A Collection of Cabled Backplane Prototype Channels for 200Gb/s per lane for .3df PHY Type Development

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Acknowledgements to:
Brandon Gore, Adam Gregory, Steve Krooswyk, Scott McMorrow, Shawn Tucker (Samtec)

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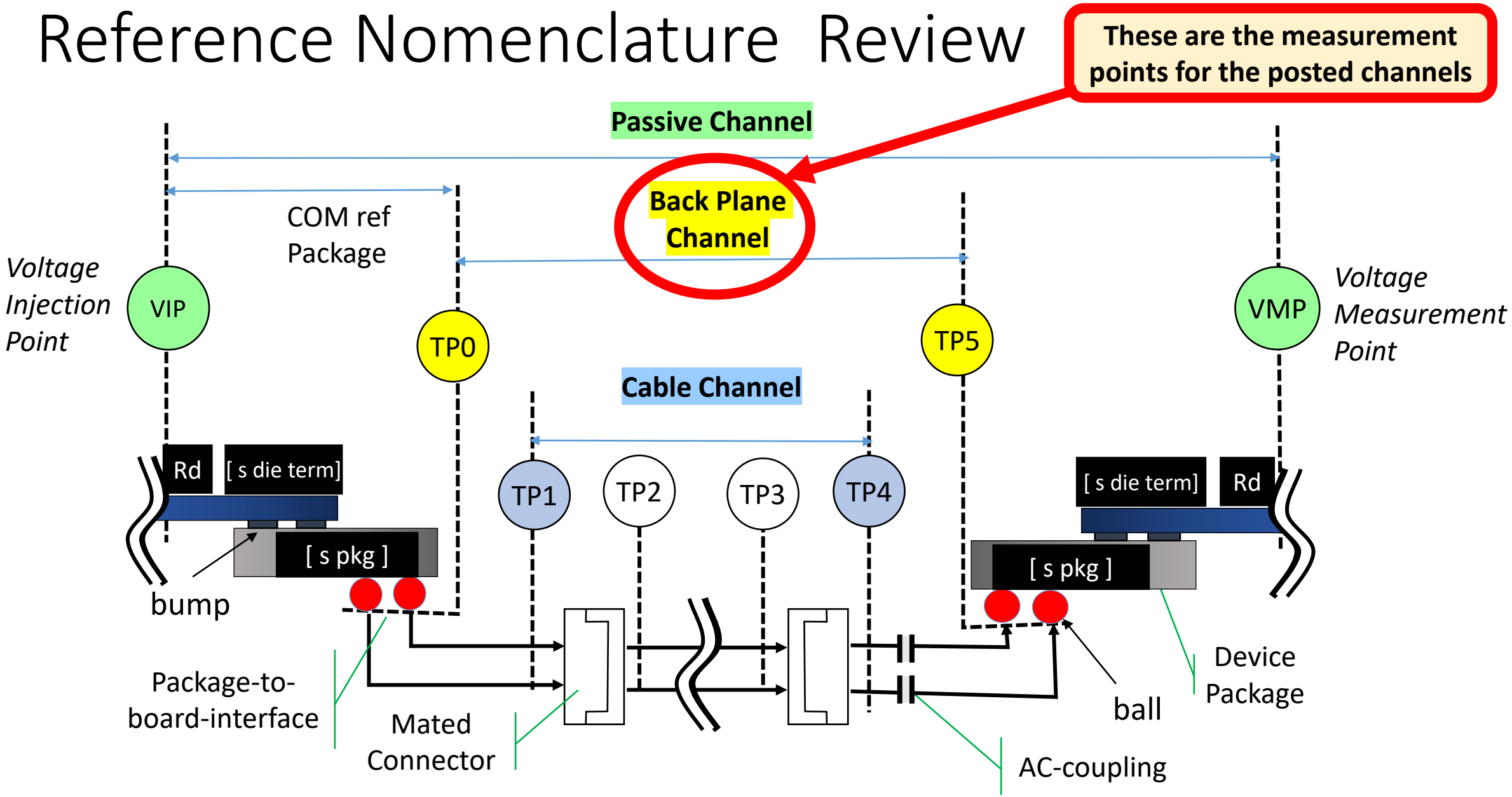
Agenda

- Introduction
- Topology
- Losses
- COM results
- Next

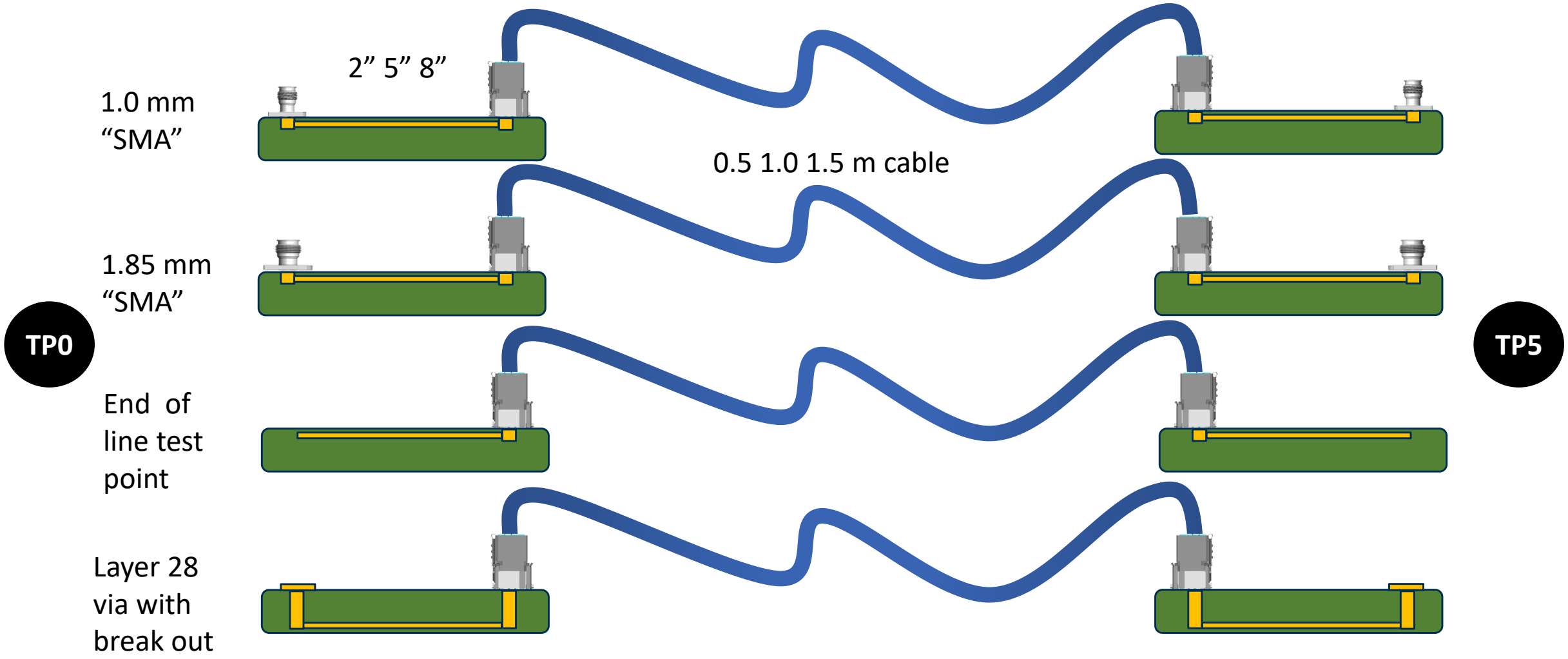
Collection of Cabled Backplane Prototype Channels (TP0 to TP5)

- These channels represent non-standard MDI cabling (CR)
  - And as before these are a subset of KR
  - Do we need a KR objective to define Tx and Rx specifications chips and requirements?
- This is a first step for channels and represents a prototype evaluation phase
- Crosstalk is not included
- Refinement expected as models move toward more specific product focused features
- Goal is to illustrate a collection of losses with 2 connector well terminated channels

Reference Nomenclature Review



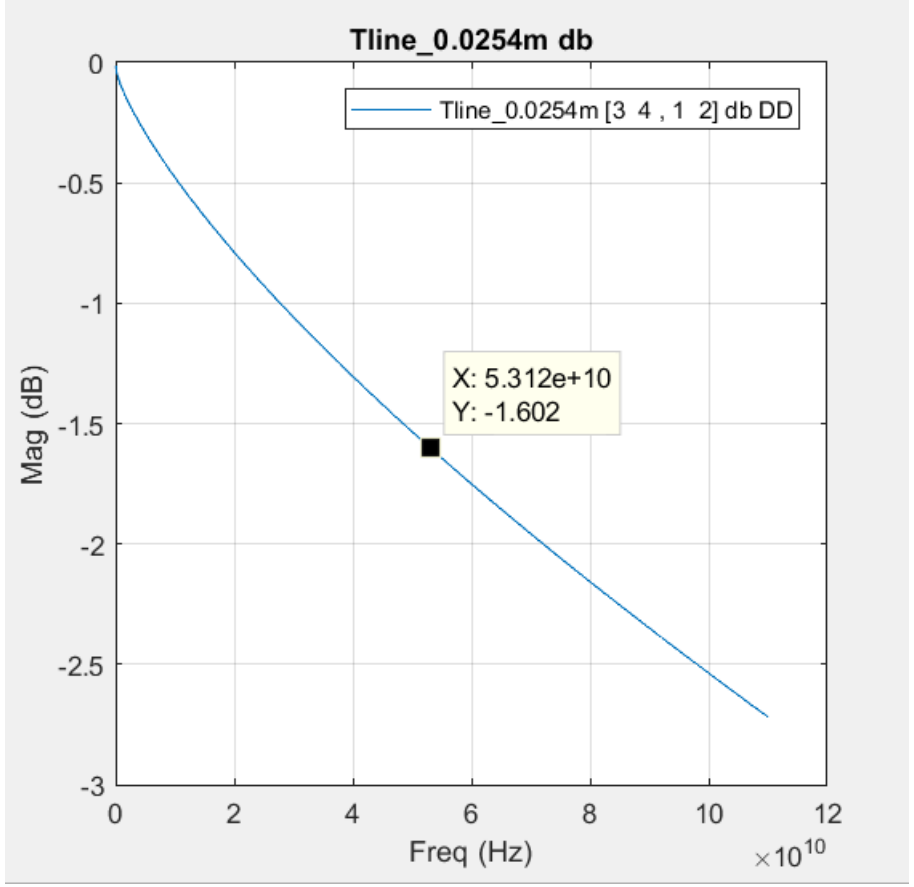
Proto-type grade channels



Channel Description 1

PCB (100 Ω target)

- 30 layers
- 3mm thick
- ~ 6 mil trace width
- HVLP
- Dk, Df = 2.8 , 0.002
- 1.6 dB /inch @ 53.125 GHz
- Conductivity = 5.3e7 S/m
- PCB loss selections (@ 53.125 GHz)
  - 3.2 dB, 8 dB, 12 dB
  - 2”, 5”, 7.45”



Channel Description 2

Verticals for 200 Gb/s Prototying

- All modeled with HFSS
  - Some correlated to measurements
- Terminations (4 types)
  - 1.0 mm and 1.85 mm “SMA” connector have a break out region (BOR)
  - Open transmission line (wave ports) … ideal
  - Top layer to layer 28 via and BOR with 4 mil stubs
    - Tuned by Scott McMorrow
    - Background:
      - https://blog.samtec.com/wp-content/uploads/2020/11/11_19_2020_practical_uses_of_ERL.pdf
- Connector
  - Board with BOR on one side to small amount of twin axial cable on other side
  - Small wipe and small contact spring stub
- Frequency range exceeds 100 GHz

Channel Description 3

Cable

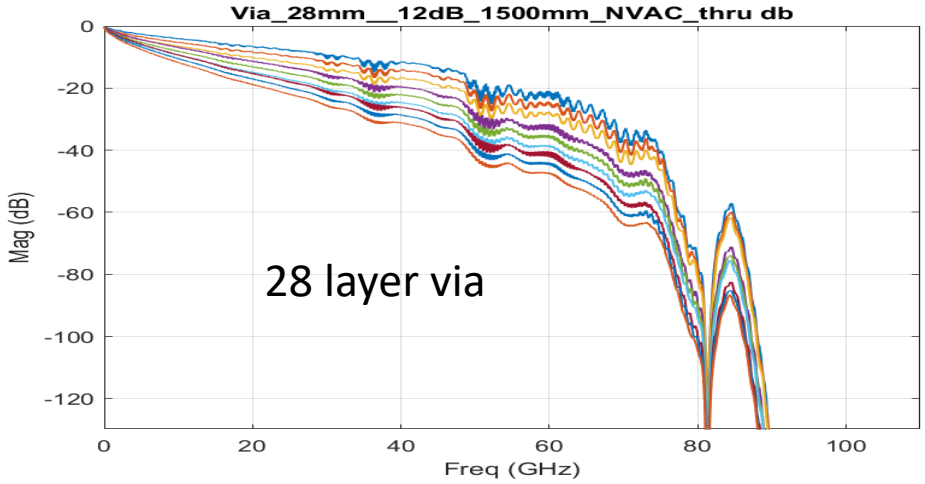
- ❑ 100 Ω target
- ❑ 27 AWG
- ❑ Solid Core Cu Micro Twin-axial Cable
- ❑ 0.5 meter, 1.0 meter, and 1.5 meter cable lengths

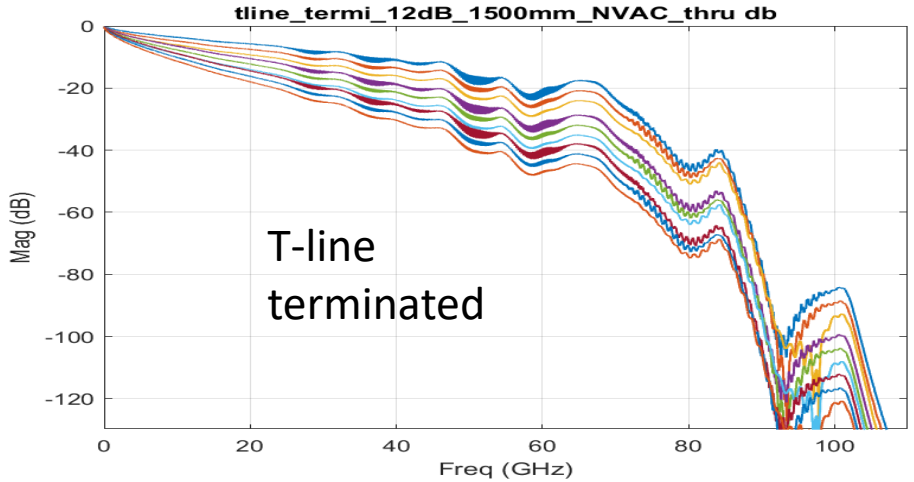
File Names

“termination”_”PCB Loss”_”Cable length”

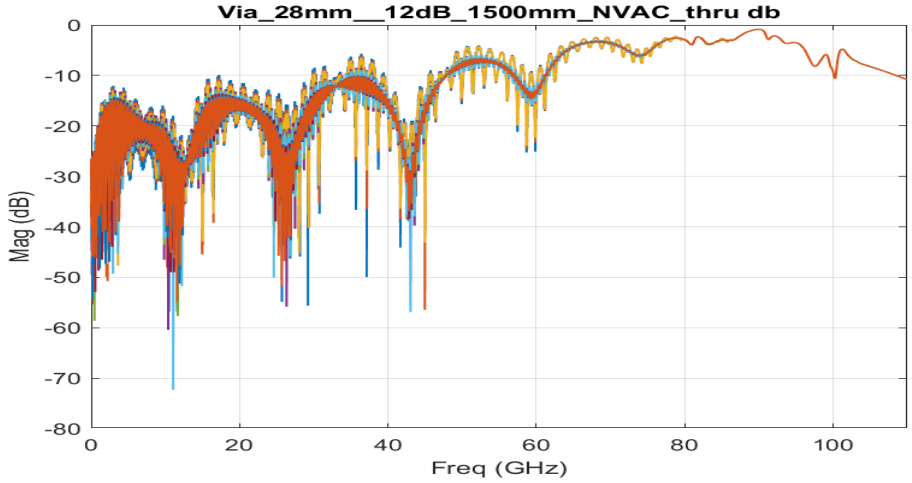
sma_1.0mm_12dB_1000mm_NVAC_thru.s4p
sma_1.0mm_12dB_1500mm_NVAC_thru.s4p
sma_1.0mm_12dB_500mm_NVAC_thru.s4p
sma_1.0mm_3.2dB_1000mm_NVAC_thru.s4p
sma_1.0mm_3.2dB_1500mm_NVAC_thru.s4p
sma_1.0mm_3.2dB_500mm_NVAC_thru.s4p
sma_1.0mm_8dB_1000mm_NVAC_thru.s4p
sma_1.0mm_8dB_1500mm_NVAC_thru.s4p
sma_1.0mm_8dB_500mm_NVAC_thru.s4p
sma_1.85mm_12dB_1000mm_NVAC_thru.s4p
sma_1.85mm_12dB_1500mm_NVAC_thru.s4p
sma_1.85mm_12dB_500mm_NVAC_thru.s4p
sma_1.85mm_3.2dB_1000mm_NVAC_thru.s4p
sma_1.85mm_3.2dB_1500mm_NVAC_thru.s4p
sma_1.85mm_3.2dB_500mm_NVAC_thru.s4p
sma_1.85mm_8dB_1000mm_NVAC_thru.s4p
sma_1.85mm_8dB_1500mm_NVAC_thru.s4p
sma_1.85mm_8dB_500mm_NVAC_thru.s4p
tline_termi_12dB_1000mm_NVAC_thru.s4p
tline_termi_12dB_1500mm_NVAC_thru.s4p
tline_termi_12dB_500mm_NVAC_thru.s4p
tline_termi_3.2dB_1000mm_NVAC_thru.s4p
tline_termi_3.2dB_1500mm_NVAC_thru.s4p
tline_termi_3.2dB_500mm_NVAC_thru.s4p
tline_termi_8dB_1000mm_NVAC_thru.s4p
tline_termi_8dB_1500mm_NVAC_thru.s4p
tline_termi_8dB_500mm_NVAC_thru.s4p
Via_28mm__12dB_1000mm_NVAC_thru.s4p
Via_28mm__12dB_1500mm_NVAC_thru.s4p
Via_28mm__12dB_500mm_NVAC_thru.s4p
Via_28mm__3.2dB_1000mm_NVAC_thru.s4p
Via_28mm__3.2dB_1500mm_NVAC_thru.s4p
Via_28mm__3.2dB_500mm_NVAC_thru.s4p
Via_28mm__8dB_1000mm_NVAC_thru.s4p
Via_28mm__8dB_1500mm_NVAC_thru.s4p
Via_28mm__8dB_500mm_NVAC_thru.s4p

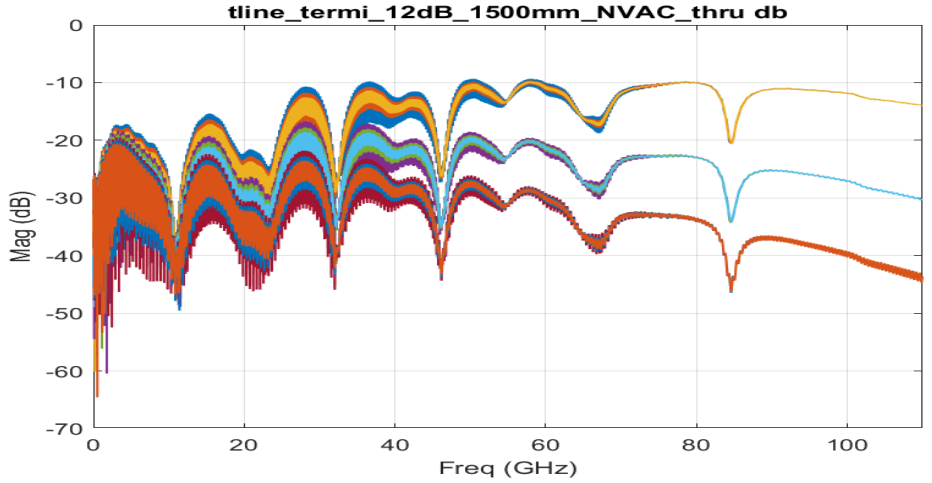
IL and RL 28th layer via and T-line terminated





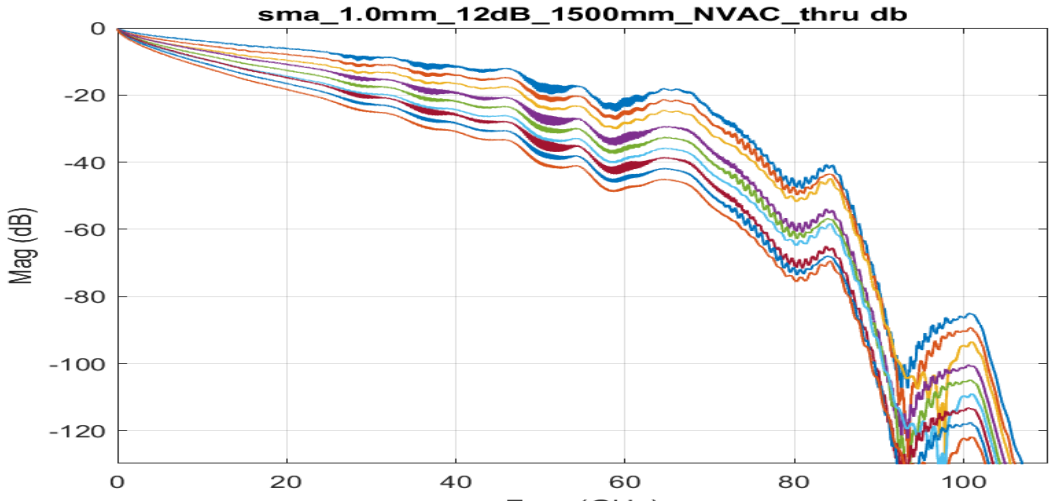
IL

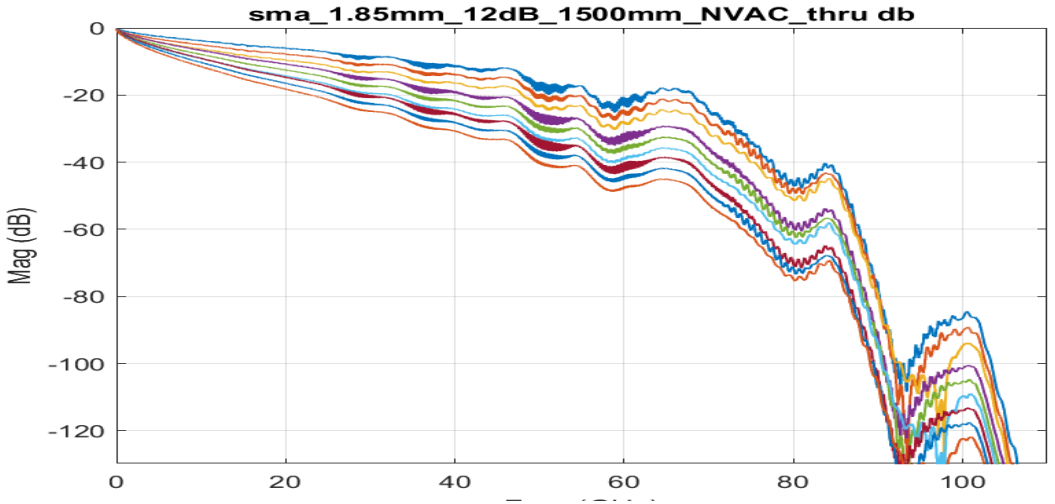




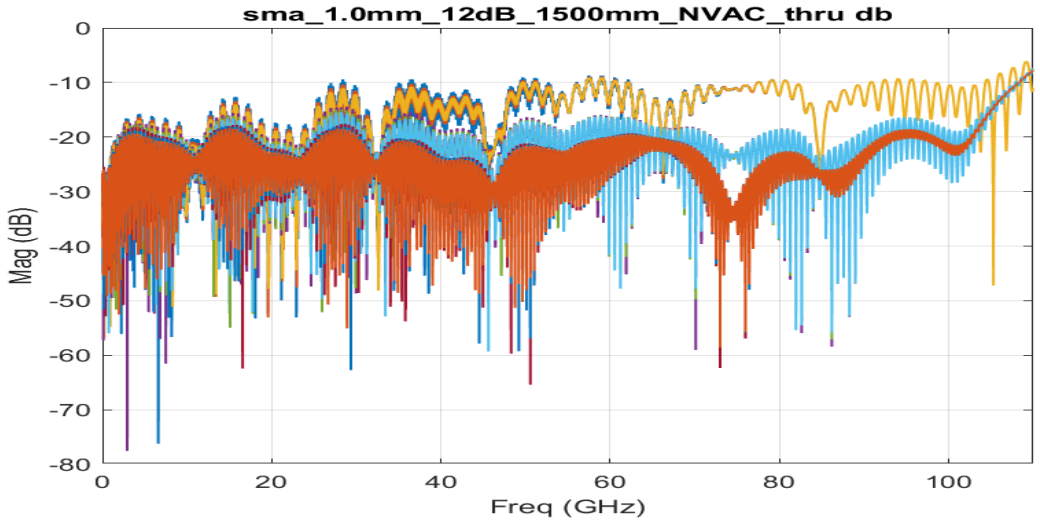
RL

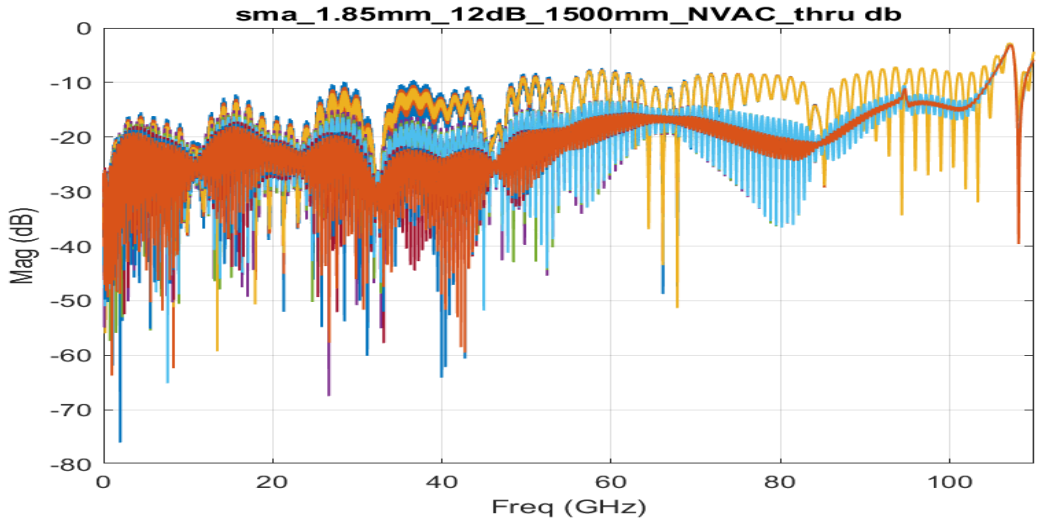
IL and RL “sma” 1.0 mm and 1.85 mm





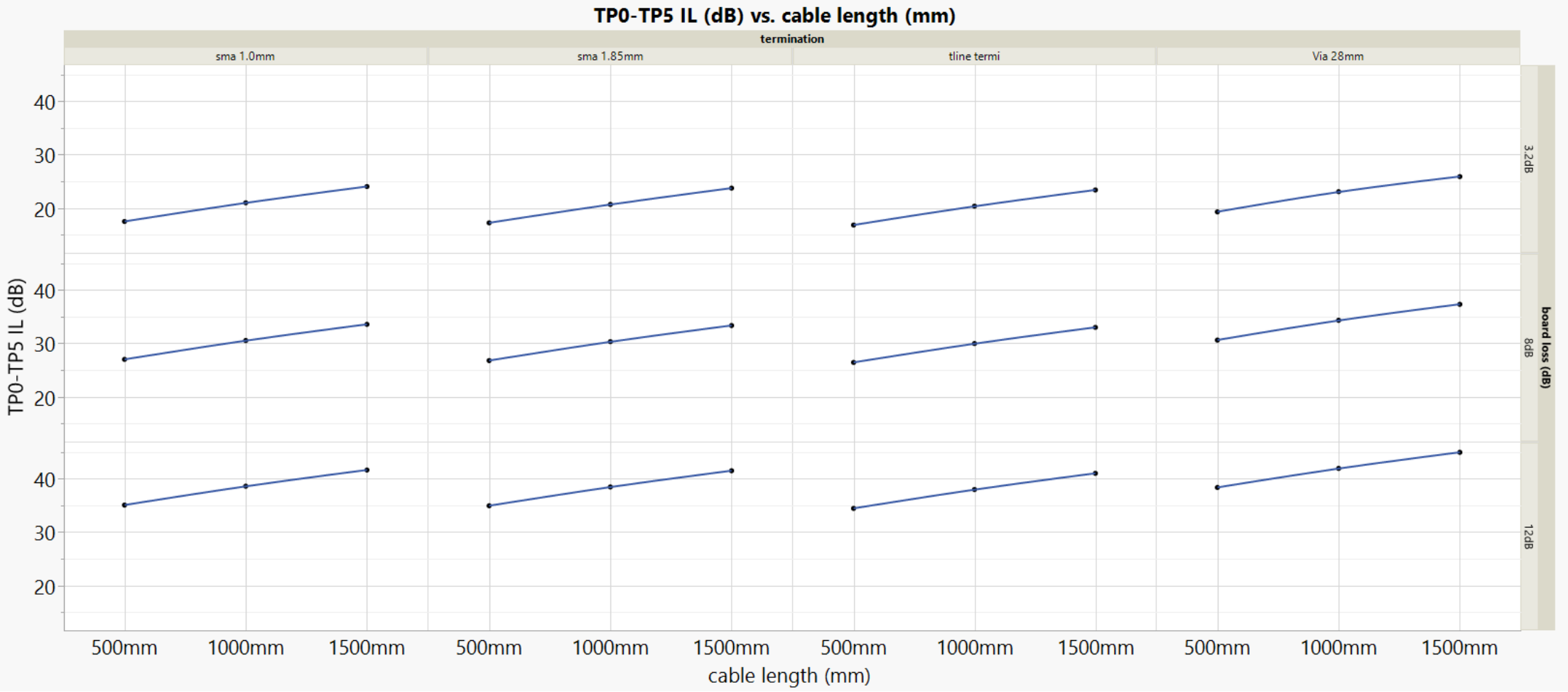
IL





RL

Loss spans 17.4 dB to 44.95 dB at 53.125 GHz



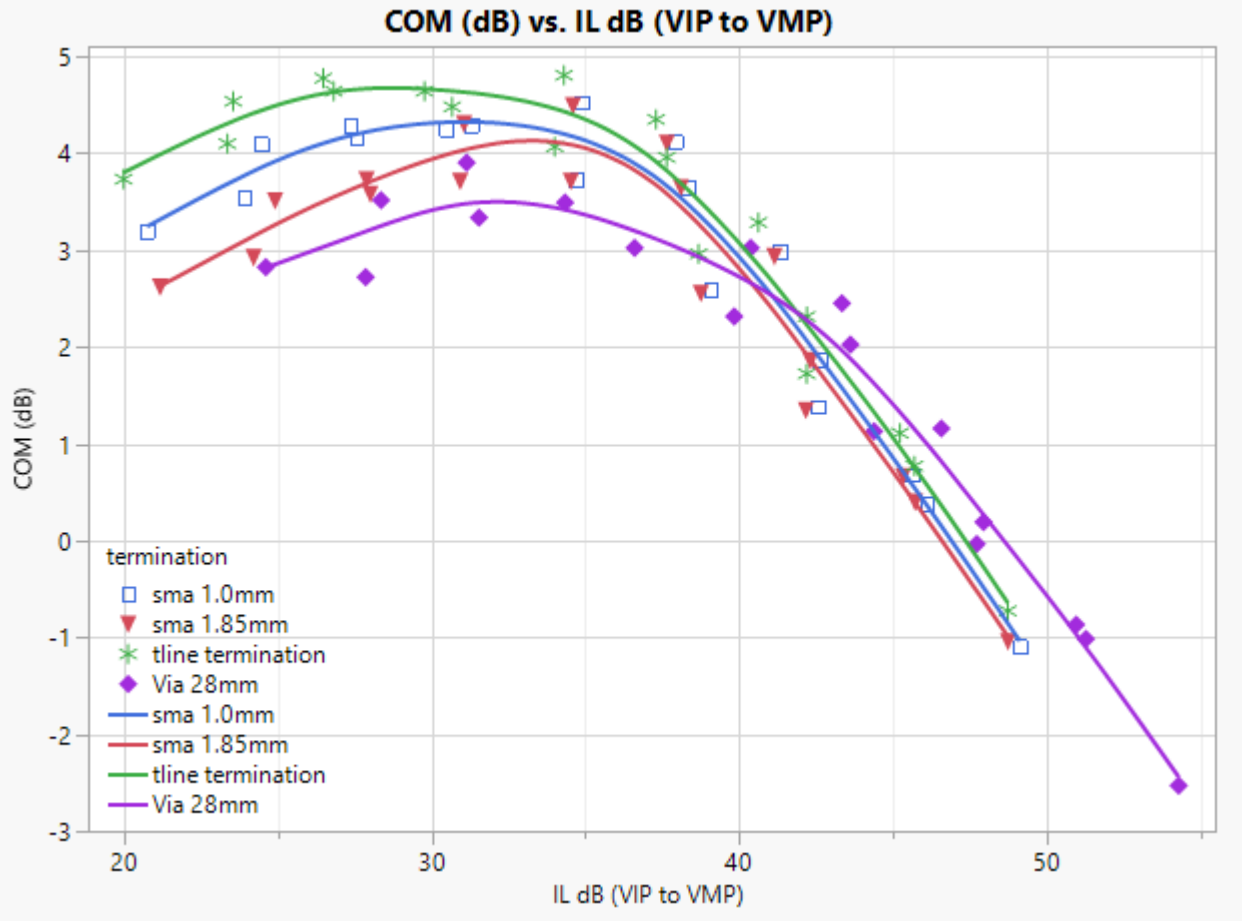
IL, ERL, COM results

termination	board loss (dB)	cable length (mm)	package case	IL dB (VIP to VMP)	COM (dB)	ERL (dB)
sma 1.0mm	12dB	1000mm	pkg 1	42.6	1.9	22.4
sma 1.0mm	12dB	1500mm	pkg 1	45.6	0.7	22.8
sma 1.0mm	12dB	500mm	pkg 1	39.1	2.6	21.9
sma 1.0mm	3.2dB	1000mm	pkg 1	24.5	4.1	16.3
sma 1.0mm	3.2dB	1500mm	pkg 1	27.4	4.3	16.7
sma 1.0mm	3.2dB	500mm	pkg 1	20.7	3.2	15.6
sma 1.0mm	8dB	1000mm	pkg 1	34.9	4.5	20.3
sma 1.0mm	8dB	1500mm	pkg 1	37.9	4.1	20.7
sma 1.0mm	8dB	500mm	pkg 1	31.3	4.3	19.7
sma 1.85mm	12dB	1000mm	pkg 1	42.3	1.9	22.3
sma 1.85mm	12dB	1500mm	pkg 1	45.3	0.7	22.7
sma 1.85mm	12dB	500mm	pkg 1	38.8	2.6	21.8
sma 1.85mm	3.2dB	1000mm	pkg 1	24.9	3.5	16.1
sma 1.85mm	3.2dB	1500mm	pkg 1	27.9	3.7	16.5
sma 1.85mm	3.2dB	500mm	pkg 1	21.2	2.6	15.5
sma 1.85mm	8dB	1000mm	pkg 1	34.6	4.5	20.2
sma 1.85mm	8dB	1500mm	pkg 1	37.6	4.1	20.6
sma 1.85mm	8dB	500mm	pkg 1	31.1	4.3	19.6
sma 1.0mm	12dB	1000mm	pkg 2	46.1	0.4	22.4
sma 1.0mm	12dB	1500mm	pkg 2	49.1	-1.1	22.8
sma 1.0mm	12dB	500mm	pkg 2	42.6	1.4	21.9
sma 1.0mm	3.2dB	1000mm	pkg 2	27.6	4.2	16.3
sma 1.0mm	3.2dB	1500mm	pkg 2	30.5	4.3	16.7
sma 1.0mm	3.2dB	500mm	pkg 2	23.9	3.5	15.6
sma 1.0mm	8dB	1000mm	pkg 2	38.3	3.6	20.3
sma 1.0mm	8dB	1500mm	pkg 2	41.3	3.0	20.7
sma 1.0mm	8dB	500mm	pkg 2	34.7	3.7	19.7
sma 1.85mm	12dB	1000mm	pkg 2	45.7	0.4	22.3
sma 1.85mm	12dB	1500mm	pkg 2	48.7	-1.0	22.7
sma 1.85mm	12dB	500mm	pkg 2	42.2	1.4	21.8
sma 1.85mm	3.2dB	1000mm	pkg 2	28.0	3.6	16.1
sma 1.85mm	3.2dB	1500mm	pkg 2	30.9	3.7	16.5
sma 1.85mm	3.2dB	500mm	pkg 2	24.2	2.9	15.5
sma 1.85mm	8dB	1000mm	pkg 2	38.1	3.6	20.2
sma 1.85mm	8dB	1500mm	pkg 2	41.1	2.9	20.6
sma 1.85mm	8dB	500mm	pkg 2	34.5	3.7	19.6

termination	board loss (dB)	cable length (mm)	package case	IL dB (VIP to VMP)	COM (dB)	ERL (dB)
tline termi	12dB	1000mm	pkg 1	42.2	2.3	23.4
tline termi	12dB	1500mm	pkg 1	45.2	1.1	23.8
tline termi	12dB	500mm	pkg 1	38.7	3.0	22.7
tline termi	3.2dB	1000mm	pkg 1	23.6	4.5	16.3
tline termi	3.2dB	1500mm	pkg 1	26.5	4.8	16.7
tline termi	3.2dB	500mm	pkg 1	20.0	3.7	15.7
tline termi	8dB	1000mm	pkg 1	34.3	4.8	20.8
tline termi	8dB	1500mm	pkg 1	37.3	4.4	21.3
tline termi	8dB	500mm	pkg 1	30.7	4.5	20.1
Via 28mm	12dB	1000mm	pkg 1	47.9	0.2	19.1
Via 28mm	12dB	1500mm	pkg 1	51.0	-0.9	19.3
Via 28mm	12dB	500mm	pkg 1	44.4	1.1	18.9
Via 28mm	3.2dB	1000mm	pkg 1	28.4	3.5	15.7
Via 28mm	3.2dB	1500mm	pkg 1	31.1	3.9	16.0
Via 28mm	3.2dB	500mm	pkg 1	24.6	2.8	15.2
Via 28mm	8dB	1000mm	pkg 1	40.4	3.0	18.0
Via 28mm	8dB	1500mm	pkg 1	43.3	2.5	18.3
Via 28mm	8dB	500mm	pkg 1	36.6	3.0	17.7
tline termi	12dB	1000mm	pkg 2	45.7	0.8	23.4
tline termi	12dB	1500mm	pkg 2	48.7	-0.7	23.8
tline termi	12dB	500mm	pkg 2	42.2	1.7	22.7
tline termi	3.2dB	1000mm	pkg 2	26.8	4.6	16.3
tline termi	3.2dB	1500mm	pkg 2	29.8	4.6	16.7
tline termi	3.2dB	500mm	pkg 2	23.4	4.1	15.7
tline termi	8dB	1000mm	pkg 2	37.6	4.0	20.8
tline termi	8dB	1500mm	pkg 2	40.6	3.3	21.3
tline termi	8dB	500mm	pkg 2	34.0	4.1	20.1
Via 28mm	12dB	1000mm	pkg 2	51.3	-1.0	19.1
Via 28mm	12dB	1500mm	pkg 2	54.3	-2.5	19.3
Via 28mm	12dB	500mm	pkg 2	47.7	0.0	18.9
Via 28mm	3.2dB	1000mm	pkg 2	31.5	3.3	15.7
Via 28mm	3.2dB	1500mm	pkg 2	34.3	3.5	16.0
Via 28mm	3.2dB	500mm	pkg 2	27.9	2.7	15.2
Via 28mm	8dB	1000mm	pkg 2	43.6	2.0	18.0
Via 28mm	8dB	1500mm	pkg 2	46.6	1.2	18.3
Via 28mm	8dB	500mm	pkg 2	39.8	2.3	17.7

Plot of COM vs Loss

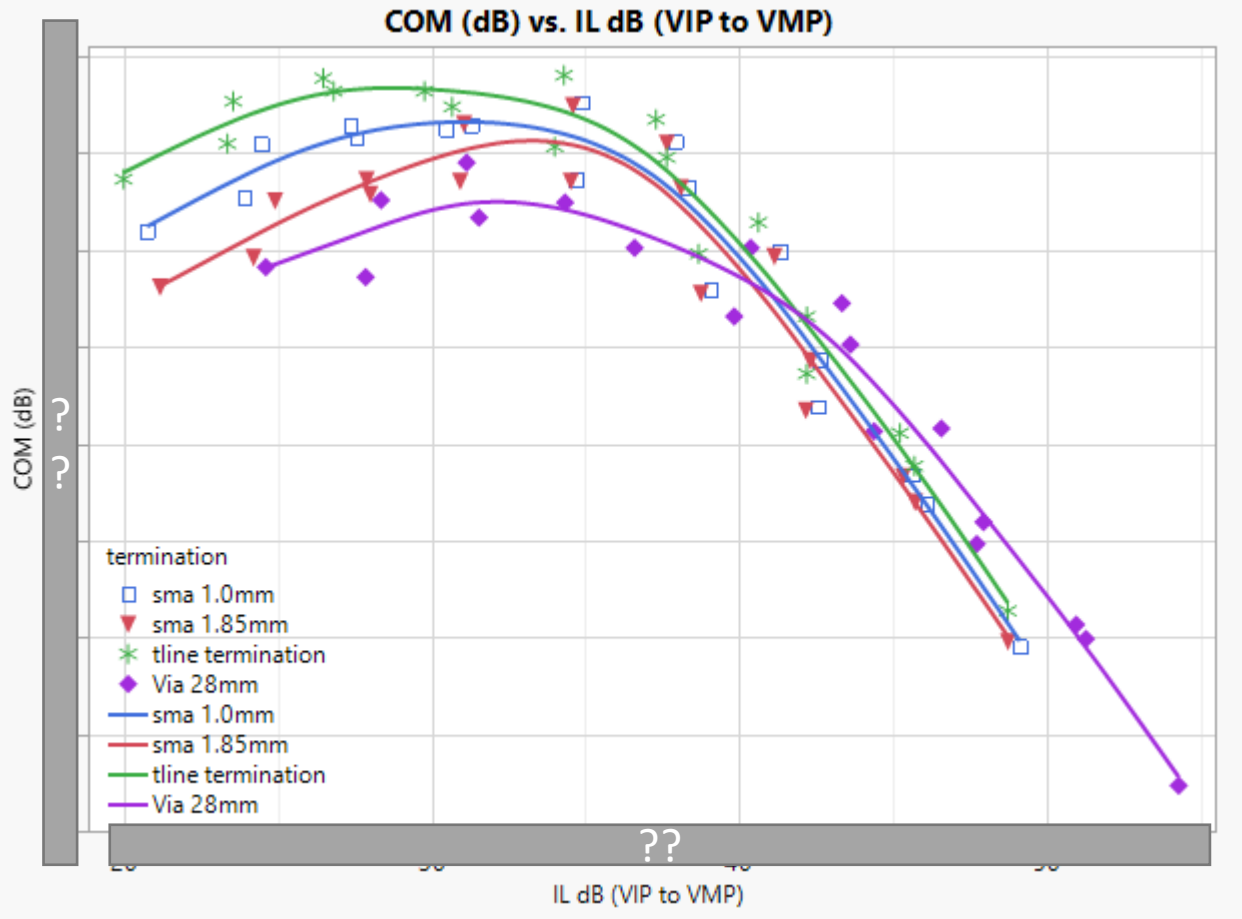
For Each Termination Selection



- ❑ This is only example based on an example COM configuration
- ❑ Observation
  - There is a loss break point based on termination

Plot of COM vs Loss Evolution

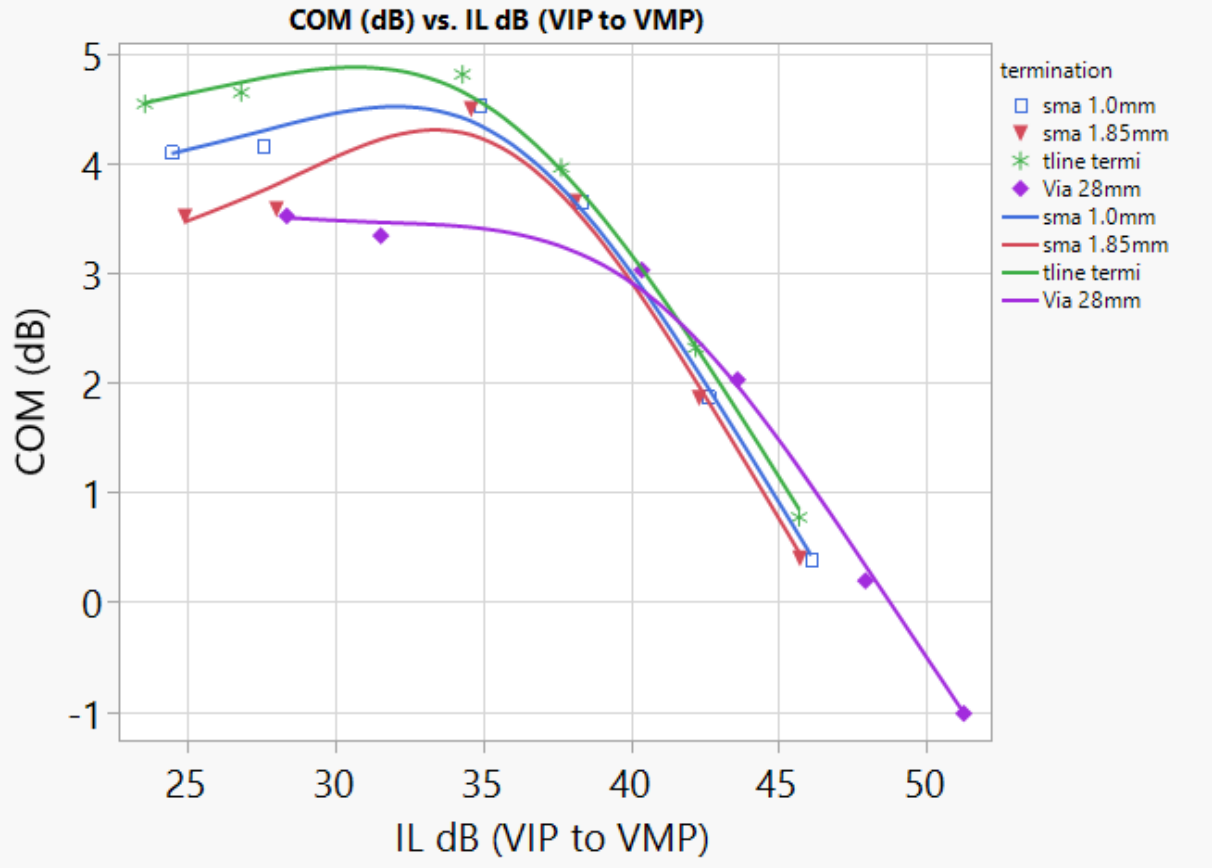
For Each Termination Selection



- This is only example based on an example COM configuration
- Observation
  - There is a loss break point based on termination
  - This break point is expected to evolve with refined channel models and Tx/Rx Parameters.

Plot of COM vs Loss for 1 m Cable Configurations

For Each Termination Selection



- ❑ This is only example based on an example COM configuration
- ❑ Observation
  - Termination effects are quite strong especially for lower loss channels
    - E.g. shorter host channels

Table 93A-1 parameters			2
Parameter	**Setting**	**Units**	**Information**
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4 ; 0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[.13 .15 .14; .13 .15 .14]	nH	[TX RX]
C_b	[.3e-4 .3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[15 31; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[15 29; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[15 31; 1.8 1.8]	mm	[test cases]
z_p (RX)	[15 29; 1.8 1.8]	mm	[test cases]
C_p	[0.5e-4 0.5e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 50]	Ohm	[TX RX]
A_v	0.408	V	
A_fe	0.408	V	
A_ne	0.608	V	
L	4		
M	32		
filter and Eq			
f_r	0.75	*fb	
c(0)	0.6		min
c(-1)	[-0.34:0.02:0]		[min:step:max]
c(-2)	[0:0.02:0.2]		[min:step:max]
c(-3)	[-0.1:0.02: 0]		[min:step:max]
c(1)	[-0.1:0.02:0]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
b_min(1)	-0.85		
b_min(2..N_b)	-0.3		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-8:1:0]		[min:step:max]
f_HP_PZ	1.0625	GHz	
GDC_MIN	0	dB	0 is and ingnore

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	.\results\200G_kR_{date}\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	R200_eval	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-04	
T_r	2.50E-03	ns
FORCE_TR	1	logical
Local Search	2	
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	6000	
beta_x	0	
rho_x	0.618	
fixture delay time	[0 0]	[port1 port2]
TDR_W_TXPKG	0	
N_bx	36	UI
Z_t	50	ohm
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	4.10E-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 8.4e-4 1.1e-4]	2.75 dB /in at 56G
package_tl_tau	6.14E-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 6.44084e-4 3.6036e-05]	1.5 dbpi at 56G
board_tl_tau	0.00579	ns/mm
board_Z_c	100	Ohm
z_bp (TX)	40	mm
z_bp (NEXT)	40	mm
z_bp (FEXT)	40	mm
z_bp (RX)	40	mm
C_0	[0.2e-4]	nF
C_1	[0.1e-4]	nF
Include PCB	0	**logical**
Floating Tap Control		
N_bg	3	0 1 2 or 3 groups
N_bf	6	taps per group
N_f	60	UI span for floating taps
bmaxg	0.2	max DFE value for floating taps
B_float_RSS_MAX	0.2	rss tail tap limit
N_tail_start	25	(UI) start of tail taps limit
ICN parameters		
f_v	0.890	*Fb
f_f	0.890	*Fb
f_n	0.890	*Fb
f_2	79.688	GHz
A_ft	0.600	V
A_nt	**0.600**	V

COM Experimental Configuration

WIP

- Channels with crosstalk for various product BOR, cable, and PCB strategies
- 1 connector TP0 to TP1a channels
  - E.g. C2M
- Determine support for a KR objective

Thank You !!