[TX RX]
A_v	0.45	V	
A_fe	0.45	V	
A_ne	0.63	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:.02:0.1]		[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	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	1		

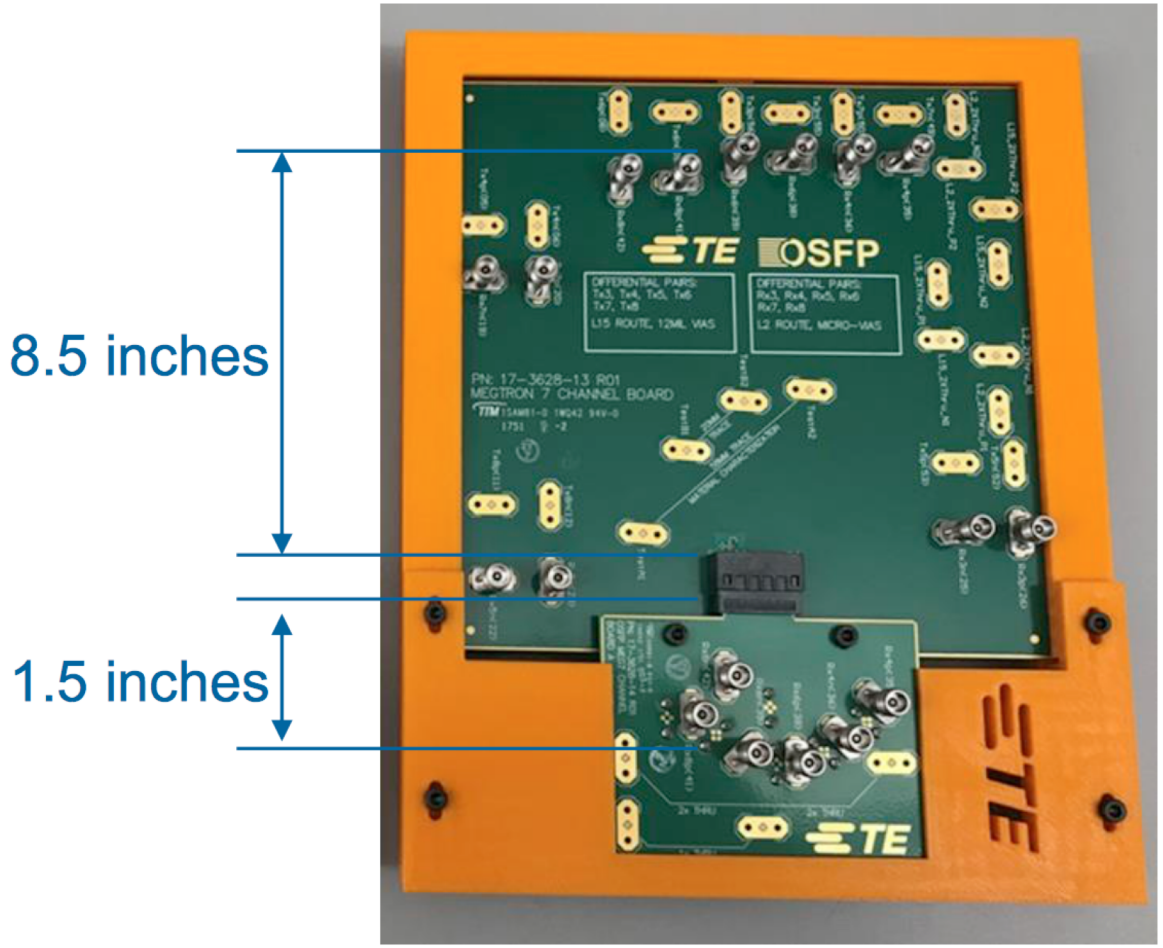
I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\100GEL_WG_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 2 3 4]	
RUNTAG	C2M_1218	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	1	dB
ERL Pass threshold	5	dB
DER_0	1.00E-05	
T_r	6.16E-03	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	

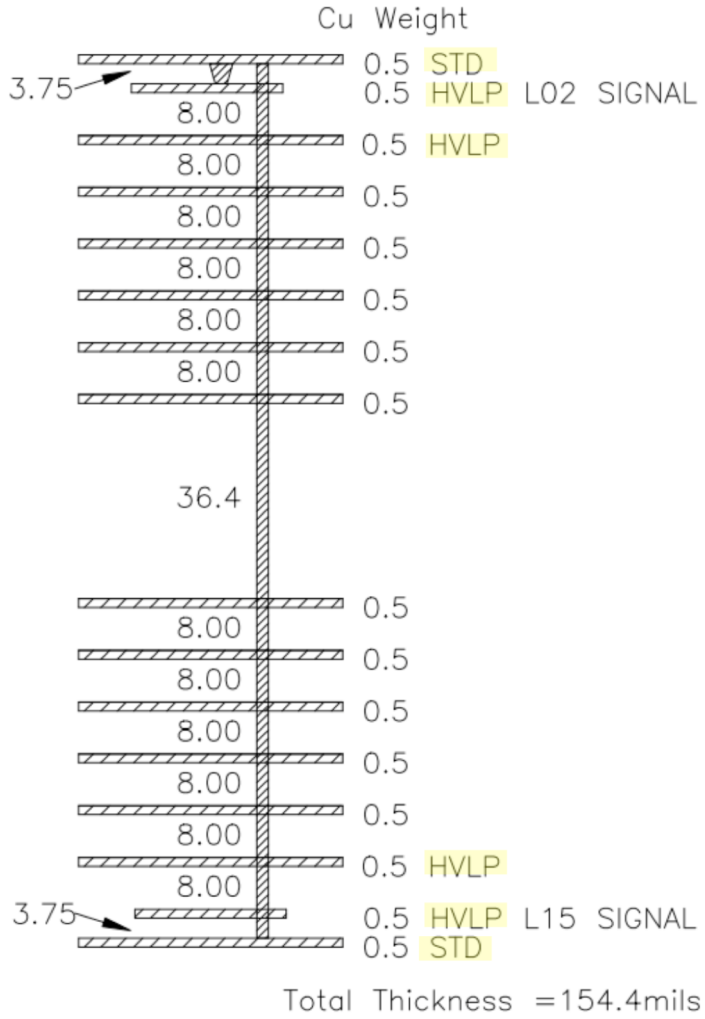
Table 93A–3 parameters		
Parameter	**Setting**	**Units**
package_tl_gamma0_a1_a2	[0 0.0009909 0.0002772]	
package_tl_tau	6.1400E-03	ns/mm
package_Z_c	[87.5 87.5 ; 92.5 92.5]	Ohm

Table 92–12 parameters		
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	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

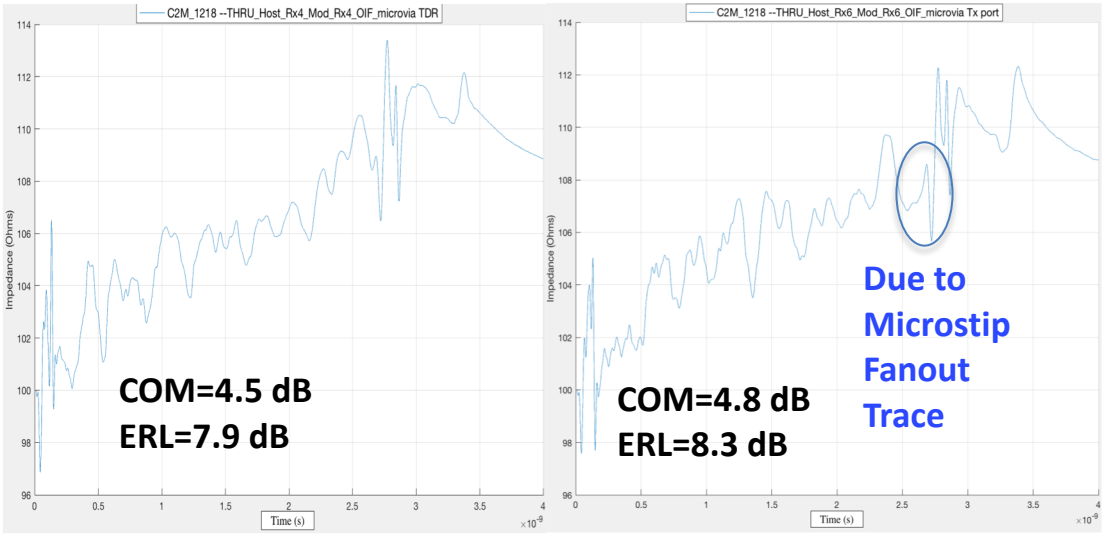
- **Board uses microvias as well as long barrel 154.4 mils vias with 3.75 mils stub.**





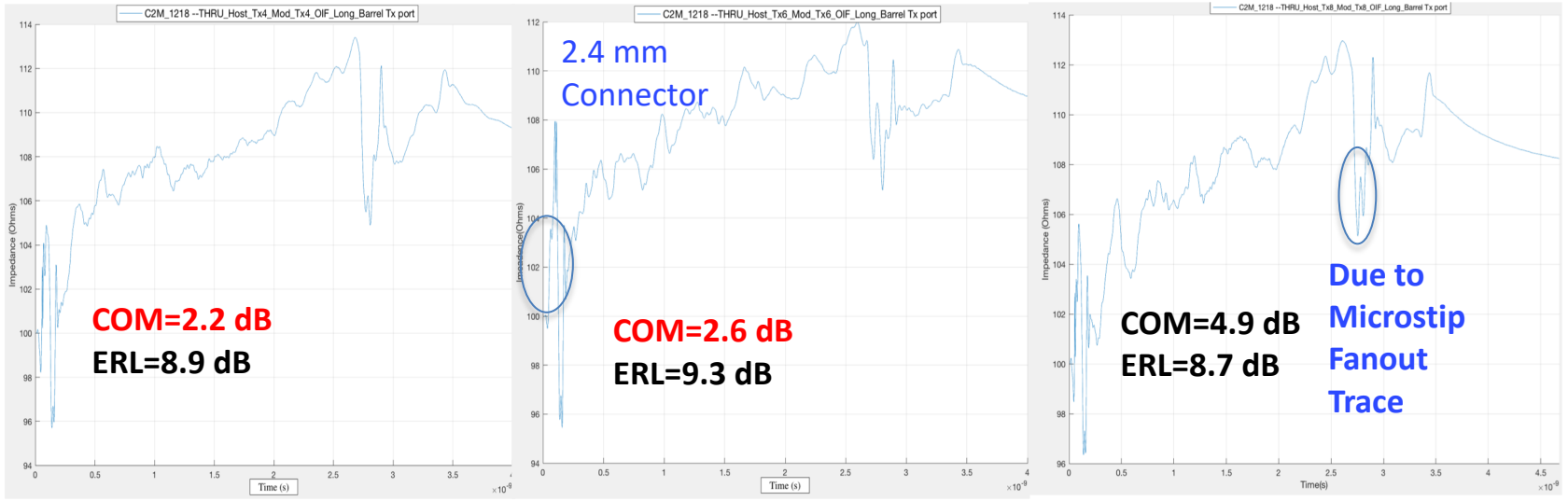
Tracy Microvia and Long Barrel Via Channels TDR T4 and T6

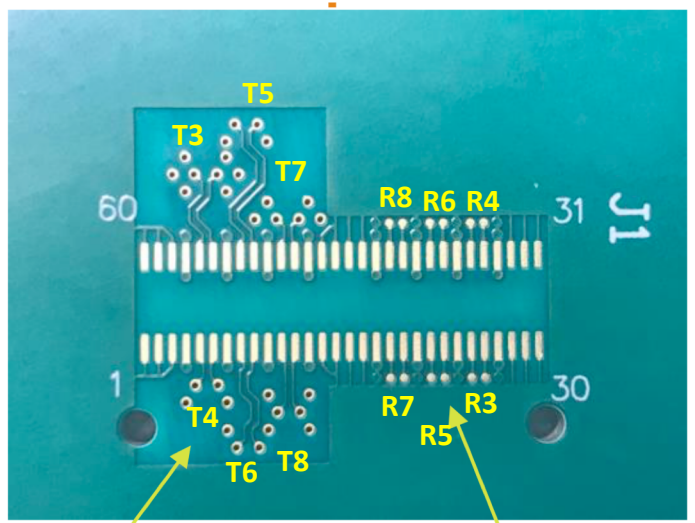
Microvia TE RX4 and RX6 Channels.



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

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

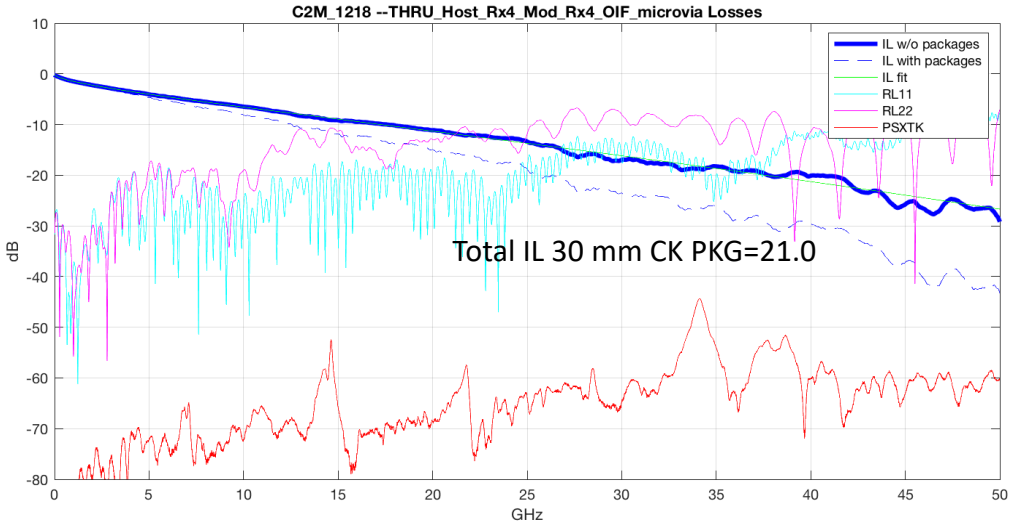


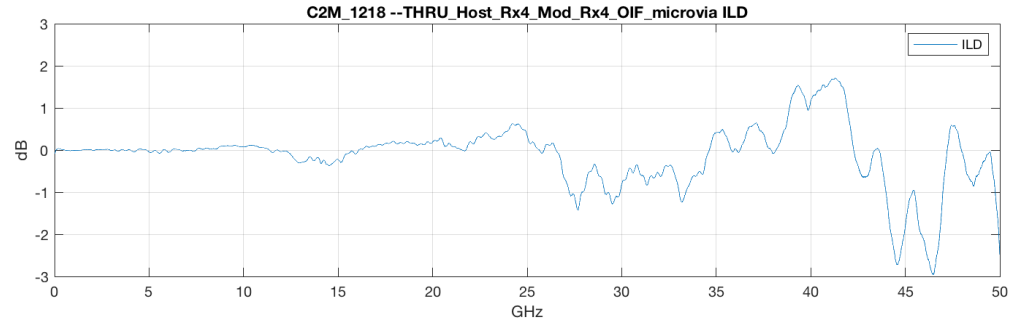


COM Analysis of Tracy Channels

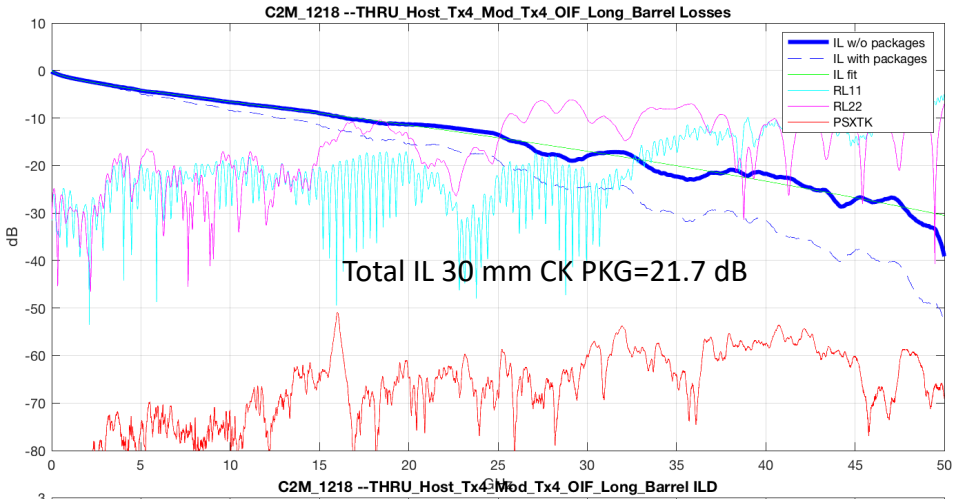
- **8.5” OSFP (16 dB) channels, CK package reduces loss but increases ILD at significant COM penalty!**
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

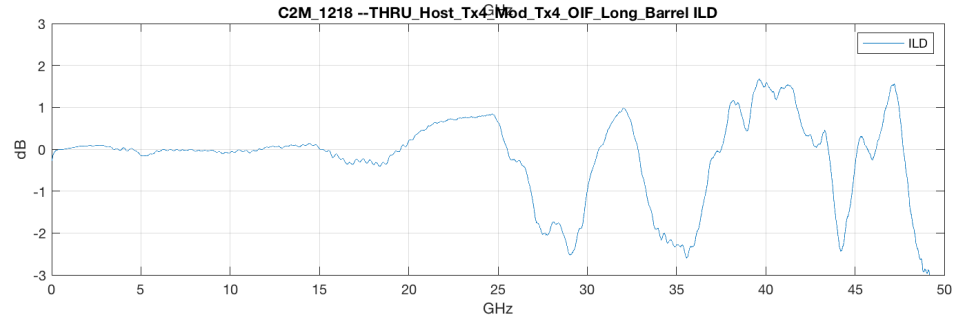
Tracy T4 MicroVia, FOM_ILD=0.20, ICN=0.62 mV, ICR=48, ERL11=14.1, ERL22=7.9
COM=4.54 (5.22) dB, EH=15.6 (14.4) mV, VEC=7.8 (6.9) dB





Tracy T4 LongBarrel, FOM_ILD=0.38, ICN=0.51 mV, ICR=46, ERL11=14.7, ERL22=8.9
5T FFE - CK PKG: COM=2.2 (3.06) dB, EH=7.8 (8.6) mV, VEC=12.9 (10.5) dB
7T FFE - CK PKG: COM=3.8 (4.53) dB, EH=12.3 (12.3) mV, VEC=9.0 (7.8) dB



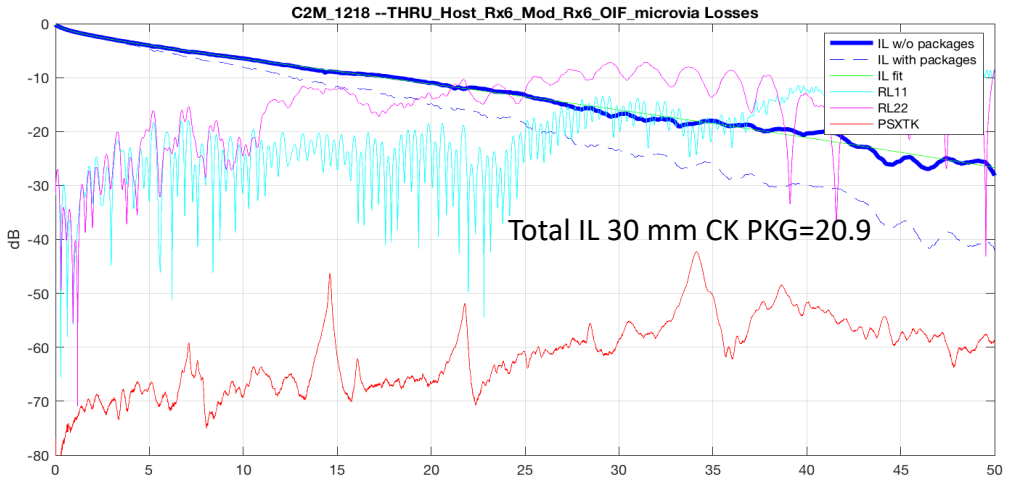


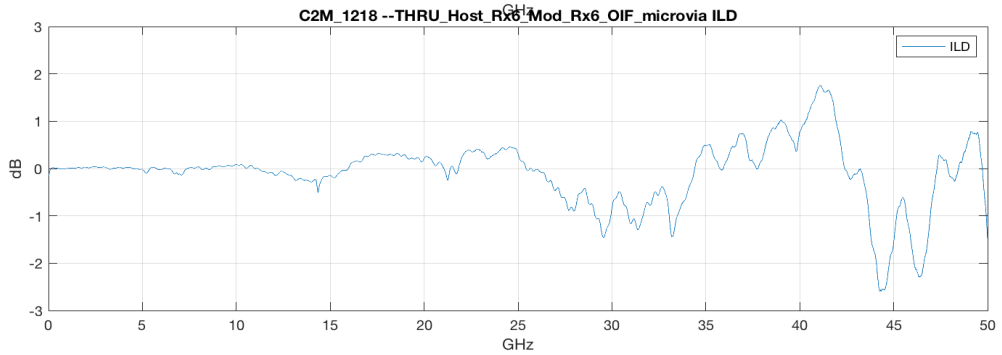
Result in (x) are for 30 mm PKG.

COM Analysis of Tracy Channels

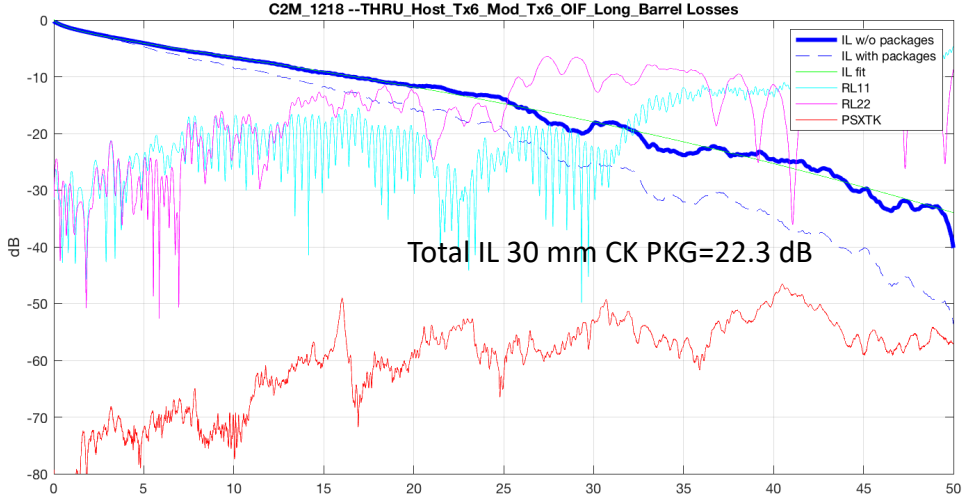
- **8.5” OSFP (16 dB) channels, CK package reduces loss but increases ILD at significant COM penalty!**
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

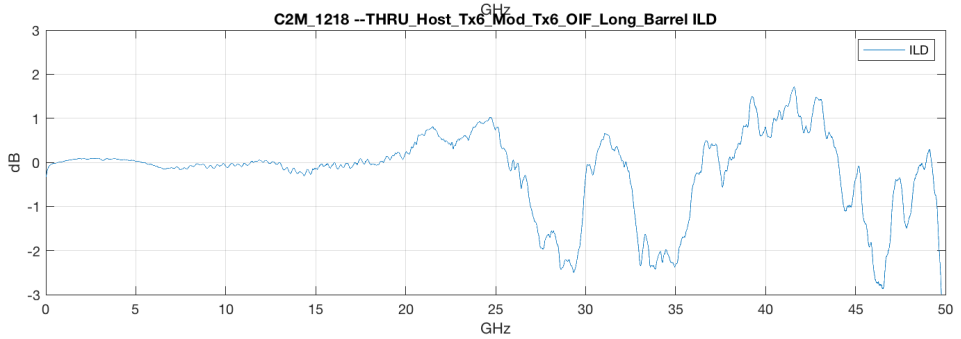
Tracy T6 MicroVia, FOM_ILD=0.21, ICN=0.91 mV, ICR=46, ERL11=15.4, ERL22=8.3
5T FFE: COM=4.7 (5.7) dB, EH=16.7 (15.8) mV, VEC=7.6 (6.3) dB
7T FFE: COM=4.8 (5.8) dB, EH=18.1 (17.6) mV, VEC=7.5 (6.3) dB





Tracy T6 LongBarrel, FOM_ILD=0.39, ICN=0.98 mV, ICR=40.2, ERL11=14.0, ERL22=9.3
5T FFE: COM=2.6 (3.4) dB, EH=8.9 (10.1) mV, VEC=11.8 (9.9) dB
7T FFE: COM=3.5 (4.2) dB, EH=11.6 (11.8) mV, VEC=9.6 (8.3) dB



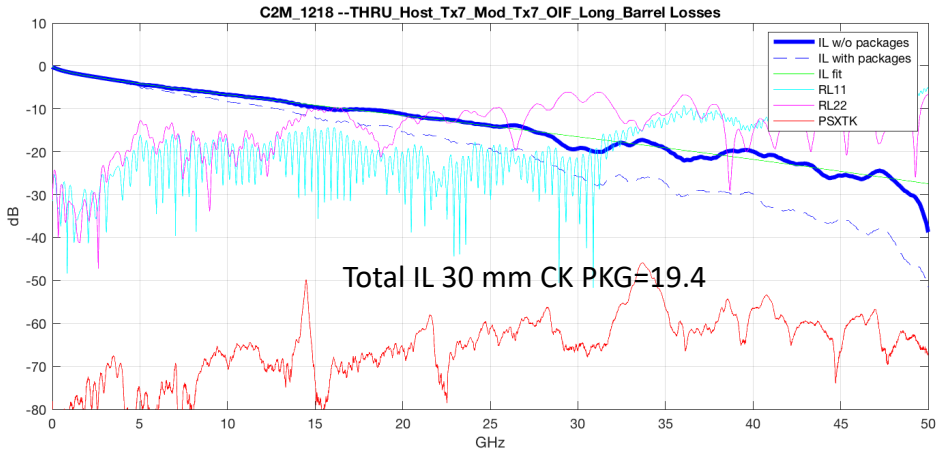


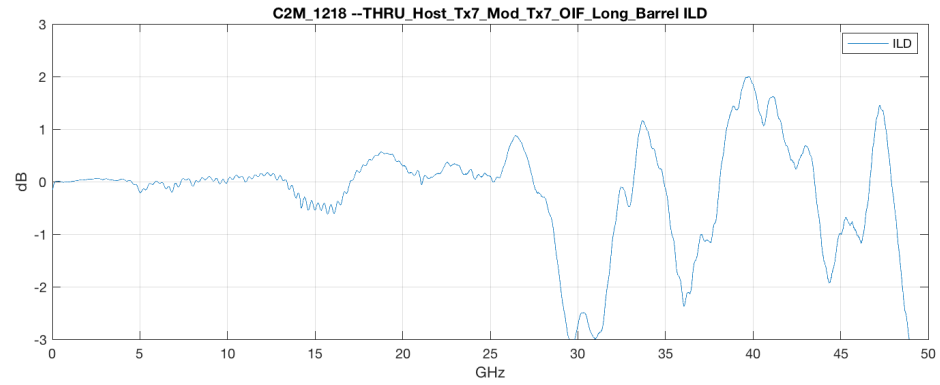
Result in (x) are for 30 mm PKG.

COM Analysis of Tracy Channels

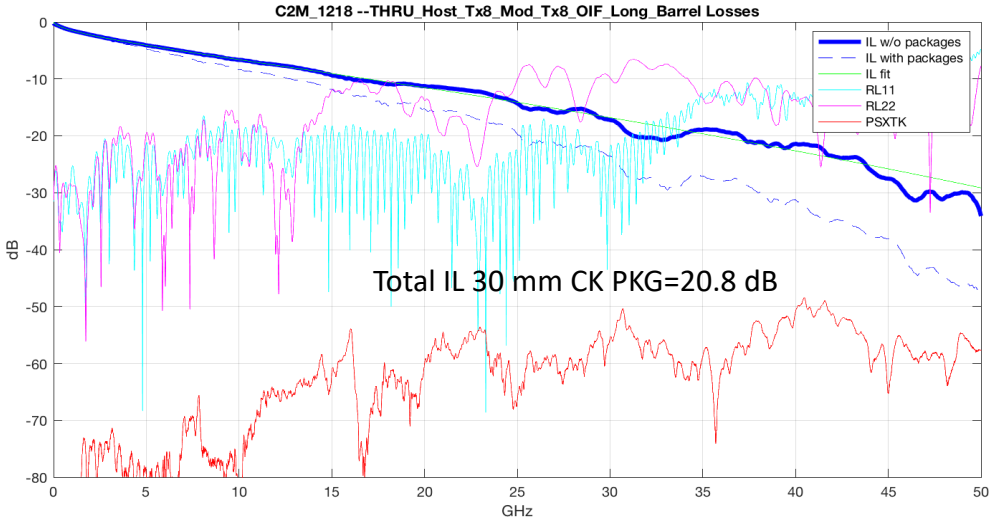
- **8.5” OSFP (16 dB) channels, CK package reduces loss but increases ILD at significant COM penalty!**
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip (long barrel)
  - http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip (Micro Via).

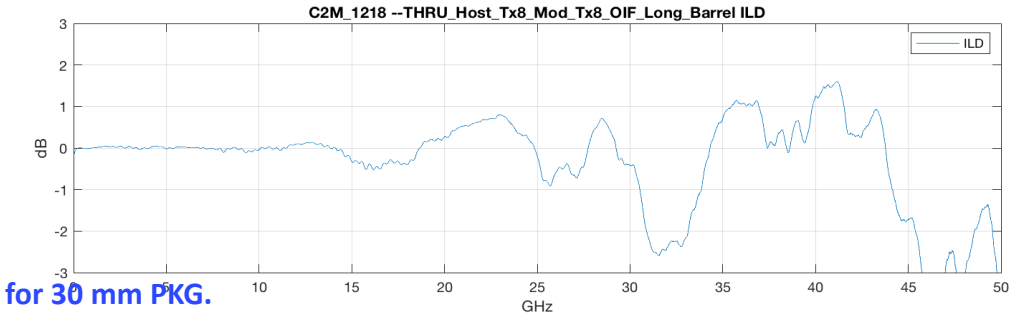
Tracy T7 LongBarrel, FOM_ILD=0.39, ICN=0.66 mV, ICR=48, ERL11=13.0, ERL22=7.3
5T FFE: COM=2.8 (3.9) dB, EH=10.8 (12.9) mV, VEC=11.2 (8.9) dB
7T FFE: COM=3.02 (4.0) dB, EH=10.8 (12.3) mV, VEC=10.6 (8.6) dB





Tracy T8 LongBarrel, FOM_ILD=0.32, ICN=0.76 mV, ICR=43, ERL11=14.9, ERL22=8.7
5T FFE: COM=4.9 (4.5) dB, EH=18.2 (13.3) mV, VEC=7.2 (7.9) dB



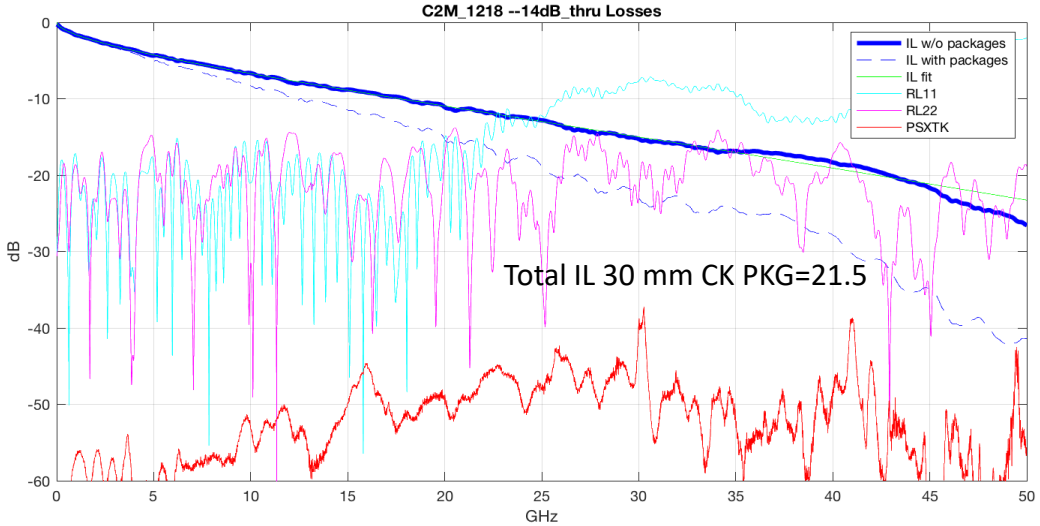


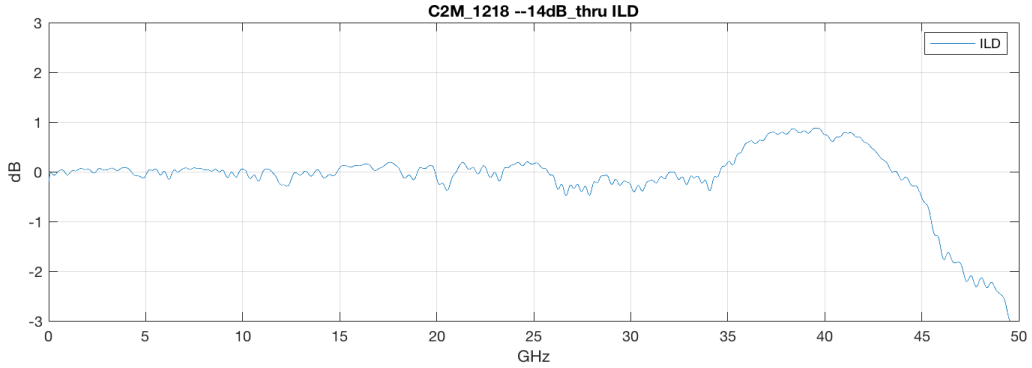
Result in (x) are for 30 mm PKG.

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

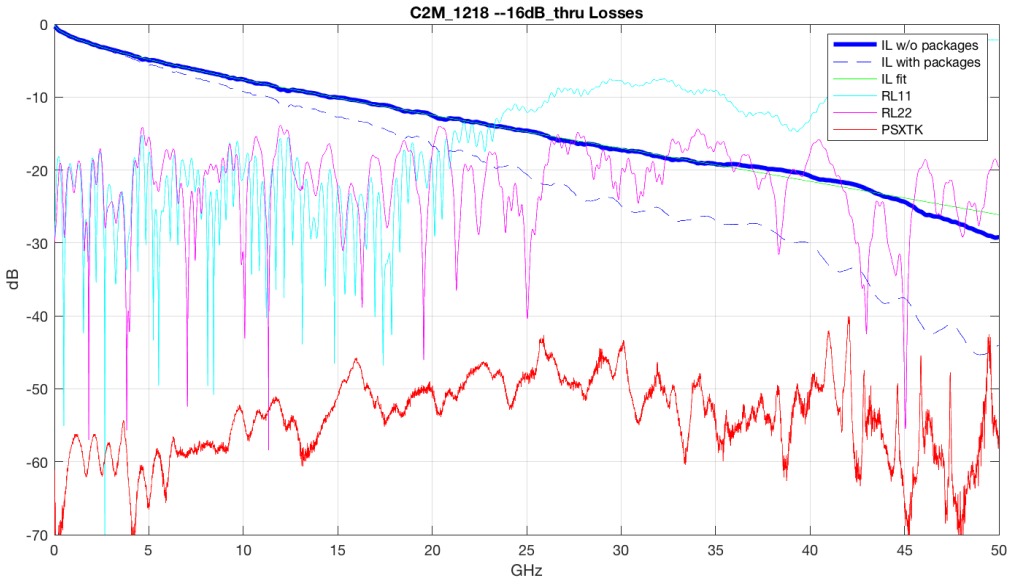
- **Lim Nov-2018 channel ICR still pretty low ~30 dB and with high ICN, but the crosstalk peak at 15 GHz eliminated, with this improvement passes with good margin on 30 mm package**
  - **http://www.ieee802.org/3/ck/public/tools/c2m/lim_3ck_01_0918_QDD_legacy_pairs.zip**

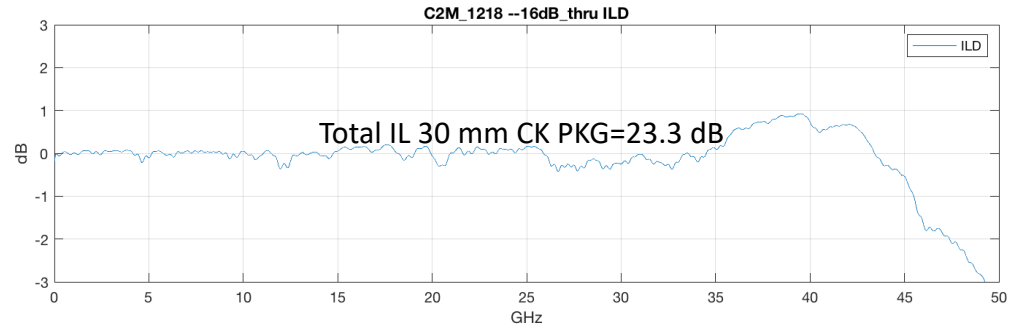
Lim 14 dB FOM_ILD=0.11, ICN=2.72 mV, ICR=31.5, ERL11=9.1, ERL22=12.2
5T FFE: COM=3.15 (4.46) dB, EH=14.9 (17.2) mV, VEC=10.3 (7.9) dB





Lim 16 dB, FOM_ILD=0.11, ICN=2.32 mV, ICR=30.8 dB, , ERL11=9.4, ERL22=12.3
5T FFE: COM=3.22 (4.92) dB, EH=12.4 (14.4) mV, VEC=10.2 (7.3) dB



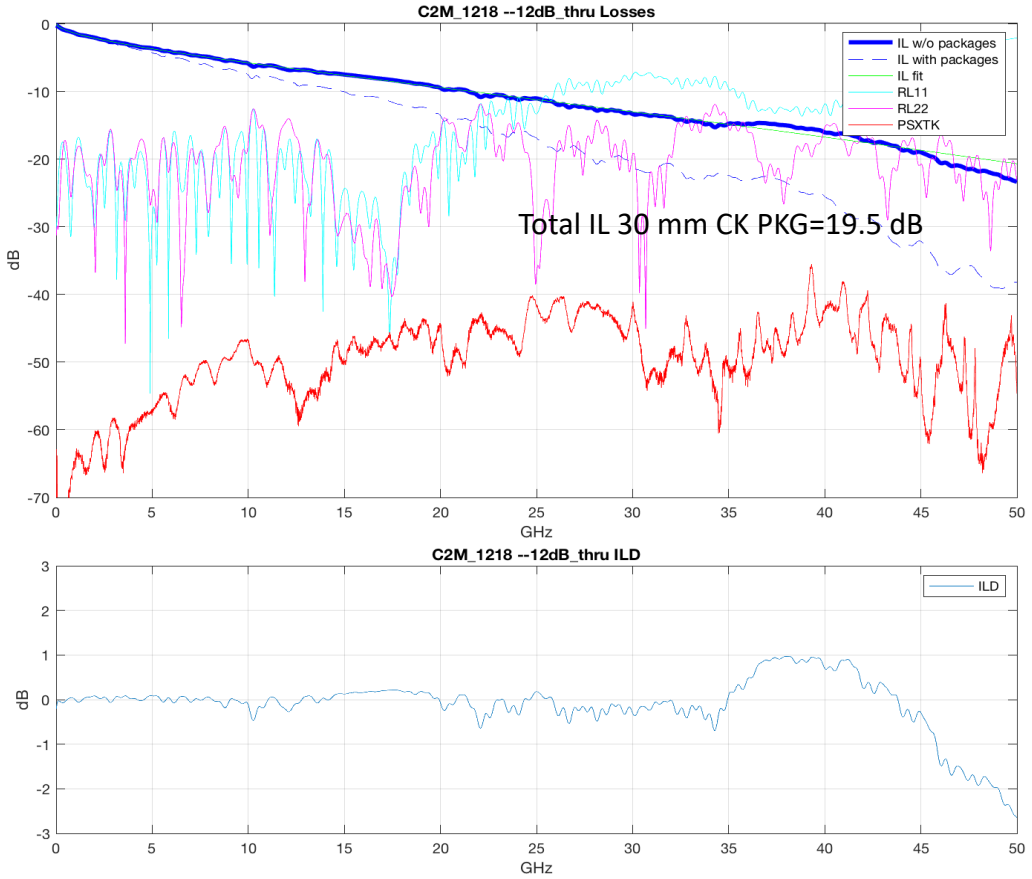


Result in (x) are for 30 mm PKG.

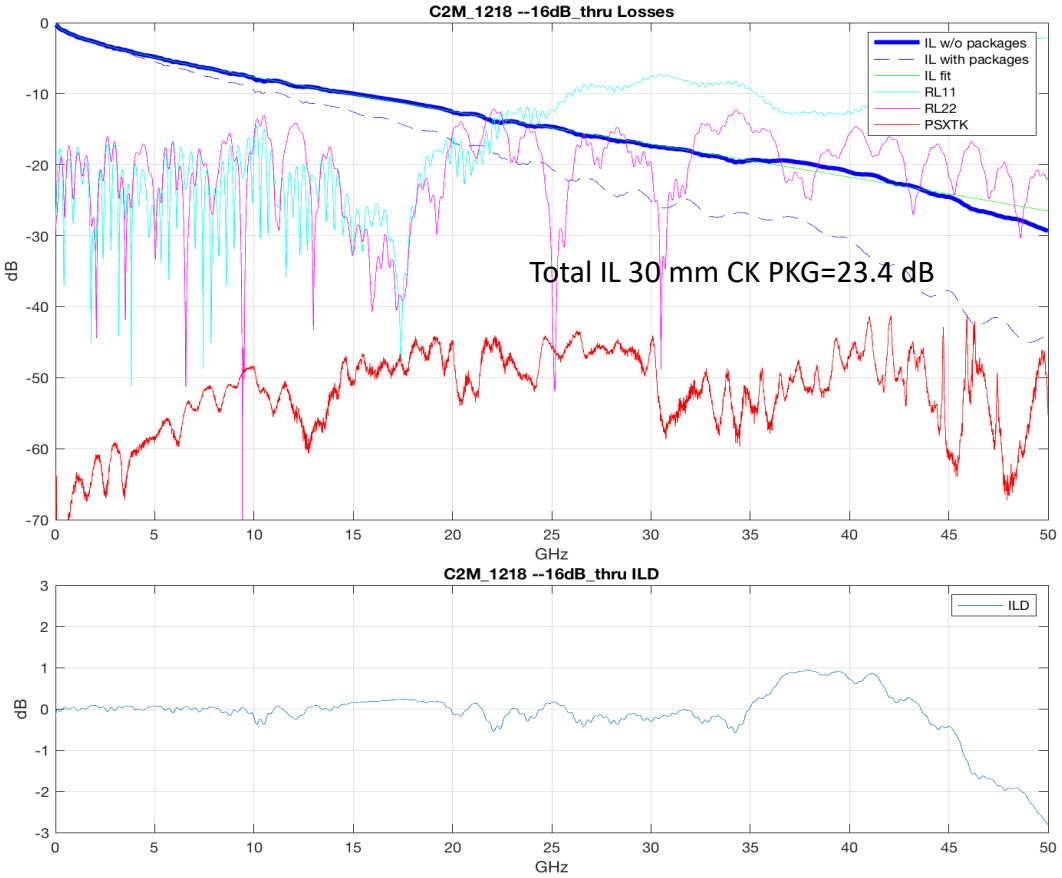
COM Analysis on Lim Nov-18 Channels (new contacts)

- **Lim Nov-2018 channel ICR still pretty low ~30 dB and with high ICN, but the crosstalk peak at 15 GHz eliminated, with this improvement passes with good margin on 30 mm package**
  - **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=3.21 (4.66) dB, EH=18.1 (23.0) mV, VEC=10.2 (7.6) dB



Lim 16 dB, FOM_ILD=0.122, ICN=2.85 mV, ICR=30.8 dB, , ERL11=9.3, ERL22=11.6
5T FFE: COM=3.13 (4.3) dB, EH=12.6 (13.3) mV, VEC=10.4 (8.1) dB



Result in (x) are for 30 mm PKG.

Summary

- **The 5 tap low power FFE equalizer may not be sufficient unless ILD, ICN, and channel reflections are better controlled**
  - The source of problems are long barrel vias and fan-in traces on 0.6 mm pitch connectors
- **The new CK package with addition of PTH results in higher ILD/reflections and penalizes C2M applications more than LR where the equalizes can cancel package double reflections**
  - The addition of PTH is consistent with most large ASIC requiring core but the 1.8 mm core could be reduced to 1 mm
  - The addition of PTH on channel with high ILD/Low ERL may result in 1-2 dB COM penalty see Ghiasi_3ck-01c_0119
- **Updated results using COM 2.5.8 on TE/Tracy and Cisco/Lim channels are promising to assume 5T FFE for TP1a reference equalizer**
  - TE/Tracy OSFP micro-via channels all exceed 3 dB COM with 5 T FFE
  - TE/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
    - The primary degradation of long barrel via channels are due to length of via length and the microstrip fan-out at OSFP connector
    - Via stub of 3.75 mils is not expected to be one of primary degradation source but conventional back drilled via with ~ 7 mils would be one of the primary source of degradation
  - Cisco/Lim QSFP-dd channels exceed 3 dB COM with 5T FFE
- **Instead of defining hard limit on ILD, ICN, IL, or ERL, COM can be used as the tool for channel goodness**
  - TE RX6 micro via having ER of 8.3 has 4.7 dB COM but TE TX6 long barrel via with ERL of 9.3 has COM of only 2.6 dB
  - Cisco Lim 12 dB channel with high ICN of 3.65 mV passes COM
  - If we have to add some channel constrains it would have be a set lax limits as we don't want good channel to fail such as: ILD<0.25, ICR<31 dB, and ERL< 7.8 dB or just simplify the acceptance by using COM of 3 dB!