AUI C2C COM Tap Weight Analysis & Recommendations

Howard Heck, Intel
Femi Akinwale, Intel

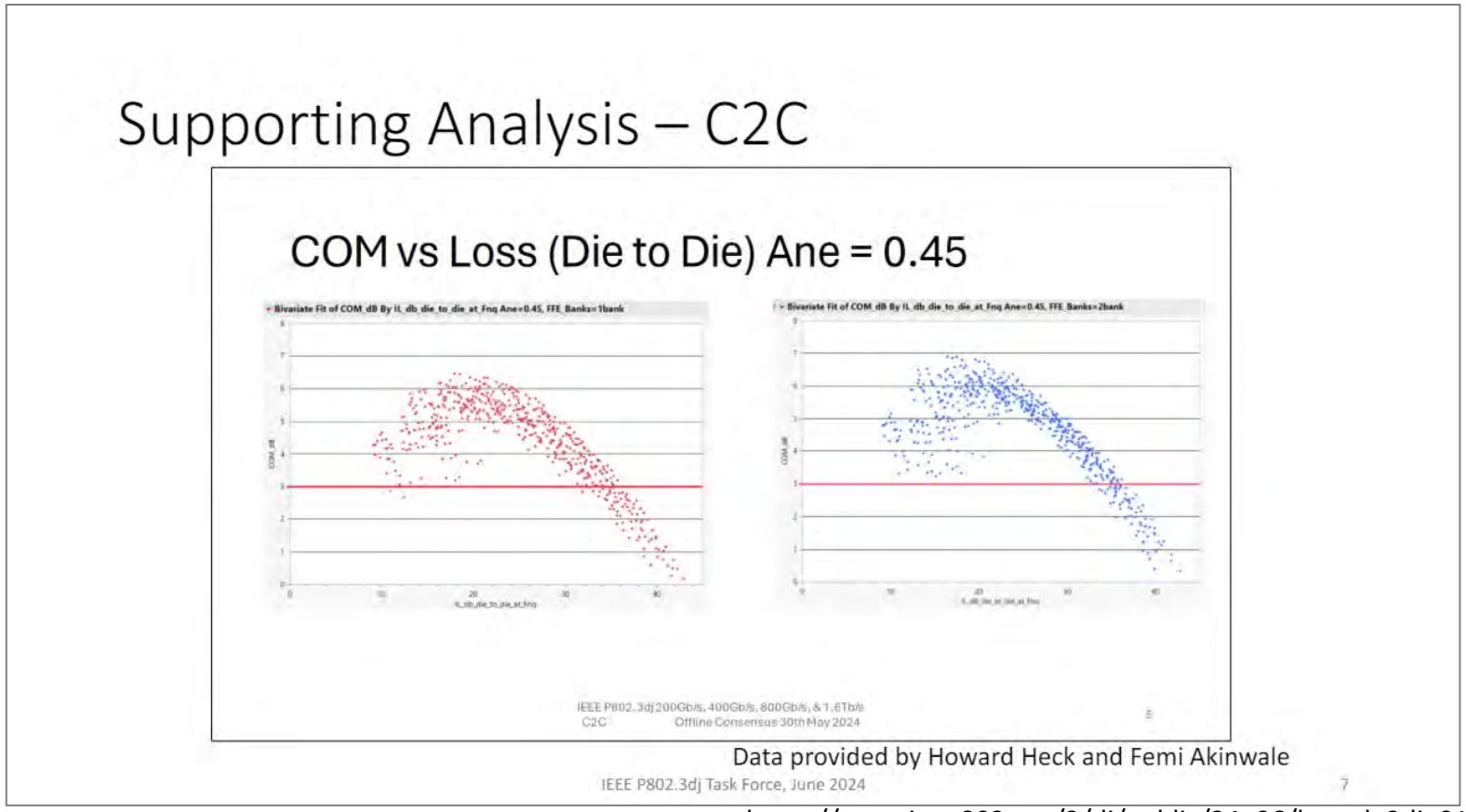
Contents

Objective

Propose values for the parameters in Table 176D-6 (Device and package parameters) and Table 176D-7 (COM parameter values).

- Analysis focuses on RX FFE coefficient ranges ($w_{\min}$,$w_{\max}$) and confirmation of highest allowed tap index ($N_{\max}$).
- Analysis uses previously agreed upon parameter values (e.g. η_0).

Background



https://www.ieee802.org/3/dj/public/24_06/lusted_3dj_01a_2406.pdf

- The COM reference RX FFE direction for AUI-C2C is based on lusted_3dj_01a_2406.
- C2C COM results for channels from heck_3dj_01b_2405 are shown above.
- Revisit that data along with data from channels contributed in mellitz_3dj_elec_03_230504.
  - Include new data for ‘retimer’ transmit/host receive path.

COM Parameter Values in D1.1

Param	Value	Units
$\mathbf{z_p^{(1)}}$	**12, 33**	**mm**

Param		Value	Units
$c(-3)$		0	
$c(-2)$	min max step	0 0.14 0.02	
$c(-1)$	min max step	-0.34 0 0.02	
$c(0)$	min	0.54	
$c(1)$	min max step	-0.2 0 0.02	

Param	Value	Units
f_r	$0.55 \cdot f_b$	GHz
g_1	-20:1:0	dB
g_2	-6:1:0	dB
f_{z1}	$f_b/2.5$	dB
f_{z2}	$f_b/80$	GHz
f_{p1}	$f_b/2.5$	GHz
f_{p2}	f_b	GHz
f_{p3}	$f_b/80$	GHz

Param	Value	Units
A_v	0.413	V
A_{fe}	0.413	V
A_{ne}	0.45	V
T_r	0.004	ns
SNR_{TX}	33.5	dB
$\boldsymbol{\eta_0}$	**TBD**	**V²/GHz**
σ_{RJ}	0.01	UI
A_{DD}	0.02	UI
R_{LM}	0.95	
DER_0	0.67e-5	

Param		Value	Units
d_w		TBD	
N_{fix}		TBD	
N_g		TBD	
N_f		TBD	
N_{max}		TBD	
N_b		1	
$b_{min}(1)$		0	
$b_{max}(1)$		0.85	
$\mathbf{w_{min}}(\boldsymbol{j})$	$-\boldsymbol{d_w} \le \boldsymbol{j} < \mathbf{0}$ $\mathbf{0} < \boldsymbol{j} \le \boldsymbol{N_{fix}}$ $\boldsymbol{N_{fix}} < \boldsymbol{j} \le \boldsymbol{N_{max}}$	**-0.7** **-0.7** **-0.05**	
$\mathbf{w_{max}}(\boldsymbol{j})$	$-\boldsymbol{d_w} \le \boldsymbol{j} < \mathbf{0}$ $\mathbf{0} < \boldsymbol{j} \le \boldsymbol{N_{fix}}$ $\boldsymbol{N_{fix}} < \boldsymbol{j} \le \boldsymbol{N_{max}}$	**0.7** **0.7** **0.05**	

Note: the $z_p^{(1)}$ values used in COM analysis were
12, 28.5, 45 (mm) for host package
4, 8, 12 (mm) for retimer package

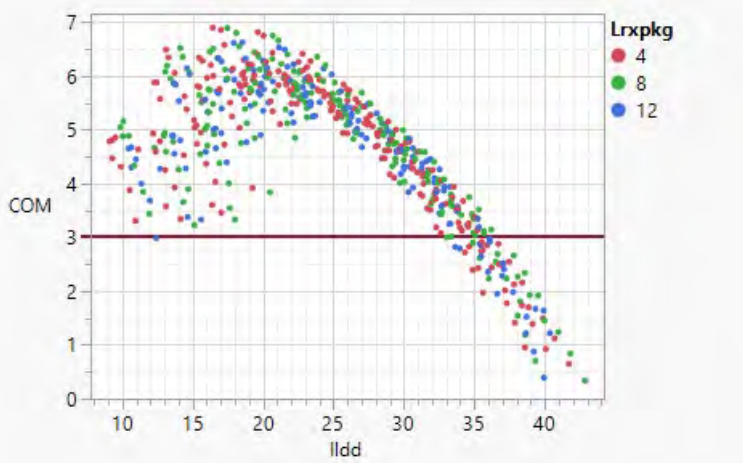
Results

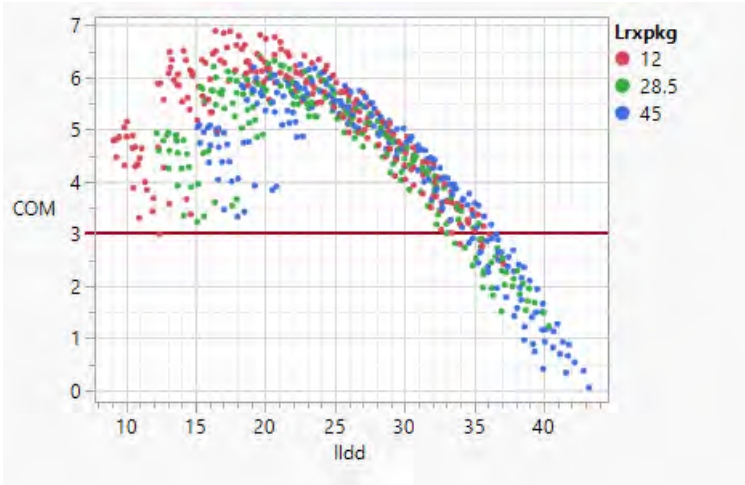
COM vs lldd

Host Transmitting

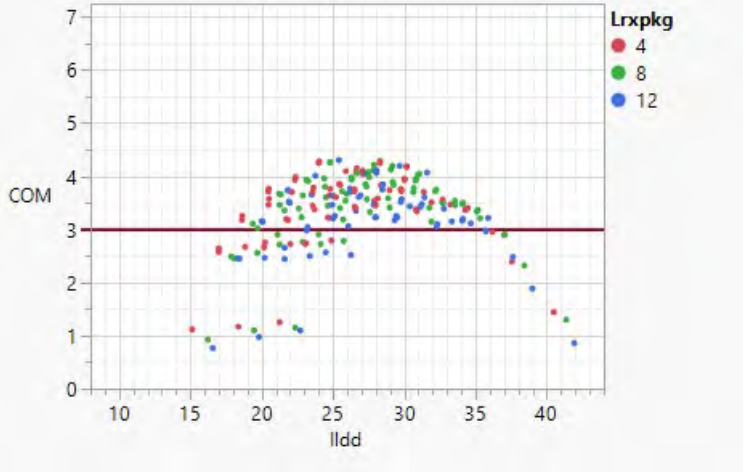
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504

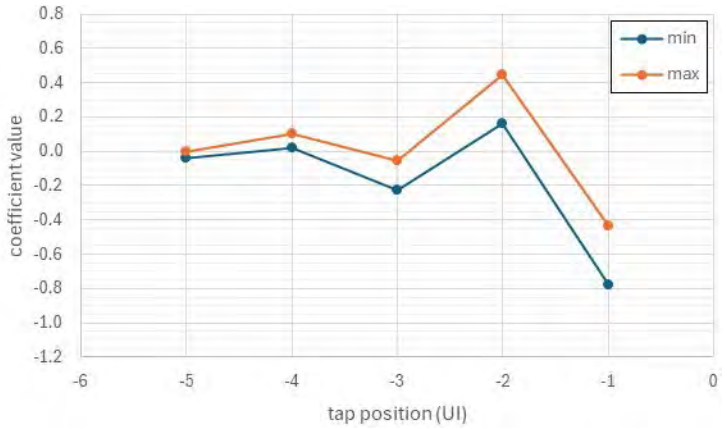


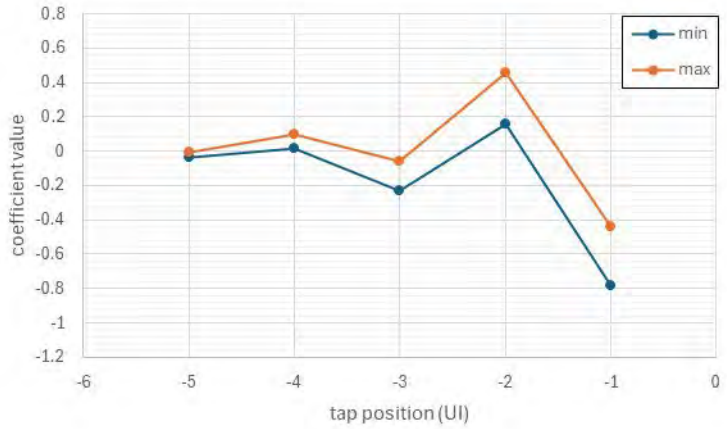
Fixed Taps: w(-5) to w(-1)

Host Transmitting

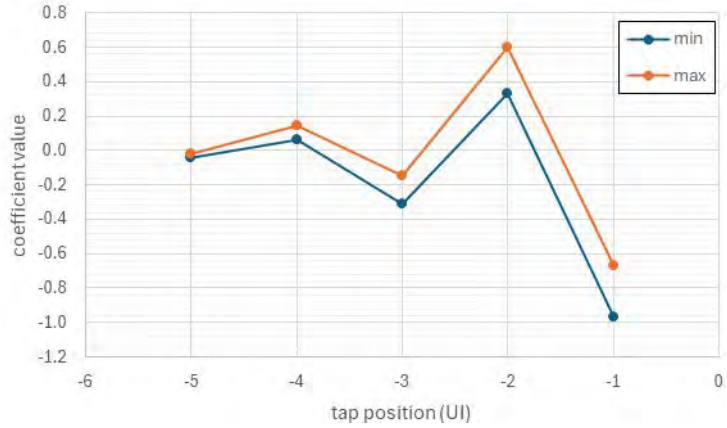
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504



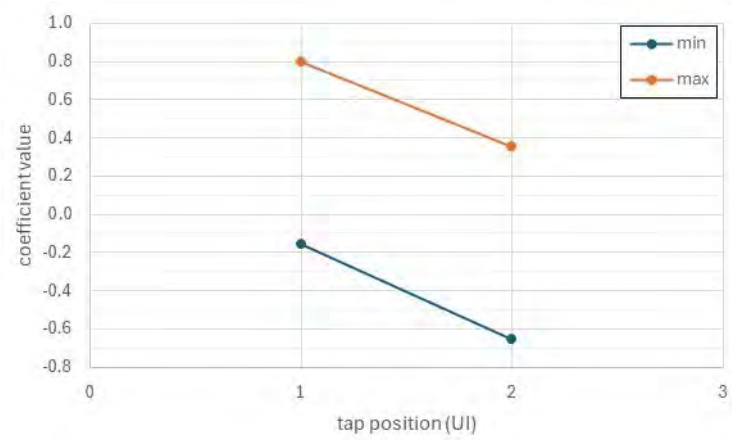
UI	-5	-4	-3	-2	-1
w_{min}	-0.05	0	-0.4	0	-1
w_{max}	0	0.15	0	0.6	0

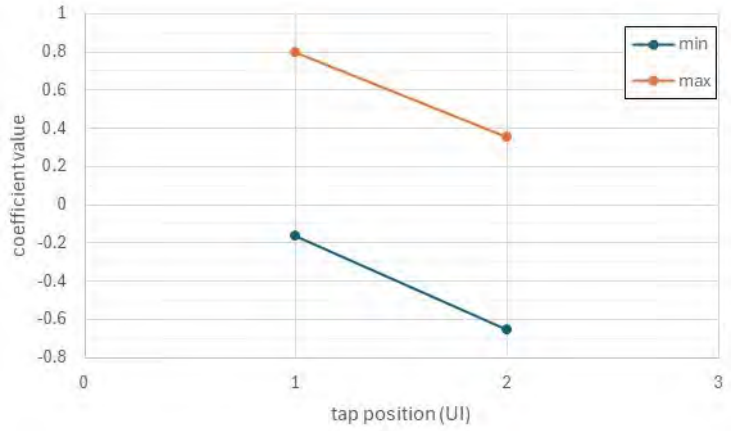
Fixed Taps: w(1) to w(2)

Host Transmitting

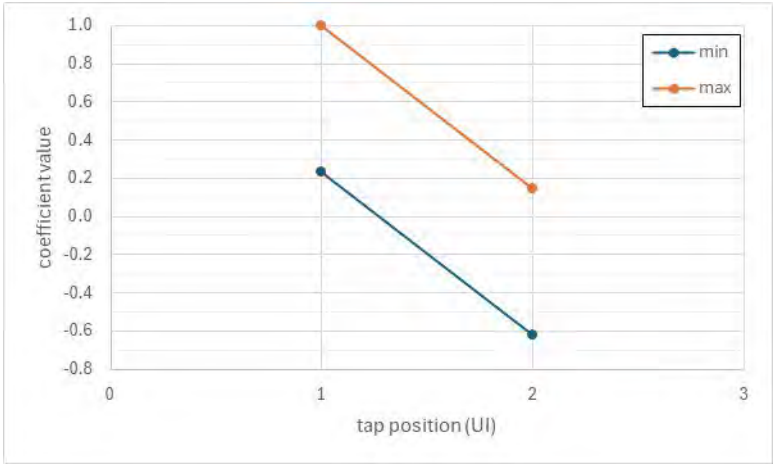
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504



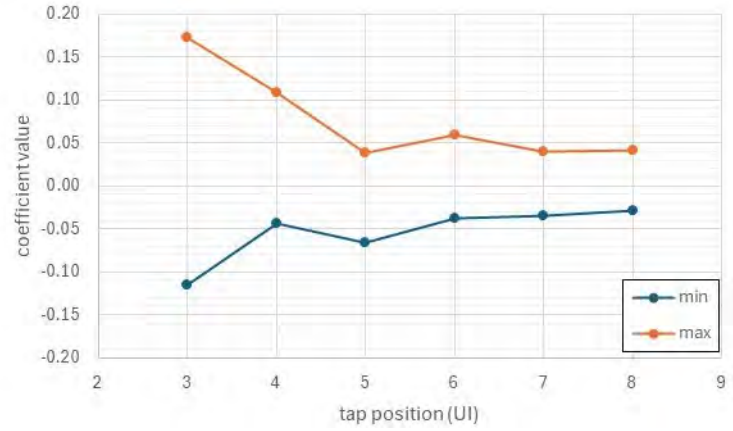
UI	1	2
w_{min}	-0.2	-0.7
w_{max}	1	-0.4

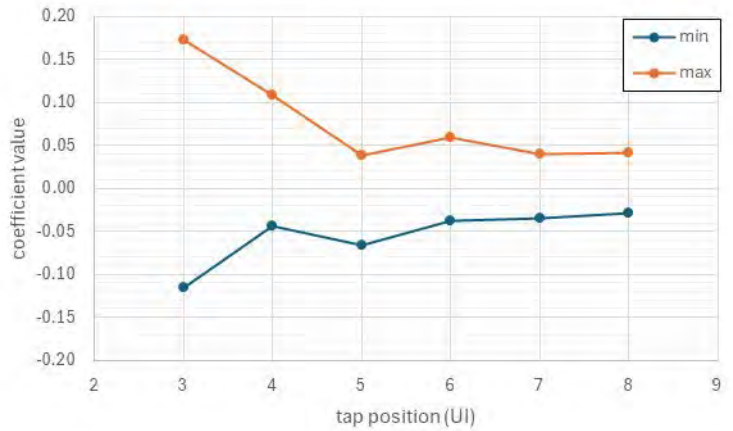
Fixed Taps: w(3) to w(8)

Host Transmitting

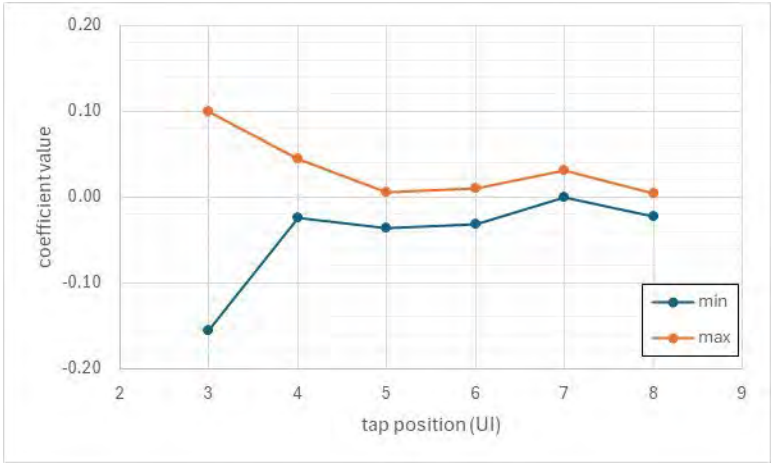
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504



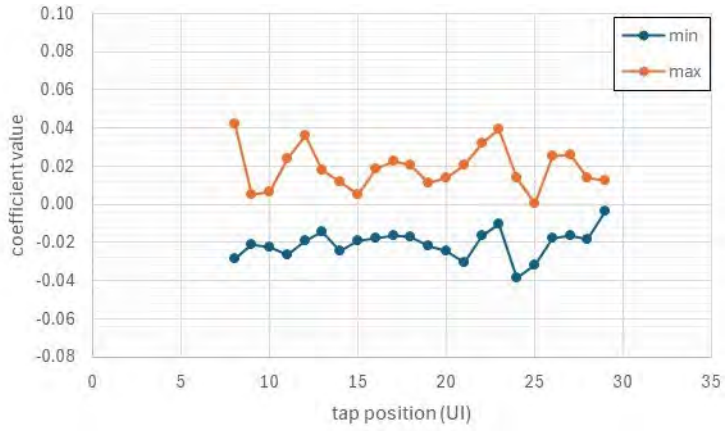
UI	3:4	5:8
w_{min}	-0.2	-0.1
w_{max}	0.2	0.1

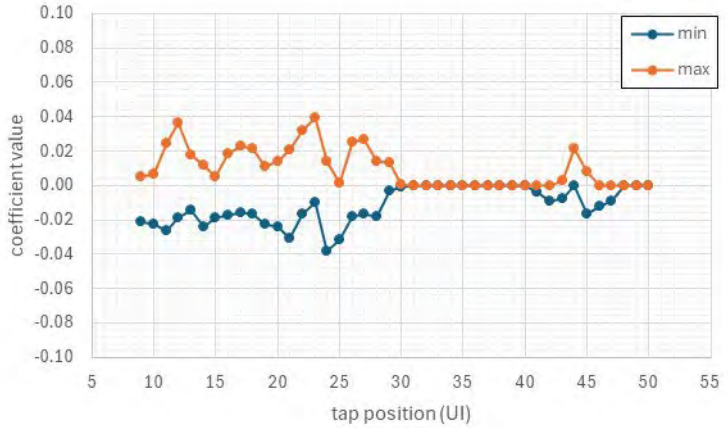
Floating Taps

Host Transmitting

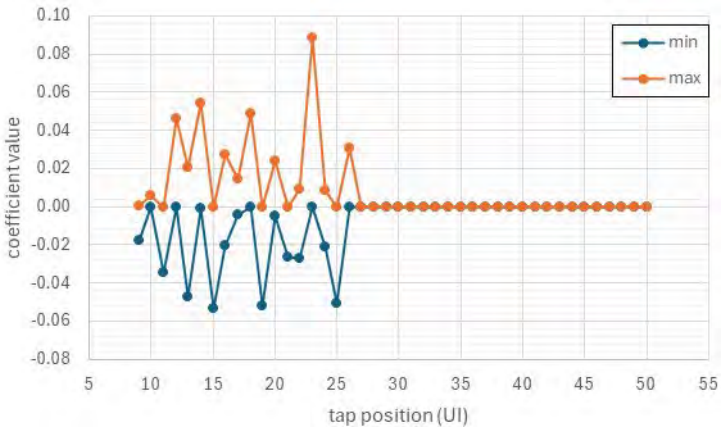
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504



UI	9:50
w_{min}	-0.1
w_{max}	0.1

Analysis indicates that N_{max}=50UI is sufficient.

Rx FFE Coefficient Limits

Precursor

Param		D1.1	This Work	Proposed
$w(-5)$	min max		-0.05 0	
$w(-4)$	min max		0 0.15	
$w(-3)$	min max	-0.7 0.7	-0.4 0	-0.7 0.7
$w(-2)$	min max		0 0.6	
$w(-1)$	min max		-1 0	

Postcursor

Param		D1.1	This Work	Proposed
$w(1)$	min max		-0.2 1	**-1** **1**
$w(2)$	min max		-0.7 -0.4	
$w(3\ to\ 4)$	min max	-0.7 0.7	-0.2 0.2	-0.7 0.7
$w(5\ to\ 8)$	min max		-0.1 0.1	
$w(9\ to\ 50)$	min max	-0.05 0.05	-0.1 0.1	-0.05 0.05

Proposed

Param		Value	Units
$w(1 \leq \mathrm{j} \leq d_w)$	min max	-0.7 0.7	
$w(d_w + 2)$	min max	-1 1	
$w(d_w + 2 < j \leq N_{fix})$	min max	-0.7 0.7	
$w(N_{fix} < j \leq N_{\max})$	min max	-0.05 0.05	

Proposed Changes to COM Parameter Values

Param	Value	Units
$z_p^{(1)}$	12, 45	mm
$z_p^{(1)}$	4, 12	mm

Param		D1.1	Proposed	Units
η_0		TBD	1e-8	V^2/GHz
d_w		TBD	5	
N_{fix}		TBD	14	
N_g		TBD	2	
N_f		TBD	4	
N_{max}		TBD	50	
$w(d_w + 2)$	min max	-0.7 0.7	-1 1	

No change proposed to $w(1 \leq \mathrm{j} \leq d_w)$, $w\left(d_w + 2 < j \leq N_{fix}\right)$, $w\left(N_{fix} < j \leq N_{\max}\right)$.

Summary

Plan to submit comments to adopt the commended values from the previous slide. Specifically:

- reference package trace lengths:$z_p^{(1)}$
- noise spectral density: η_0
- FFE parameters: $d_w, N_{fix}, N_g, N_f, N_{max}$
- FFE coefficient limits: $w(j)$

Thank you

Additional Info

Physical Channel Description (Simulated)

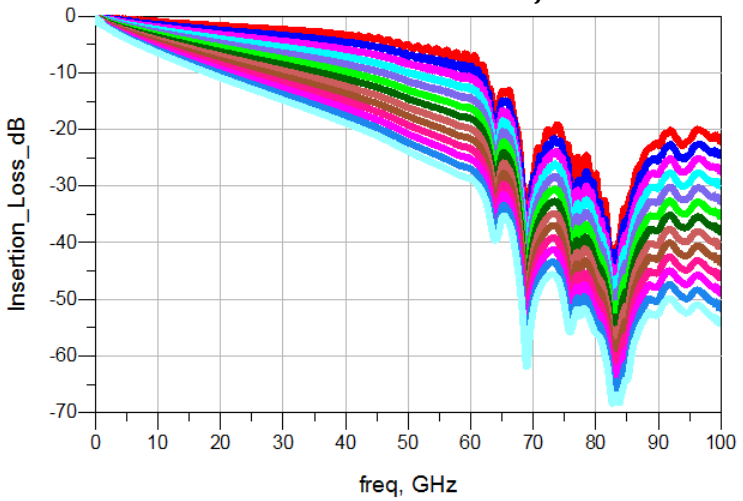
- Number of Aggressors: 3 FEXT and 4 NEXT
- BGA escape model
  - BGA ball not included, 5 mil stub
  - Tx/RX via drill depths: 10/20, 35/45, 60/70
- Host PCB
  - Impedance: 85, 93, 100 Ω
  - Insertion loss: 1.5dB/in @53.125GHz
- Does not include package or silicon structures

Channels based on heck_3dj_01b_2403 w/ the addition of longer via lengths & PCB impedance corners.

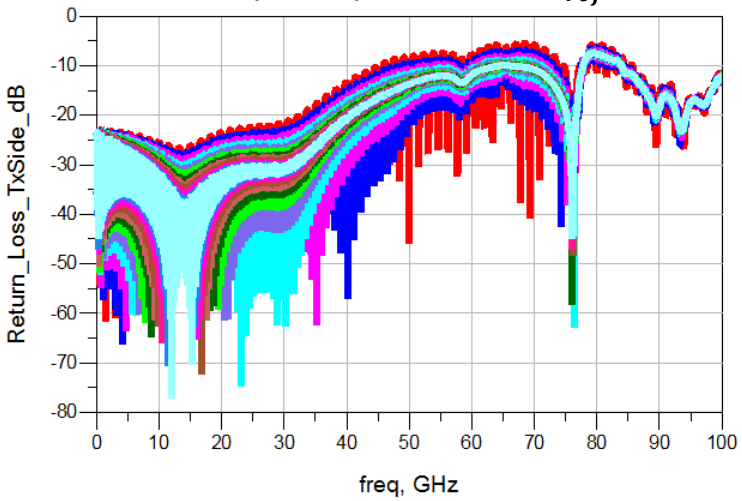
We also analyze contributed channels in mellitz_3dj_elec_01_230504.

Channel Response

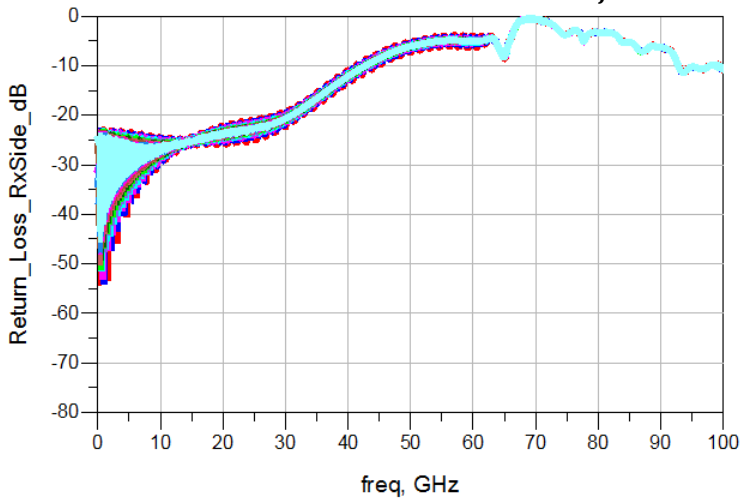
Insertion Loss, Differential, Z_{ref} =100 Ω



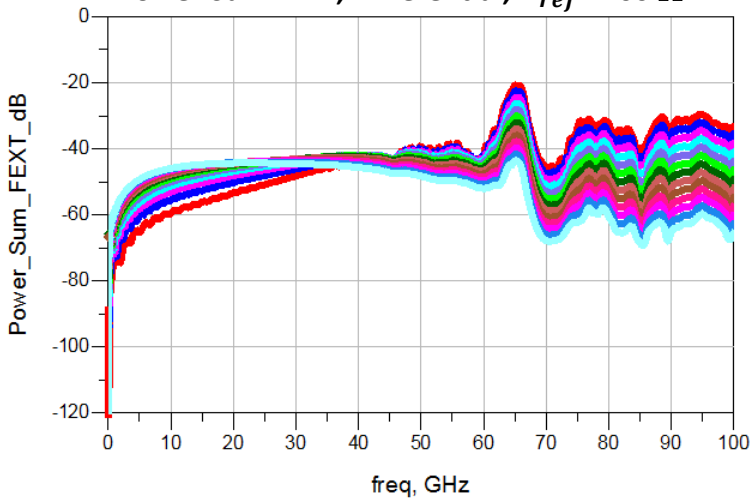
Return Loss (Tx Side), Differential, Z_{ref} =100 Ω



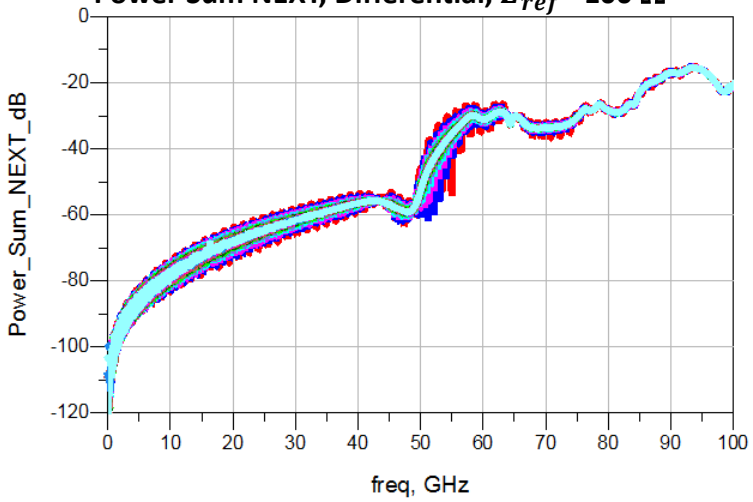
Return Loss (Rx Side), Differential, Z_{ref} =100 Ω



Power Sum FEXT, Differential, Z_{ref} =100 Ω



Power Sum NEXT, Differential, Z_{ref} =100 Ω



COM Template

Table 93A-1 parameters			
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	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
R_0	5.00E+01	Ohm	
R_d	[50 50]	Ohm	[TX RX]
PKG_NAME	PKG_LowR_CLASSA PKG_HiR_CLASSB		TX RX
A_v	0.413	V	
A_fe	0.413	V	
A_ne	0.45	V	
z_p select	[1 2 3]		
L	4		
M	32		
filter and Eq			
f_r	0.55	*fb	
c(0)	0.54		min
c(-1)	[-0.4:0.02:0]		[min:step:max]
c(-2)	[0:.02:0.04]		[min:step:max]
c(-3)	0		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	1	UI	
b_max(1)	0.75		As/dffe1
b_max(2..N_b)	0.15		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-15:1:0]	dB	[min:step:max]
f_z	42.5	GHz	
f_p1	42.5	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr

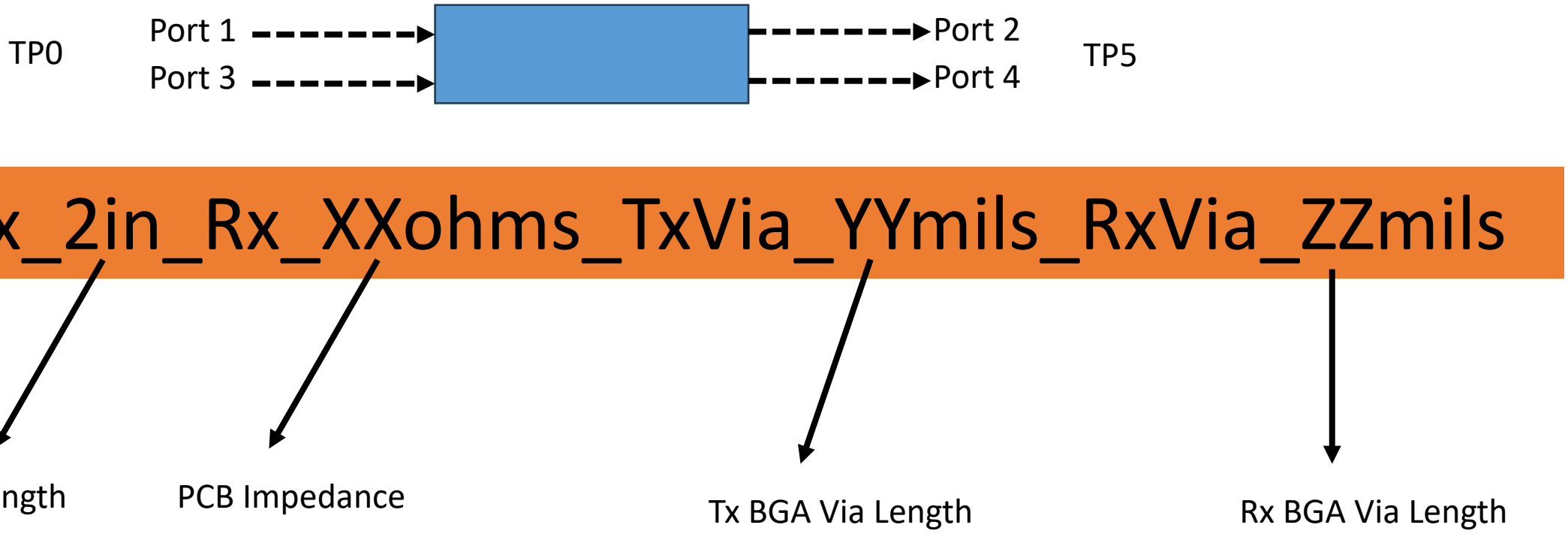
Noise, jitter		UI
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	1.00E-08	dB
SNR_TX	33	
R_LM	0.95	

.START	PKG_LowR_CLASSA	[2.44 5.7] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 6.5e-4 2.93e-4]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95;100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[4 8 12 12;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[4 8 12 12;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (FEXT)	[4 8 12 12;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[4 8 12 12;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.413 0.413 0.413 0.413]	V	Vf=0.400
A_fe	[0.413 0.413 0.413 0.413]	V	Vf=0.399
A_ne	[0.450 0.450 0.450 0.450]	V	Vf=0.400
.END			

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db	
Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 6.5e-4 2.93e-4]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95;100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[45 45 45 45;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[45 45 45 45;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (FEXT)	[45 45 45 45;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[45 45 45 45;2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.400
A_fe	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.399
A_ne	[0.600 0.600 0.600 0.600]	V	Vf=0.400
.END			

Table 93A–3 parameters			
Parameter	**Setting**	**Units**	Information
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	92 ; 70 70; 80 80; 100 1	Ohm	
z_p (TX)	1 1 1 1; 1 1 1 1 ; 0.5 (	mm	[test cases to run]
z_p (NEXT)	1 1 1 1; 1 1 1 1 ; 0.5 (	mm	[test cases]
z_p (FEXT)	1 1 1 1; 1 1 1 1 ; 0.5 (	mm	[test cases]
z_p (RX)	1 1 1 1; 1 1 1 1 ; 0.5 (	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[test cases]
Operational			
ERL Pass threshold	10	dB	
COM Pass threshold	3	db	
DER_0	6.70E-06		
T_r	0.00400	ns	
FORCE_TR	1	logical	
PMD_type	C2C		
EW	1		
MLSE	0	logical	
ts_anchor	1		
sample_adjustment	[-8 8]		
Local Search	2		
Filter: Rx FFE			
ffe_pre_tap_len	5	UI	
ffe_post_tap_len	8	UI	
ffe_pre_tap1_max	1		
ffe_post_tap1_max	1		
ffe_tapn_max	1		
FFE_OPT_METHOD	MMSE		FV-LMS or MMSE
num_ui_RXFF_noise	1024		
Floating Tap Control			
N_bg	2	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	80	UI span for floating taps	
bmaxg	0.2	max DFE value for floating taps	
B_float_RSS_MAX	1	rss tail tap limit	
N_tail_start	25	(UI) start of tail taps limit	

AUI C2C Channels – File Naming Convention



XX: 85 ohms, 93 ohms, and 100 ohms
YY: 10 mils, 35 mils , 60 mils
ZZ: 20 mils, 45 mils , 70 mils

Channel Naming Convention

XX: 85 ohms, 93 ohms, and 100 ohms
YY: 10 mils, 35 mils , 60 mils
ZZ: 20 mils, 45 mils , 70 mils

el 1	Channel 2	Channel 3	Channel 4
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fex
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fex
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fex
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Ne
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Ne
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Ne
_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_4in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_6in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_8in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Ne

Channel Naming Convention

XX: 85 ohms, 93 ohms, and 100 ohms
YY: 10 mils, 35 mils , 60 mils
ZZ: 20 mils, 45 mils , 70 mils

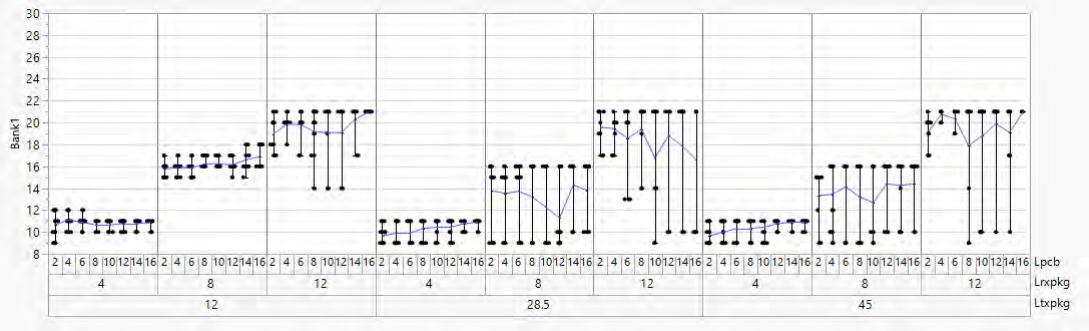
	Channel 2	Channel 3	Channel 4
_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_thru1.s4p
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fext.s4p	Tx_16n_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk1_Fex
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fext.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk2_Fex
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fext.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk3_Fex
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Next.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk4_Ne
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Next.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk5_Ne
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Next.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk6_Ne
_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_12in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_14in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Next.s4p	Tx_16in_Rx_XXohms_TxVia_YYmils_RxVia_ZZmils_xtalk7_Ne

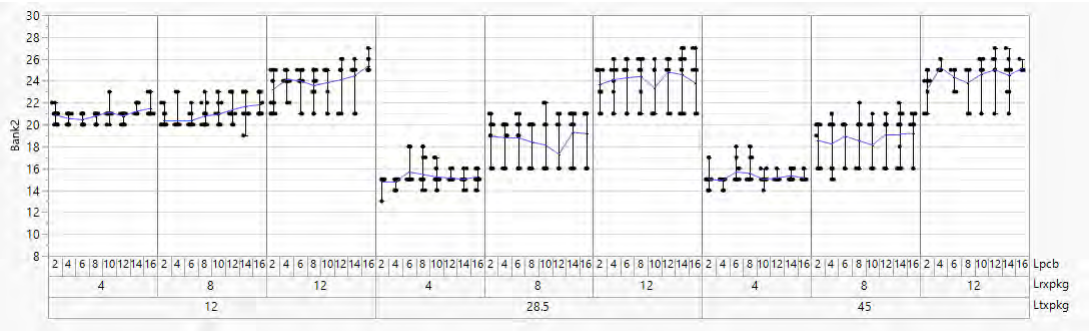
Floating Bank Locations

Bank 1

Bank 2

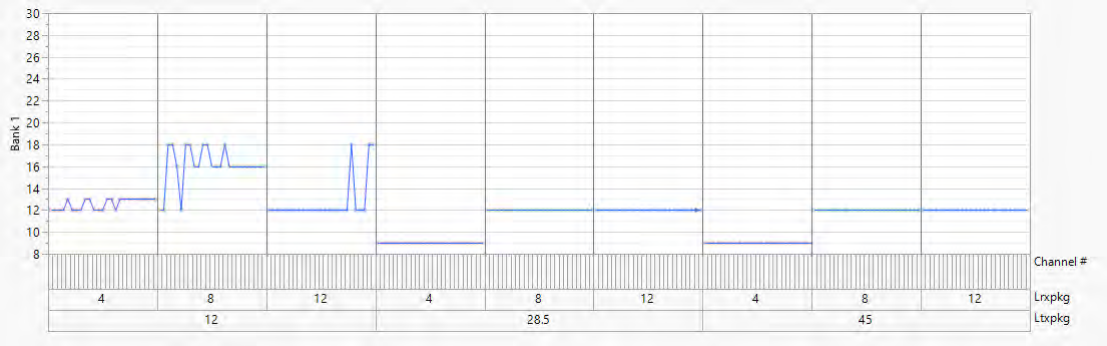
heck_3dj_02_2405

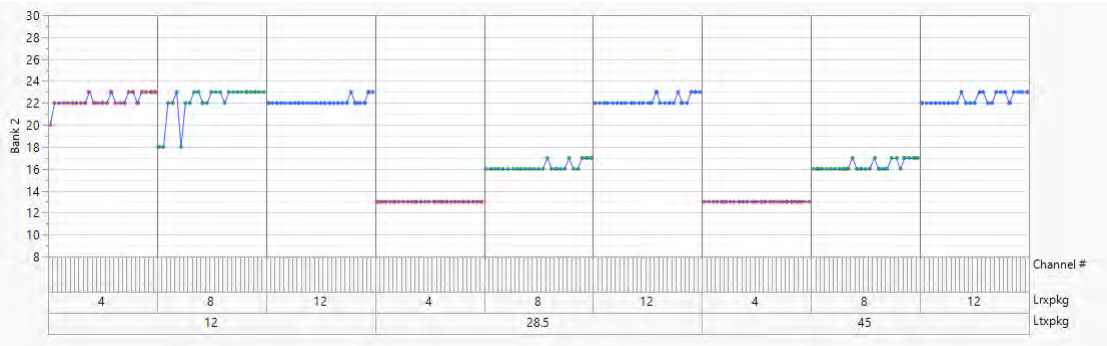




Data corresponds to the location of the 1st tap of the bank.

mellitz_3dj_elec_03_230504





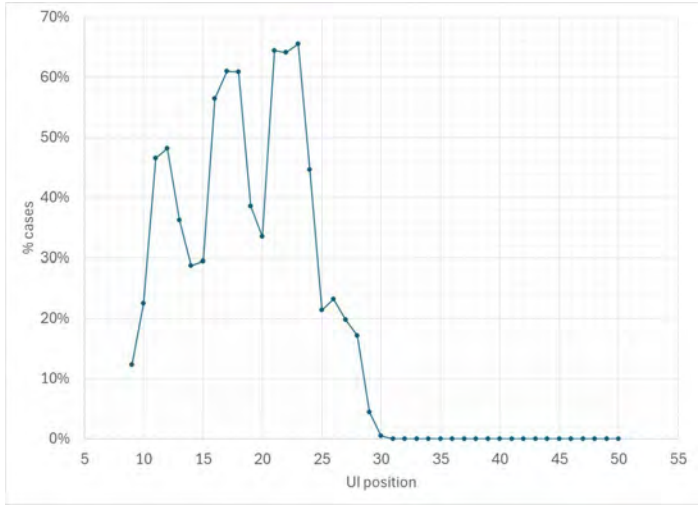
Bank location shows correlation to RX pkg trace length.

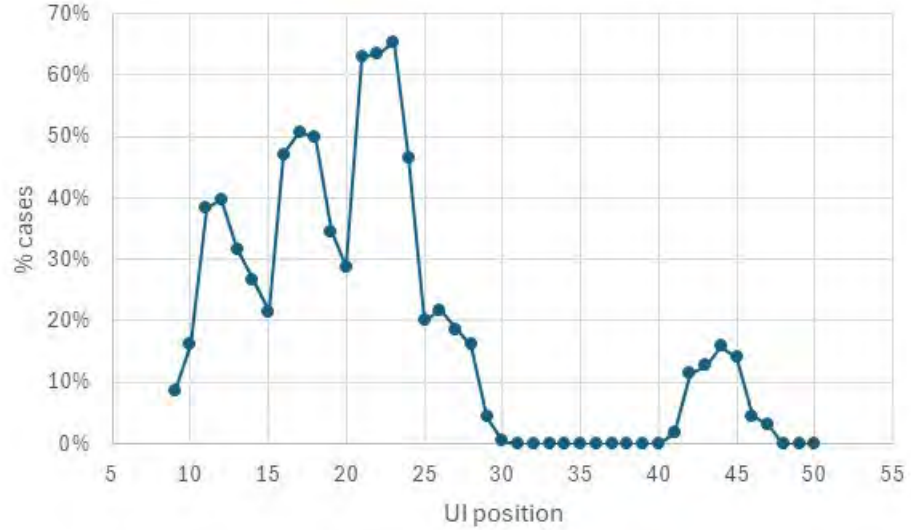
Floating Tap Coefficient Range & Location

Host Transmitting

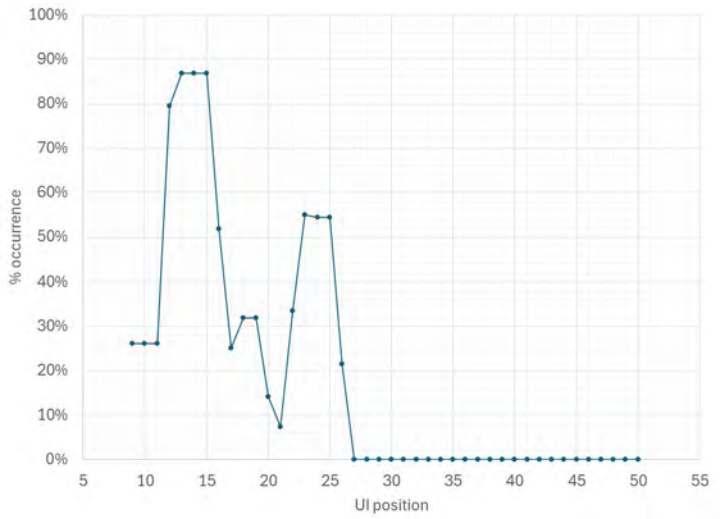
Host Receiving

heck_3dj_02_2405





mellitz_3dj_elec_03_230504



Channels: https://www.ieee802.org/3/dj/public/tools/c2c/heck_3dj_02_2405.zip