Floating Tap Benefit for Backplane Channels

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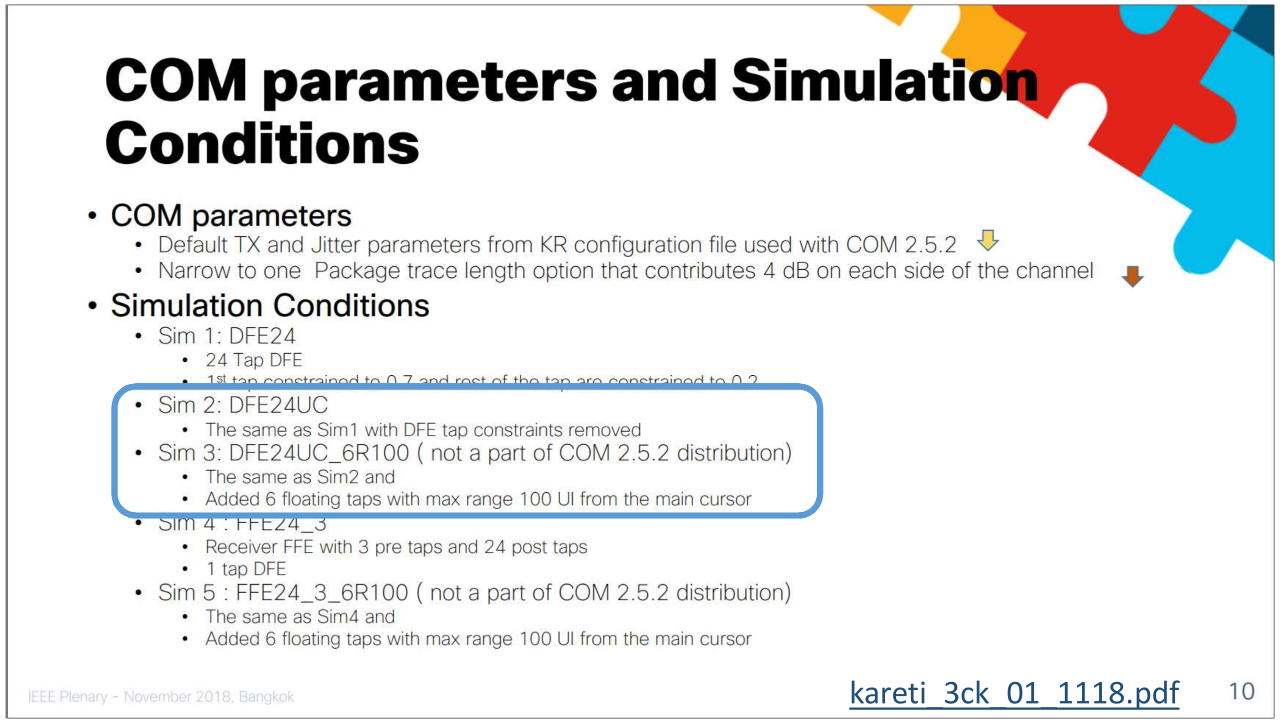
IEEE 802.3ck 100 Gb/s, 200 Gb/s and 400 Gb/s
Electrical Interfaces Task Force

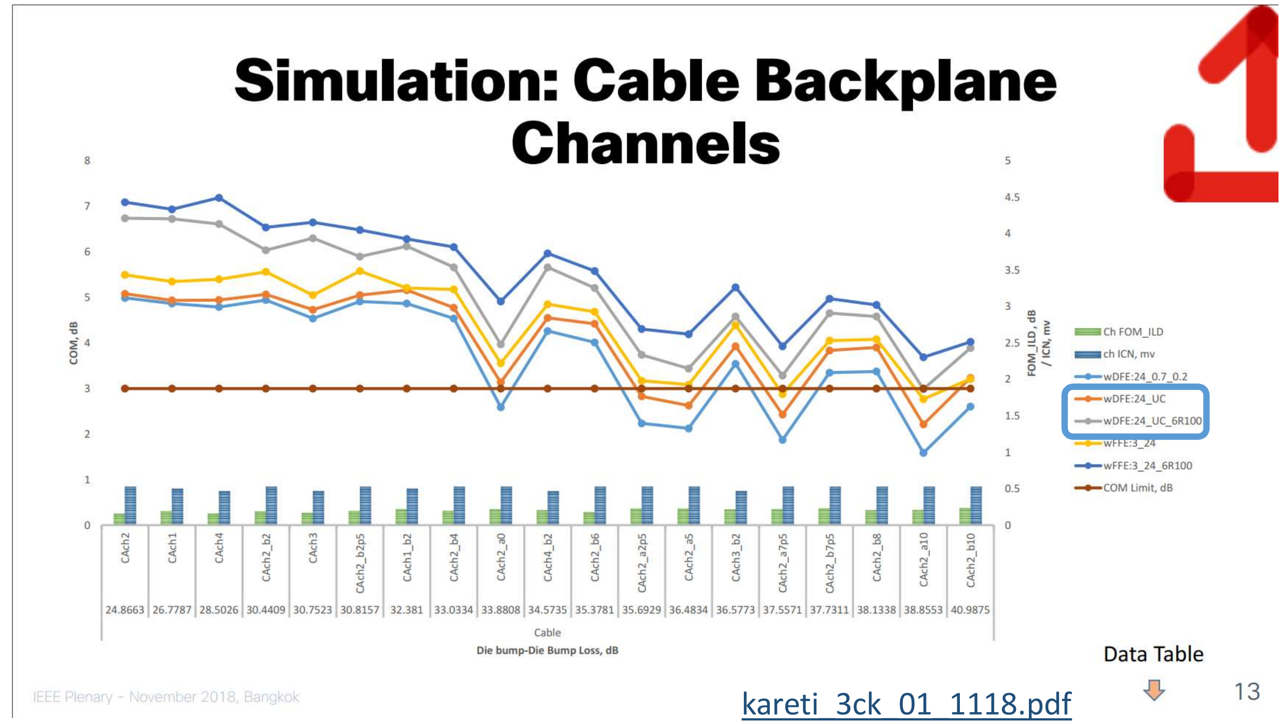
Messages

- Floating DFE taps can provide 1.5+ dB of COM improvement in cabled backplane channels with up to 28dB insertion loss.
  - Significant COM deficit reduction for our 28dB contributed channels.
  - Little difference between 20taps and 24taps.
- Recommendation: Consider a reference receiver with
  - 20 tap DFE (total taps)
  - 4-6 floating taps
  - Span at least 40UI from the cursor
- Even with floating taps, more improvement is needed.

Contents

Background





- kareti_3ck_01_1119.pdf showed 0.6dB to 1.8dB COM improvement with floating taps.
- This work applies the same floating tap characteristics to assess whether they can close the deficit to 3dB COM for our contributed cabled backplane channels.
- Considers DFE only.

Modification to COM 2.58

- Config spreadsheet modification

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	19	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	
ffe_pre_tap_len	**0**	UI	
ffe_post_tap_len	0	UI	
ffe_tap_step_size	0.02		
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	0		
Nb_floating	1		
Floating_maxUI	100	UI	>N_b+Nb_floating
Floating_maxBound	0.2		

Fixed DFE taps

Floating DFE taps (new fields)

- Code modification is transparent to the user
  - same run as original COM
  - Floating DFE location and coefficient write to output file (.csv)

Floating Tap Training Algorithm

- Apply the N_b fixed taps using the existing algorithm (zero forcing, subject to max coefficient constraint).
- For the N_b_floating floating taps, find the postcursor UIs
  - with the maximum ISI magnitudes
  - within the UI range from to N_b to the specified maximum distance from the cursor (in UI)
- Apply the floating taps: zero forcing, subject to max coefficient constraint.

COM Spreadsheet

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	[1.3e-4 1.3e-4]	nF	[TX RX]
z_p select	[1 2]		[test cases to run]
z_p (TX)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (NEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (FEXT)	[12 32; 1.8 1.8]	mm	[test cases]
z_p (RX)	[12 32; 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	0.413	V	vp/vf=.694
A_fe	0.413	V	vp/vf=.694
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)	[-0.1:0.05:0]		[min:step:max]
N_b	24	UI	
b_max(1)	0.85		
b_max(2..N_b)	0.3		
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	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	CR_eval_	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
ERL Pass threshold	10.5	dB
DER_0	1.00E-04	
T_r	6.16E-03	ns
FORCE_TR	1	logical
Include PCB	0	logical
TDR and ERL options		
TDR	1	logical
ERL	1	logical
ERL_ONLY	0	logical
TR_TDR	0.01	ns
N	1000	
TDR_Butterworth	1	logical
beta_x	1.70E+09	
rho_x	**0.18**	
fixture delay time	0	enter sec
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	

Plus the modifications shown on slide 5.

Channels

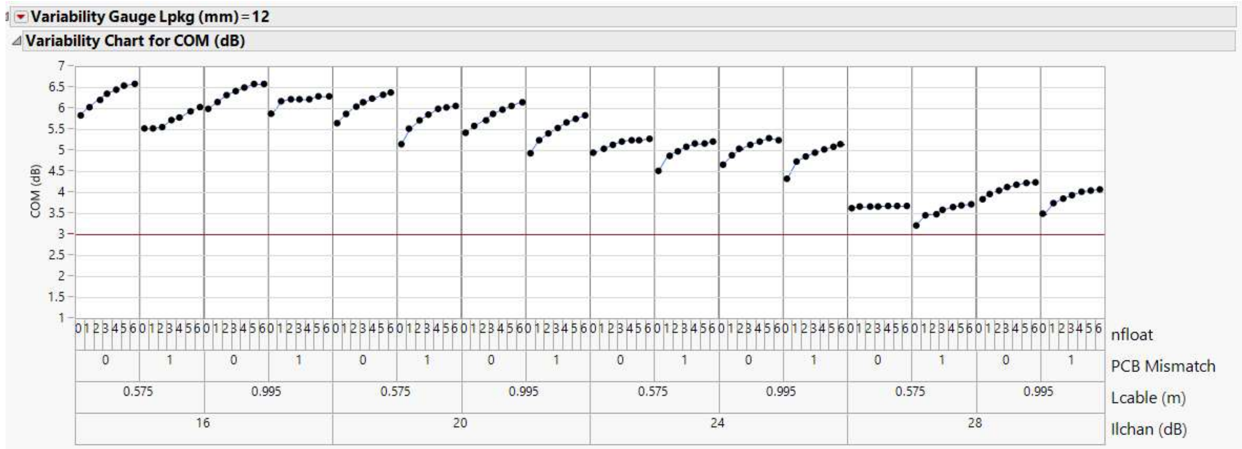
- Channels: see table
  - These are the channels that we contributed previously (heck_3ck_02_0119.pdf)
- DFE
  - 20 & 24 total taps
  - 0-6 floating
  - independent location for each floating tap
  - up to 100UI from cursor
- Package
  - 12mm & 32mm

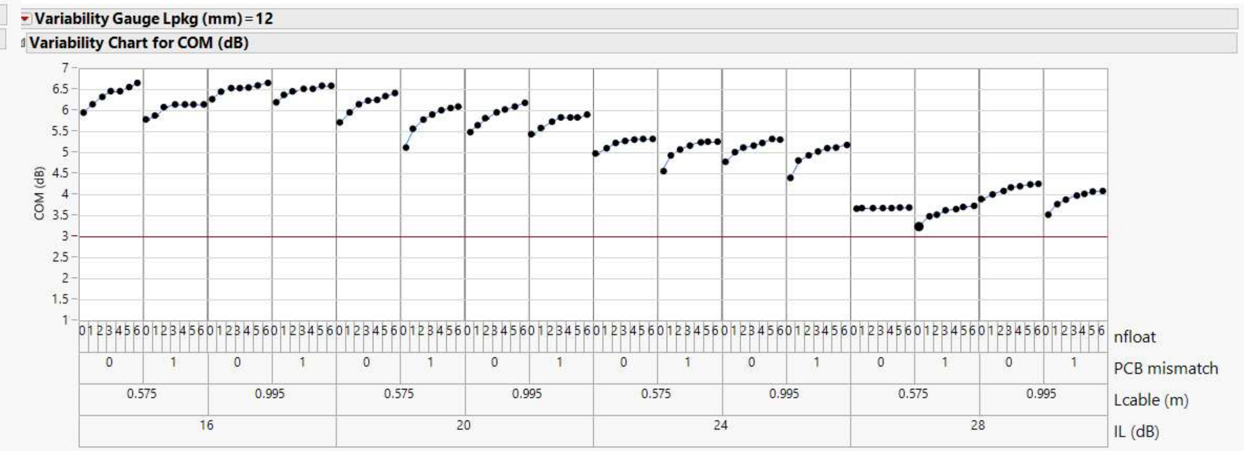
IL (dB)	Cable (mm)	Z_{PCB} mismatch	file
16	575	No	Cable_BKP_16dB_0p575m.zip
		Yes	Cable_BKP_16dB_0p575m_more_isi.zip(R)
	995	No	Cable_BKP_16dB_0p995m.zip
		Yes	Cable_BKP_16dB_0p0p995m_more_isi.zip
20	575	No	Cable_BKP_20dB_0p575m.zip
		Yes	Cable_BKP_20dB_0p575m_more_isi.zip
	995	No	Cable_BKP_20dB_0p995m.zip
		Yes	Cable_BKP_20dB_0p0p995m_more_isi.zip
24	575	No	Cable_BKP_24dB_0p575m.zip
		Yes	Cable_BKP_24dB_0p575m_more_isi.zip
	995	No	Cable_BKP_24dB_0p995m.zip
		Yes	Cable_BKP_24dB_0p0p995m_more_isi.zip
28	575	No	Cable_BKP_28dB_0p575m.zip
		Yes	Cable_BKP_28dB_0p575m_more_isi.zip(L)
	995	No	Cable_BKP_28dB_0p995m.zip
		Yes	Cable_BKP_28dB_0p0p995m_more_isi.zip

COM Results w/ Contributed Channels

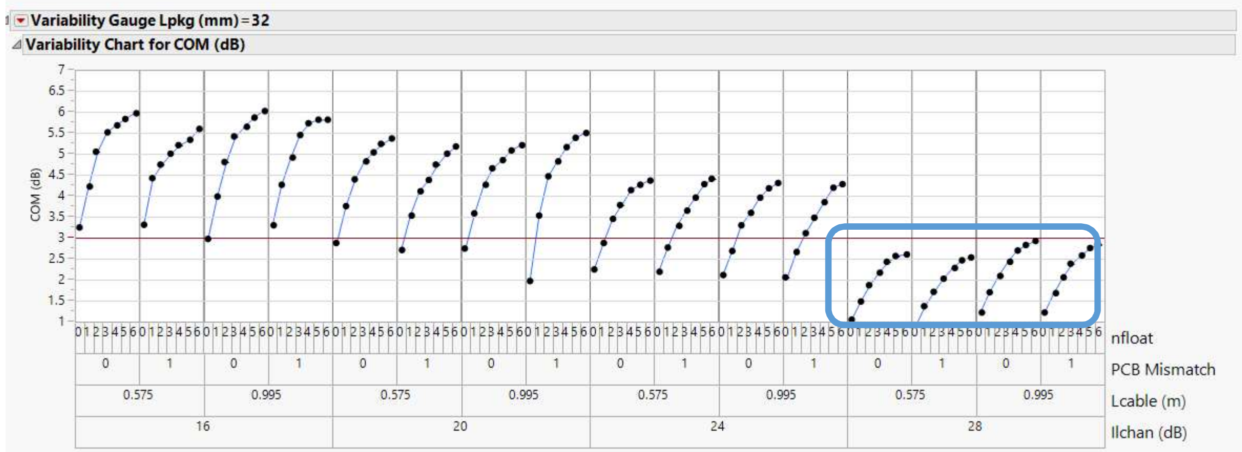
20 tap DFE | **24 tap DFE**

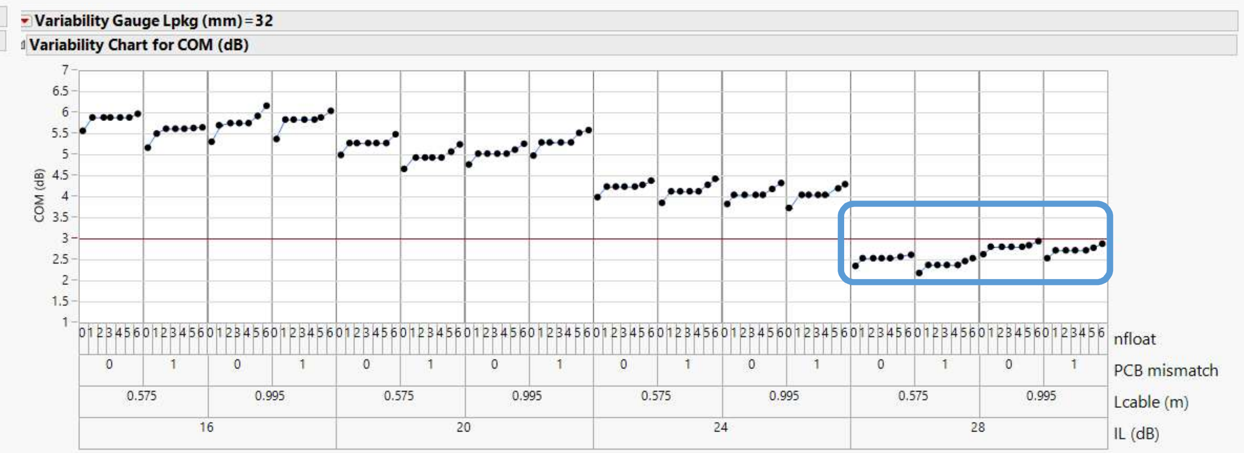
12mm pkg





32mm pkg

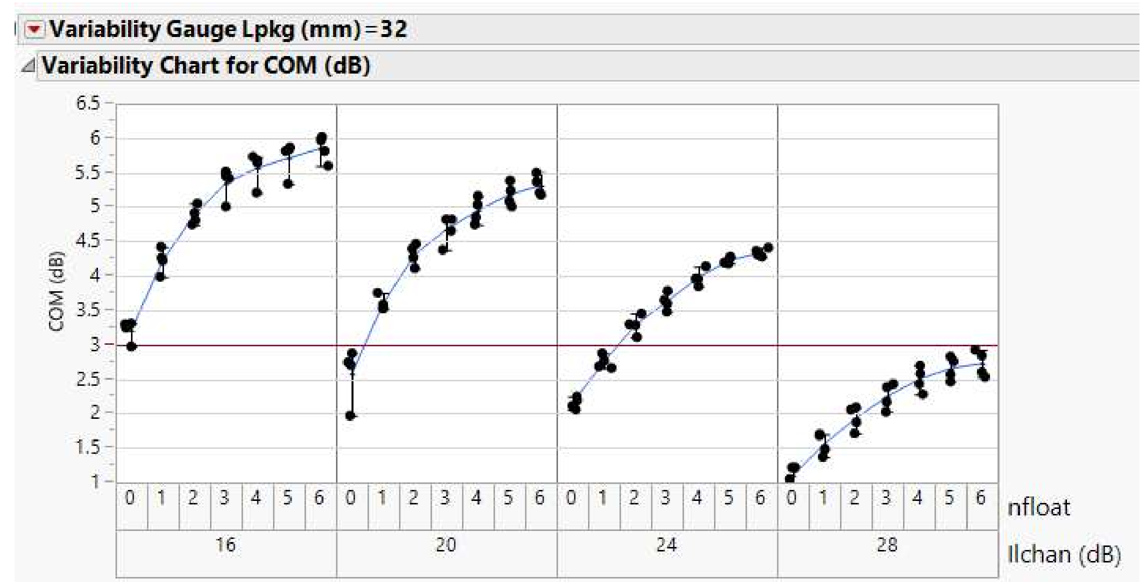




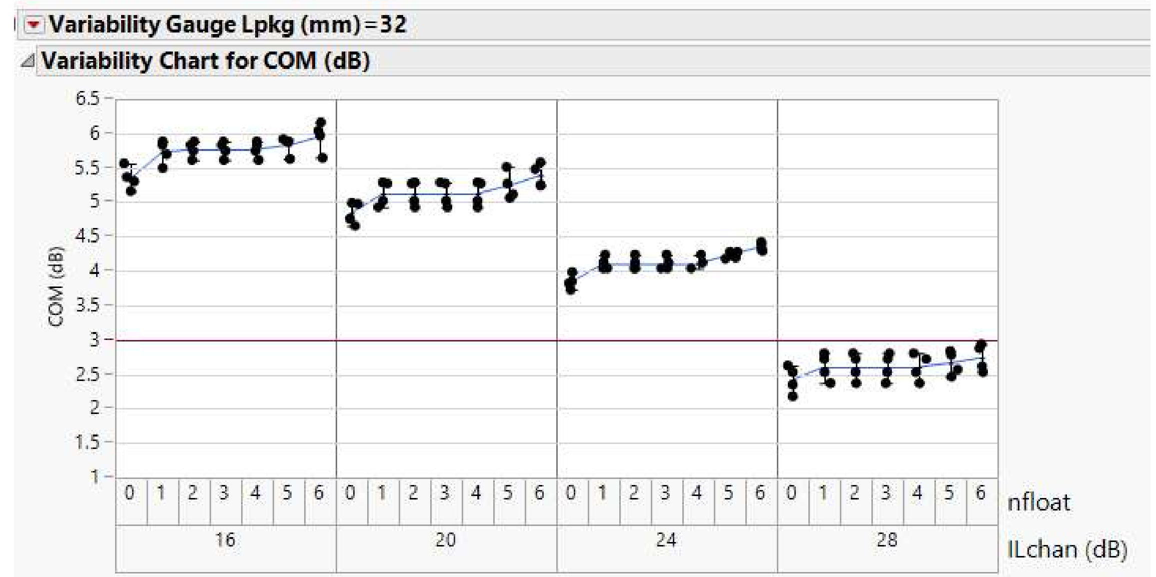
COM Sensitivity to # of Floating Taps

- For the 28dB channel we get 2.5-3dB COM with our contributed channels for:
  - 20taps with 5-6 floating
  - 24taps with 5-6 floating
- >2.5dB COM improvement with 5-6 floating taps out of 20 total taps.
- COM is relatively insensitive to the # of floating taps for 24 total taps.
- Neither case meets 3dB minimum.

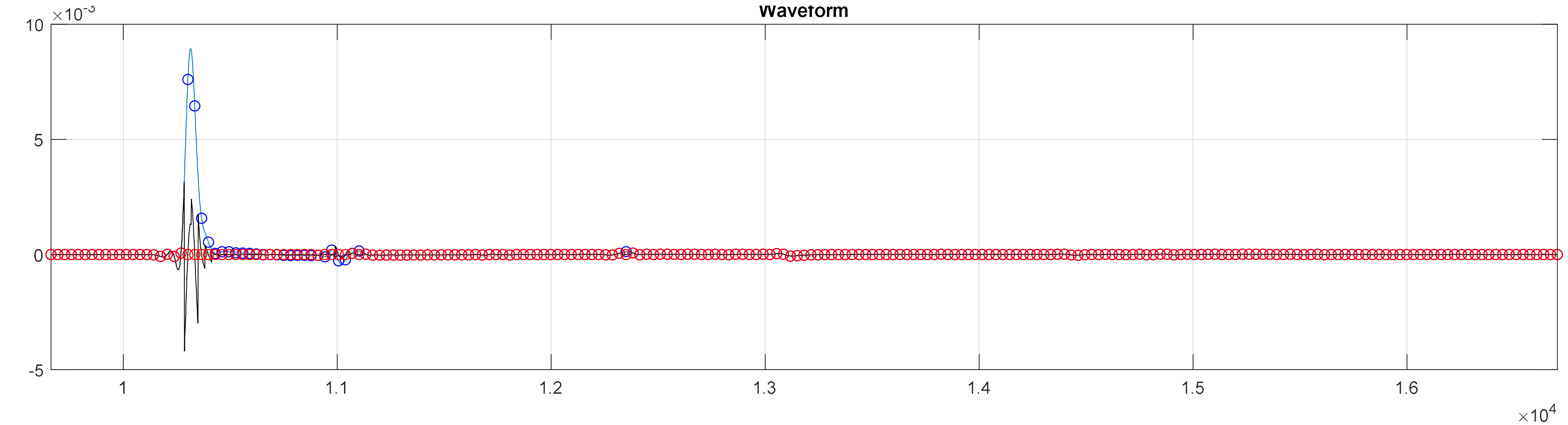
20taps

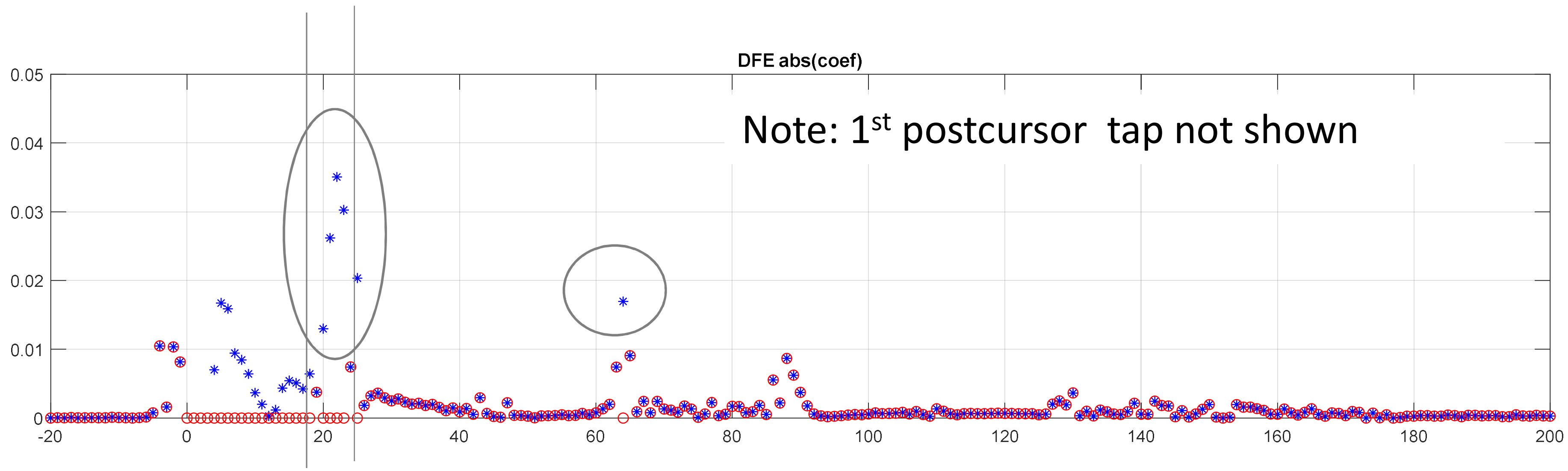


24taps



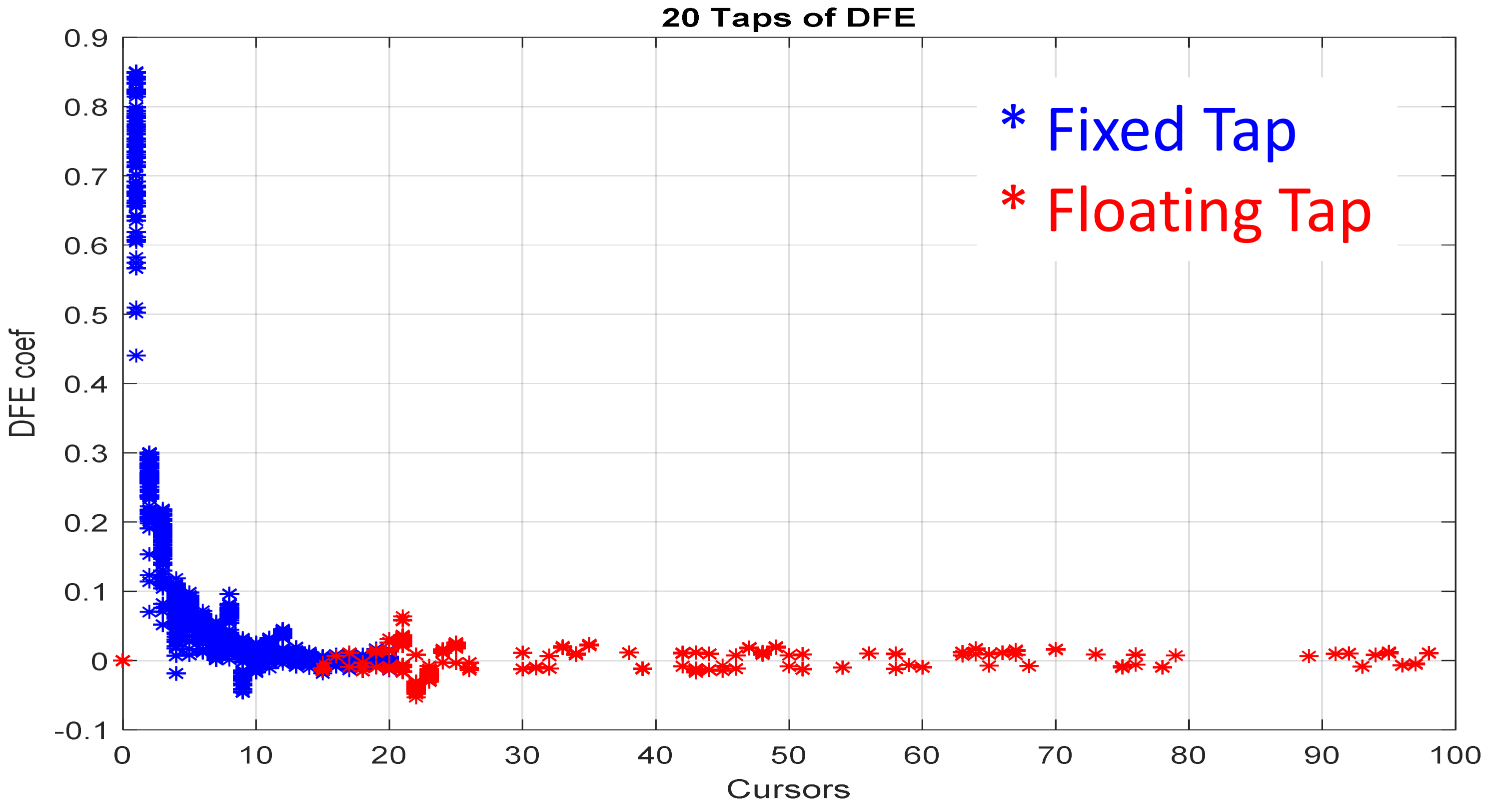
Example Pulse Response & Taps





Channel: 28dB, 0.575m cable, Z_{PCB} mismatch

DFE Taps Weights & Locations



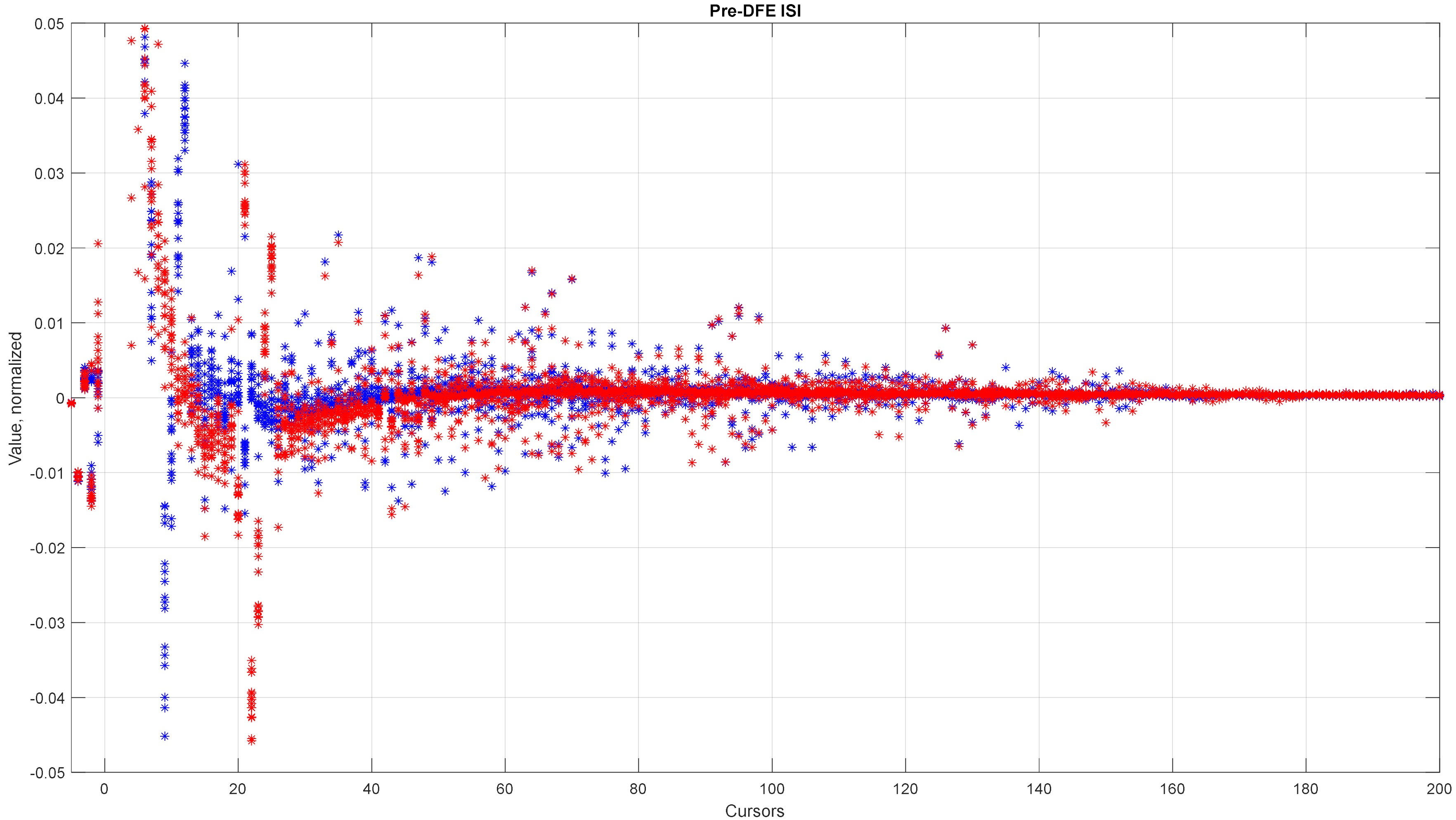
Results include

- all contributed channels
- 12mm & 32mm package lengths
- all fixed/floating configurations that we analyzed.

Selected tap locations span the full range that we considered.

ISI Location

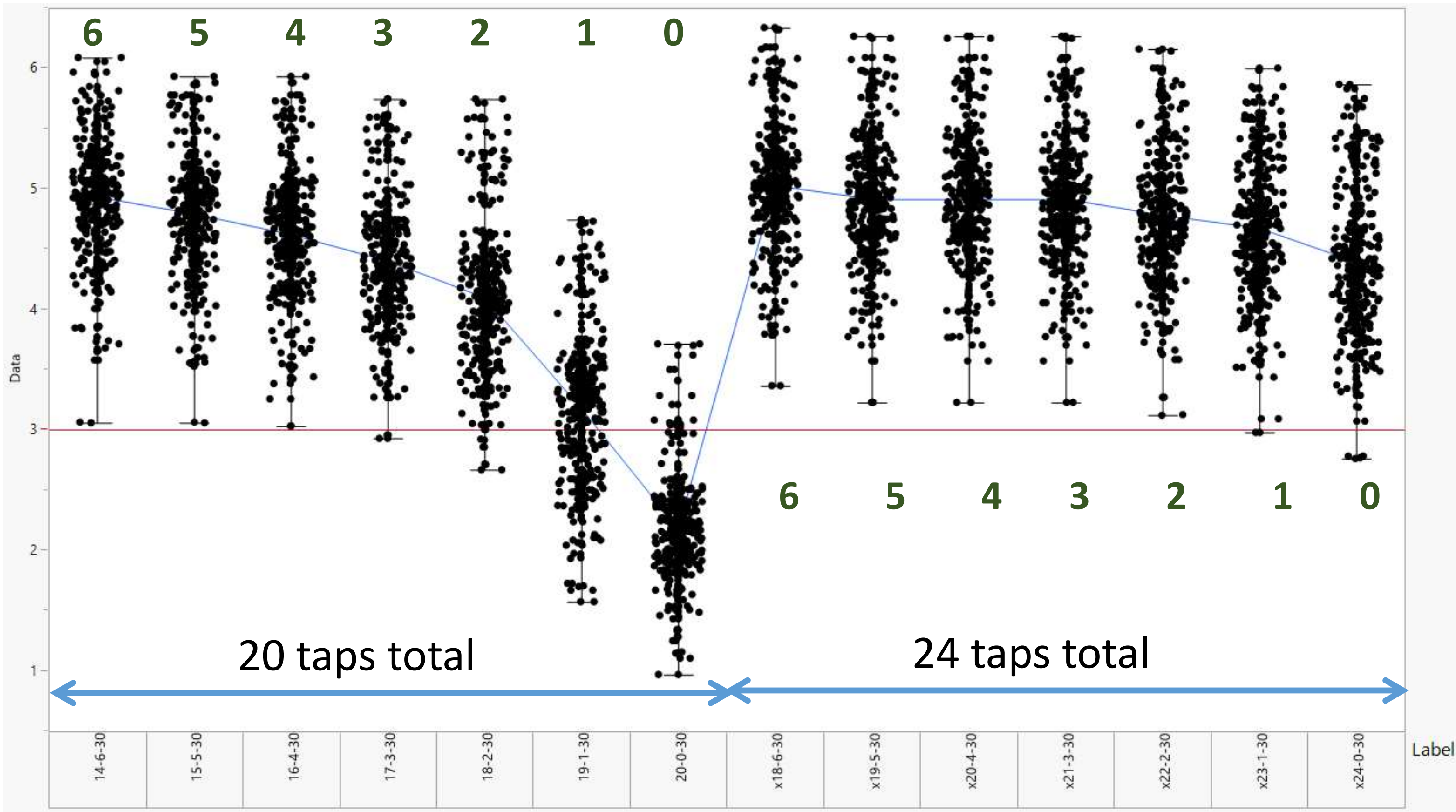
- For these channels, we see ISI up to 160UI from the cursor.
  - Due to the delay of the cables used in these channels.
- We haven’t seen much benefit for tap magnitude <0.02.



Broader Cabled Backplane Channel Analysis

- 480 Cases w/ varying:
  - Breakout Zpcb
  - Breakout PCB length
  - main Zpcb
  - main PCB length
  - cable length
  - cable temp
- 10.6 dB to 28.2dB insertion loss range
- Note: these results were obtained with 12mm and 30mm packages.

30mm package

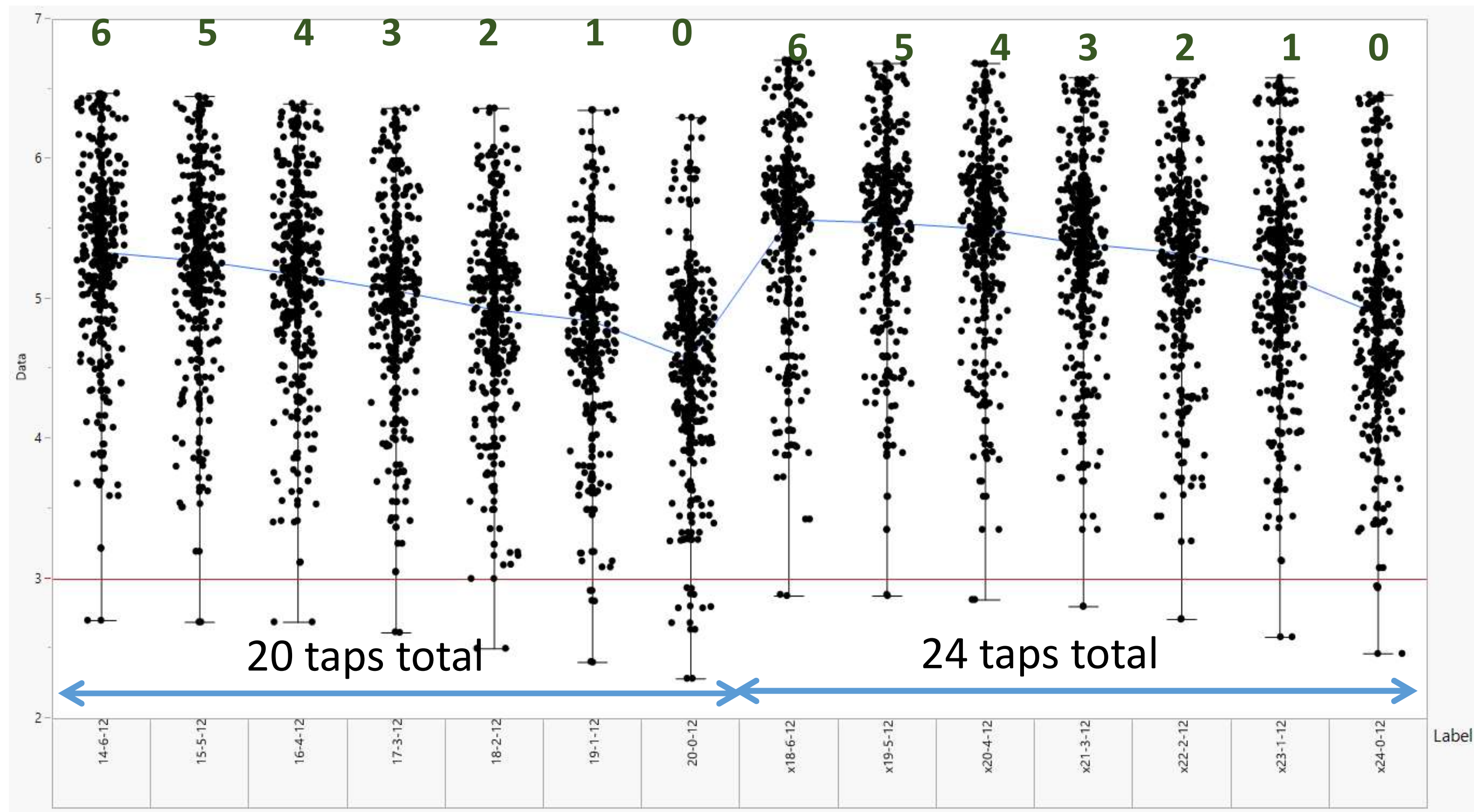


Better COM with 14+6 taps than with 24+0 taps.

Broader Cabled Backplane Channel Analysis

- 480 Cases w/ varying:
  - – Breakout Zpcb
  - – Breakout PCB length
  - – main Zpcb
  - – main PCB length
  - – cable length
  - – cable temp
- 10.6 dB to 28.2dB insertion loss range

12mm package



Similar COM with 20taps or 24 taps.

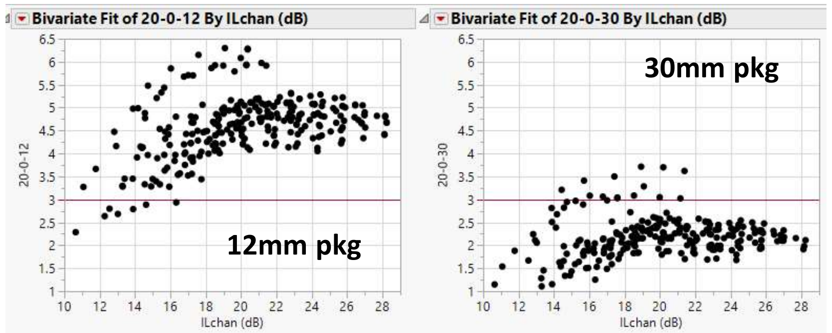
Messages

- Floating DFE taps can provide 1.5+ dB of COM improvement in cabled backplane channels with up to 28dB insertion loss.
  - Significant COM deficit reduction for our 28dB contributed channels.
  - Little difference between 20taps and 24taps.
- Recommendation: Consider a reference receiver with
  - 20 tap DFE (total taps)
  - 4-6 floating taps
  - Span at least 40UI from the cursor
- Even with floating taps, more improvement is needed.

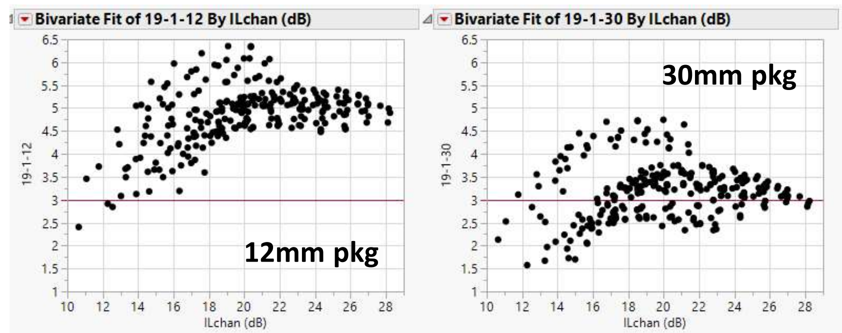
Thank you!

Broader Cabled Analysis – 20 Taps

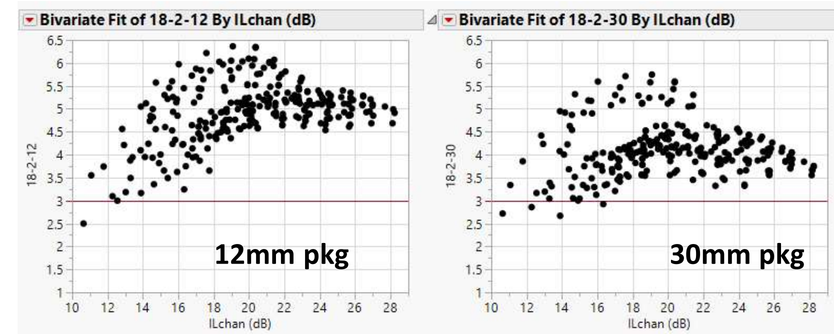
20taps/0float



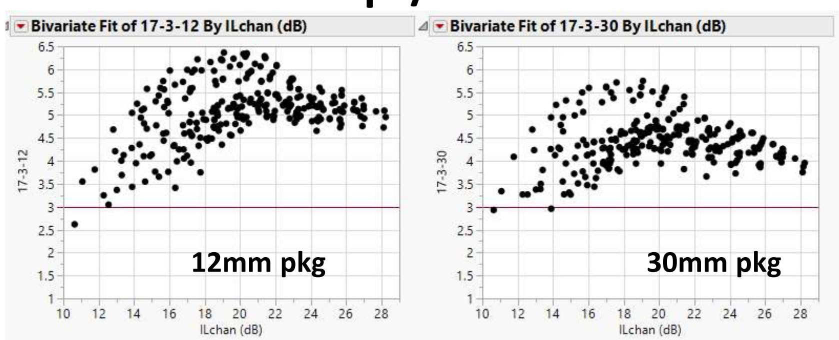
19taps/1float



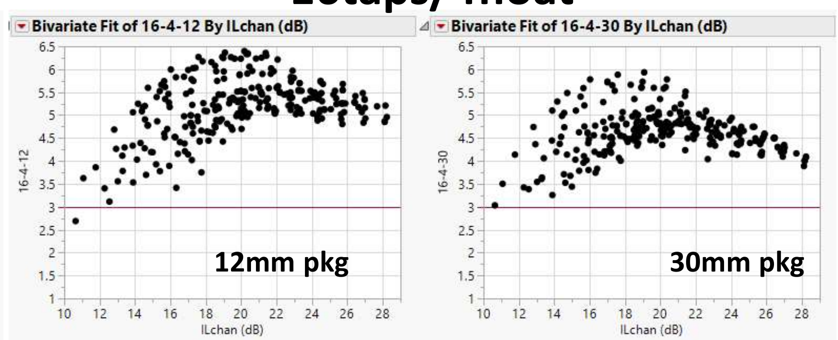
18taps/2float



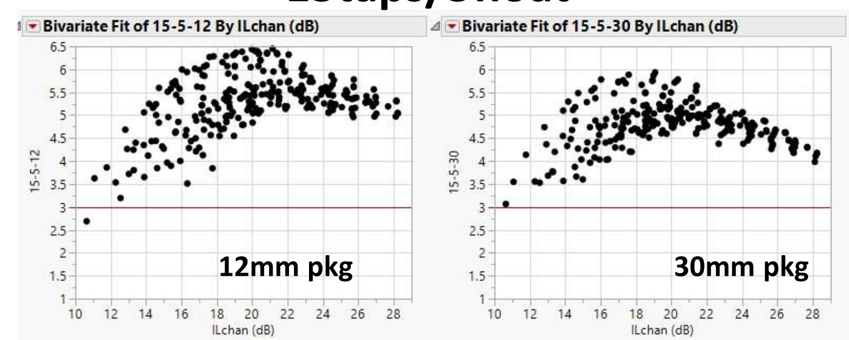
17taps/3float



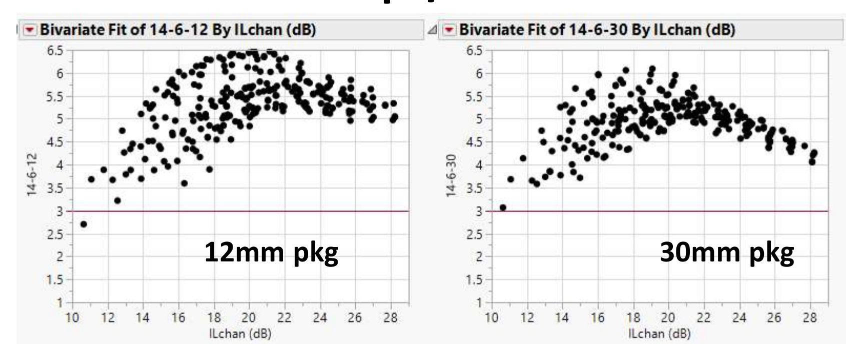
16taps/4float



15taps/5float



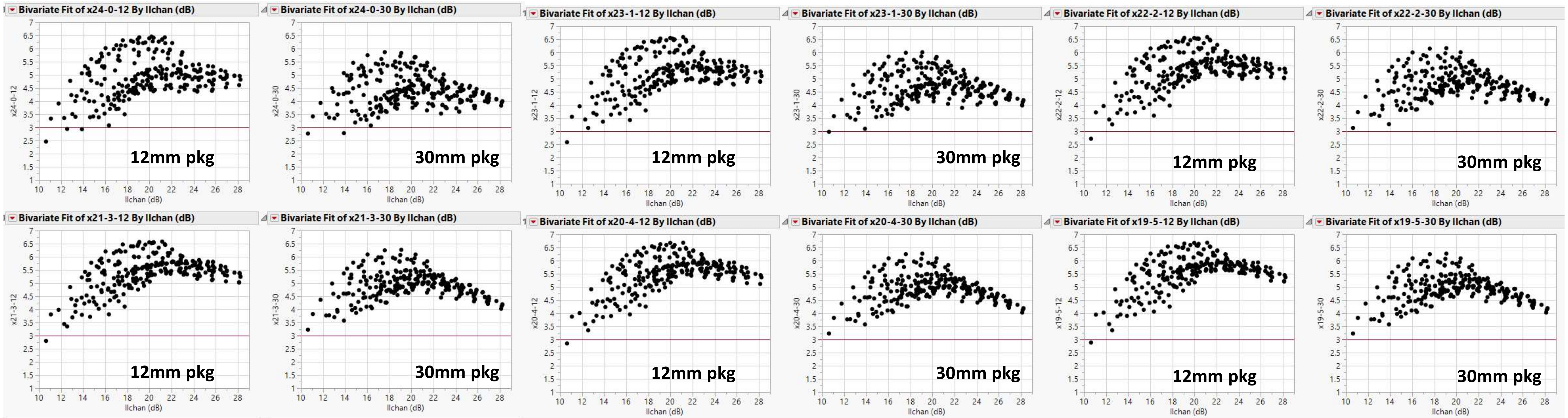
14taps/6float

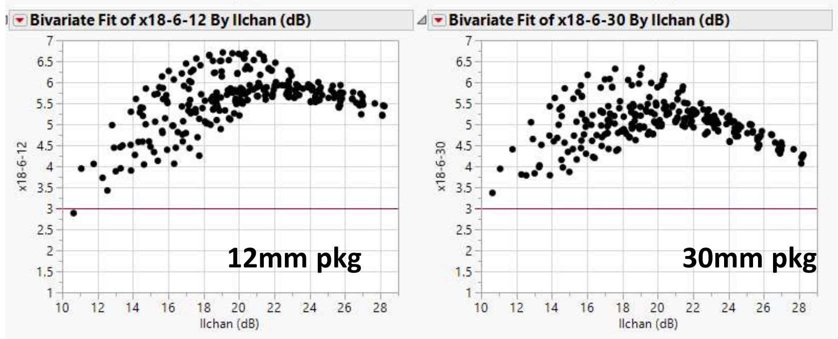


Little benefit from more than 4 floating taps.

Broader Analysis – 24 Taps

24fixed/0float **23fixed/1float** **22fixed/2float**





18fixed/6float

No real benefit vs 20 taps.