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for better quality of experience

100Gb/s KR COM
- Reference Receiver (FFE / DFE)
- Reference PKG

IEEE802.3ck

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Hiroki Miyaoka, Toshiaki Sakai
Socionext Inc.

Contents

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1. Overview

1. **100G-KR COM Reference Receiver studies**
   - At ad hoc on 10/24/2018, "DFE-based model vs FFE-based model for Reference Rx of COM" (hidaka_3ck_adhoc_01_102418.pdf) was presented. In that, reference receiver equalizer, no FFE pre-tap and n-tap DFE reference receiver was recommended.
   - A study based on this proposal was done.
   - Comparison of COM reference receiver configuration (16-tap FFE with 1-tap DFE or 16-tap DFE) using proprietary tool for two (2) channels.
   - Similar comparison using COM for more channels and equalizer settings.

2. **COM PKG studies**
   (1) Tx/Rx COM PKG impedance combination
   (2) Tx/Rx COM PKG trace length combination

1.1 reference receiver configuration/condition

#	Tx FFE pre		Rx FFE pre		Rx FFE post		Rx DFE		PKG	result	note
	tap	step	tap	step	tap	step	tap	step			
1	3	2.5%	3	0%	16	0%	1	0%	30mm / 87.5Ω +1.8mm (PTH) / 92.5Ω Cd=110fF Cp=70fF	No significant COM difference	hidaka_3ck_adhoc_01_102418.pdf - COM 2.52 - channel used #4, 11, 5, 7, 9, 6, 8, 10 (BP channel)
2		4%									
3		1%									
4	1	2.5%									
5	3	2.5%	0	-	16	0%	1	0%		0.55~0.96dB worse COM than with Rx FFE-pre (#1-4)	
6	3	2.5%	0	-	0	-	16	0%		No major COM difference to #5	
7	0	-	3	0%	16	0%	1	0%	27mm extracted Cd=110fF	No major difference between FFE and DFE.	- proprietary tool - channel #8,18
8					0	-	16	0%			
9	2	2.5%	0	-	n	0%	1	0%	30/20mm* / 92.5Ω +1.8mm / 92.5Ω Cd=110fF, Cp=80fF	No major difference between FFE and DFE.	- COM 2.51 n=12/16/20/24/28 - channel #1-2,4-18
10					0	-	n	0%			
11	1	5%	0	-	n	0%	1	0%			
12					0	-	n	0%			

This work

Rx FFE pre-3/post-0 cases equalization fails with current COM (2.51, 2.53)

Tx FFE : 1-post / 5%, fb = 53.125Gbd
* 30mm and 20mm Tx/Rx combination (4-cases each)

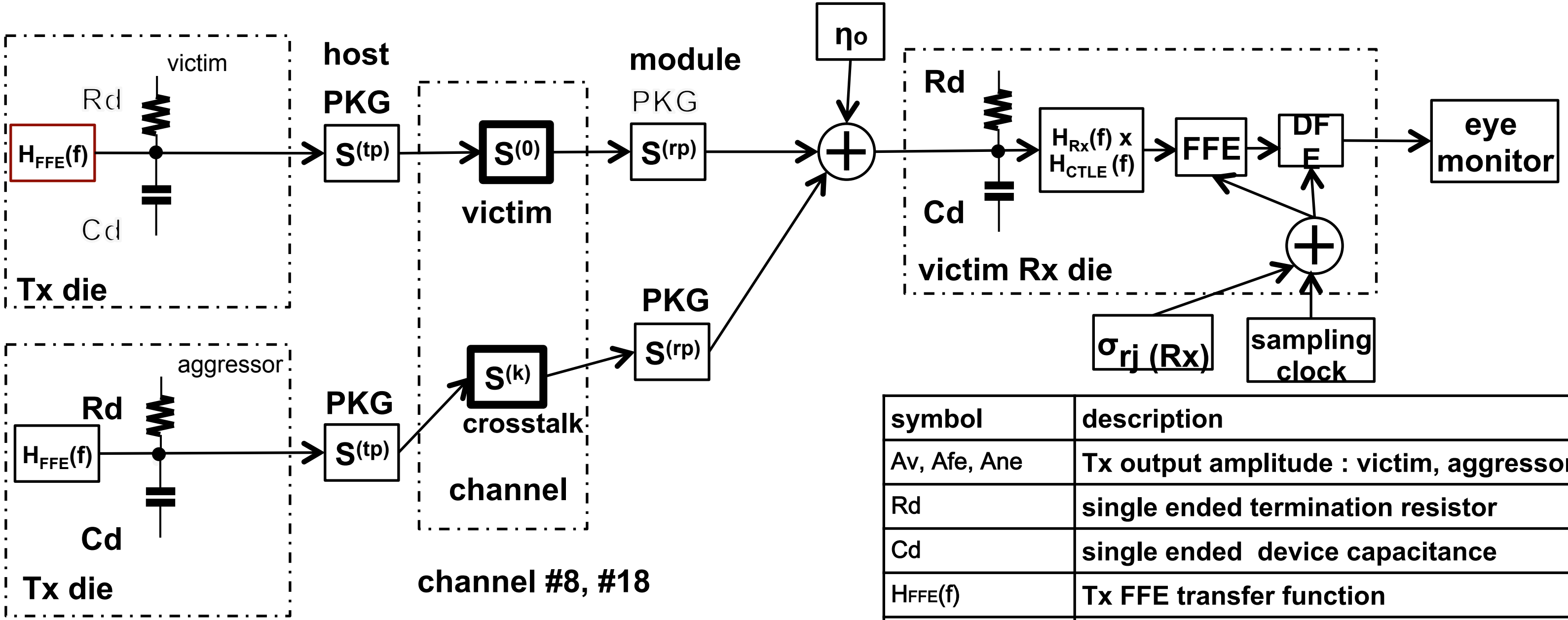
2. Backplane Channels for Simulation

#	contributor	type	IL [dB]*	ERL [dB]**	ICN [mV]	note	name in graph	reference
1	Mellitz	legacy	15.88	12.02	3.53	Tachyon_3”	ST3	[1][2]
2			25.55	12.89	2.68	Tachyon_13”	ST13	[1][3]
3			30.34	13.07	2.65	Tachyon_18”	ST18	[1][4]
4			28.01	52.77	0.00	“smooth” PCB Megtron-6	Sm	[7][8]
5		cabled	23.79	19.85	0.76	24dB_opt1, 30AWG 1m+0.3mx2+PCB 2.3”x2	S241	[5][6]
6			22.98	17.53	0.88	24dB_opt2, 30AWG 1m+0.3mx2+PCB 2.3”x2	S242	
7			27.59	20.85	0.56	28dB_opt1, 30AWG 1m+0.3mx2+PCB 4”x2	S281	
8			26.72	18.35	0.65	28dB_opt2, 30AWG 1m+0.3mx2+PCB 4”x2	S282	
9			31.36	21.80	0.44	32dB_opt1, 30AWG 1m+0.3mx2+PCB 5.8”x2	S321	
10			30.42	19.08	0.50	32dB_opt2, 30AWG 1m+0.3mx2+PCB 5.8”x2	S322	
11			27.98	73.98	0.00	“smooth” 26AWG twinax cabled	St	[7][8]
12	Zambell	cabled	28.60	21.99	0.39	1m 30 AWG, 3.2” PCB	Ac	
13		ortho	26.64	14.55	1.52	20” orthogonal	Ao	[10][11]
14	Heck	legacy	29.74	9.51	2.05	30dB, nominal, 85-ohm	In	[12][13]
15			29.62	8.80	2.03	30dB, high-low-high, 85-ohm	Ihlh	[12][14]
16			29.85	8.04	2.05	30dB, low-high-low, 85-ohm	Ilhl	[12][15]
17	Tracy	cabled				1m 30 AWG, 12” PCB	Tc	[17][18]
18		ortho				18” orthogonal	To	[17][19]

@ 53.125Gbd * : no PKG, raw (not fitted) ** : 1-tap DFE

Not all the channels are used.

3.1 Simulation Model (proprietary tool)



PKG : 27mm
extracted model

✓ The same as previous ones.
sakai_100GEL_01b_0118.pdf, sakai_100GEL_01_0318.pdf
sakai_3ck_01b_0918.pdf

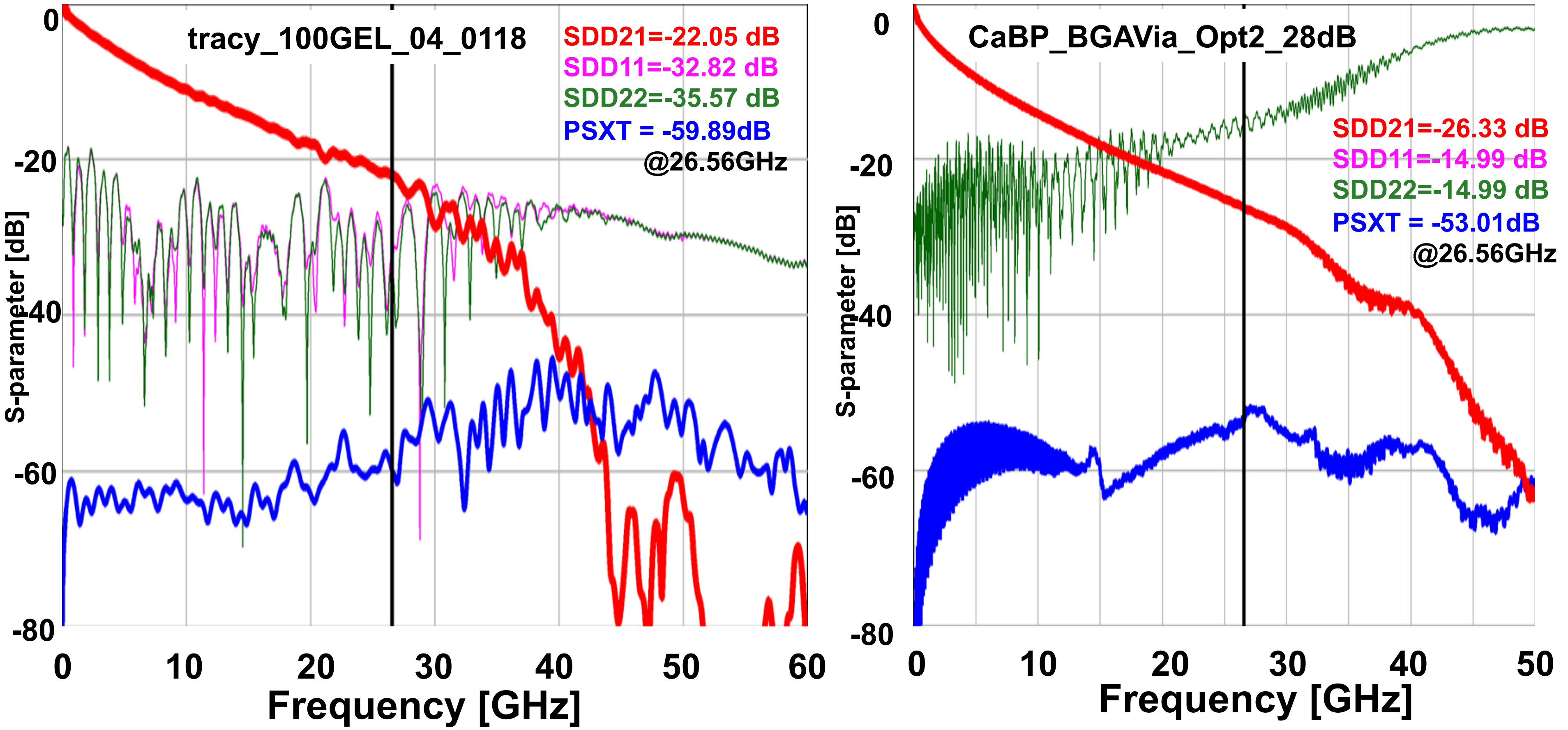
symbol	description
Av, Afe, Ane	Tx output amplitude : victim, aggressor (FEXT, NEXT)
Rd	single ended termination resistor
Cd	single ended device capacitance
$H_{FFE}(f)$	Tx FFE transfer function
$S^{(tp)}$, $S^{(rp)}$	PKG model Tx/Rx
$S^{(0)}$	channel under test
$H_{Rx}(f)$	Rx noise filter
$H_{CTLE}(f)$	Rx CTLE transfer function
η_0	one-sided noise spec
Add	Dual-Dirac jitter, peak to peak Tx : before FFE Rx : considered as eye margin
σrj	random jitter, RMS Tx : before FFE Rx : before FFE/ DFE

3.2 Simulation Set Up (proprietary tool)

- ✓ Static Channel Model Simulation (proprietary)
- ✓ Behavior model using MatLab
- ✓ Rx/CDR jitter (DJ) are considered as eye opening margin. (EW4, EH4)
- ✓ Crosstalk noise in channel S-parameter
- ✓ Impedance are nominal : 50-ohm single ended
- ✓ Transmitter equalization : none
- ✓ Receiver equalization :
  - "FFE" : FFE 3-pre + 16-post + 1-tap DFE
  - "DFE" : FFE 3-pre + 0-post + 16-tap DFE
- ✓ Same CTLE coefficients are used for both "FFE" and "DFE".
- ✓ PKG model is based on current design.
  - PKG material : "GZ41"

item	value	unit	note
modulation	PAM4		
pattern	PRBS13Q		
baud rate	53.125	Gbd	
DJ_Tx	60	mUI_pk-pk	conservative
RJ_Tx	10	mUI_rms	
EOJ_Tx	0	UI	
SNR_Tx	32.5	dB	
Rt_Tx	50	ohm	
Tx_FFE	1/0	tap/pre	no Tx equalization
Cd_Tx/Rx	110	fF	
Cp Tx/Rx	extracted		S-parameter PKG model
Rx FFE + DFE	3/n+1, 3/0+n		
Rx fr	3/4 fb		
Av	0.8	Vppd	
AVx	1.2	Vppd	
BER	1.0E-4		
η_0 eta0	8.2E-09	V^2/GHz	
DJ_Rx	0	UI	included as eye margin
RJ_Rx	10	mUI_rms	
Rt_Rx	50	ohm	

3.3 Backplane Channel Characteristics



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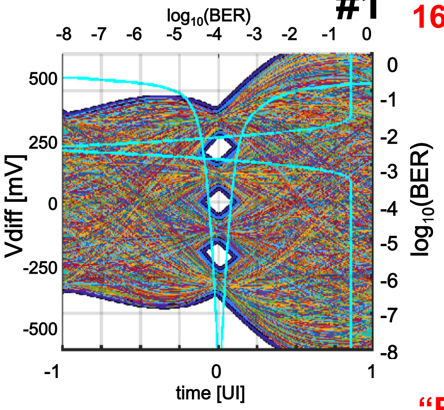
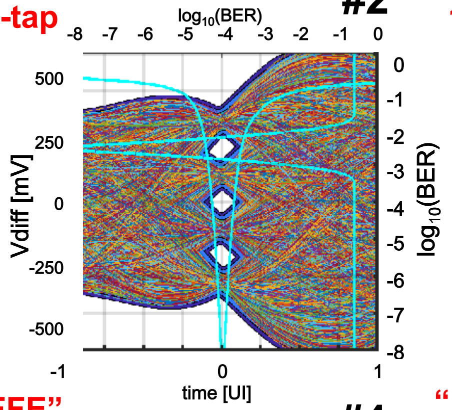
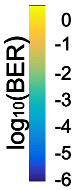
3.4 Simulation Result (FFE/DFE post taps)

#1 "FFE" 16-tap



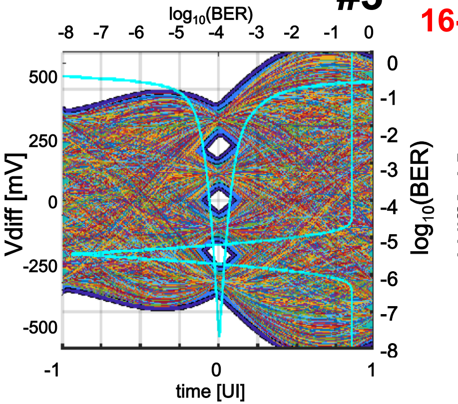
#2 "DFE" 16-tap



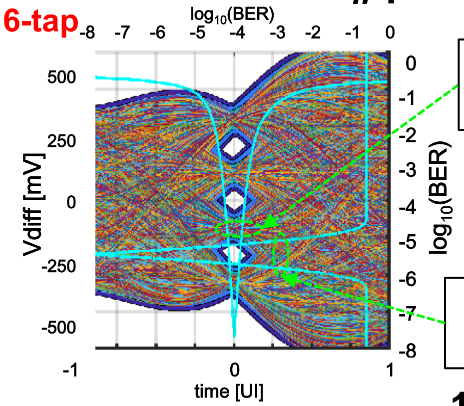


"Colors" are corresponding to each "line" BER.

#3 "FFE" 16-tap



#4 "DFE" 16-tap



time BER bathtub curve (worst eye)

voltage BER bathtub curve (worst eye)

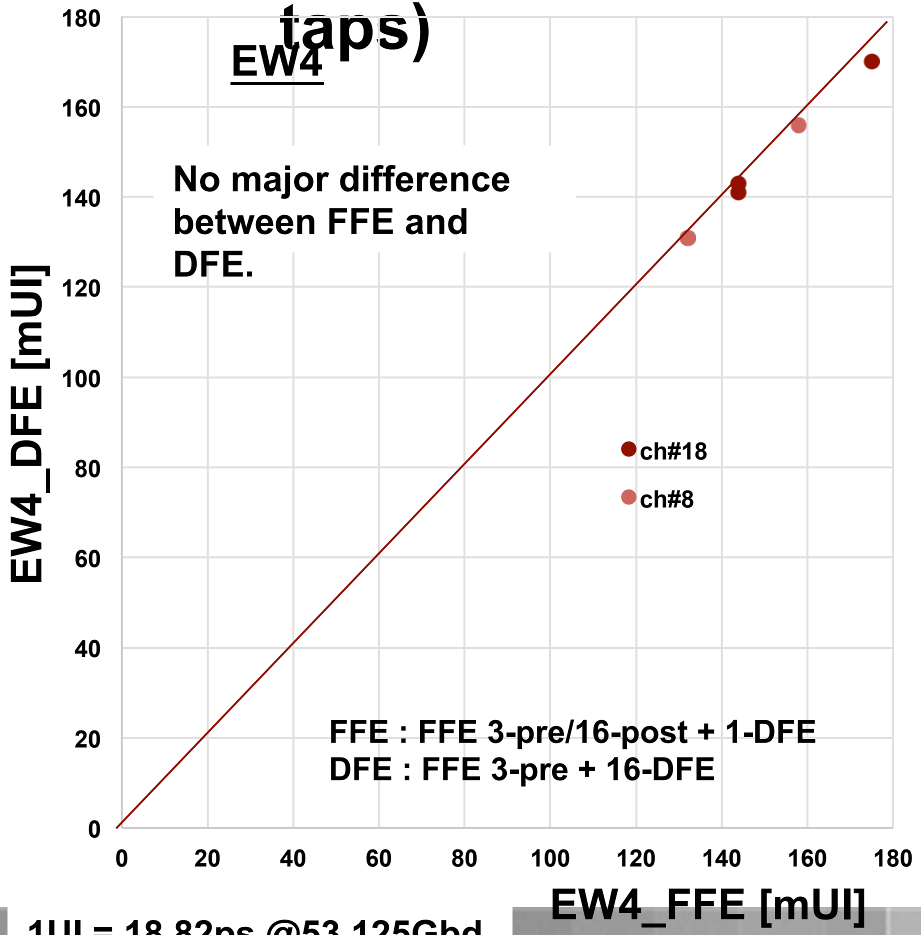
1UI = 18.82ps @53.125Gbd

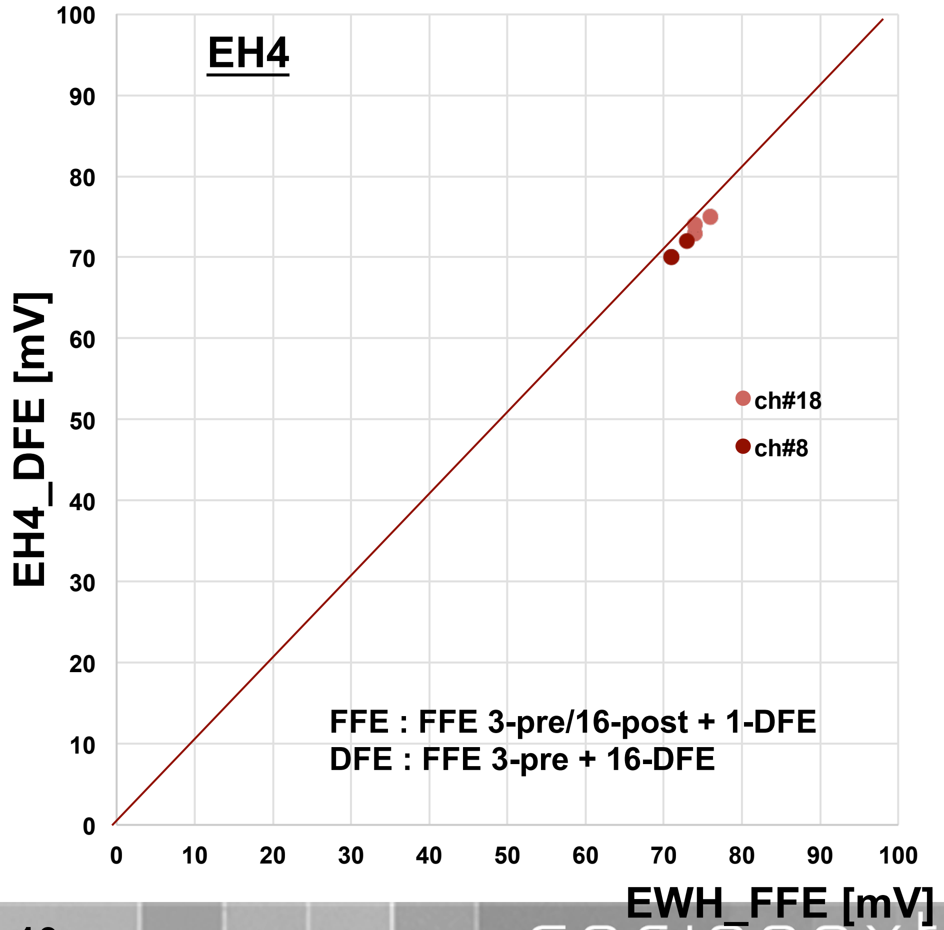
item			unit	#1	#2	#3	#4
baud rate			Gbd	53.125			
channel				#18/ortho		#8/cabled	
Tx	FFE	tap/pre		1/0			
Tx	RJrms		mUI	10			
Tx	SNR		dB	32.5			
Tx/Rx	PKG trace		mm	27mm (extracted)			
Tx/Rx	Cd		fF	110			
Tx/Rx	Cp		fF	extracted			
Rx	CTLE	HF/LF		2p-1z/1p-1z			
Rx	eta0	V²/GHz		8.2E-9			
Rx	fr	x fb	GHz	3/4			
Rx	FFE	pre		3			
Rx	FFE	post		16	0	16	0
Rx	DFE	post		1	16	1	16
Rx	RJrms		mUI	10			
eye	EW4	upp	mUI	144	141	132	131
eye	EW4	mid	mUI	175	170	158	156
eye	EW4	low	mUI	144	143	132	131
eye	EH4	upp	mV	74	73	71	70
eye	EH4	mid	mV	76	75	73	72
eye	EH4	low	mV	74	74	71	70

criteria : EW4 ≥ 100mUI, EH4 ≥ 20mV

No major difference between "FFE" and "DFE".

3.4.1 Simulation Result (FFE/DFE post taps)





1UI = 18.82ps @53.125Gbd

4.1 COM parameters (example)

Table 93A-1 parameters

Parameter	Setting	Units	Information
f_b	58	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 3 4 5]		[test cases to run]
z_p (TX)	[15 5 10 20 30 ;1.8 1.8 1.8 1.8 0.0 ;7.5 12.5 10.0 5.0 0.0 ;7.0 12.5 10.0 5.0 0.0]	mm	[test cases]
z_p (NEXT)	[15 5 10 20 30 ;1.8 1.8 1.8 1.8 0.0 ;7.5 12.5 10.0 5.0 0.0 ;7.0 12.5 10.0 5.0 0.0]	mm	[test cases]
z_p (FEXT)	[15 5 10 20 30 ;1.8 1.8 1.8 1.8 0.0 ;7.5 12.5 10.0 5.0 0.0 ;7.0 12.5 10.0 5.0 0.0]	mm	[test cases]
z_p (RX)	[15 5 10 20 30 ;1.8 1.8 1.8 1.8 0.0 ;7.5 12.5 10.0 5.0 0.0 ;7.0 12.5 10.0 5.0 0.0]	mm	[test cases]
C_p	[1.0e-4 1.0e-4]	nF	[TX RX]
C_v	[0.1e-4 0.1e-4]	nF	[TX RX]
R_0	50	Ohm	
R_d	[50 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)	0.6		min
c(-1)	[-0.3:0.025:0]		[min:step:max]
c(-2)	[0:0.025:0.1]		[min:step:max]
c(-3)	[0]		[min:step:max]
c(-4)	[0]		[min:step:max]
c(1)	[-0.3:0.05:0]		[min:step:max]
N_b	1	UI	
b_max(1)	0.7		
b_max(2..N_b)	0.2		
g_DC	[-20:1:0]	dB	[min:step:max]
f_z	23.2	GHz	
f_p1	23.2	GHz	
f_p2	58	GHz	
g_DC_HP	[-6:1:0]		[min:step:max]
f_HP_PZ	0.725	GHz	
ffe_pre_tap_len	3	UI	
ffe_post_tap_len	12		
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		

flex_PKG model

with Rx FFE

Rx FFE constraints

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	1	logical
RESULT_DIR	./results/	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	112G-LR_58_130-D01-R3-12	
COM_CONTRIBUTION	0	logical
Operational		
COM Pass threshold	3	dB
DER_0	1.E-04	
Include PCB	0	Value
T_r	6.E-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	1000	
TDR_Butterworth	1	logical
beta_x	1.7.E+09	
rho_x	0.18	
fixture delay time	0	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	0.005	V
Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	UI
eta_0	8.2E-09	V^2/GHz
SNR_TX	32.5	dB
R_LM	0.95	

Table 93A・ parameters

Parameter	Setting	Units
package_tl_gamma0_a1_a2	[0 1.734e-3 1.455e-4]	
package_tl_tau	0.006141	ns/mm
package_Z_c	[87.5 87.5; 110 110; 87.5 87.5; 87.5 87.5]	Ohm (tdr sel)

flex_PKG model

Table 92・2 parameters

Parameter	Setting	
board_tl_gamma0_a1_a2	[0 3.8206e-04 9.5909e-05]	
board_tl_tau	0.00579	ns/mm
board_Z_c	90	Ohm
z_bp (TX)	115	mm
z_bp (NEXT)	115	mm
z_bp (FEXT)	115	mm
z_bp (RX)	115	mm

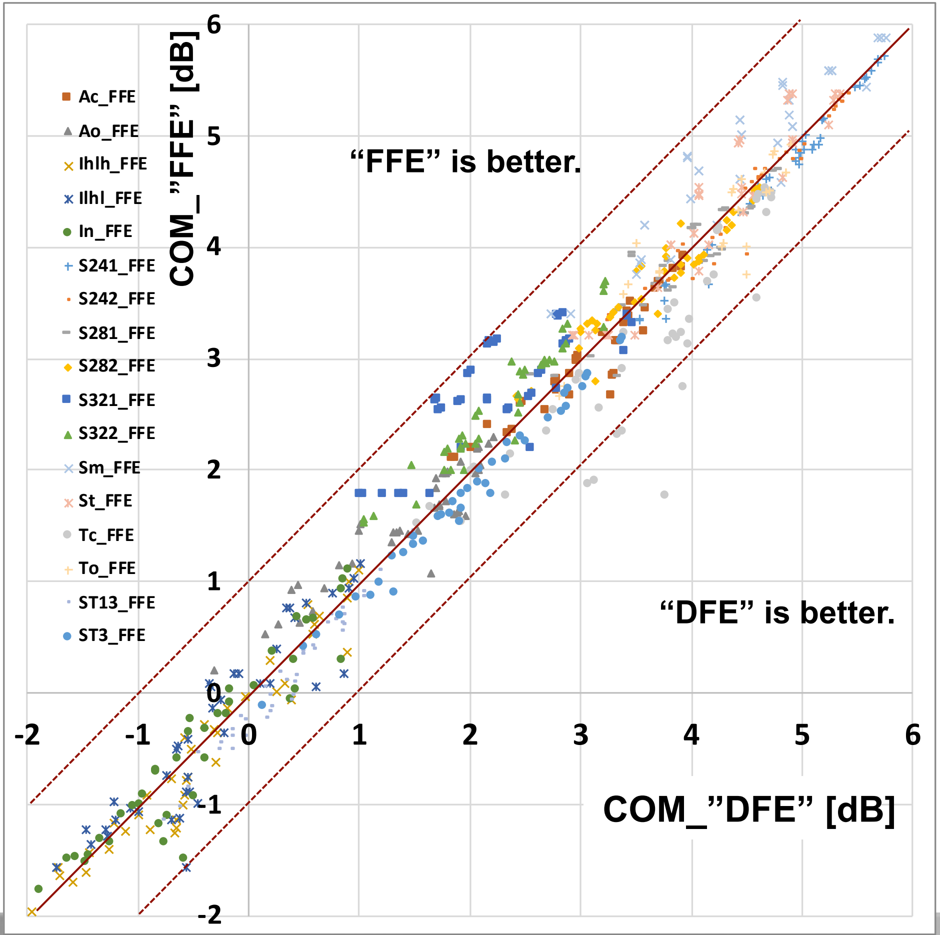
COM 2.51

Similar comparison is done using COM.

- ✓ fb : 53.125Gbd (PAM4)
- ✓ CTLE pole/zero frequencies : proportional to fb
- ✓ Cd=110fF, Cp : 80fF
- ✓ Rd=50 ohm, Zc : 92.5-ohm
- ✓ sigma_RJ : 0.01UI, A_DD : 0.02UI
- ✓ SNR_TX : 32.5dB
- ✓ DER_0 : 1E-4

case	Tx_FFE				Rx_FFE				Rx_DFE	
	pre		post		pre		post			
	tap	step	tap	step	tap	step	tap	step	tap	step
"FFE"	2	2.5%	1	5%	3	0%	n	0%	1	0%
"DFE"	2	2.5%	1	5%	3	0%	0	-	n	0%

4.2 COM FFE/DFE comparison



case	Tx_FFE				Rx_FFE				Rx_DFE	
	pre		post		pre		post			
	tap	step	tap	step	tap	step	tap	step	tap	step
"FFE"	2	2.5%	1	2.5%	0	-	n	0%	1	0%
	1	5%	1	5%	0	-	n	0%	1	0%
"DFE"	2	2.5%	1	2.5%	0	-	0	-	n	0%
	1	5%	1	5%	0	-	0	-	n	0%

COM 2.51

"FFE" : Rx FFE-rich
"DFE" : Rx DFE-rich

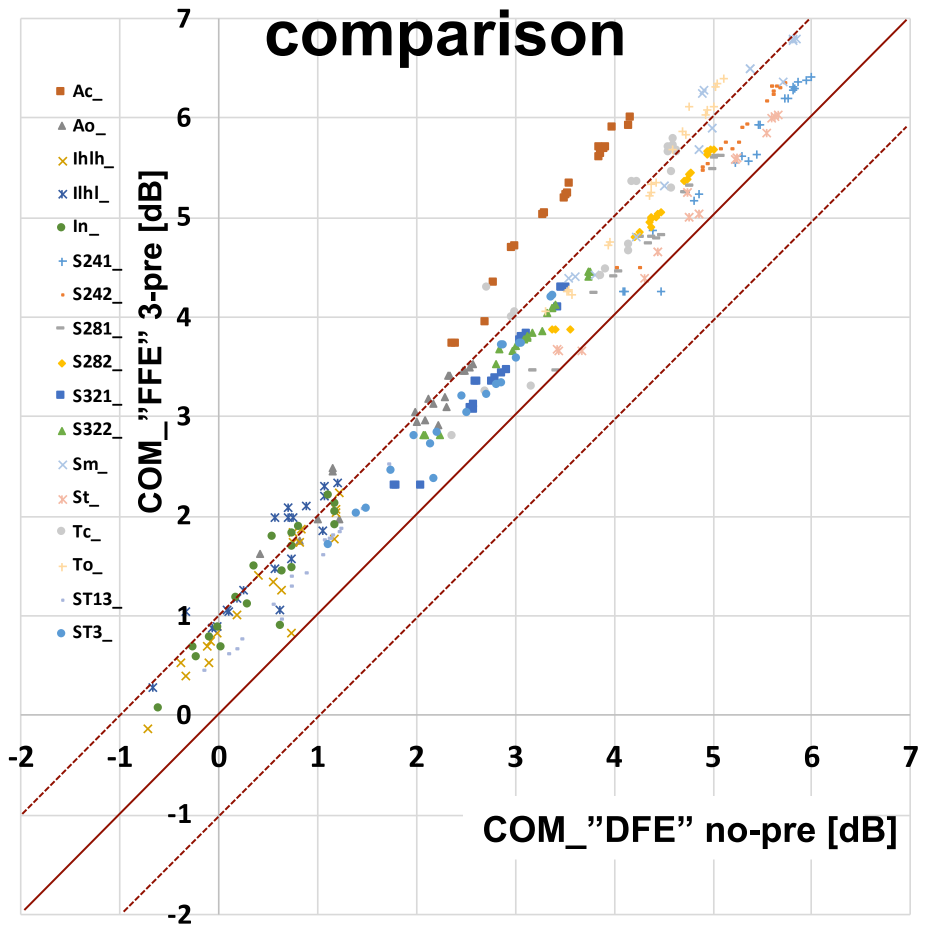
- n=12/16/20/24/28
- with crosstalk, noise
- Tx/Rx trace combination
20mm/20mm, 20/30, 30/20, 30/30

EQ (4) * PKG (4) * post (5) * ch (17) = 1700 cases

✓ No major differences between, "DFE" and "FFE".
However, in some cases more than 1dB differences are existing.
Can these be handled as COM 3dB (TBD) margin?

With ~~current~~ COM version (2.51, ~~2.53~~), Rx FFE pre-n/post-0 conditions fail equalization.

4.3 COM FFE(3-pre FFE)/DFE(0-pre FFE) comparison



case	Tx_FFE				Rx_FFE				Rx_DFE	
	pre		post		pre		post			
	tap	step	tap	step	tap	step	tap	step	tap	step
FFE	1	5%	1	5%	3	0%	n	0%	1	0%
DFE	1	5%	1	5%	0	-	0	-	n	0%

- n=12/16/20/24/28

COM 2.51

- with crosstalk, noise
- Tx/Rx trace combination 20mm/20mm, 20/30, 30/20, 30/30

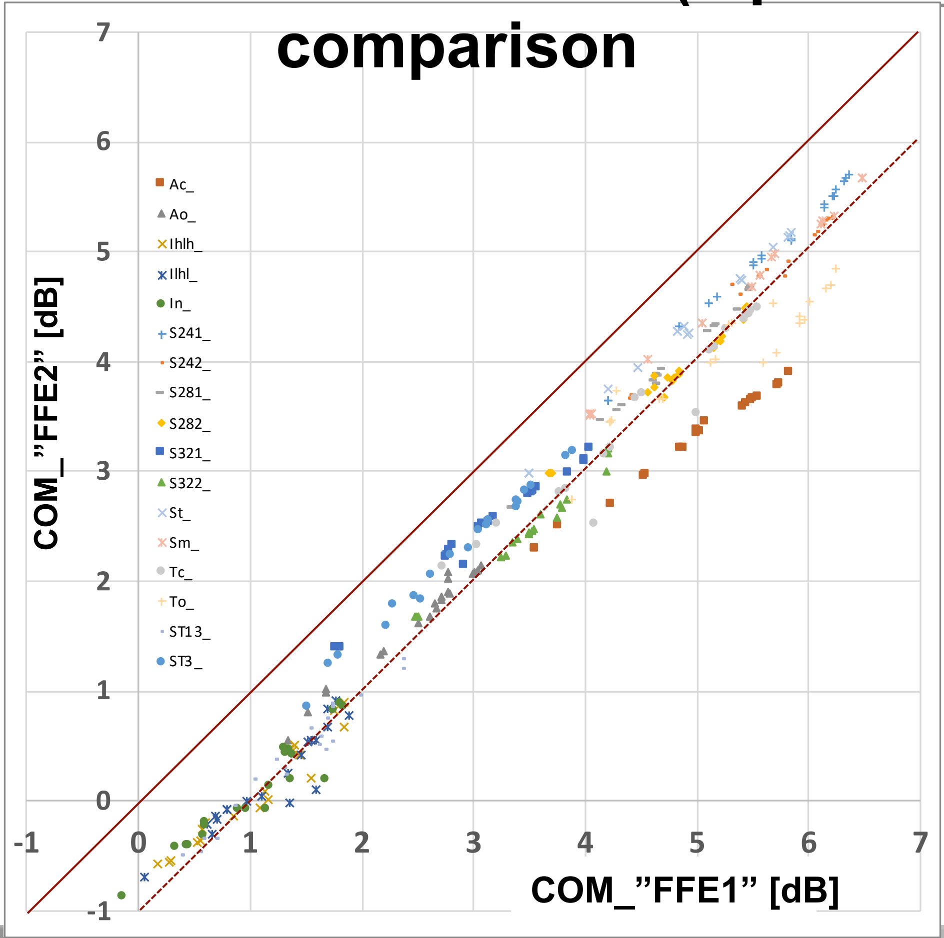
"FFE" : Rx FFE-rich
"DFE" : Rx DFE-rich

EQ (2) * PKG (4) * ch (17) = 136 cases

✓ With Rx FFE 3-pre-taps, "FFE" performs 0~2dB better than "DFE" with no Rx FFE pre-tap.
✓ "DFE" with no Rx FFE pre-taps show worse COM values.
- Lower COM criteria

With ~~current~~ COM version (2.51, ~~2.53~~), Rx FFE pre-n/post-0 conditions fail equalization.

4.4 COM FFE(3-pre FFE)/FFE(0-pre FFE) comparison



case	Tx_FFE				Rx_FFE				Rx_DFE	
	pre		post		pre		post			
	tap	step	tap	step	tap	step	tap	step	tap	step
FFE 1	1	5%	1	5%	3	0%	n	0%	1	0%
FFE 2	2	5%	1	5%	0	-	n	0%	1	0%

"FFE" : Rx FFE-rich
"DFE" : Rx DFE-rich

- n=12/16/20/24/28
- with crosstalk, noise
- Tx/Rx trace combination
20mm/20mm, 20/30, 30/20, 30/30

COM 2.53

✓ With Rx FFE 3-pre-taps, even Tx FFE only has 1 pre-tap,
COM is 0.3~1.5dB better.

With ~~current~~ COM version (2.51, ~~2.53~~), Rx FFE pre-n/post-0 conditions fail equalization.

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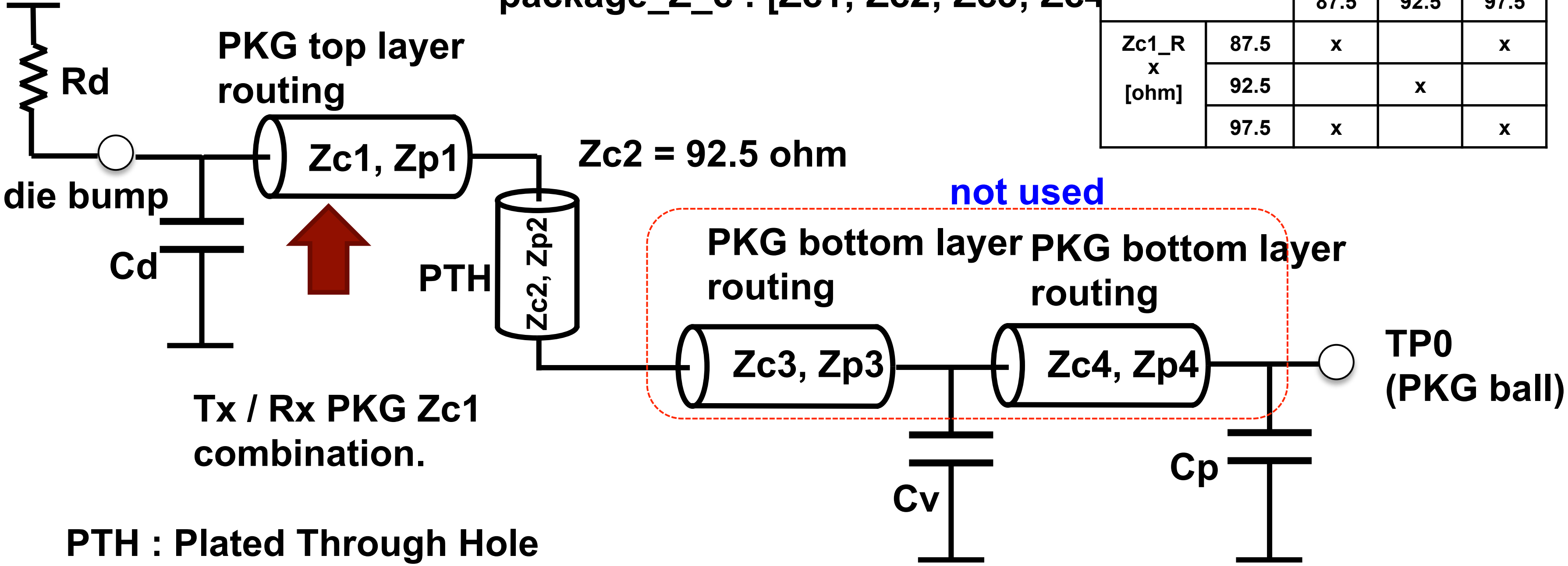
5. flexible_PKG model parameters

z_p : [Zp1; Zp2; Zp3; Zp4]
package_Z_c : [Zc1; Zc2; Zc3; Zc4]

PKG Zc combination		Zc1_Tx [ohm]		
		87.5	92.5	97.5
Zc1_Rx [ohm]	87.5	x		x
	92.5		x	
	97.5	x		x

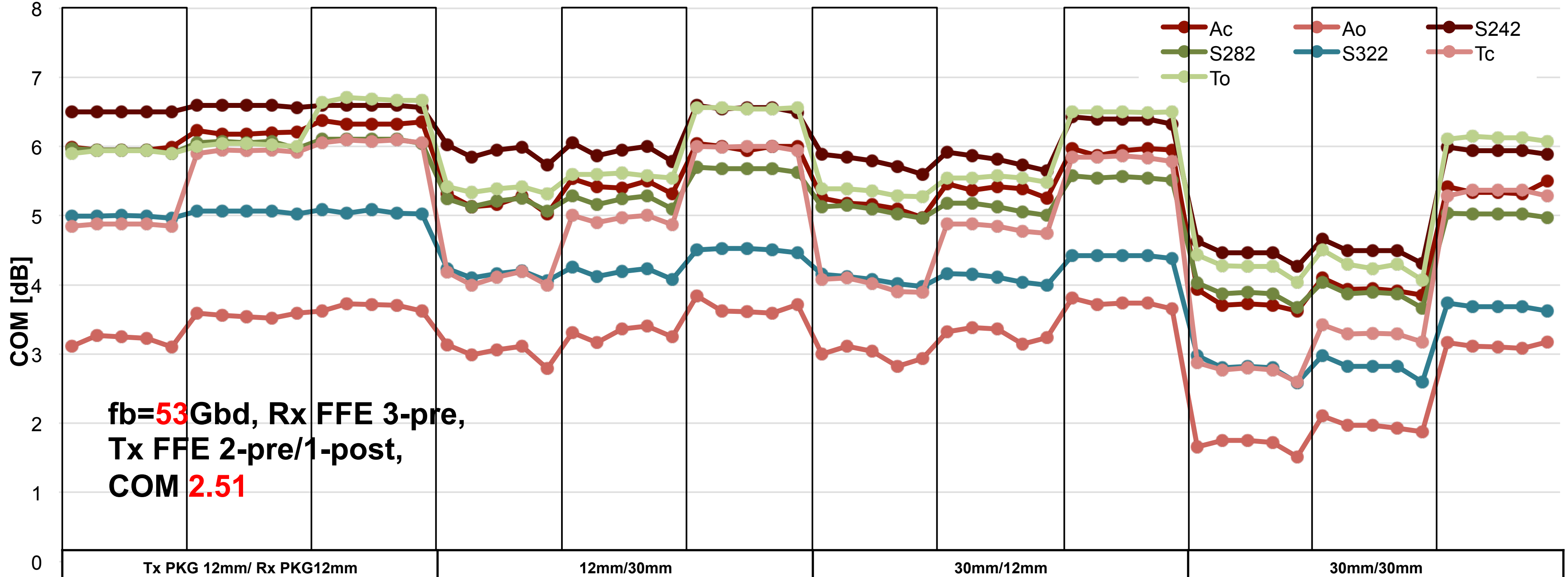


PTH : Plated Through Hole
PKG : package

http://www.ieee802.org/3/ck/public/18_09/mellitz_3ck_01_0918.pdf

✓ In this COM sim, Zp3 and Zp4 are set to “0”.

5.1 PKG trace (Tx/Rx) impedance vs COM



	Tx PKG 12mm/ Rx PKG12mm														
	Rx FFE 12-post					20-post					28-post				
Zc_Rx	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5
Zc_Tx	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5

	12mm/30mm														
	12-post					20-post					28-post				
Zc_Rx	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5
Zc_Tx	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5

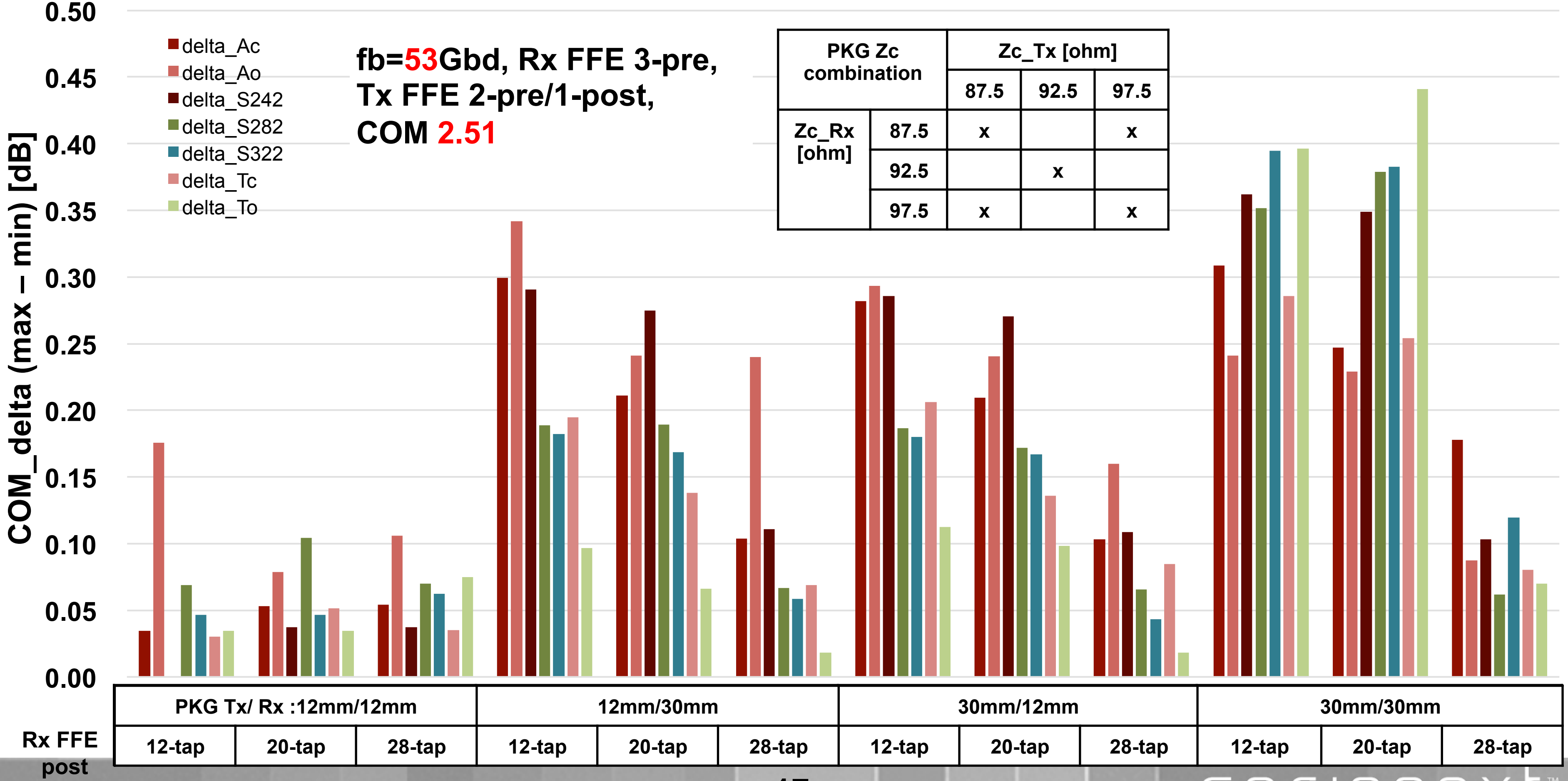
	30mm/12mm														
	12-post					20-post					28-post				
Zc_Rx	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5
Zc_Tx	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5

	30mm/30mm														
	12-post					20-post					28-post				
Zc_Rx	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5	87.5	87.5	92.5	97.5	97.5
Zc_Tx	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5	87.5	97.5	92.5	87.5	97.5

5.2 PKG trace impedance vs COM_delta (max-min)

fb=53Gbd, Rx FFE 3-pre,
Tx FFE 2-pre/1-post,
COM 2.51

PKG Zc combination		Zc_Tx [ohm]		
		87.5	92.5	97.5
Zc_Rx [ohm]	87.5	x		x
	92.5		x	
	97.5	x		x



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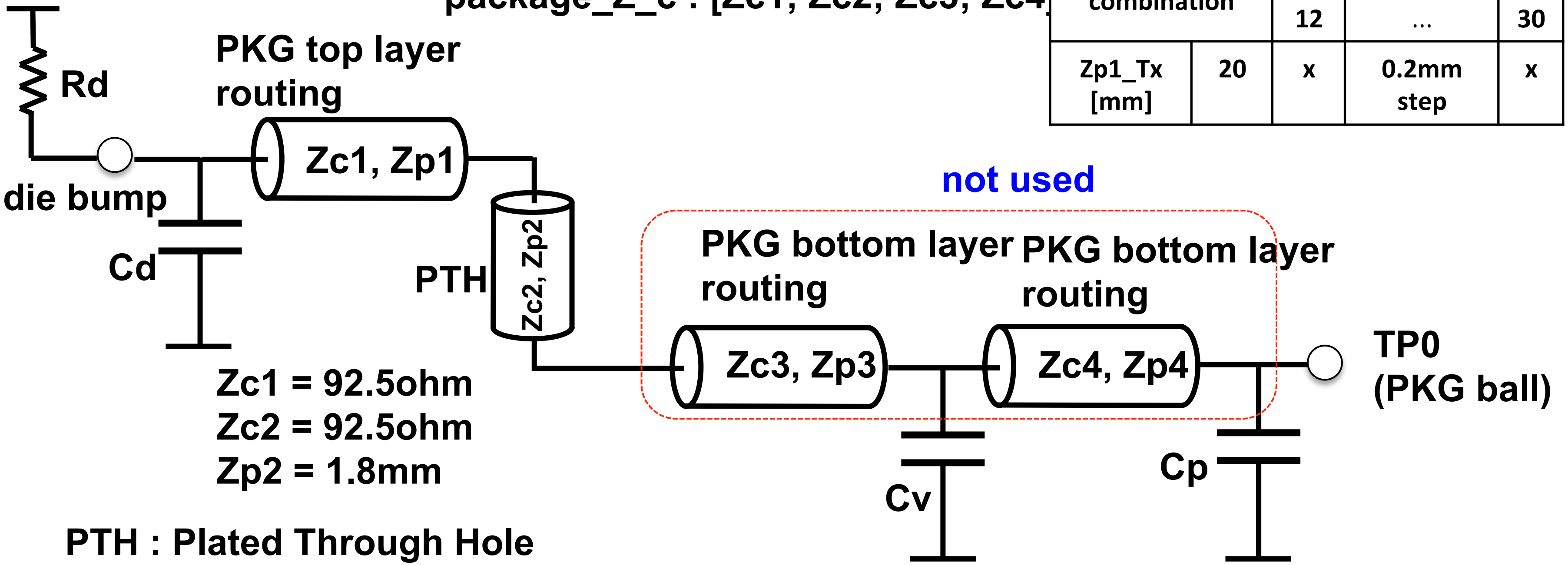
6. flexible_PKG model parameters

z_p : [Zp1; Zp2; Zp3; Zp4]
package_Z_c : [Zc1; Zc2; Zc3; Zc4]

PKG Zp1 combination		Zp1_Rx [mm]		
		12	…	30
Zp1_Tx [mm]	20	x	0.2mm step	x



Zc1 = 92.5ohm
Zc2 = 92.5ohm
Zp2 = 1.8mm

PTH : Plated Through Hole
PKG : package

http://www.ieee802.org/3/ck/public/18_09/mellitz_3ck_01_0918.pdf

✓ In this COM sim, Zp3 and Zp4 are set to “0”.

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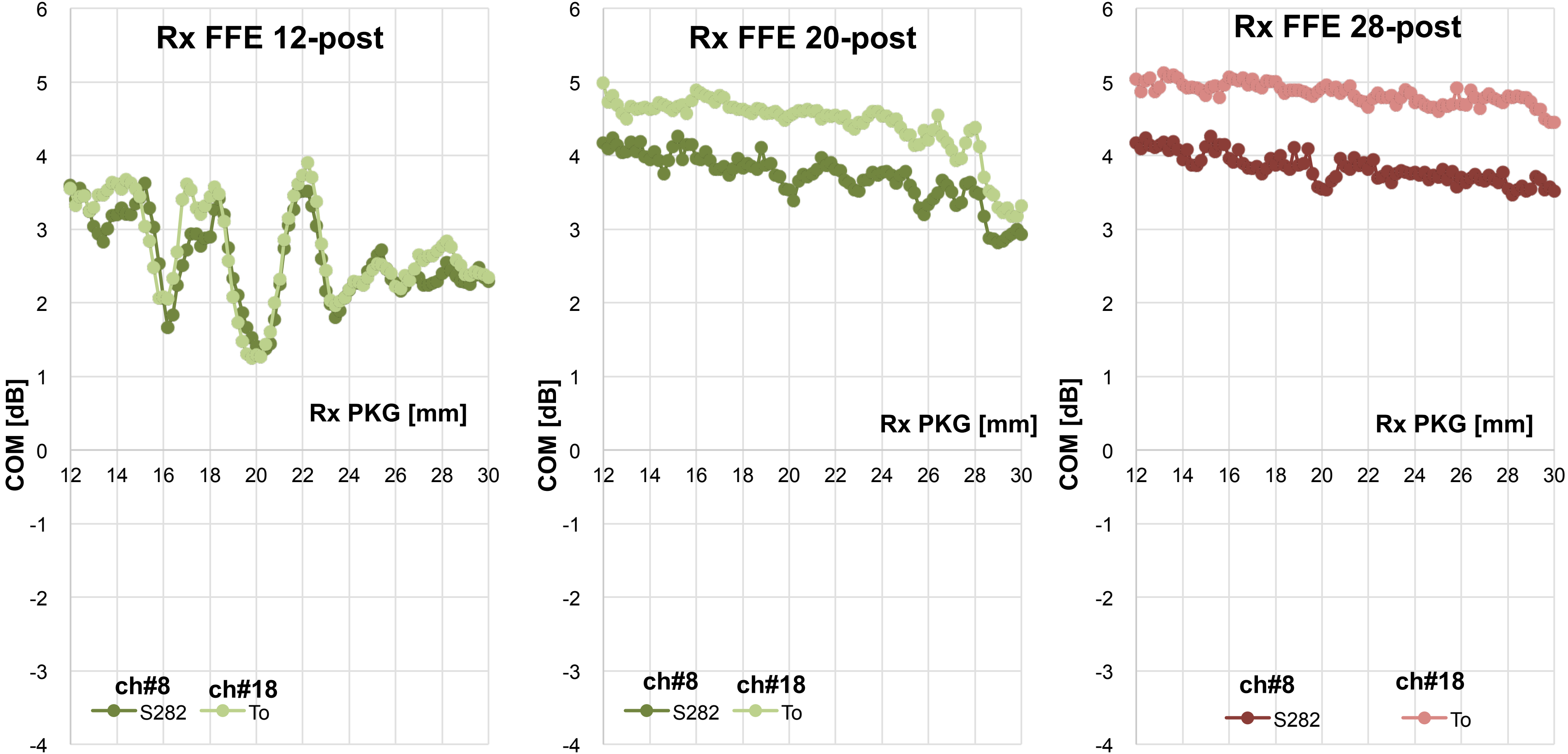
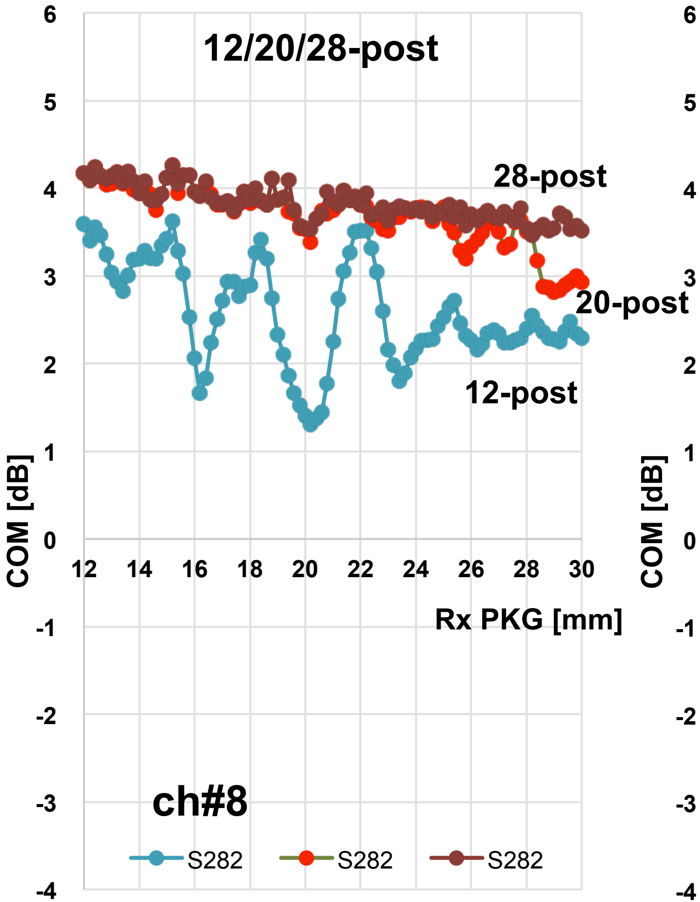
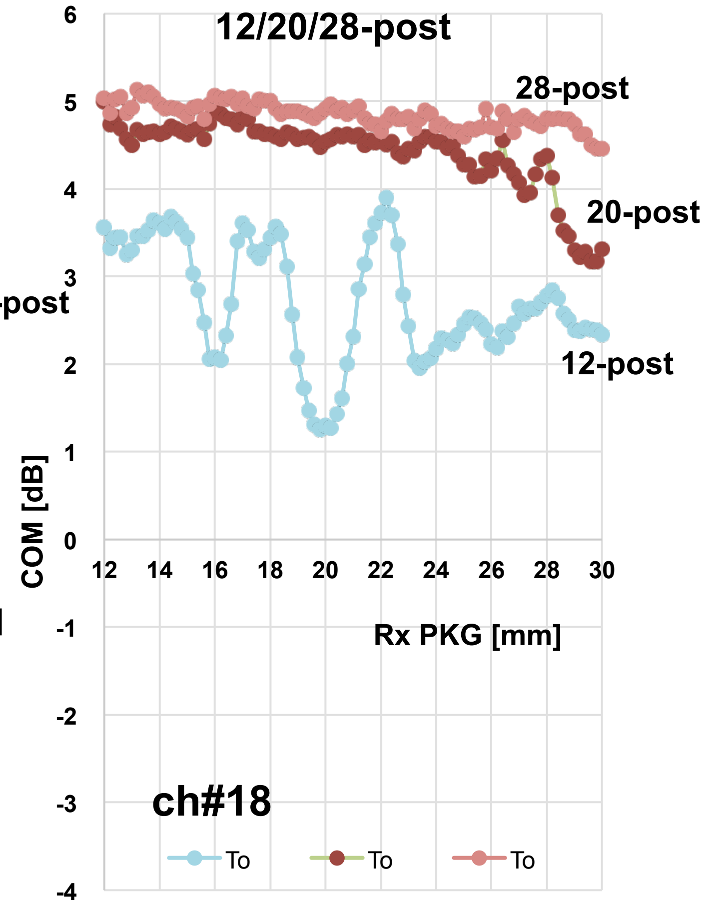
6.1 Rx-PKG trace length vs COM (Tx PKG 20mm)



fb=58Gbd, Cp=110fF, Cd=130fF, Rx FFE 3-pre, COM 2.51

6.2 Rx-PKG trace length vs COM (Tx PKG 20mm)





fb=58Gbd, Cp=110fF, CD=130fF, Rx FFE 3-pre, COM 2.51

7. Conclusion

1. Several contributions including this show “DFE-based” reference receiver model has comparable performance compared with “FFE-based” model.

- However, some results show “DFE” performance and “FFE” performance differ more than 1dB, depending on conditions and channels.
- Using no Rx FFE pre-taps degrades COM in 0.55~0.96dB* due to coarse Tx FFE pre-tap resolution (step). However in actual silicon implementation including Tx FFE-rich design with no Rx FFE, fine resolution Tx FFE pre-taps will be used, I think.
    - So, for COM reference receiver model, using Rx FFE pre-tap (probably 3-taps, no-post) and coarse Tx FFE pre-tap resolution (because of simulation time) will be acceptable
        - Rx-FFE step tuning is necessary considering real circuit implementation.
- Rx (Tx) reference equalizer option
    - Option-1 : coarse Tx-FFE tap step + Rx FFE 0-pre/0-post + DFE n-taps + COM “0.5~1dB margin”
    - Option-2 : coarse Tx-FFE tap step + Rx FFE 3-pre/0-post + DFE n-taps

- It is necessary to verify further with more channels, tap conditions (Rx or Tx FFE pre/post-tap, tap resolution) and other parameters (like PKG trace combination) to refine COM reference receiver configuration and parameters.

* http://www.ieee802.org/3/ck/public/adhoc/oct24_18/hidaka_3ck_adhoc_01_102418.pdf

7. Conclusion (continues)

2. COM PKG impedance combination (Tx_PKG and Rx_PKG) affects up to 0.4dB.
   - Is it necessary to run the PKG impedance combinations?

3. COM PKG Tx and Rx trace combination affects COM values.
   - How should this be handled?
   - Run various combinations?

A. references

Mellitz
[1] http://www.ieee802.org/3/100GEL/public/adhoc/jan03_18/mellitz_100GEL_adhoc_01_010318.pdf
[2] http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_03_010318.zip
[3] http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_02_010318.zip
[4] http://www.ieee802.org/3/100GEL/public/tools/backplane/mellitz_100GEL_adhoc_04_010318.zip
[5] http://www.ieee802.org/3/ck/public/adhoc/aug15_18/mellitz_3ck_adhoc_02_081518.pdf
[6] http://www.ieee802.org/3/ck/public/tools/backplane/mellitz_3ck_adhoc_02_081518_cabledbackplane.zip
[7] http://www.ieee802.org/3/ck/public/adhoc/july25_18/mellitz_3ck_adhoc_02_072518.pdf
[8] http://www.ieee802.org/3/ck/public/tools/backplane/mellitz_3ck_adhoc_02_072518_channels.zip
[9] http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_01a_0517.pdf
[10] http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_03_0517.zip

Zambell
[11] http://www.ieee802.org/3/100GEL/public/18_03/zambell_100GEL_01a_0318.pdf
[12] http://www.ieee802.org/3/100GEL/public/tools/backplane/zambell_100GEL_02_0318.zip

Heck
[13] http://www.ieee802.org/3/100GEL/public/18_01/heck_100GEL_01_0118.pdf
[14] http://www.ieee802.org/3/100GEL/public/tools/backplane/heck_100GEL_85ohm_hlh_01_011718.zip
[15] http://www.ieee802.org/3/100GEL/public/tools/backplane/heck_100GEL_85ohm_lhl_01_011718.zip
[16] http://www.ieee802.org/3/100GEL/public/tools/backplane/heck_100GEL_85ohm_nom_01_011718.zip

Tracy
[17] http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_03_0118.pdf
[18] http://www.ieee802.org/3/100GEL/public/tools/backplane/tracy_100GEL_05_0118.zip
[19] http://www.ieee802.org/3/100GEL/public/tools/backplane/tracy_100GEL_04_0118.zip

Thank you!

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