

Technical Feasibility of 100Gb/s per lane SerDes for Backplanes (update)

IEEE802.3 100GEL Study Group

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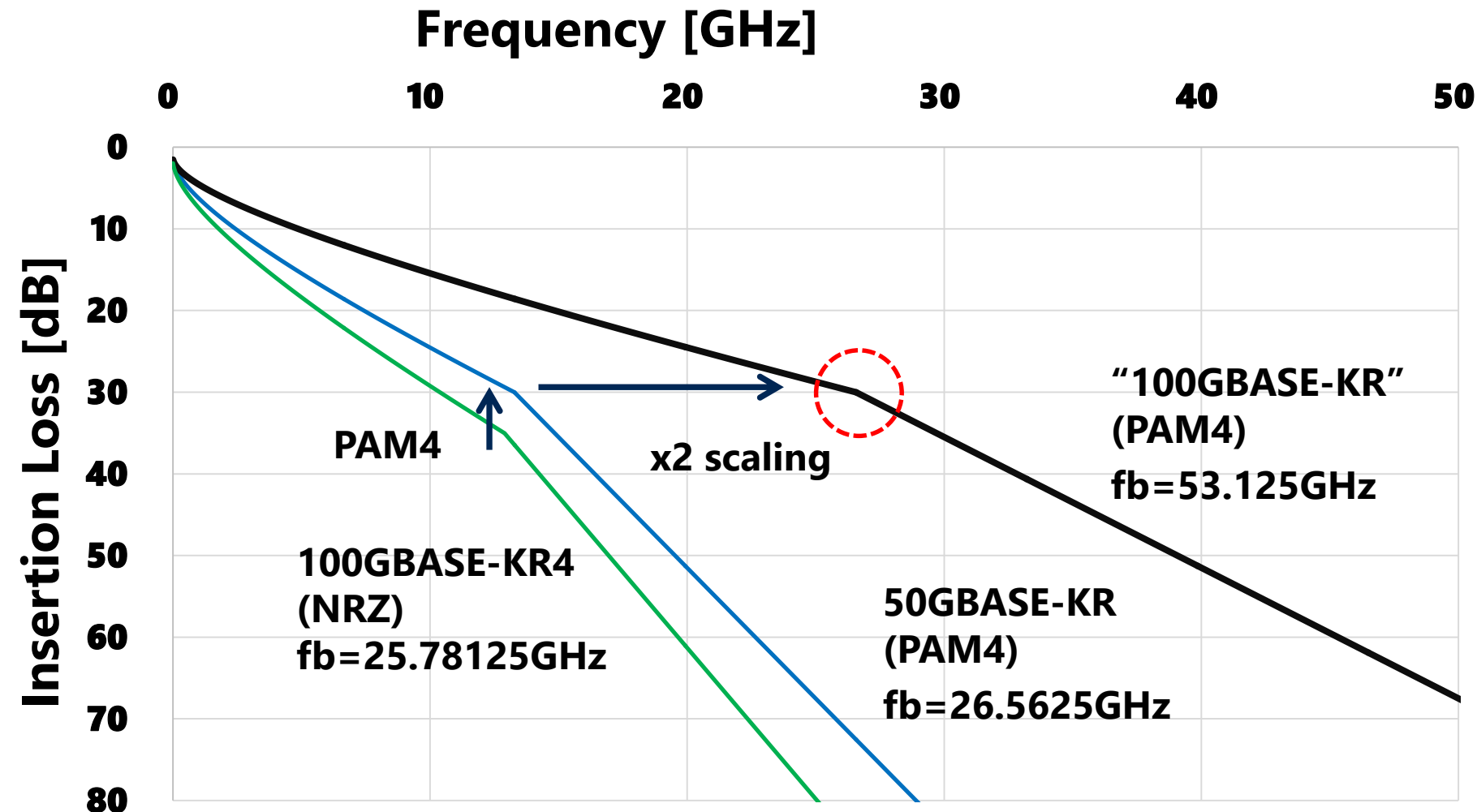
1. Overview

- **Feasibility of 100Gb/s per lane electrical backplane transmission by channel simulation for “TBD” dB and “TBD” GHz numbers in objectives.**

- **COM PKG model feasibility are studied.**
 - **Cp and Rx FFE post-tap number are swept.**
 - **Cp value between COM PKG and real PKG.**

- **Some device parameters are studied.**
 - **Cd value**
 - **CTLE bandwidth, device noise**
 - **LF-CTLE pole and zero**
 - **Rx FFE pre-tap, post-tap**

1.1 channel insertion loss target

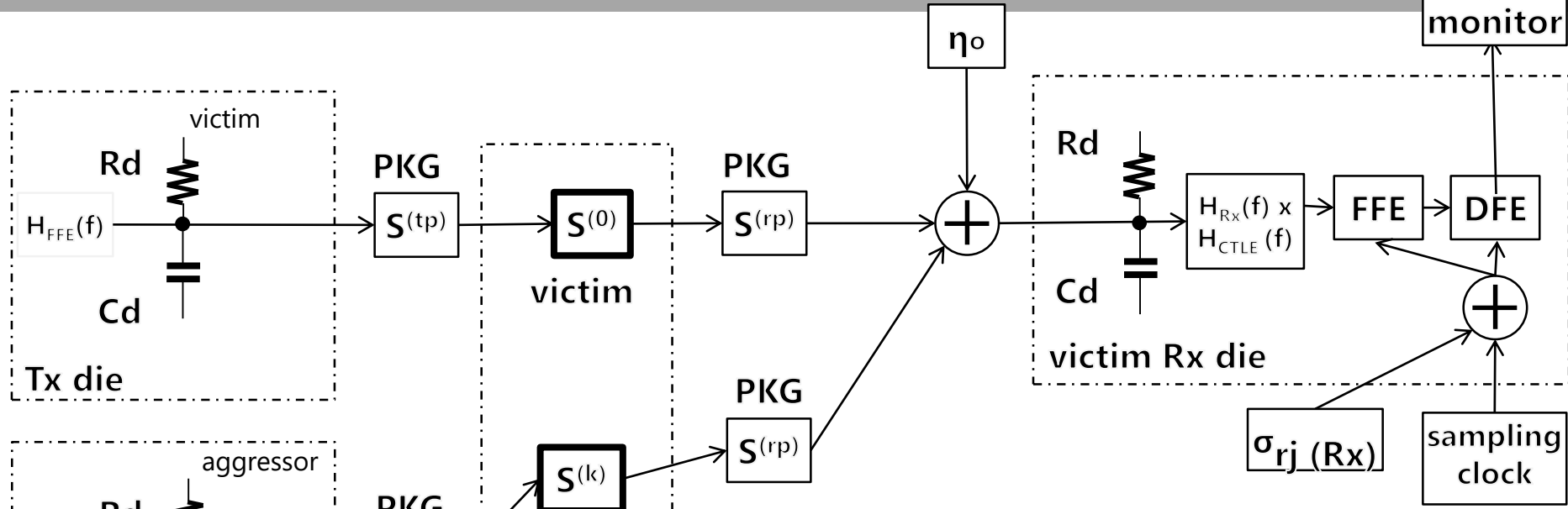


If PAM4 modulation is selected, 30dB (ball-to-ball) insertion loss at Nyquist frequency (26.5625GHz) is an appropriate target.
=> Studied if this is appropriate.

2. Channel simulation

2.1 Simulation Conditions

2.1.1 Simulation Model



✓ The simulation configuration is the same as previous presentation.
http://www.ieee802.org/3/100GEL/public/18_01/sakai_100GEL_01b_0118.pdf

symbol	description
A_v, A_{fe}, A_{ne}	Tx output amplitude : victim, FEXT, NEXT
R_d	single ended termination resistor
C_d	single ended device capacitance
$H_{FFE}(f)$	Tx FFE transfer function
$S^{(tp)}, S^{(rp)}$	PKG model Tx/Rx, Also COM model is used.
$S^{(0)}, S^{(k)}$	channel under test, 2m(B) cabled BP model
$H_{Rx}(f)$	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
σ_{rj}	random jitter, RMS Tx : before FFE, Rx : considered as eye margin

2.1.2 Simulation Set Up

- ✓ Static Channel Model Simulation
- ✓ Behavior model using MatLab
- ✓ PAM4 at 58.0Gbd to see margin and other applications. (conservative)
- ✓ Jitter, noise and crosstalk are considered.
- ✓ Tx jitter, (DJ, RJ) included : Basically RJ is the same as 50G-PAM4 (conservative).
- ✓ Rx/CDR jitter (DJ, RJ) are considered as eye opening margin. (EW4, EH4)
- ✓ crosstalk noise in channel S-parameter
- ✓ Device noise (η_0) is swept.
- ✓ Device capacitance (Cd) is swept
- ✓ Impedance are nominal : 50-ohm single ended
- ✓ T-spaced FFE
 - ✓ Rx FFE parameters are set to minimize ISI.
 - ✓ Rx FFE pre/post-tap are swept
- ✓ CTLE coefficients are optimized for each channel. (See backup slides "C".)
- ✓ PKG model is based on current design (27mm) and a COM PKG model (30mm) for 50G-KR.
 - ✓ Cp is swept.

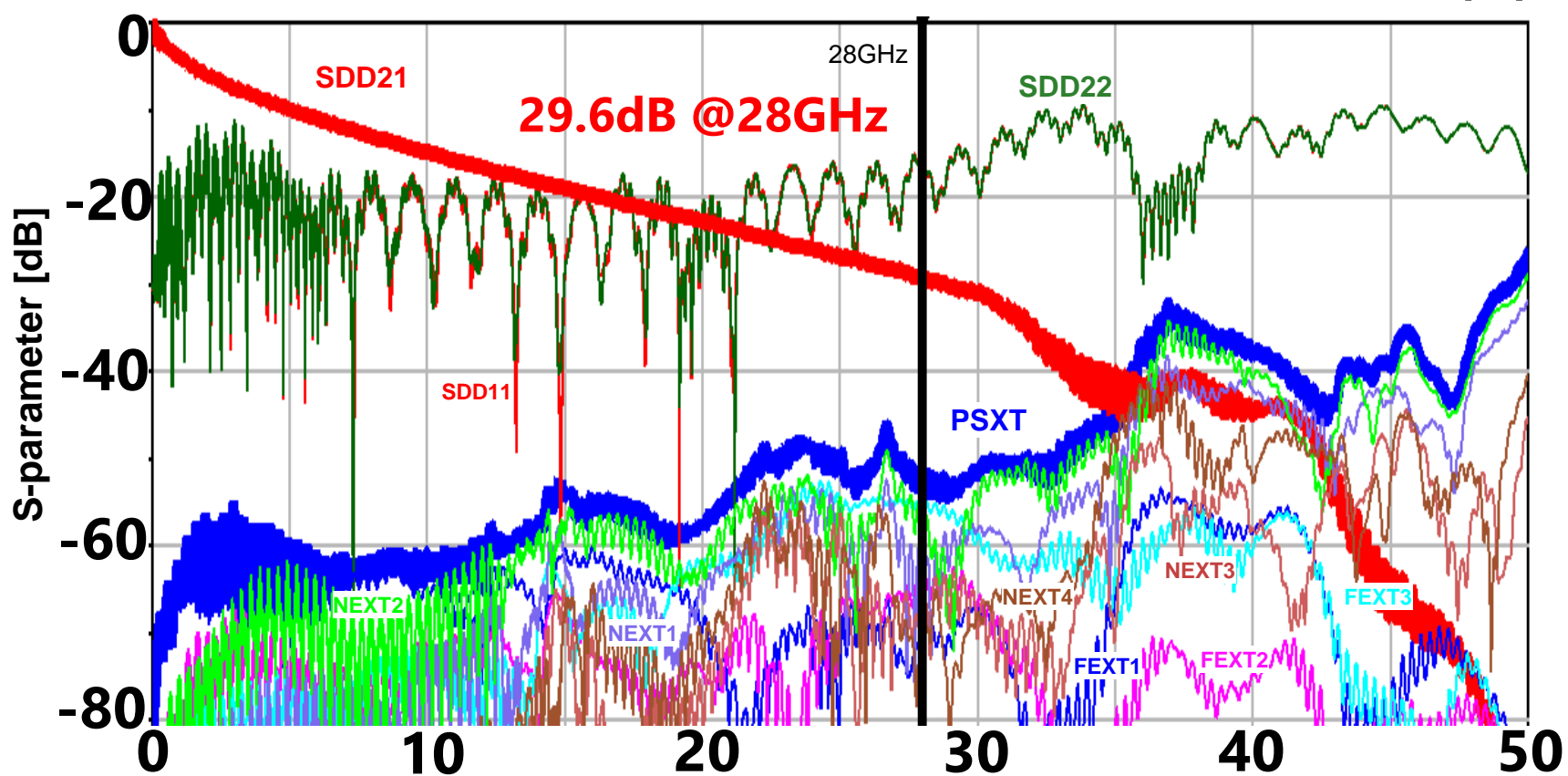
item	value	sweep	unit
pattern	PRBS13Q		
DJ_Tx	60		mUI
RJ_Tx	10		mUI
EOJ_Tx	0		UI
SNR_Tx	32.5		dB
Rt_Tx	50		ohm
Cd_Tx/Rx	160	100	fF
Cp Tx/Rx	110	60/30/0	fF
Rx FFE	54/5	post : 106/5 54/5 32/5 24/5 18/5 pre : 33/6 32/5 31/4 30/3 29/2 28/1 27/0	tap/pre
Rx fr	3/8 fb	3/4 fb	
Av	0.8		Vppd
AVx	1.2		Vppd
BER	1.0E-4		
η_0 eta0	1.64E-08	8.2E-09 2.3E-09	V ² /GHz
DJ_Rx	0		UI
Rt_Rx	50		ohm

2. Channel simulation

2.2 Channel for Simulation

2.2.1 Channel Characteristics (cabled backplane)

channel : 2m (B)

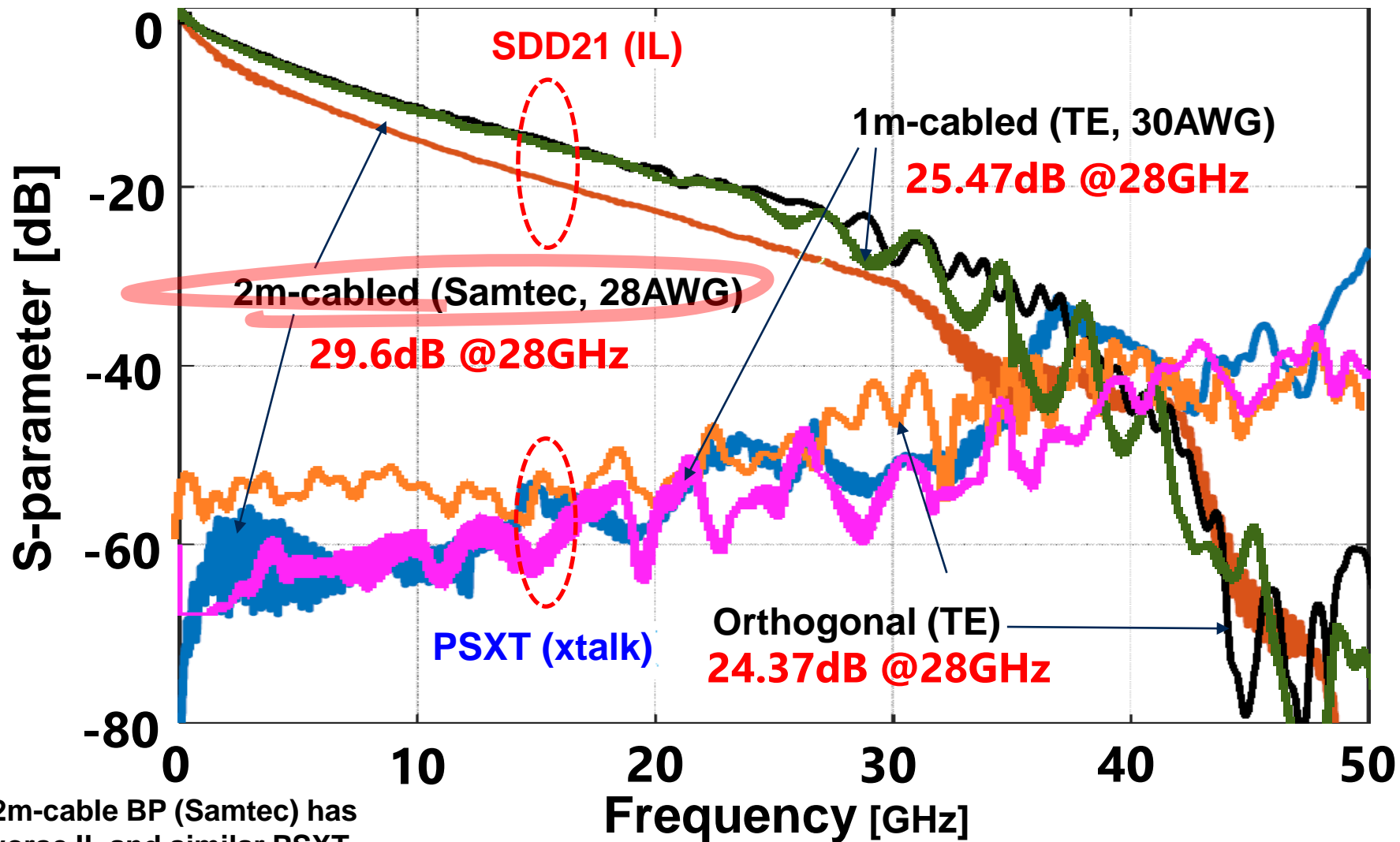


2m (B)
 at f = 28GHz
 SDD21= **-29.6dB**
 SDD22= -15.2dB
 SDD11= -15.1dB
 PSXT = -53.8dB
 FEXT1 = -69.2dB
 FEXT2 = -65.4dB
 FEXT3 = -56.0dB
 NEXT1 = -75.3dB
 NEXT2 = -59.6dB
 NEXT3 = -71.2dB
 NEXT4 = -75.9dB

300mm 34AWG
 2000mm 28AWG
 300mm 34AWG

✓ The channel is the same as cabled BP in previous presentation.
http://www.ieee802.org/3/100GEL/public/18_01/sakai_100GEL_01b_0118.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_03_0517.zip

2.2.1 Channel Characteristics



2m-cable BP (Samtec) has worse IL and similar PSXT compared to Orthogonal BP (TE) or 1m-cabled BP (TE).

http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_03_0118.pdf
http://www.ieee802.org/3/ad_hoc/ngrates/public/17_05/mellitz_nea_01a_0517.pdf

2.2.2 PKG Characteristics

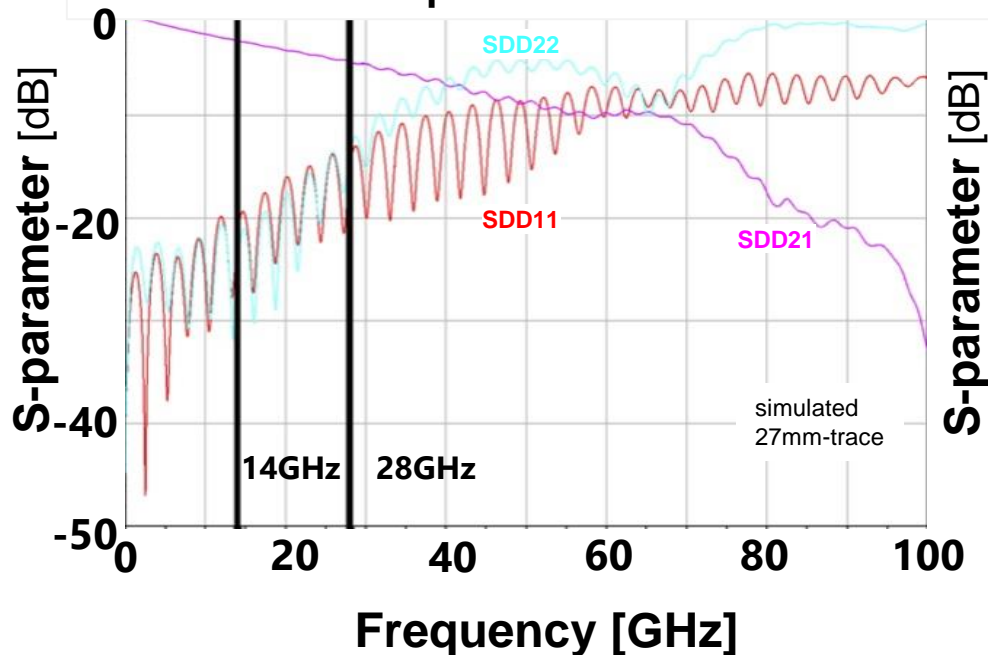
Simulated PKG model and “COM” PKG model are used.

27mm PKG (FCBGA, actual design)

SDD21: -4.81dB @28GHz, -4.95dB @29GHz

SDD22: -13.9dB @28GHz

- This was used in previous simulation.

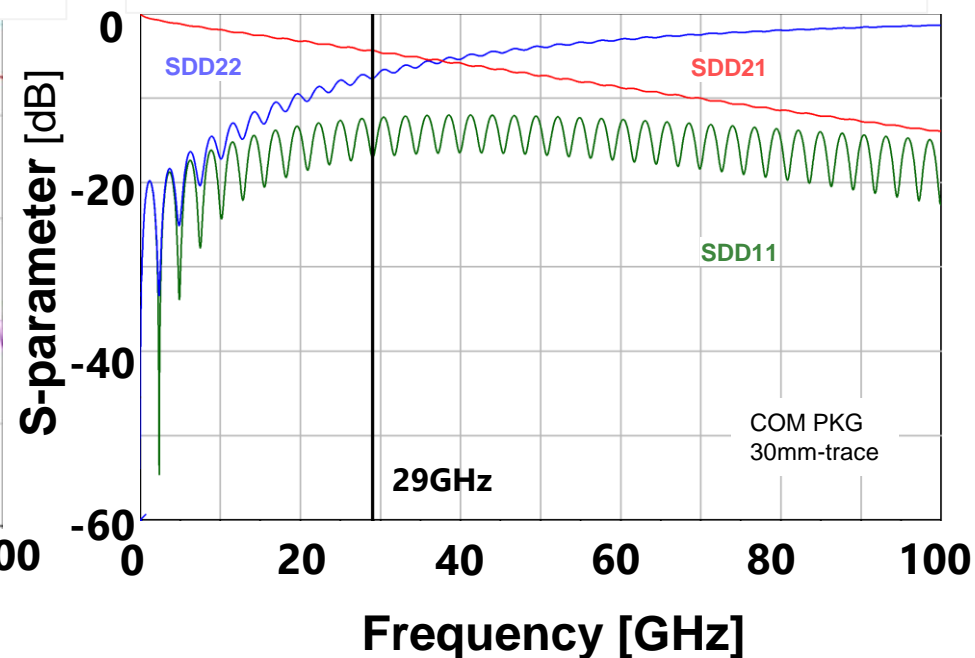


COM-30mm PKG ($C_p=110\text{fF}$)

SDD21: -4.35dB @29GHz

SDD22: -7.70dB @29GHz

- COM PKG is also used this time.



note : No xtalk is considered in PKG model.

- C_d is not included, since it is a device capacitance.

- COM PKG ($C_p=110\text{fF}$) has worse SDD22 than actual designed PKG.

2. Channel simulation

2.3 Simulation Results

- 2.3.1 Rx FFE post-taps, COM PKG Cp
 - 2.3.1.1 COM PKG Cp
- 2.3.2 Rx FFE post-taps
- 2.3.3 Rx FFE pre-taps
- 2.3.4
 - 2.3.4.1 LF-CTLE pole/zero
 - 2.3.4.2 Cd
 - 2.3.4.3 CTLE parameters, f_r , η_{a0} , pole/zero frequency

2.3.1 Rx FFE post-taps, COM PKG Cp (1/2)

- Rx FFE post-taps, PKG Cp (COM PKG, 30mm)

item		unit	#41	#42	#43	#44	#48	#49	#50	#51	#52	#53	#54	#55	#56	#57	#58	#59	
baud rate		Gbd	58																
channel	type	cabled BP	2m(B)																
	IL	no PKG	30.5																
		w/ PKG	dB	39.2				38.1				37.7				37.6			
Tx	FFE	tap/pre	1/0																
	RJrms	mUI	10																
	SNR	dB	32.5																
Tx/Rx	PKG	trace	30 (COM PKG)																
	Cd	fF	160																
	Cp	fF	110				60				30				0				
Rx	CTLE	HF/LF	2p-1z/1p-1z																
	eta0	V ² /GHz	1.64E-8																
	fr	x fb	GHz	3/8															
	FFE	tap/pre	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	
	DFE	tap		1															
	RJrms	mUI		10															
eye	width EW4	upp	mUI	93	82	14	14	98	94	69	69	100	98	90	89	100	99	99	98
		mid	126	113	21	20	134	128	95	95	137	134	123	123	140	138	137	137	
		low	93	79	3	3	98	93	67	67	101	98	90	89	101	100	99	99	
	height EH4	upp	mV	38	32	4	4	40	39	27	27	41	42	37	37	41	43	42	42
		mid	40	33	3	3	43	41	26	26	44	44	38	38	44	45	45	44	
		low	38	32	1	1	40	39	26	25	41	42	37	36	41	43	42	42	

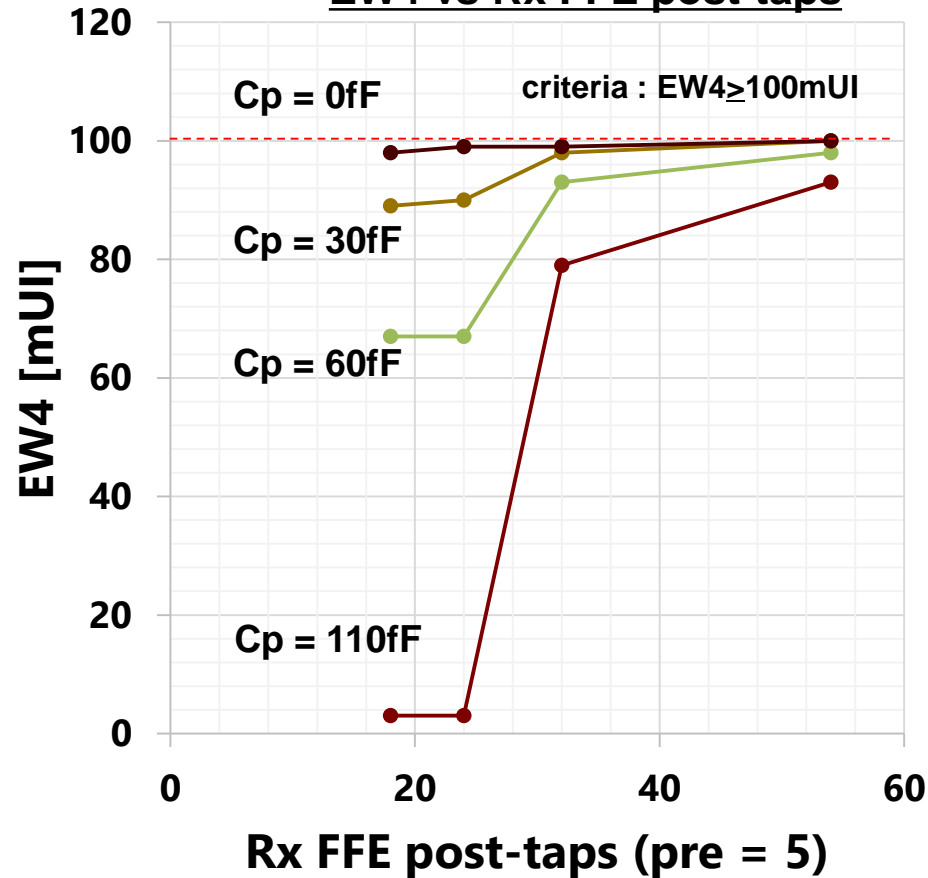
13

criteria : EW4 \geq 100mUI, EH4 \geq 20mV

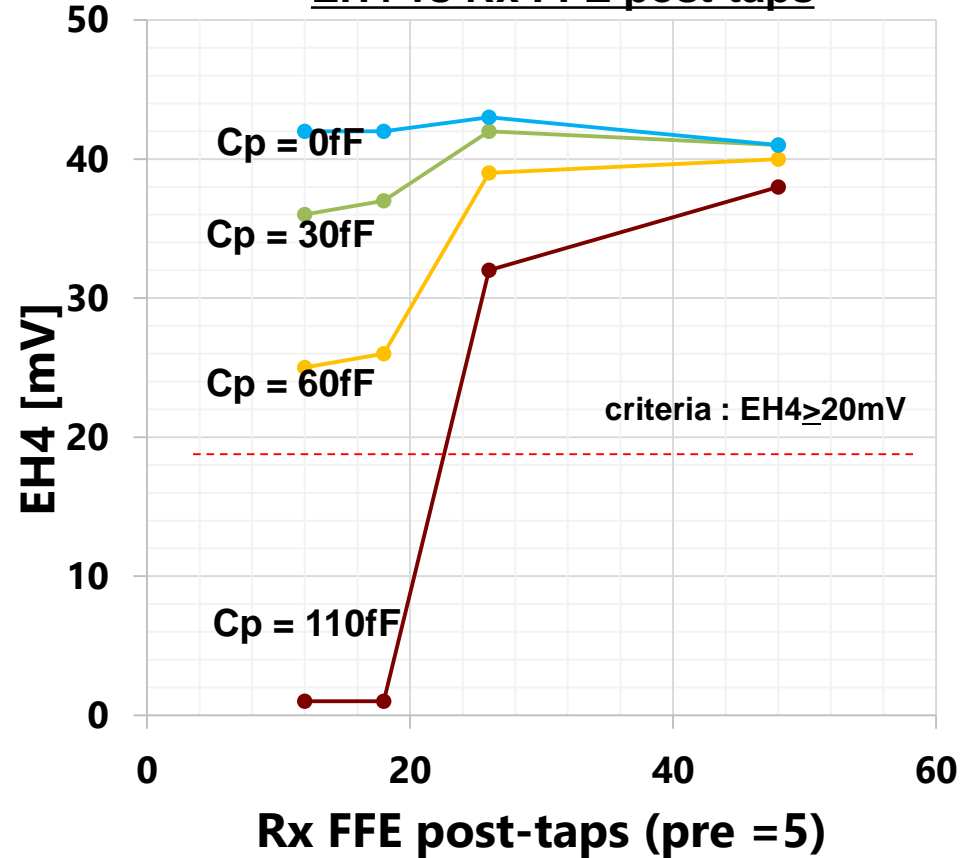
- PKG IL (Tx + Rx, @58Gbd=29GHz) : 9.6dB(27mm), 8.7dB(30mm,COM, Cp=110fF)

2.3.1 Rx FFE post-taps, COM PKG Cp (2/2)

EW4 vs Rx FFE post-taps



EH4 vs Rx FFE post-taps



- COM-PKG 30mm
- Cd = 160fF
- DFE : 1-tap
- Tx-FFE : 1-tap
- 58Gbd

✓ Reduction of Cp helps eye opening, especially fewer Rx FFE tap cases.
 - This is due to smaller reflection between bump-ball and/or ball-connector. (See next page)

2.3.1.1 COM PKG Cp (summary)

- Rx FFE post-taps , PKG Cp (COM) / S-param

item		unit	#48	#49	#50	#51	#10	#16	#60	#61	#52	#53	#54	#55
baud rate		Gbd	58											
channel	type	cabled BP	2m(B)											
	IL	no PKG	30.5											
		w/ PKG	dB	38.1				40.4				37.7		
Tx	FFE	tap/pre	1/0											
	RJrms		mUI											
	SNR		dB											
Tx/Rx	PKG	trace	30 (COM PKG)				27				30 (COM PKG)			
	Cd		fF											
	Cp		60				no Cp (S-param)				30			
Rx	CTLE	HF/LF	2p-1z/1p-1z											
	eta0		V ² /GHz											
	fr	x fb	GHz											
	FFE	tap/pre	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5
	DFE	tap	1											
	RJrms		mUI											
eye	width EW4	upp	98	94	69	69	93	92	80	79	100	98	90	89
		mid	134	128	95	95	131	128	115	114	137	134	123	123
		low	98	93	67	67	93	91	80	79	101	98	90	89
	height EH4	upp	40	39	27	27	38	38	33	32	41	42	37	37
		mid	43	41	26	26	40	41	35	35	44	44	38	38
		low	40	39	26	25	38	38	32	32	41	42	37	36

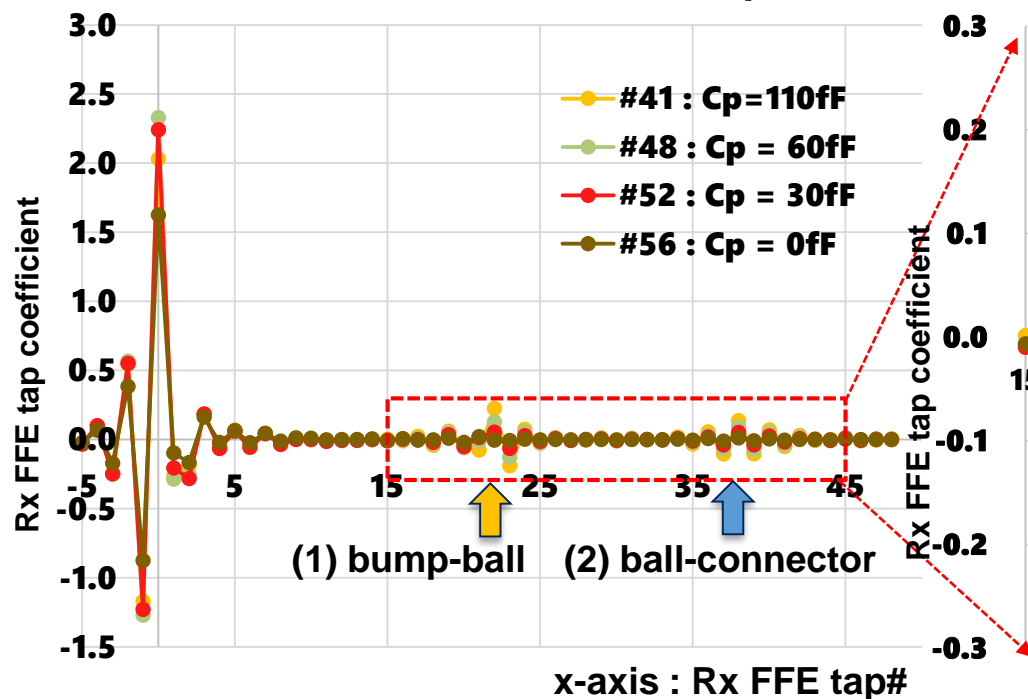
15

criteria : EW4 \geq 100mUI, EH4 \geq 20mV

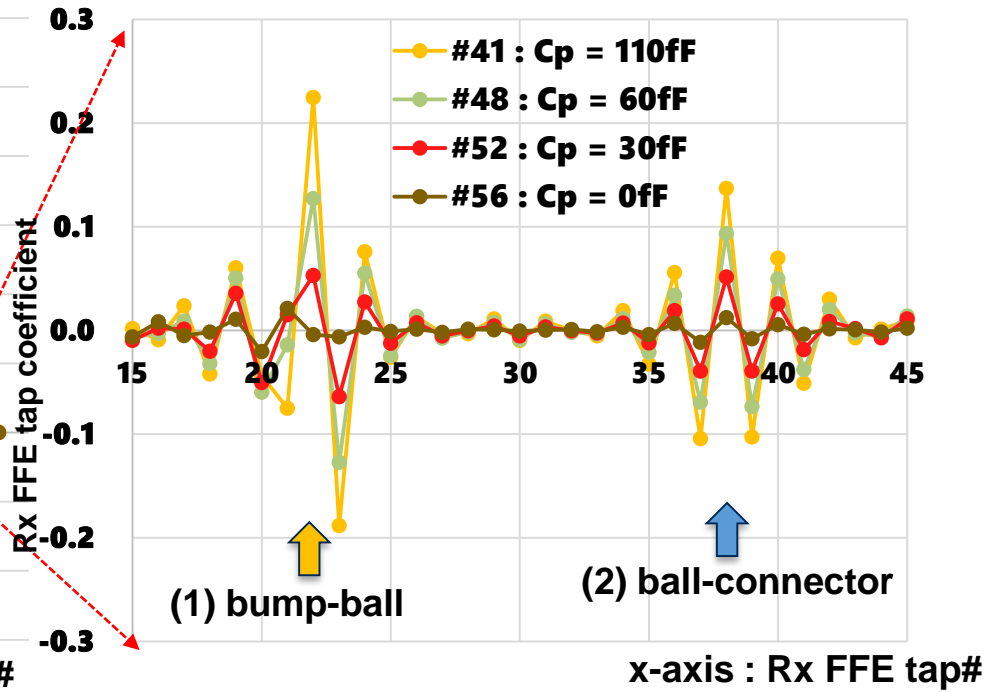
- PKG IL (Tx + Rx, @58Gbd=29GHz) : 9.6dB(27mm), 8.7dB(30mm,COM, Cp=110fF)

2.3.1.1 COM PKG Cp (Rx FFE tap coeff)

Rx FFE coefficient vs tap

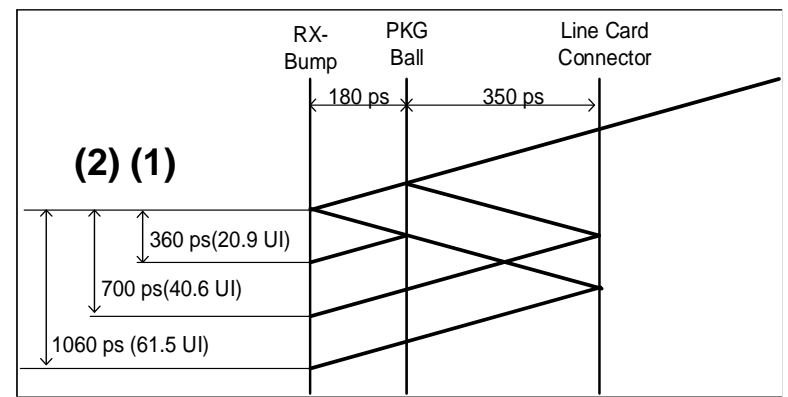


Rx FFE coefficient vs tap (zoomed)



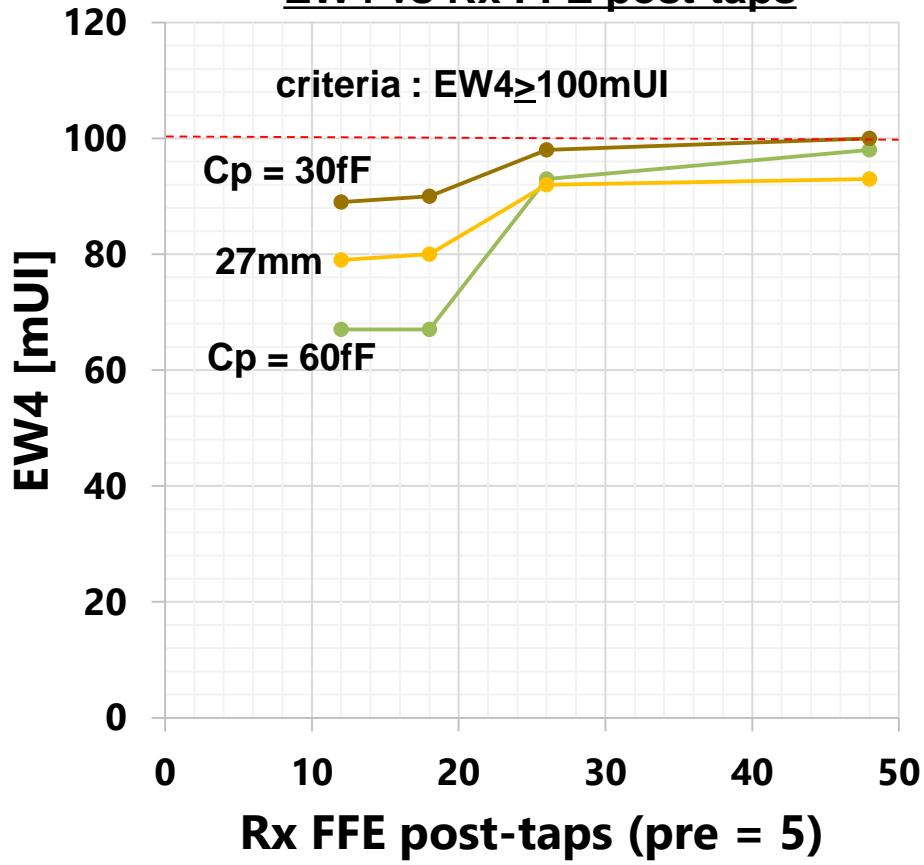
- COM-PKG 30mm
- Cd = 160fF
- Rx-DFE : 1-tap
- Rx- FFE : 54-taps
- Tx-FFE : 1-tap
- 58Gbd

- ✓ Reduction of Cp (PKG capacitance) leads smaller Rx FFE coefficient for tap-22 (bump-ball) and tap-38 (ball-connector).
- ✓ So, reduction of Cp will help to reduce number of Rx FFE taps and power.

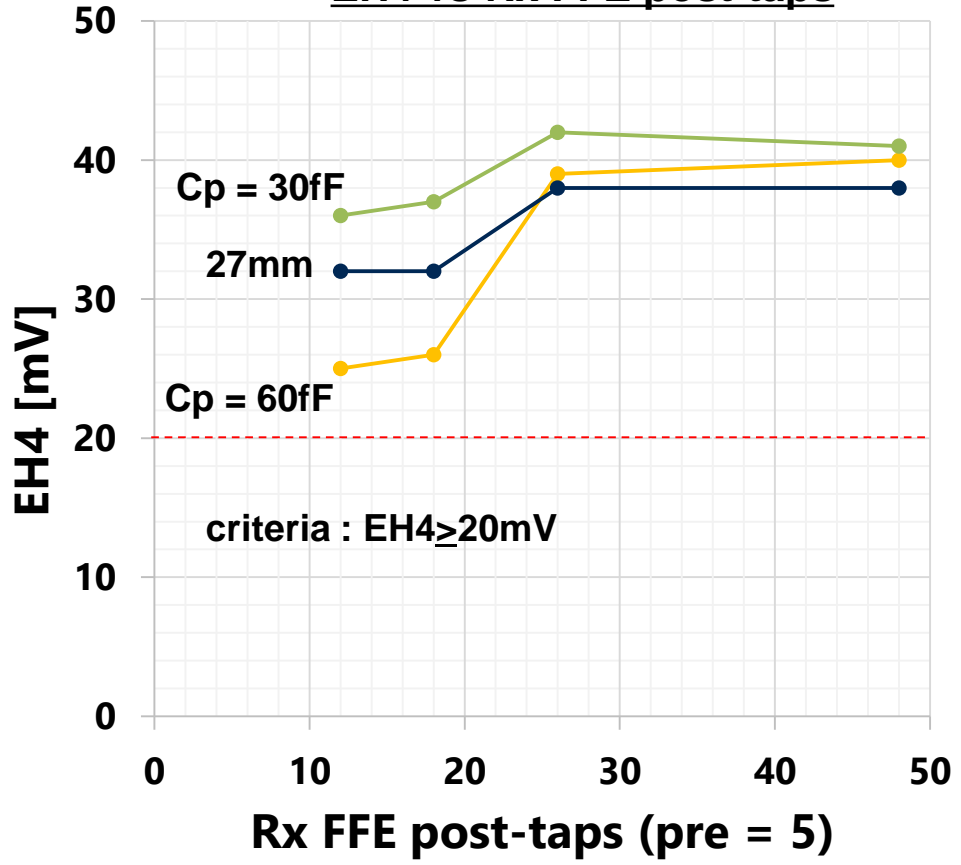


2.3.1.1 COM PKG Cp (compared to actual PKG)

EW4 vs Rx FFE post-taps



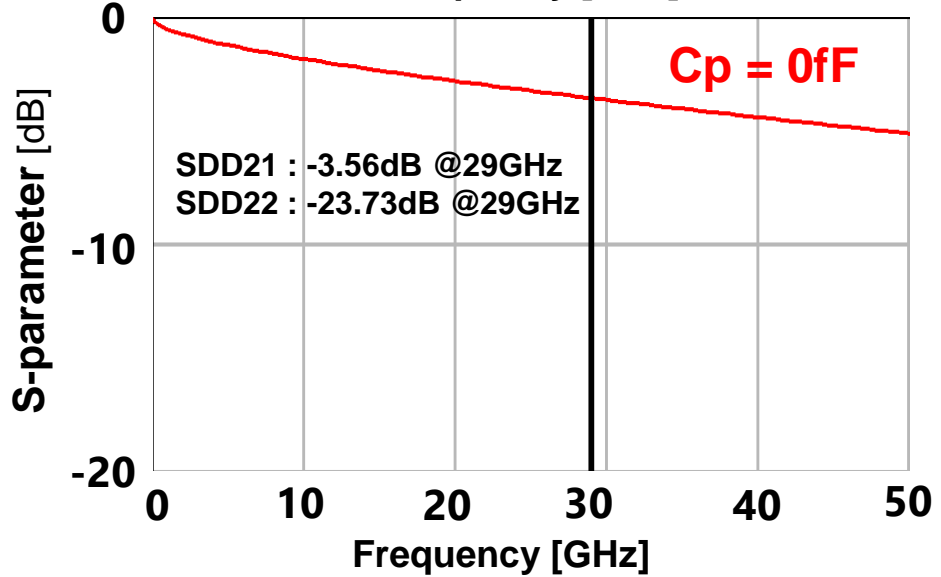
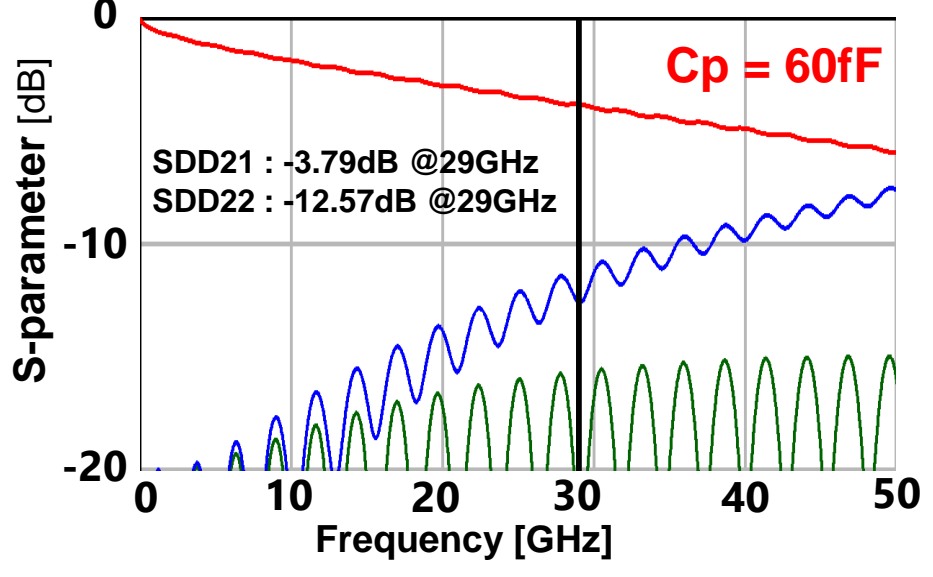
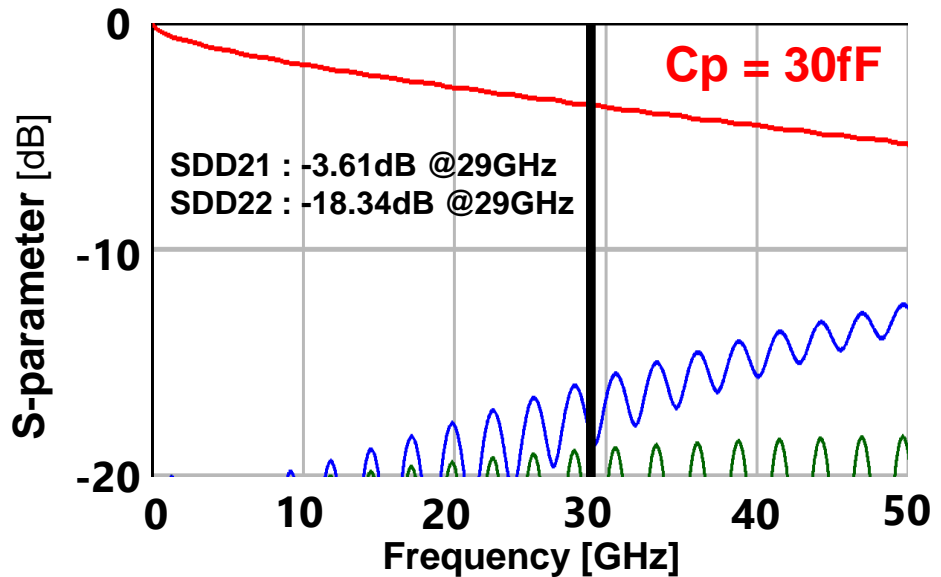
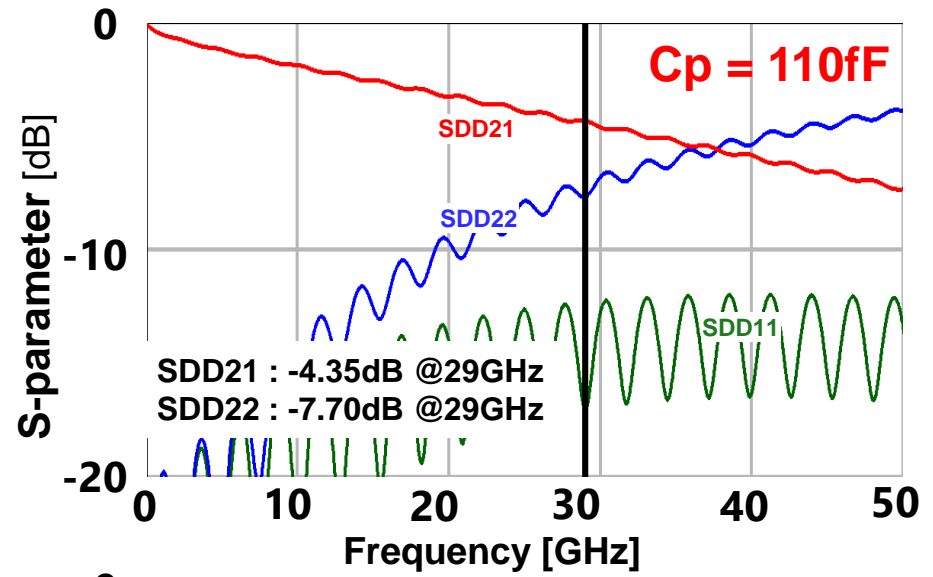
EH4 vs Rx FFE post-taps



- COM-PKG 30mm / actual PKG 27mm*(simulated)
- Cd = 160fF
- Rx DFE : 1-tap
- Tx-FFE : 1-tap
- 58Gbd

- ✓ Considering SDD22 and channel simulation results, Cp = 55fF (x1/2 of 50G COM) is a reasonable number.
- ✓ Rx FFE taps can be 24 (18-post) or 18 (12-post), considering better channel (lower IL, xtalk, RL) , better PKG (lower IL, Cp) and Cd reduction (device).
 - Fewer Rx FFE taps will help device power and area reduction.

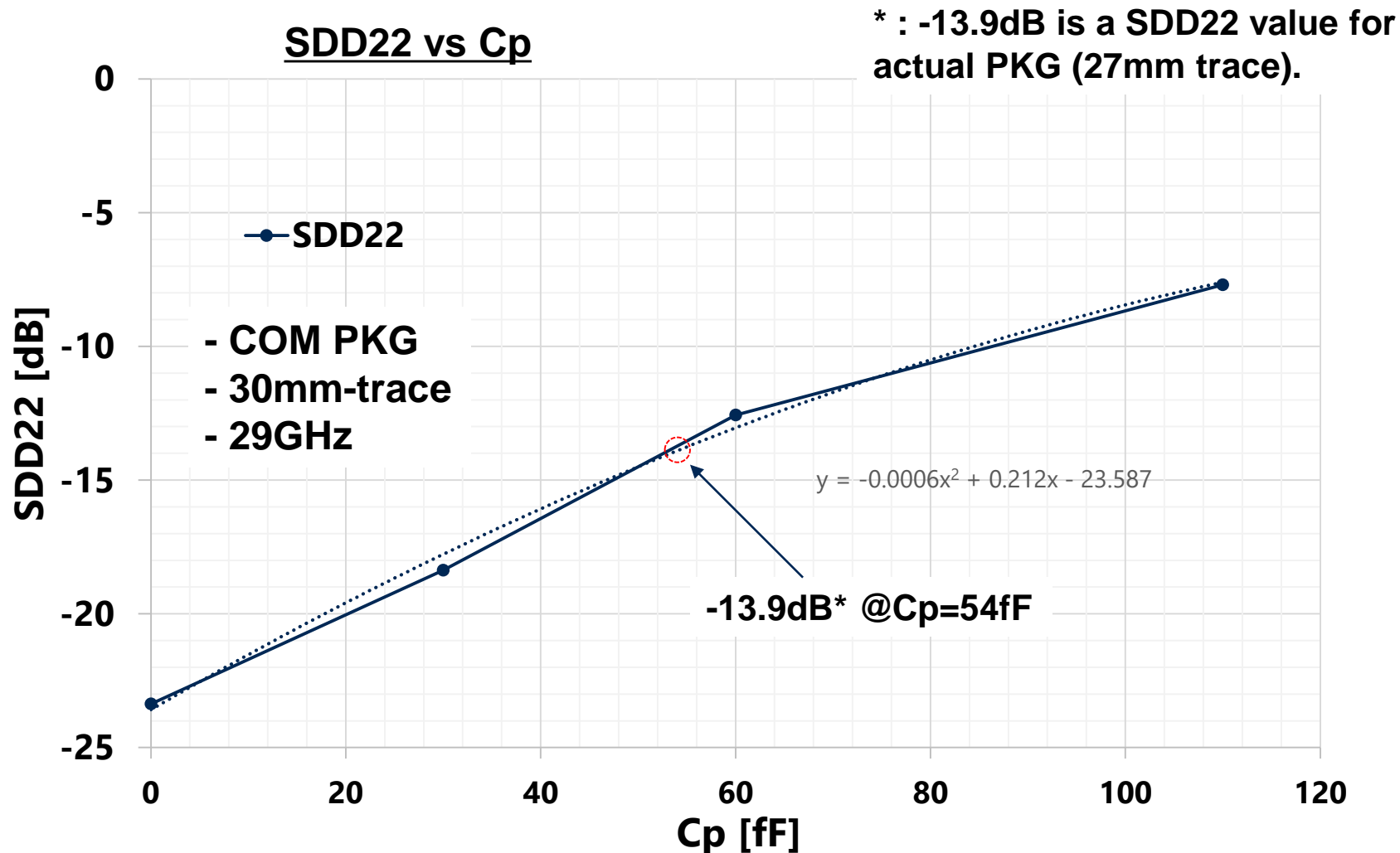
2.3.1.1 COM PKG Cp (SDD11/22)



note : No xtalk is considered in PKG model.
- Cd is not included, since it is a device capacitance.

COM PKG : 30mm-trace

2.3.1.1 COM PKG Cp (SDD22)



- COM Cp value (50G-KR) 110fF seems too large.
- Considering SDD22 and channel simulation results, Cp = 55fF (x1/2 of 50G COM) is a reasonable value.

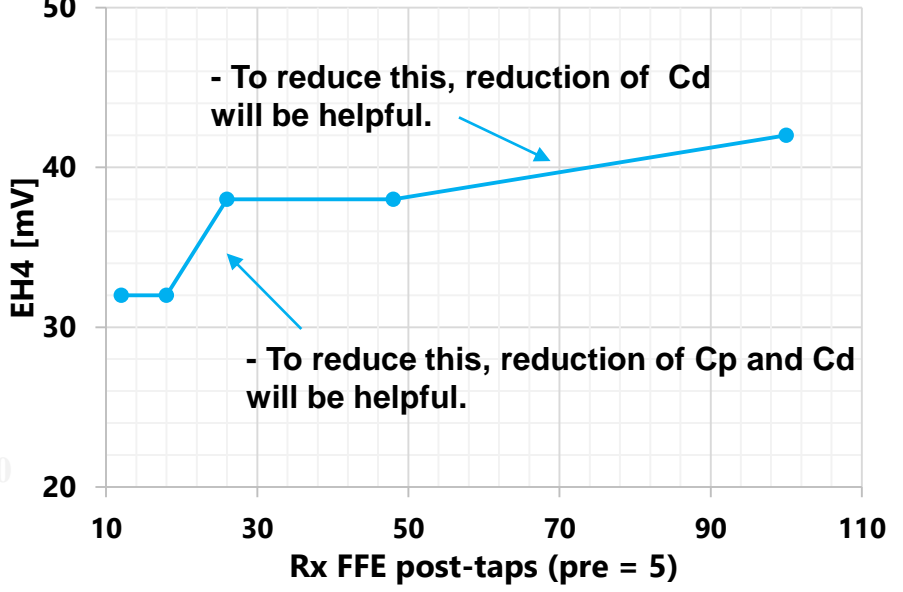
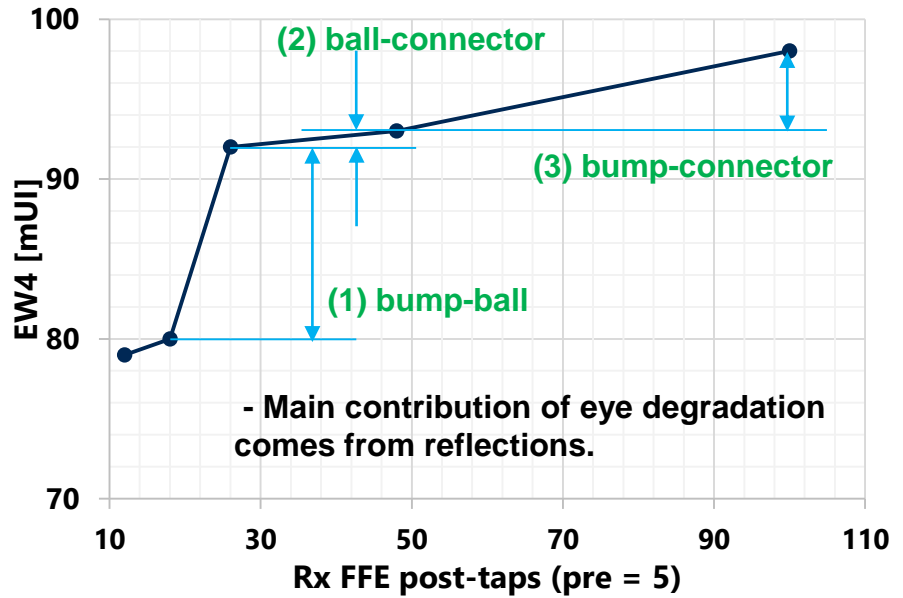
2.3.2 Rx FFE post-taps

- Rx FFE post-taps

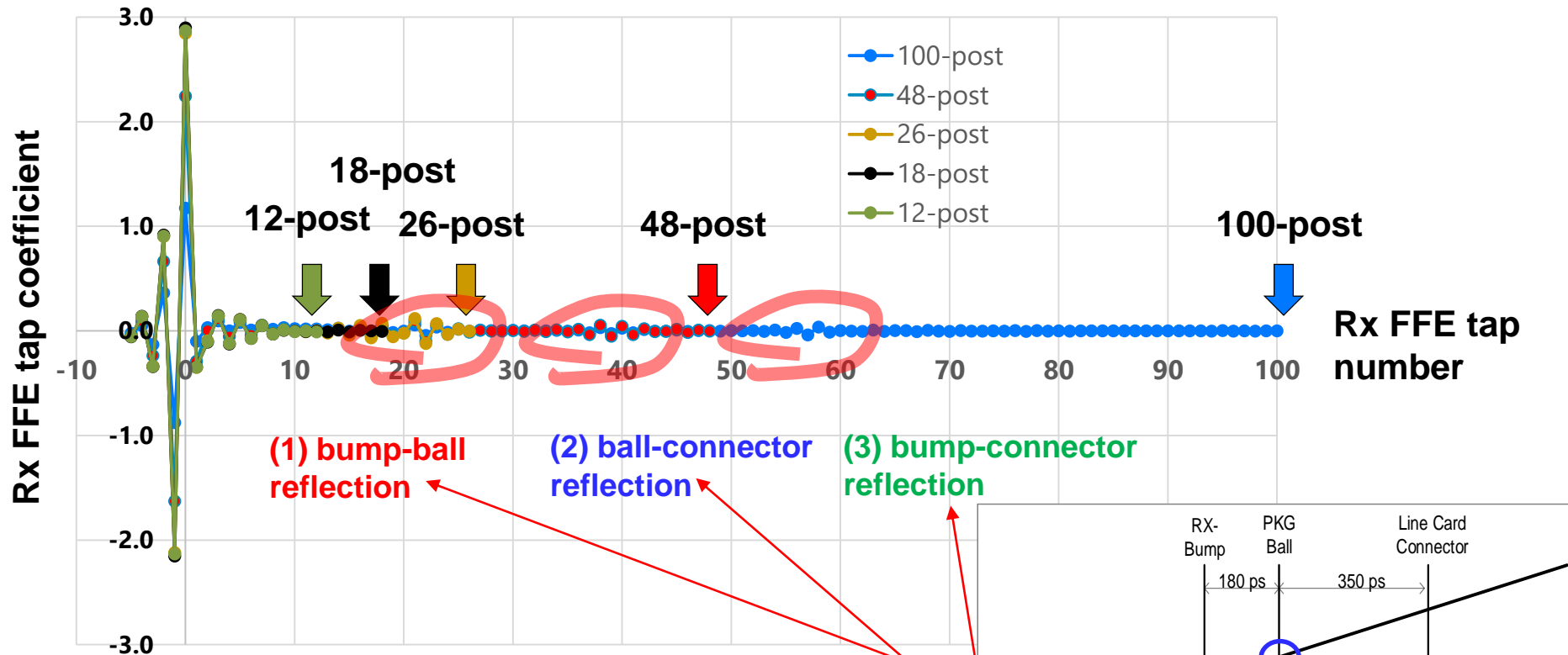
item		unit	#11	#10	#16	#60	#61
baud rate		Gbd	58				
channel	type	cabled BP	2m(B)				
	IL	no PKG	30.5				
		w/ PKG	40.4				
Tx	FFE	tap/pre	1/0				
	RJrms		10				
	SNR		32.5				
Tx/Rx	PKG	trace	27				
	Cd	fF	160				
	Cp	fF	no Cp (S-param)				
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	1.64E-8				
	fr	x fb	3/8				
	FFE	tap/pre	106/5	54/5	32/5	24/5	18/5
	DFE	tap	1				
	RJrms		10				
eye	width EW4	upp	98	93	92	80	79
		mid	137	131	128	115	114
		low	98	93	91	80	79
	height EH4	upp	42	38	38	33	32
		mid	45	40	41	35	35
		low	42	38	38	32	32

criteria : EW4 ≥ 100mUI, EH4 ≥ 20mV

Considering power and area, too many Rx FFE taps are not practical.

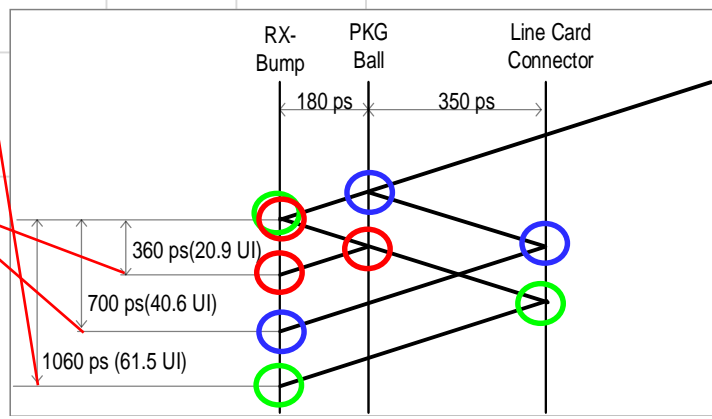


2.3.2 Rx FFE post-tap coefficient



post-taps	bump-ball	ball-conn	bump-conn
100	✓	✓	✓
48	✓	✓	✗
26	✓	✗	✗
18	✗	✗	✗
12	✗	✗	✗

✓ Rx FFE can compensate
✗ Rx FFE can NOT compensate



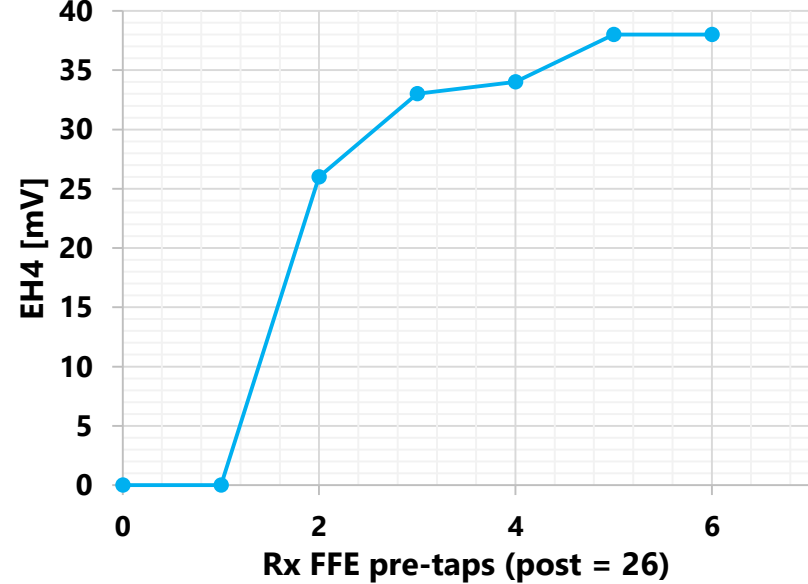
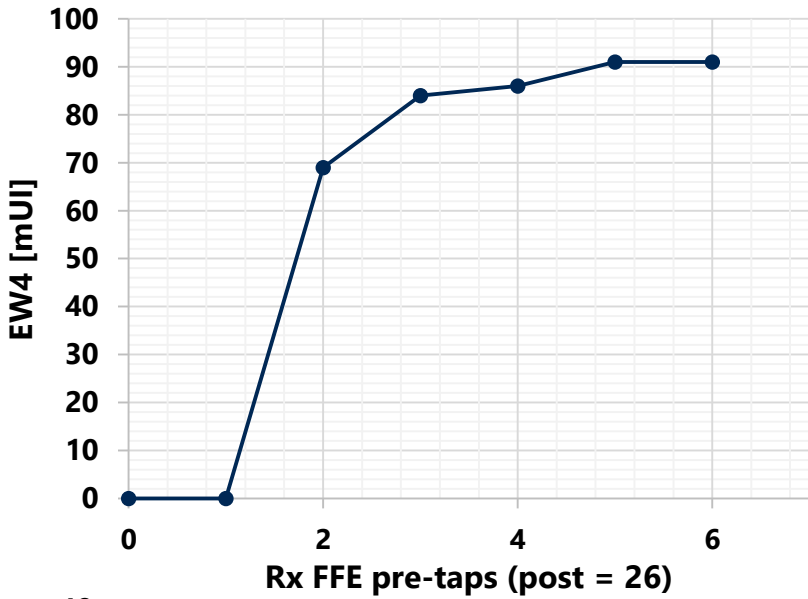
- If connector is located “further” in other channels, 48-post tap may not be enough.
- So, concentrate FFE compensation for “bump-ball” reflection is practical.
- Channel improvement is also helpful for reduction of ball/bump-connector reflection, together with device (ball/bump) improvement.

2.3.3 Rx FFE pre-taps

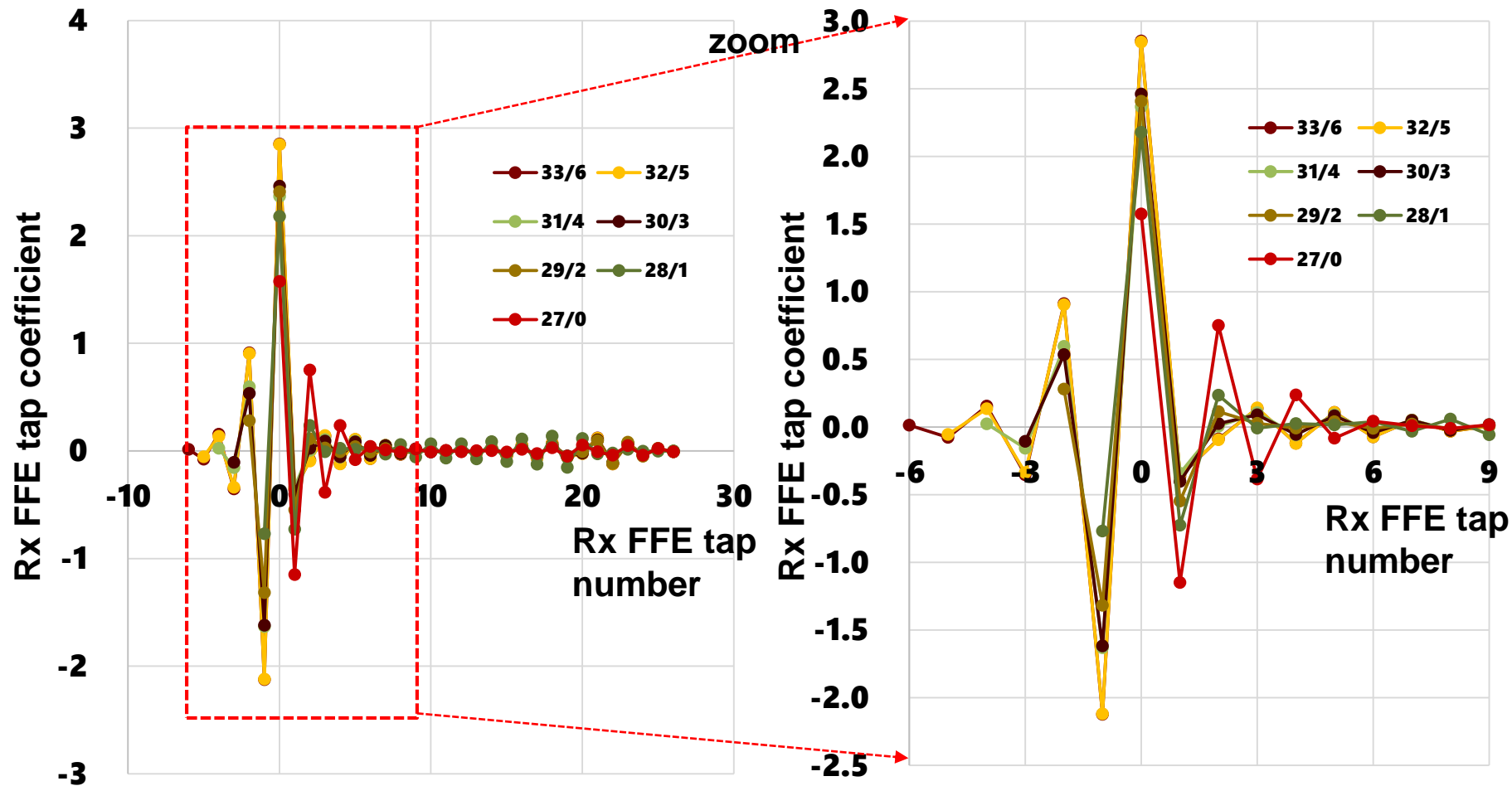
- Rx FFE pre-taps

item		unit	#18	#16	#19	#20	#21	#22	#23	
baud rate		Gbd	58							
chann el	type	cabled BP	2m(B)							
	IL	no PKG	30.5							
		w/ PKG	40.4							
Tx	FFE	tap/pre	1/0							
	RJrms		mUI							
	SNR	dB								
Tx/Rx	PKG	trace	mm							
	Cd		fF							
	Cp		no Cp (S-parameter)							
Rx	CTLE	HF/LF	2p-1z/1p-1z							
	eta0	V ² /GHz		1.64E-8						
	fr	x fb	GHz							
	FFE	tap/pre	33/6	32/5	31/4	30/3	29/2	28/1	27/0	
	DFE	tap	1							
	RJrms		mUI							
eye	width EW4	upp	92	92	87	85	69	0	0	
		mid	128	128	124	125	117	26	0	
		low	91	91	86	84	70	0	0	
	height EH4	upp	38	38	34	33	26	0	0	
		mid	41	41	37	36	29	2	0	
		low	38	38	34	33	26	0	0	

criteria : EW4 ≥ 100mUI, EH4 ≥ 20mV



2.3.3 Rx FFE pre-taps



- Increasing FFE pre-taps helps to improve eye opening.
- However, considering real Si implementation, too many taps will cause lots of issues, power, area and timings.

2.3.4 others (LF-pole/zero, Cd, Rx fr, eta0, CTLE)

- others

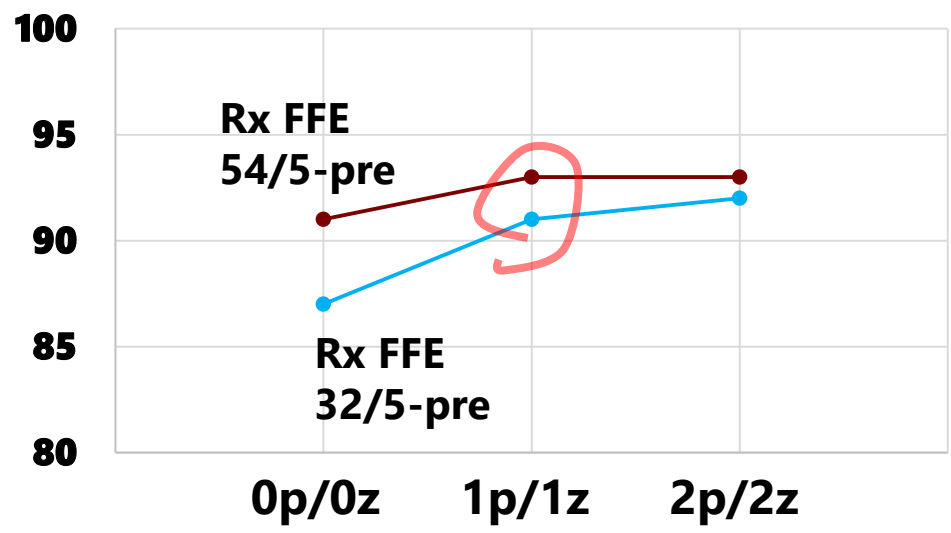
item		unit	#10	#41	#45	#46	#47	#13	#10	#14	#15	#16	#17	
baud rate		Gbd	58											
channel	type	cabled BP	2m(B)											
	IL	no PKG	30.5											
		w/ PKG	dB	40.4	39.2				40.4					
Tx	FFE	tap/pre	1/0											
	RJrms	mUI	10											
	SNR	dB	32.5											
Tx/Rx	PKG	trace	mm	27	30 (COM PKG)				27					
	Cd	fF	160	100	160									
	Cp	fF	---	110				--- : no Cp (S-param)						
Rx	CTLE	HF	2p1z											
		LF	1p-1z					2p2z	1p1z	0p0z	2p2z	1p1z	0p/0z	
	eta0	V ² /GHz	1.64E-8		8.2E-9	2.3E-9	1.64E-8							
	fr	x fb	GHz	3/8		3/4		3/8						
	FFE	tap/pre	54/5					54/5			32/5			
	DFE	tap	1											
	RJrms	mUI	10											
eye	width EW4	upp	mUI	93	93	102	66	100	93	93	91	92	92	87
		mid	mUI	131	126	138	99	135	132	131	128	129	128	121
		low	mUI	93	93	102	66	100	93	93	91	92	91	87
	height EH4	upp	mV	38	38	42	24	43	39	38	36	38	38	32
		mid	mV	40	40	45	26	45	42	40	38	41	41	34
		low	mV	38	38	42	24	43	39	38	35	38	38	32

criteria : EW4≥100mUI, EH4≥20mV

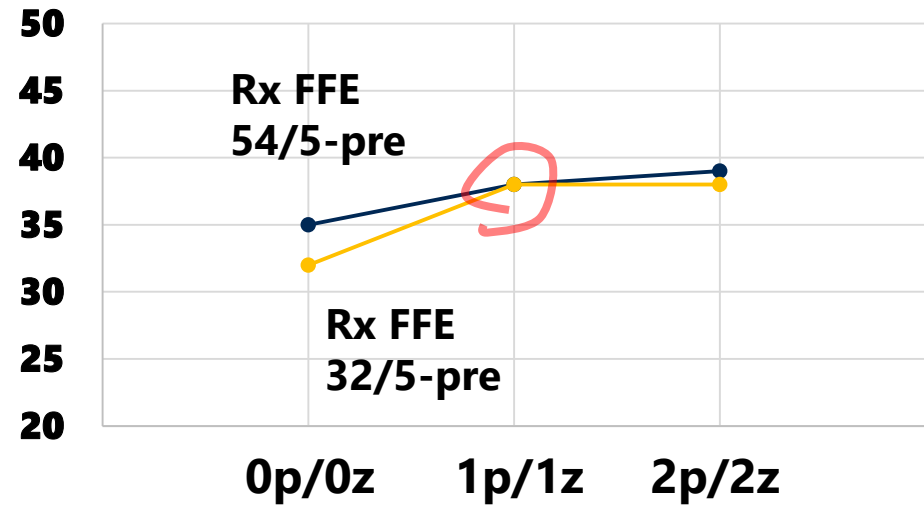
- PKG IL (Tx + Rx, @58Gbd=29GHz) : 9.6dB(27mm), 8.7dB(30mm,COM, Cp=110fF)

2.3.4.1 LF-CTLE pole and zero

EW4 [mUI]

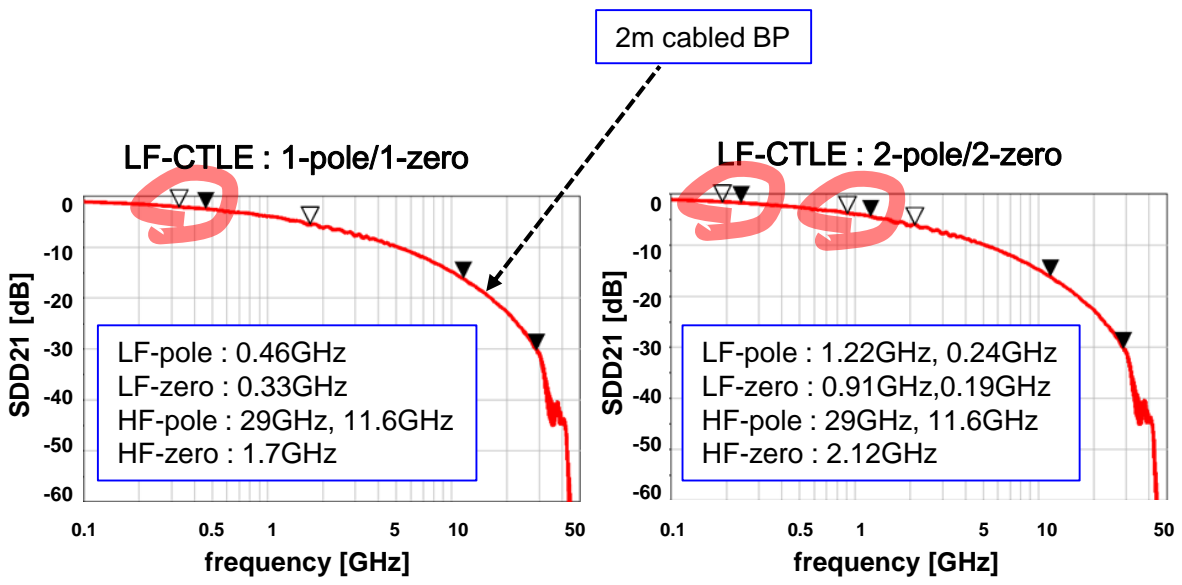


EH4 [mV]

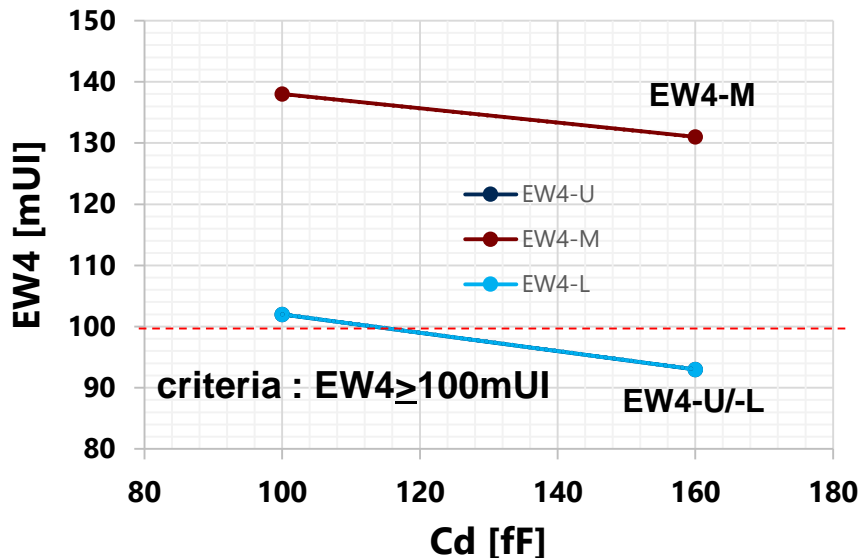


- With fewer Rx FFE post-taps, LF-CTLE is effective.
- 2p/2z LF-CTLE helps some, however, effect is limited, considering LF-CTLE implementation including stability.
- > 1p/1z LF-CTLE will be good enough.

- 27mm PKG
- Cd = 160fF
- DFE : 1-tap
- Tx-FFE : 1-tap
- 58Gbd



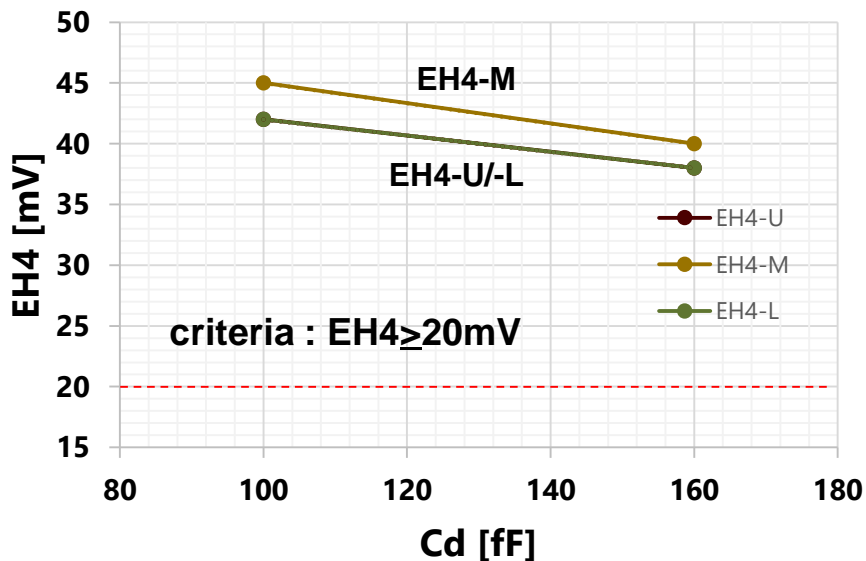
2.3.4.2 Cd (COM model) value



item			unit	#41	#45
Tx/Rx	PKG	trace	mm	30 (COM PKG)	
	Cd		fF	160	100
	Cp		fF	110	
eye	width EW4	upp	mUI	93	102
		mid		126	138
		low		93	102
	height EH4	upp	mV	38	42
		mid		40	45
		low		38	42

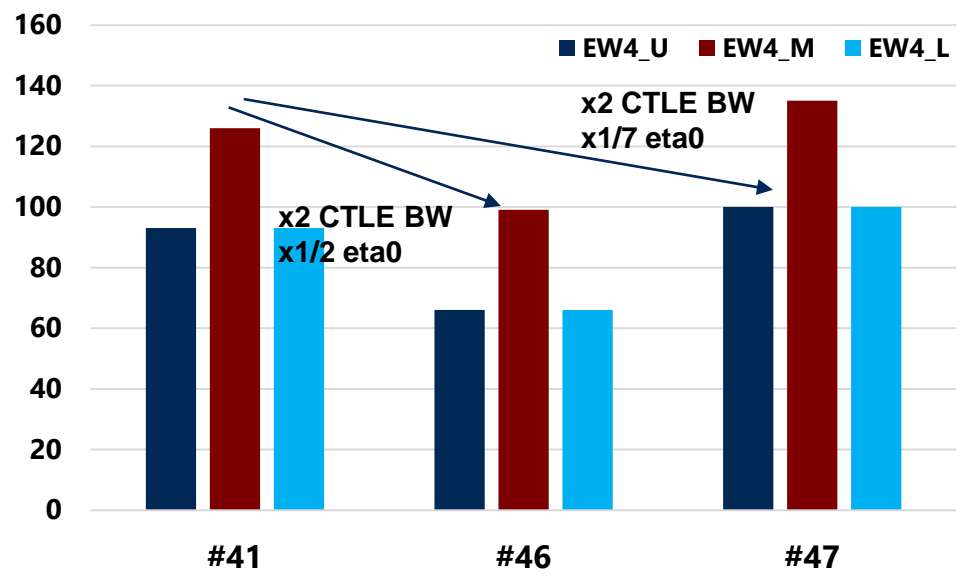
Reducing Cd from 160fF to 100fF improves eye opening.

- EW4 +9mUI, EH4 +4mV (in this case)

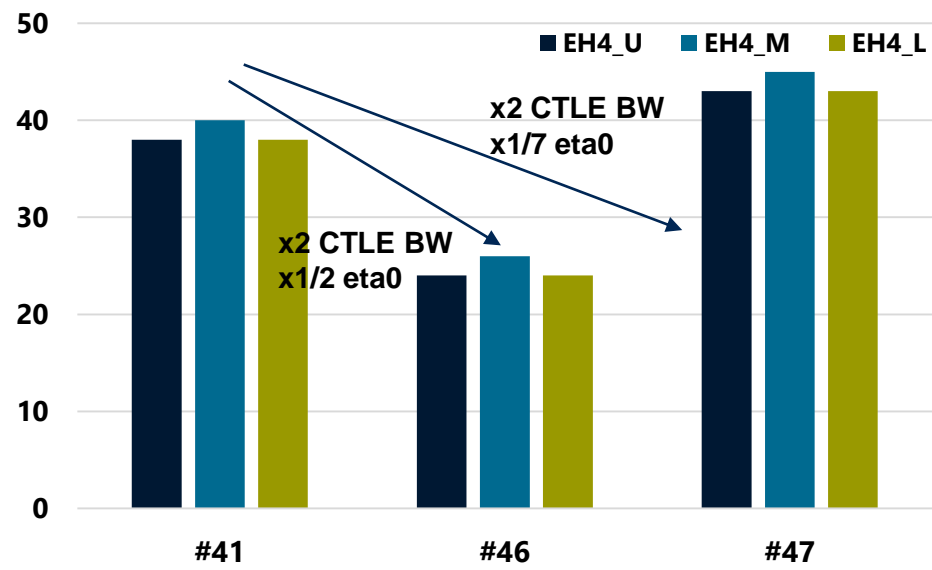


- 58Gbd, 2m cable BP
- IL 30.5dB (no PKG), 39.2dB (w/ PKG)
- COM-PKG 30mm Cp 110fF
- Tx-FFE : 1-tap
- Tx RJrms : 10mUI, Tx SNR 32.5dB
- Rx-CTLE 2p1z(HF) 1p1z (LF)
- Rx-FFE : 54/5-pre, DFE : 1-tap
- Rx RJrms : 10mUI

2.3.4.3 CTLE parameters (fr, eta0, pole/zero)



item		unit	#41	#46	#47	
Rx	eta0	V ² /GHz	1.64E-8	8.2E-9	2.3E-9	
	fr	x fb	3/8	3/4		
	pole	HF	fp1	0.5	1	1
			fp2	0.2	0.4	0.4
	zero	LF	fLF	0.008	0.008	0.008
			HF	0.033	0.038	0.038
			fLF	0.005	0.005	0.005
eye	width EW4	upp	93	66	100	
		mid	126	99	135	
		low	93	66	100	
	height EH4	upp	38	24	43	
		mid	40	26	45	
		low	38	24	43	



- Simply increase CTLE BW (band width) decrease eye opening.
- It is necessary to reduce device noise to utilize higher CTLE BW.
- Higher CTLE BW will help to reduce ADC ENOB requirement.

- 58Gbd, 2m cable BP
- IL 30.5dB (no PKG), 39.2dB (w/ PKG)
- COM-PKG 30mm Cd 160fF, Cp 110fF
- Tx-FFE : 1-tap
- Tx RJrms : 10mUI, Tx SNR 32.5dB
- Rx-CTLE 2p1z(HF) 1p1z (LF)
- Rx-FFE : 54/5-pre, DFE : 1-tap
- Rx RJrms : 10mUI

3. Conclusion

3. Conclusion

- 1. With cabled backplane, 100Gb/s transmission with 30dB @29GHz channel seems feasible.**
 - For 802.3 100GEL applications (KR, backplane), 30dB @26.5625GHz will be enough with margin.
 - For CR (cable) application, total IL budget is the same as KR.
 - Besides IL, crosstalk (XT) reduction is required for channels.
- 2. With relaxed device parameters, some improvements are observed.**
- 3. PKG affects performance significantly, so COM PKG model has to be improved to meet IL and reflection requirement in 100Gb/s transmission.**
 - As a tentative value, $C_p=55\text{fF}$ seems reasonable.
- 4. Appropriate equalization (like Rx FFE) is necessary, considering performance, power and area in real Si implementation.**
 - It is a trade off issue both channel (including PKG) and SerDes design.
- 5. Further investigation needed.**
 - Device parameters
 - PKG parameters
 - Other Channel models

Thank you!

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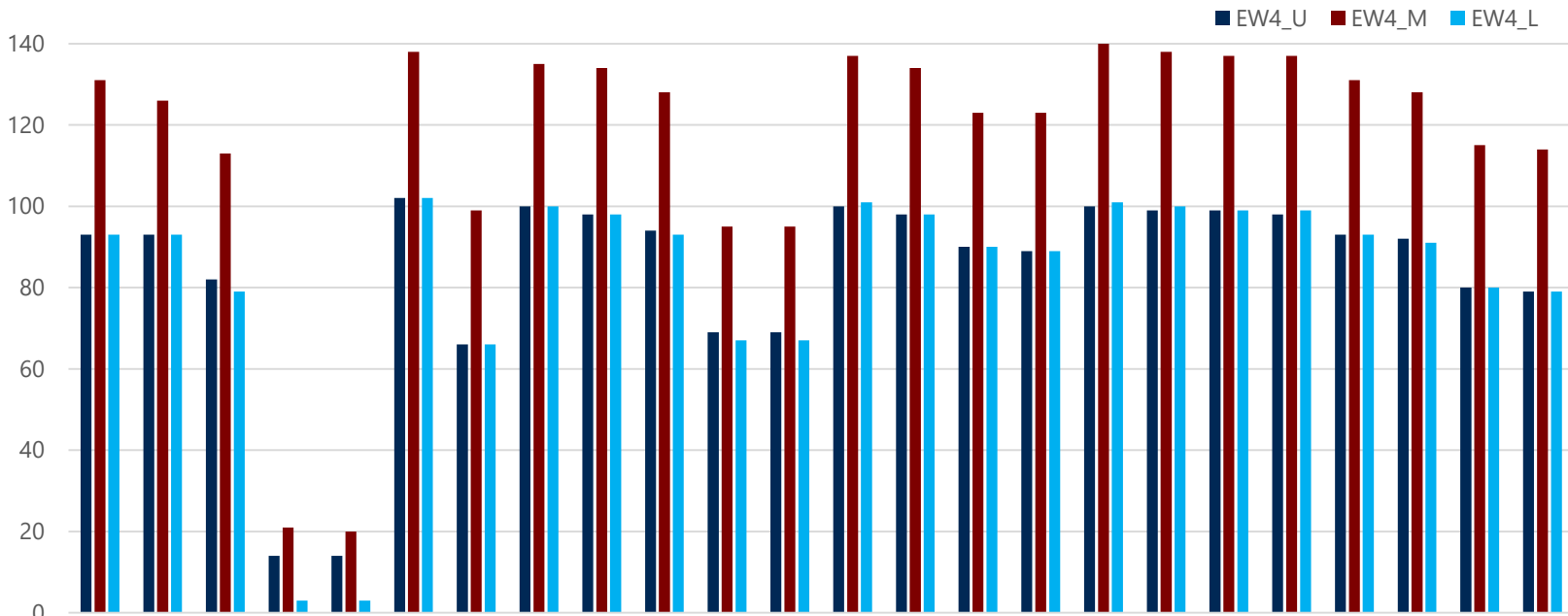
back up slides

A. Simulation Summary

B. DFE output eye

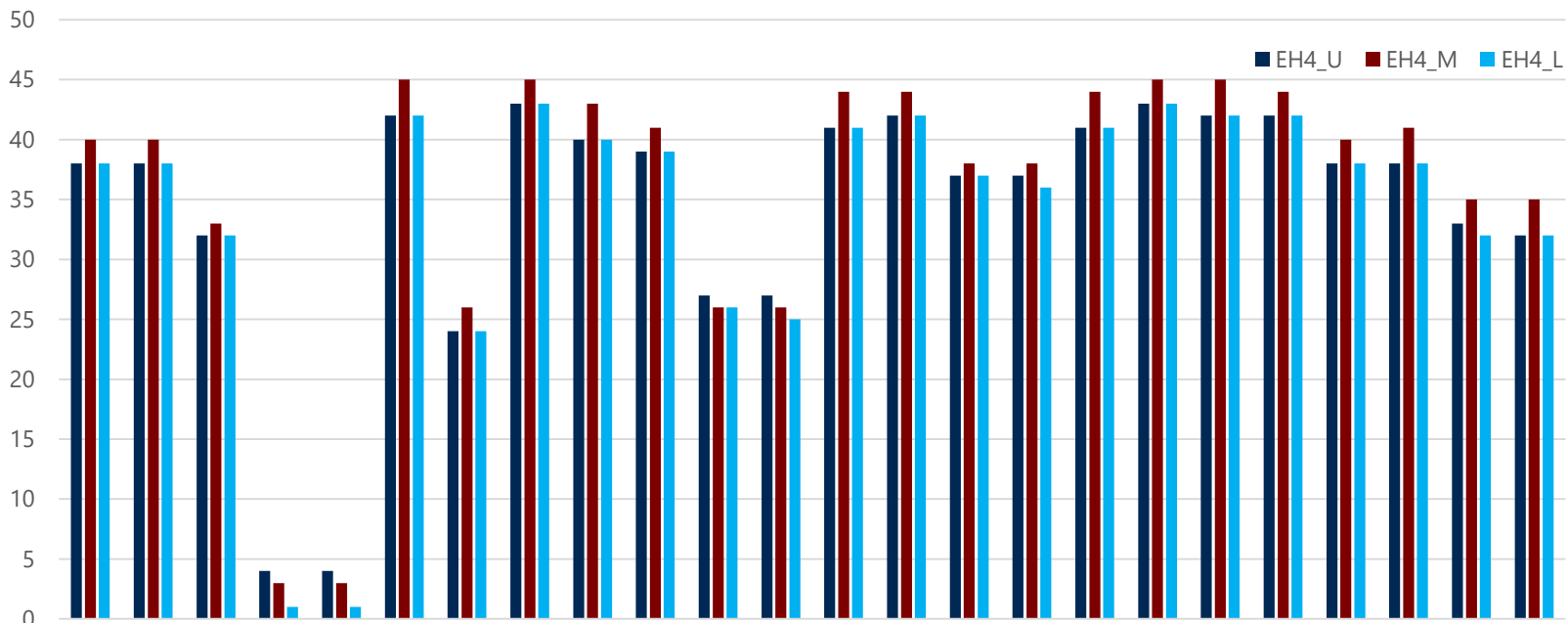
C. CTLE parameters

A-1 Simulation Summary (EW4)



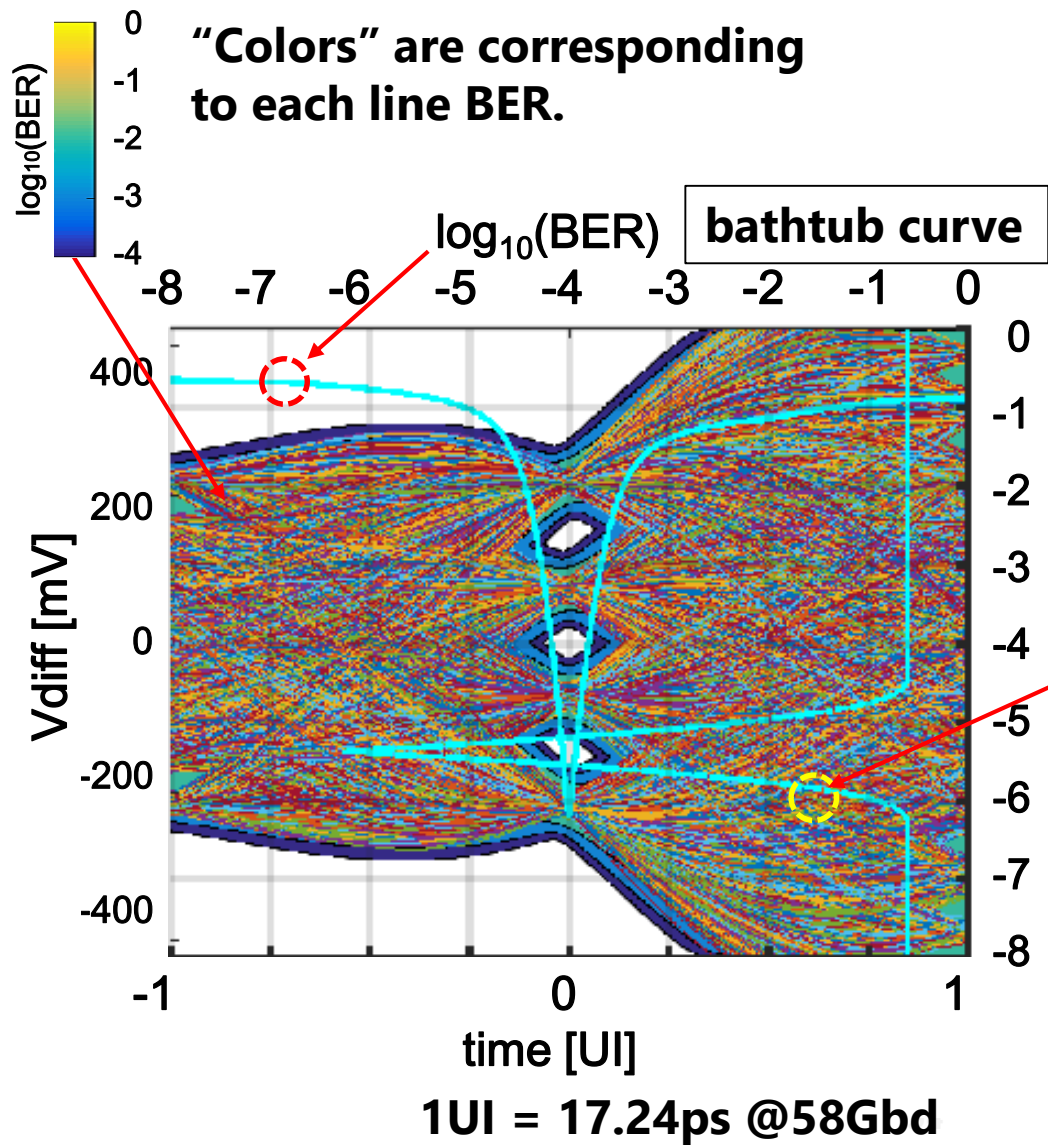
item		unit	#10	#41	#42	#43	#44	#45	#46	#47	#48	#49	#50	#51	#52	#53	#54	#55	#56	#57	#58	#59	#10	#16	#60	#61																											
channel	IL w/ PKG	dB	40.4	39.2						38.1						37.7						37.6						40.4																									
Tx/Rx	PKG trace	mm	27	30 (COM PKG)																								27																									
	Cd	fF	160						100						160																																						
	Cp	fF	---	110						60						30						0						--- (S-param)																									
Rx	eta0	V ² /GHz	1.64E-8						8.2E-9						2.3E-9						1.64E-8																																
	fr	x fb GHz	3/8						3/4						3/8																																						
	FFE	tap/pre	54/5				32/5				24/5				18/5				54/5				54/5				32/5				24/5				18/5				54/5				32/5				24/5				18/5		
eye	EW4	upp	mUI	93	93	82	14	14	102	66	100	98	94	69	69	100	98	90	89	100	99	99	98	93	92	80	79																										
		mid	131	126	113	21	20	138	99	135	134	128	95	95	137	134	123	123	140	138	137	137	131	128	115	114																											
		low	93	93	79	3	3	102	66	100	98	93	67	67	101	98	90	89	101	100	99	99	93	91	80	79																											
	EH4	upp	mV	38	38	32	4	4	42	24	43	40	39	27	27	41	42	37	37	41	43	42	42	38	38	33	32																										
		mid	40	40	33	3	3	45	26	45	43	41	26	26	44	44	38	38	44	45	45	44	40	41	35	35																											
		low	38	38	32	1	1	42	24	43	40	39	26	25	41	42	37	36	41	43	42	42	38	38	32	32																											

A-2 Simulation Summary (EH4)



item		unit	#10	#41	#42	#43	#44	#45	#46	#47	#48	#49	#50	#51	#52	#53	#54	#55	#56	#57	#58	#59	#10	#16	#60	#61				
channel	IL w/ PKG	dB	40.4	39.2						38.1						37.7				37.6				40.4						
Tx/Rx	PKG trace	mm	27	30 (COM PKG)																				27						
	Cd	fF	160						100				160																	
	Cp	fF	---	110						60						30				0				--- (S-param)						
Rx	eta0	V ² /GHz	1.64E-8						8.2E-9		2.3E-9		1.64E-8																	
	fr	x fb GHz	3/8						3/4						3/8															
	FFE	tap/pre	54/5	32/5	24/5	18/5	54/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5	54/5	32/5	24/5	18/5			
eye	EW4	upp	mUI	93	93	82	14	14	102	66	100	98	94	69	69	100	98	90	89	100	99	99	98	93	92	80	79			
		mid	131	126	113	21	20	138	99	135	134	128	95	95	137	134	123	123	140	138	137	137	131	128	115	114				
		low	93	93	79	3	3	102	66	100	98	93	67	67	101	98	90	89	101	100	99	99	93	91	80	79				
	EH4	upp	mV	38	38	32	4	4	42	24	43	40	39	27	27	41	42	37	37	41	43	42	42	38	38	33	32			
		mid	40	40	33	3	3	45	26	45	43	41	26	26	44	44	38	38	44	45	45	44	40	41	35	35				
		low	38	38	32	1	1	42	24	43	40	39	26	25	41	42	37	36	41	43	42	42	38	38	32	32				

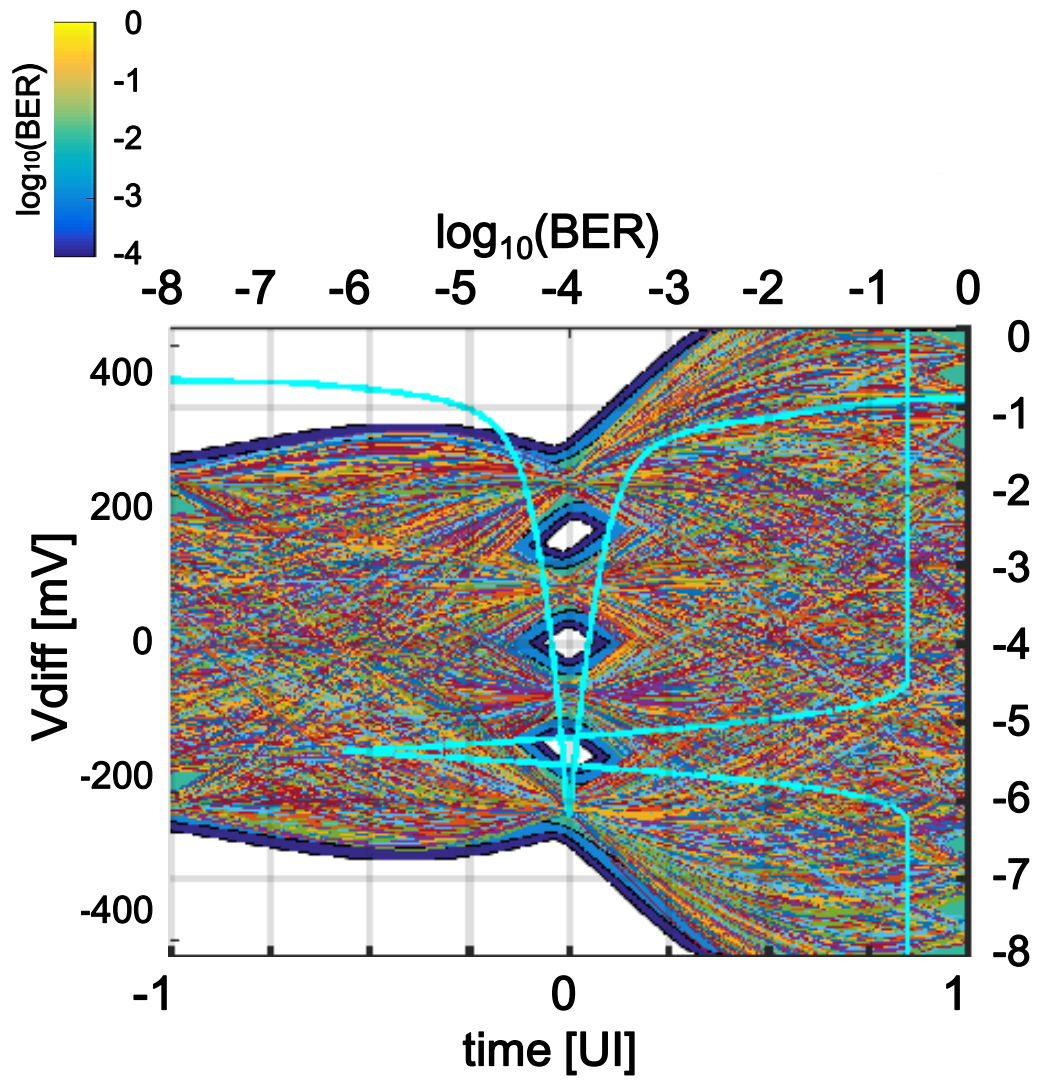
B-0 DFE output eye (Legend)



- parameters

item	unit	#10	#41	#42	
baud rate	Gbd	58			
chan nel	type		2m(B), cabled BP		
	IL	no PKG	30.5		
w/ PKG		40.4	39.2		
Tx	FFE	tap/pre		1/0	
	RJrms	mUI		10	
	SNR	dB		32.5	
Tx/ Rx	PKG	trace	mm	27 30 (COM PKG)	
	Cd	fF		160	
	Cp	fF		--- 110	
Rx	CTLE	HF/LF	2p-1z/1p-1z		
	eta0	V ² /GHz		1.64E-8	
	fr	x fb	GHz		3/8
	FFE	tap/pre		54/5 32/5	
	DFE	tap		1	
eye	EW4	upp	mUI	93 93 82	
		mid		131 126 113	
		low		93 93 79	
	EH4	upp	mV	38 38 32	
		mid		40 40 33	
		low		38 38 32	

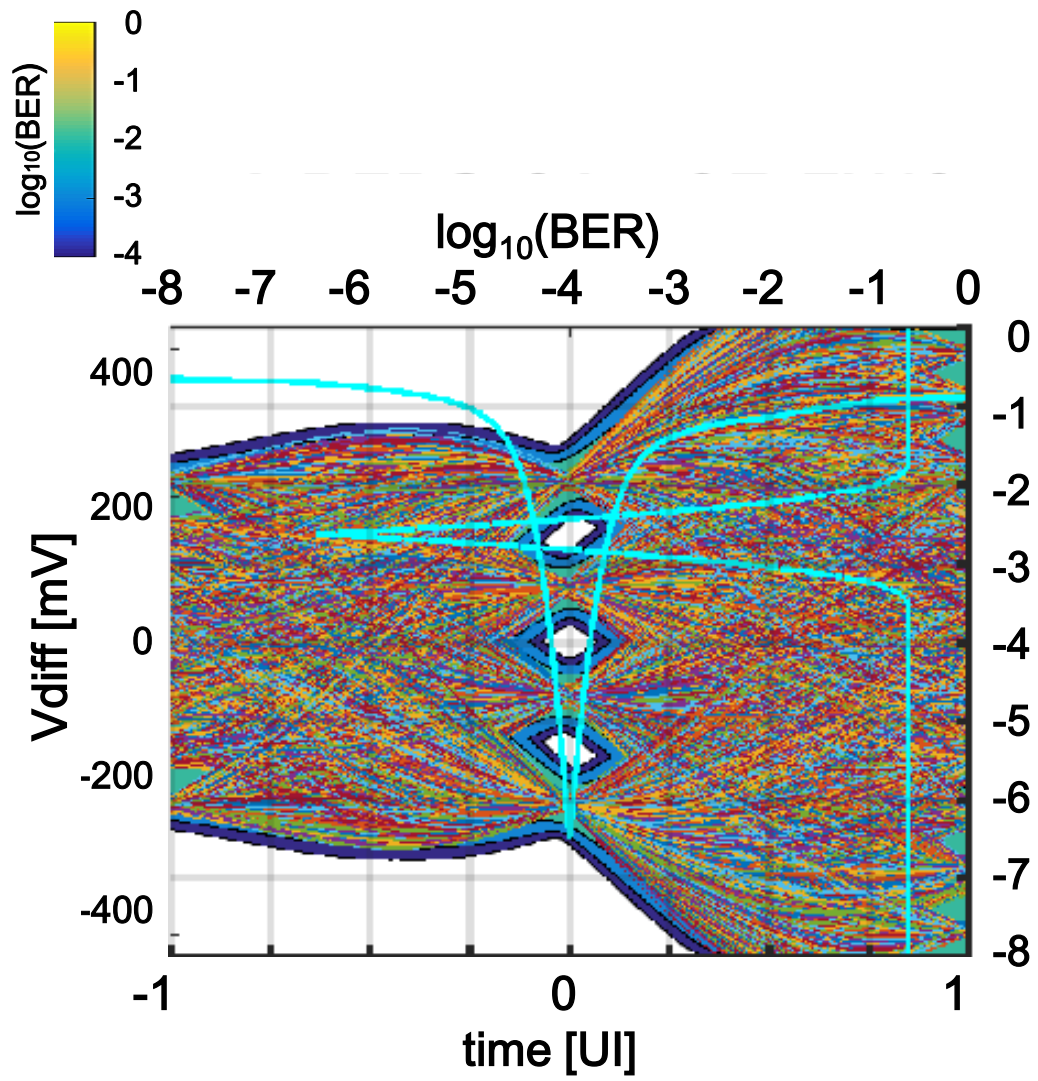
B-1 DFE output eye (#10)



↓

item	unit	#10	#41	#42	#43	#44		
baud rate	Gbd	58						
channel	type		2m(B), cabled BP					
	IL	no PKG	dB				30.5	
		w/ PKG	dB	40.4	39.2			
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm	27	30 (COM PKG)			
	Cd	fF		160				
	Cp	fF		---	110			
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz	3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap		1				
	RJrms	mUI		10				
eye	EW4	upp	mUI	93	93	82	14	14
		mid	mUI	131	126	113	21	20
		low	mUI	93	93	79	3	3
	EH4	upp	mV	38	38	32	4	4
		mid	mV	40	40	33	3	3
		low	mV	38	38	32	1	1

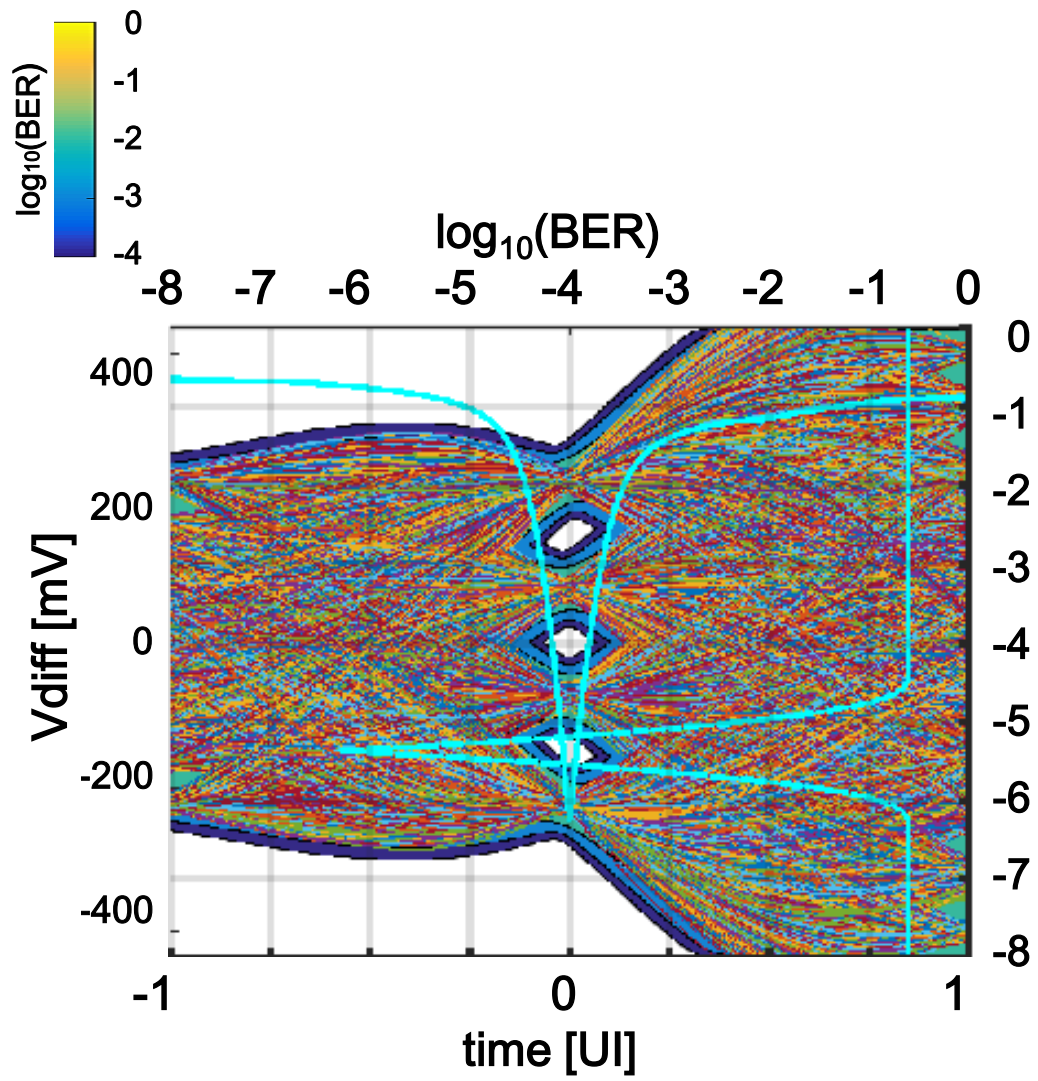
B-1 DFE output eye (#11)



↓

item		unit	#11	#10	#16	#60	#61
baud rate		Gbd	58				
channel	type	cabled BP	2m(B)				
	IL	no PKG	30.5				
		w/ PKG	38.1				
Tx	FFE	tap/pre	1/0				
	RJrms	mUI	10				
	SNR	dB	32.5				
Tx/Rx	PKG	trace	27				
	Cd	fF	160				
	Cp	fF	no Cp (S-param)				
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	1.64E-8				
	fr	x fb	3/8				
	FFE	tap/pre	106/5	54/5	32/5	24/5	18/5
	DFE	tap	1				
		RJrms	mUI	10			
eye	width EW4	upp	98	93	92	80	79
		mid	137	131	128	115	114
		low	98	93	91	80	79
	height EH4	upp	42	38	38	33	32
		mid	45	40	41	35	35
		low	42	38	38	32	32

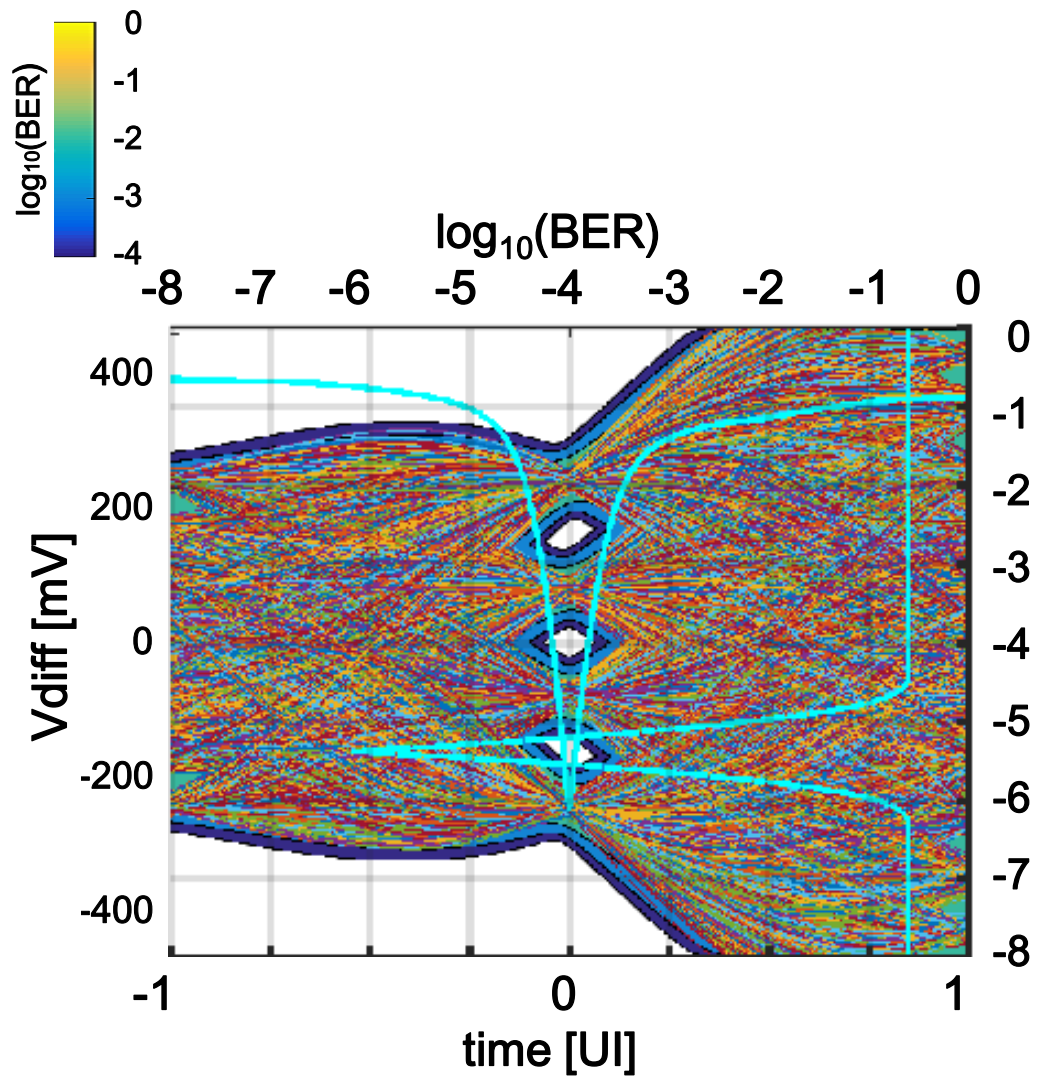
B-1 DFE output eye (#13)



↓

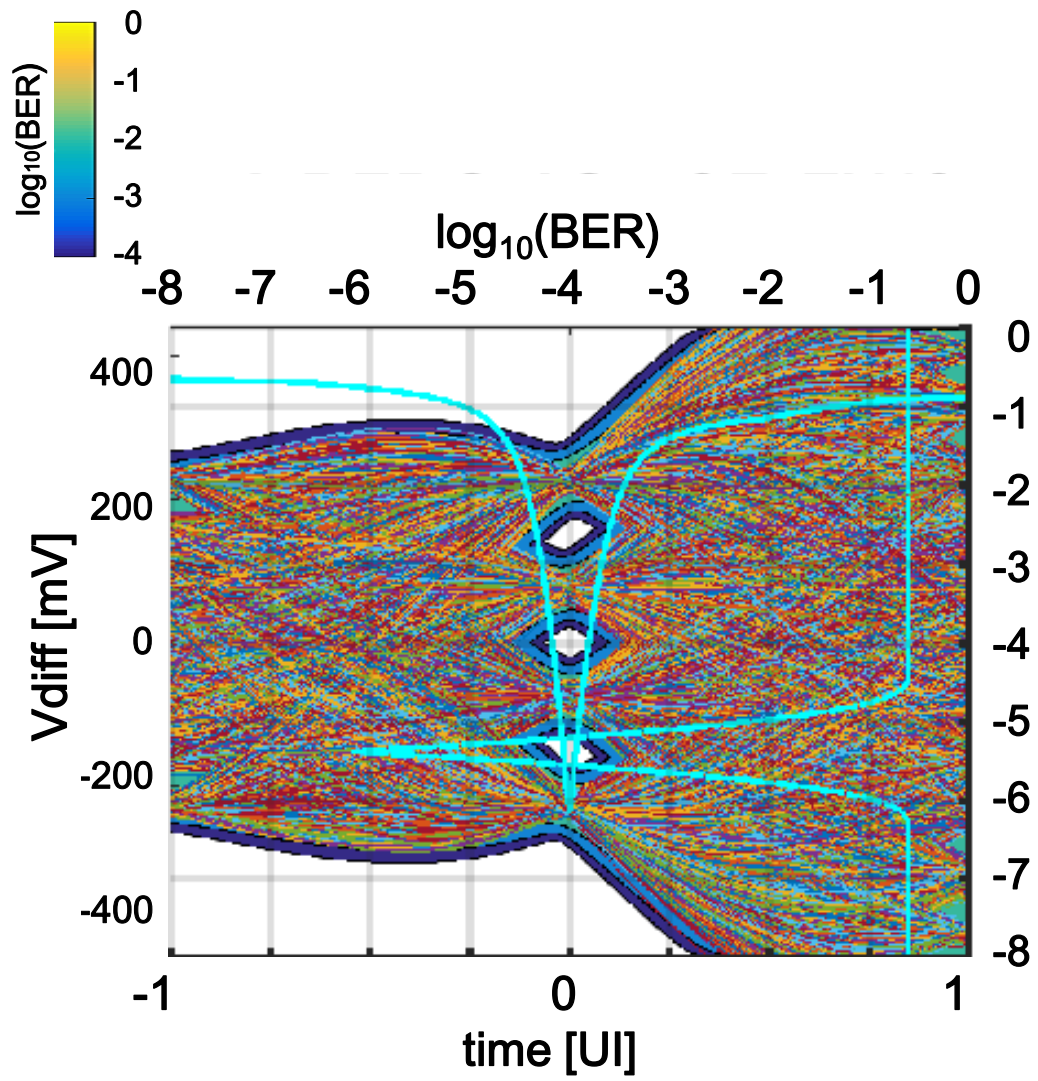
item	unit	#13	#10	#14	#15	#16	#17		
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB					30.5	
		w/ PKG	dB						
Tx	FFE	tap/pre	1/0						
	RJrms	mUI	10						
	SNR	dB	32.5						
Tx/Rx	PKG	trace	mm					27	
	Cd	fF	160						
	Cp	fF	no Cp (S-param)						
Rx	CTLE	HF	2p1z						
		LF	2p2z	1p1z	0p0z	2p2z	1p1z	0p0z	
	eta0	V ² /GHz	1.64E-8						
	fr	x fb	GHz						3/8
	FFE	tap/pre	54/5			32/5			
	DFE	tap	1						
	RJrms	mUI	10						
eye	width EW4	upp	93	93	91	92	92	87	
		mid	132	131	128	129	128	121	
		low	93	93	91	92	91	87	
	height EH4	upp	39	38	36	38	38	32	
		mid	42	40	38	41	41	34	
		low	39	38	35	38	38	32	

B-1 DFE output eye (#14)



item	unit	#13	#10	#14	#15	#16	#17	
baud rate	Gbd	58						
channel	type	cabled BP						
	IL	no PKG	dB					
		w/ PKG	dB					
Tx	FFE	tap/pre						
	RJrms	mUI						
	SNR	dB						
Tx/Rx	PKG	trace						
	Cd	fF						
	Cp	no Cp (S-param)						
Rx	CTLE	HF	2p1z					
		LF	2p2z	1p1z	0p0z	2p2z	1p1z	0p0z
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz					
	FFE	tap/pre	54/5			32/5		
	DFE	tap	1					
	RJrms	mUI	10					
eye	width EW4	upp	93	93	91	92	92	87
		mid	132	131	128	129	128	121
		low	93	93	91	92	91	87
	height EH4	upp	39	38	36	38	38	32
		mid	42	40	38	41	41	34
		low	39	38	35	38	38	32

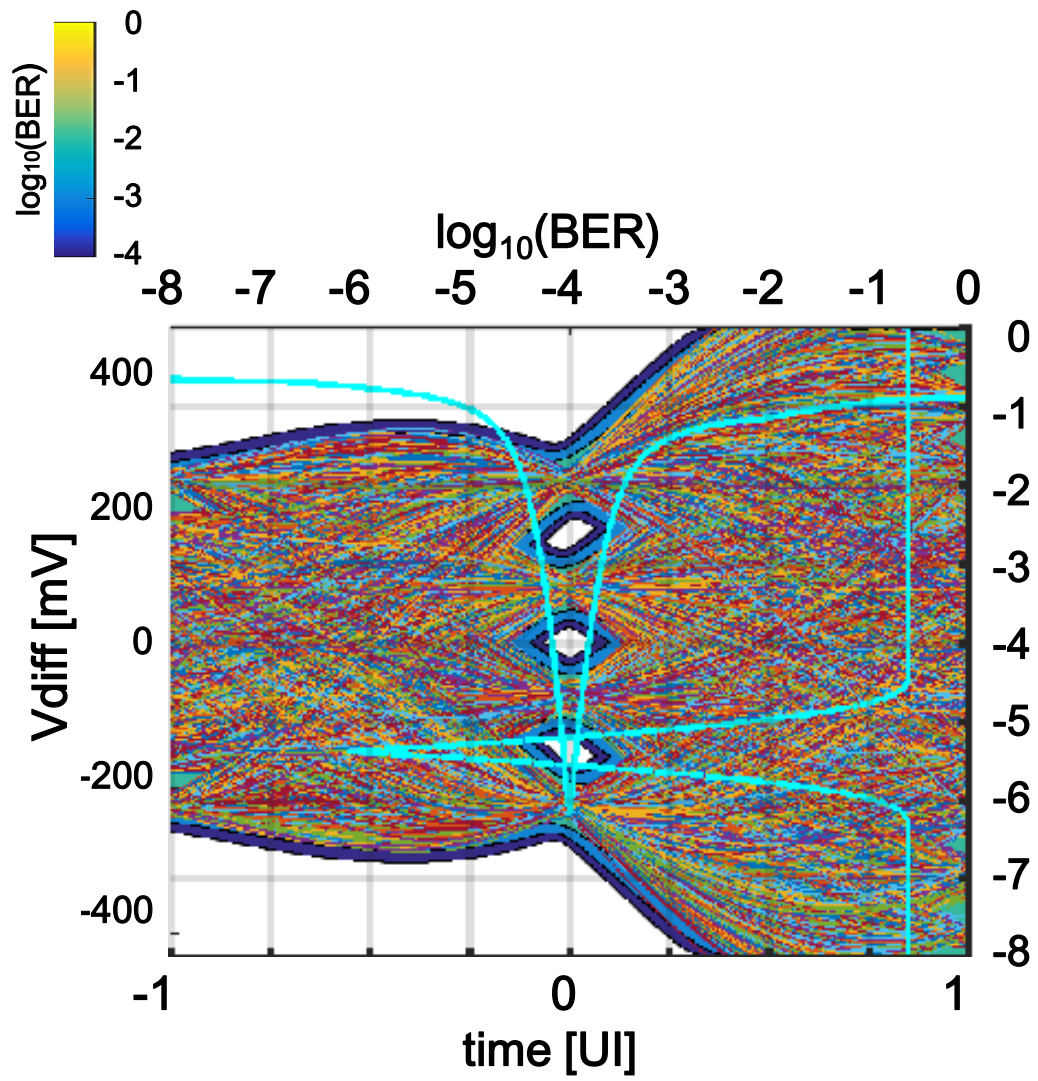
B-1 DFE output eye(#15)



↓

item	unit	#13	#10	#14	#15	#16	#17	
baud rate	Gbd	58						
channel	type	cabled BP						
	IL	no PKG	dB					30.5
		w/ PKG	dB					
Tx	FFE	tap/pre	1/0					
	RJrms	mUI	10					
	SNR	dB	32.5					
Tx/Rx	PKG	trace	mm				27	
	Cd	fF	160					
	Cp	fF	no Cp (S-param)					
Rx	CTLE	HF	2p1z					
		LF	2p2z	1p1z	0p0z	2p2z	1p1z	0p0z
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz					
	FFE	tap/pre	54/5			32/5		
	DFE	tap	1					
	RJrms	mUI	10					
eye	width EW4	upp	93	93	91	92	92	87
		mid	132	131	128	129	128	121
		low	93	93	91	92	91	87
	height EH4	upp	39	38	36	38	38	32
		mid	42	40	38	41	41	34
		low	39	38	35	38	38	32

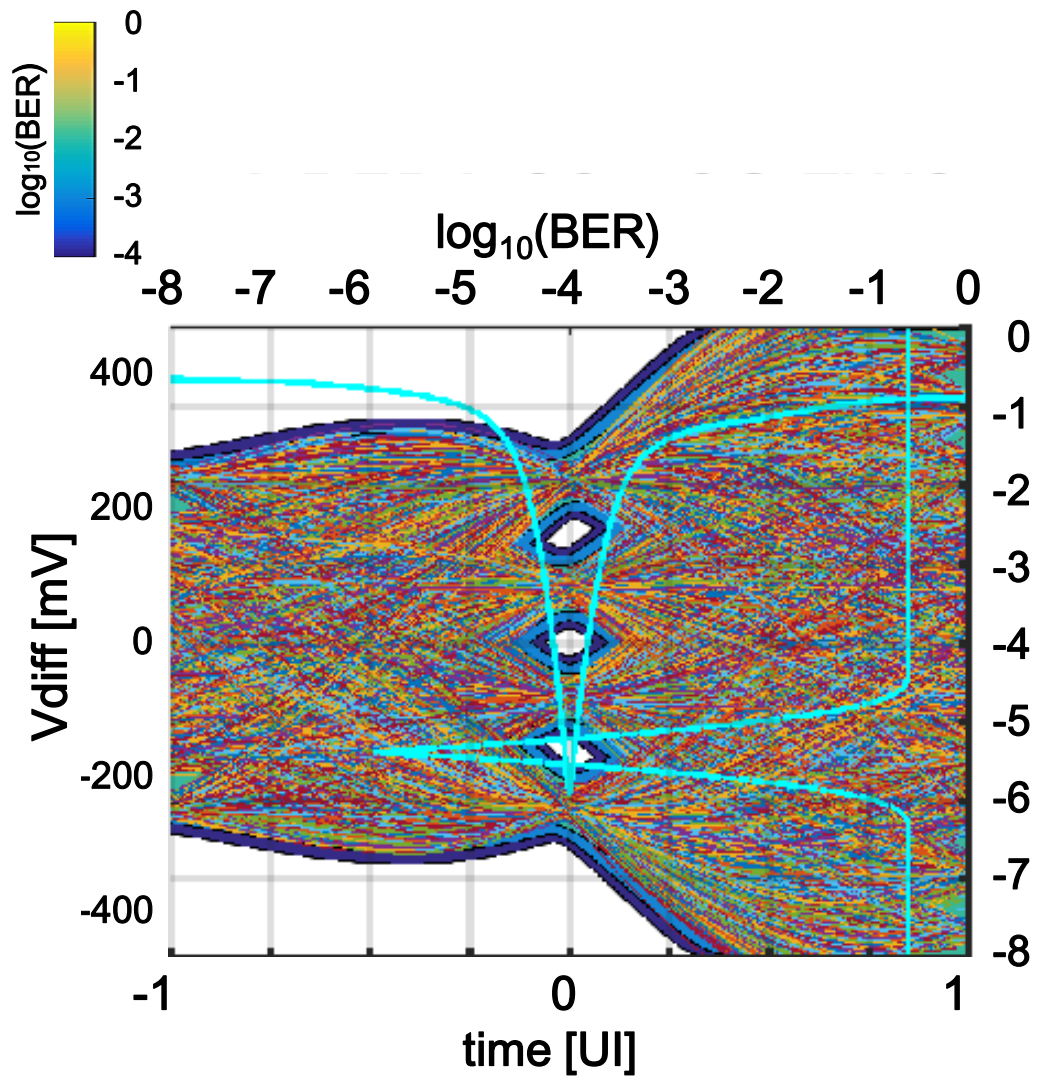
B-1 DFE output eye(#16)



↓

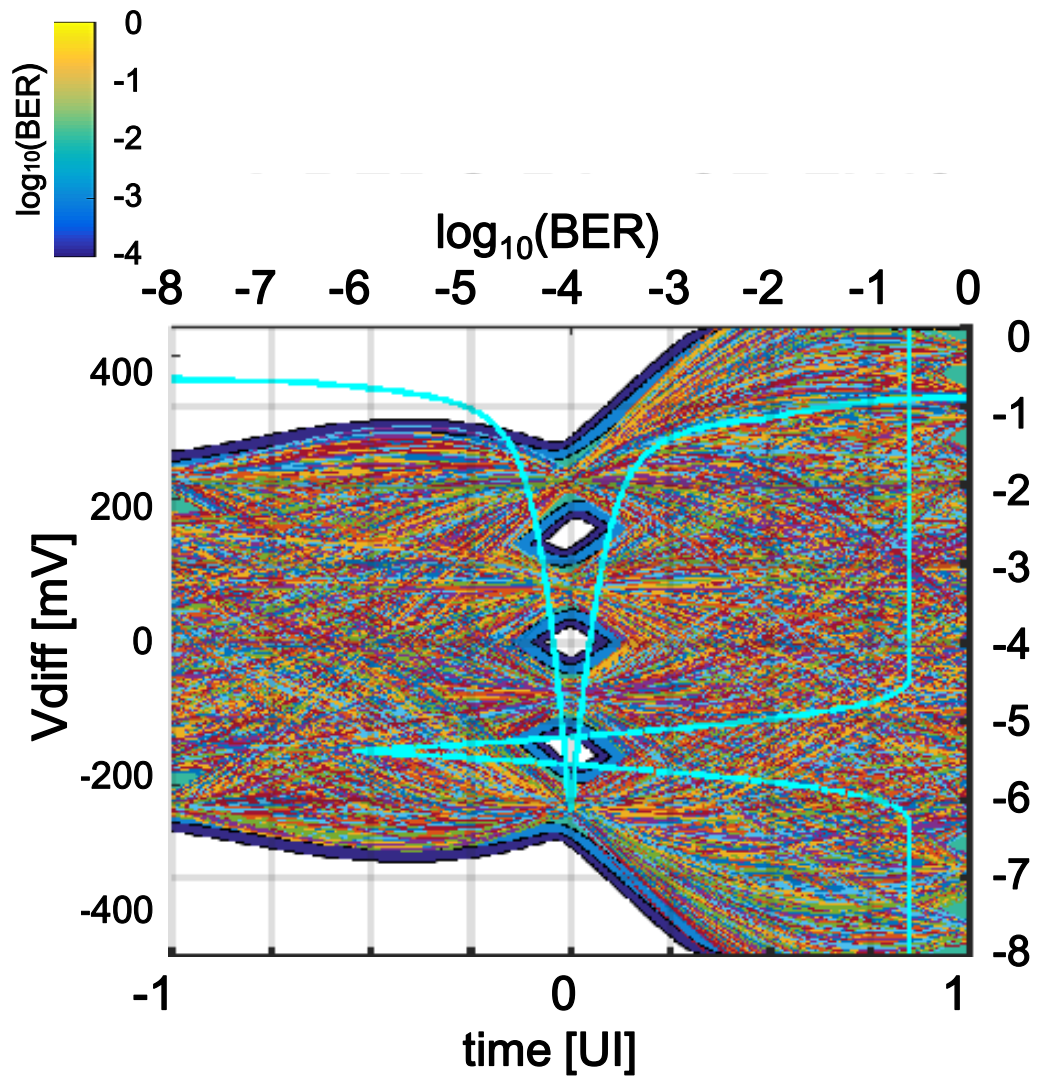
item	unit	#13	#10	#14	#15	#16	#17	
baud rate	Gbd	58						
channel	type	cabled BP						
	IL	no PKG	dB					30.5
		w/ PKG	dB					
Tx	FFE	tap/pre	1/0					
	RJrms	mUI	10					
	SNR	dB	32.5					
Tx/Rx	PKG	trace	mm				27	
	Cd	fF	160					
	Cp	fF	no Cp (S-param)					
Rx	CTLE	HF	2p1z					
		LF	2p2z	1p1z	0p0z	2p2z	1p1z	0p0z
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz					3/8
	FFE	tap/pre	54/5			32/5		
	DFE	tap	1					
	RJrms	mUI	10					
eye	width EW4	upp	93	93	91	92	92	87
		mid	132	131	128	129	128	121
		low	93	93	91	92	91	87
	height EH4	upp	39	38	36	38	38	32
		mid	42	40	38	41	41	34
		low	39	38	35	38	38	32

B-1 DFE output eye (#17)



item	unit	#13	#10	#14	#15	#16	#17	
baud rate	Gbd	58						
channel	type	cabled BP						
	IL	no PKG	dB					30.5
		w/ PKG	dB					
Tx	FFE	tap/pre	1/0					
	RJrms	mUI	10					
	SNR	dB	32.5					
Tx/Rx	PKG	trace	mm				27	
	Cd	fF	160					
	Cp	fF	no Cp (S-param)					
Rx	CTLE	HF	2p1z					
		LF	2p2z	1p1z	0p0z	2p2z	1p1z	0p0z
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz					3/8
	FFE	tap/pre	54/5		32/5			
	DFE	tap	1					
	RJrms	mUI	10					
eye	width EW4	upp	93	93	91	92	92	87
		mid	132	131	128	129	128	121
		low	93	93	91	92	91	87
	height EH4	upp	39	38	36	38	38	32
		mid	42	40	38	41	41	34
		low	39	38	35	38	38	32

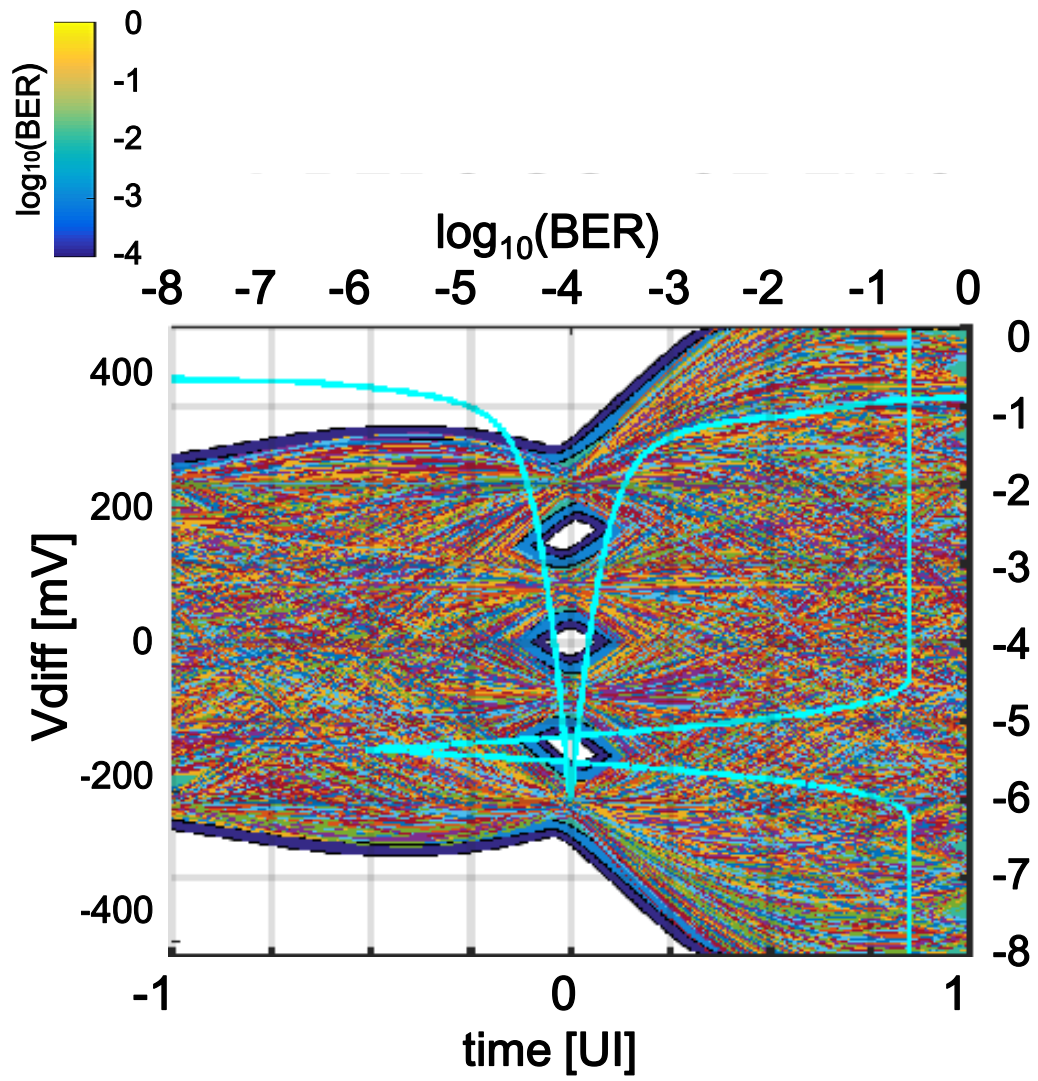
B-1 DFE output eye (#18)



↓

item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB						30.5
		w/ PKG	dB						40.4
Tx	FFE	tap/pre						1/0	
	RJrms	mUI						10	
	SNR	dB						32.5	
Tx/ Rx	PKG trace	mm						27	
	Cd	fF						160	
	Cp	fF						no Cp (S-parameter)	
Rx	CTLE	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz	1.64E-8						
	fr	x fb	GHz						3/8
	FFE	tap/pre	33/6	32/5	31/4	30/3	29/2	28/1	27/0
	DFE	tap	1						
	RJrms	mUI	10						
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

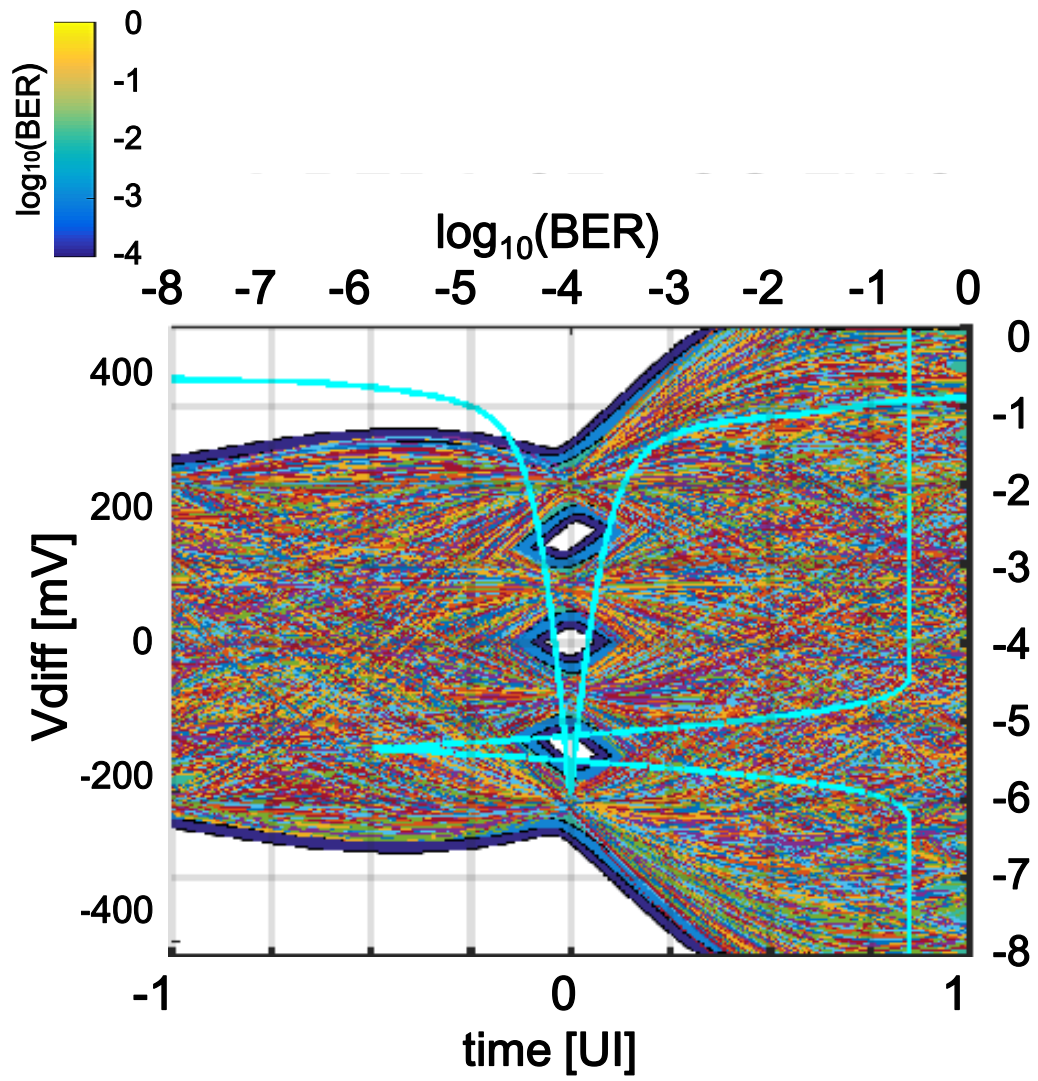
B-1 DFE output eye (#19)



item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB						30.5
		w/ PKG	dB						40.4
Tx	FFE	tap/pre						1/0	
	RJrms	mUI						10	
	SNR	dB						32.5	
Tx/ Rx	PKG trace	mm						27	
	Cd	fF						160	
	Cp	fF						no Cp (S-parameter)	
Rx	CTL E	HF/LF						2p-1z/1p-1z	
	eta0	V ² /GHz						1.64E-8	
	fr	x fb						GHz	3/8
	FFE	tap/pre						33/6 32/5 31/4 30/3 29/2 28/1 27/0	
	DFE	tap						1	
	RJrms	mUI						10	
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

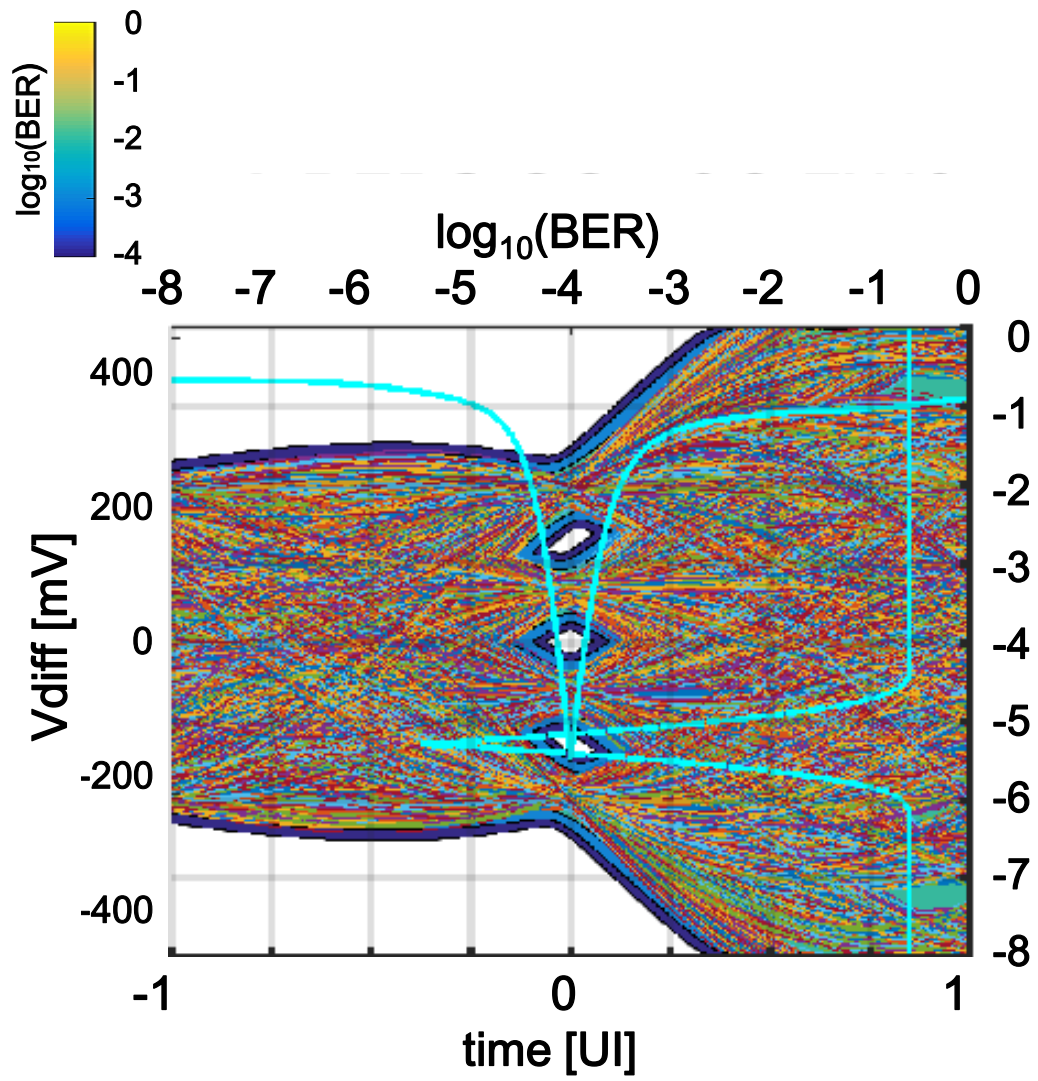


B-1 DFE output eye (#20)



item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB						30.5
		w/ PKG	dB						40.4
Tx	FFE	tap/pre						1/0	
	RJrms	mUI						10	
	SNR	dB						32.5	
Tx/ Rx	PKG trace	mm						27	
	Cd	fF						160	
	Cp	fF						no Cp (S-parameter)	
Rx	CTL E	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz	1.64E-8						
	fr	x fb	GHz						3/8
	FFE	tap/pre	33/6	32/5	31/4	30/3	29/2	28/1	27/0
	DFE	tap	1						
	RJrms	mUI	10						
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

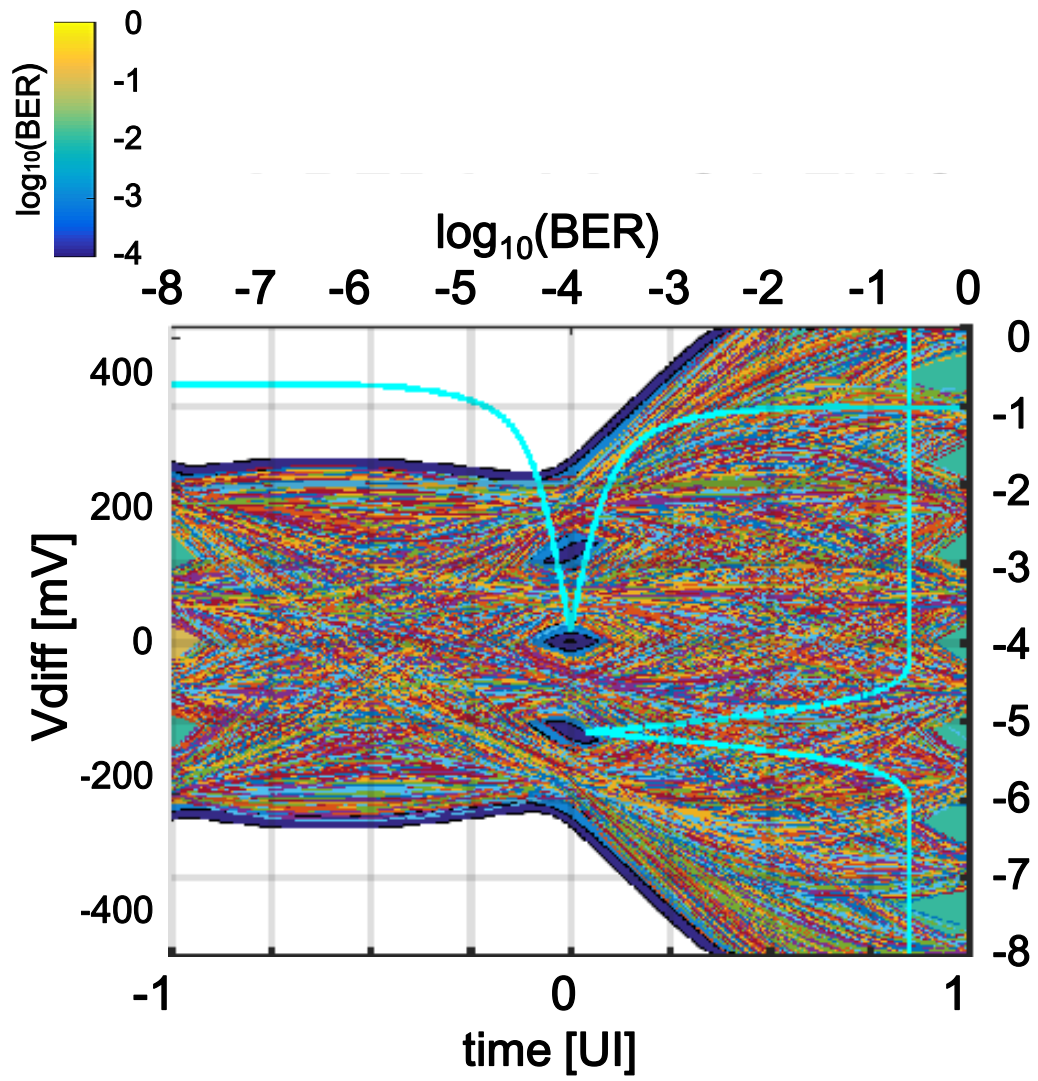
B-1 DFE output eye (#21)



↓

item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB						30.5
		w/ PKG	dB						40.4
Tx	FFE	tap/pre						1/0	
	RJrms	mUI						10	
	SNR	dB						32.5	
Tx/ Rx	PKG trace	mm						27	
	Cd	fF						160	
	Cp	fF						no Cp (S-parameter)	
Rx	CTL E	HF/LF						2p-1z/1p-1z	
	eta0	V ² /GHz						1.64E-8	
	fr	x fb						GHz	3/8
	FFE	tap/pre						33/6 32/5 31/4 30/3 29/2 28/1 27/0	
	DFE	tap						1	
	RJrms	mUI						10	
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

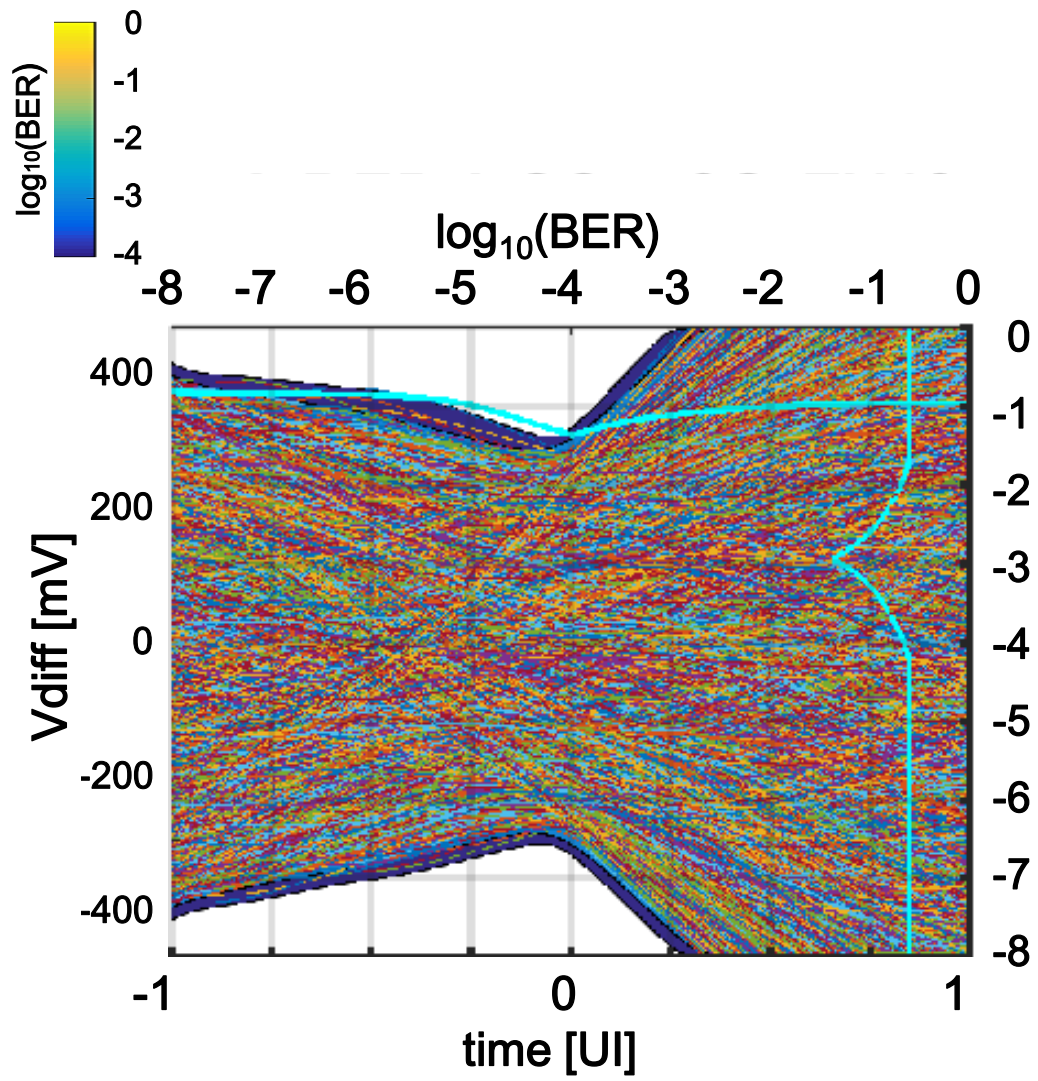
B-1 DFE output eye (#22)



item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB					30.5	
		w/ PKG	dB					40.4	
Tx	FFE	tap/pre					1/0		
	RJrms	mUI					10		
	SNR	dB					32.5		
Tx/Rx	PKG trace	mm					27		
	Cd	fF					160		
	Cp	fF					no Cp (S-parameter)		
Rx	CTL E	HF/LF					2p-1z/1p-1z		
	eta0	V ² /GHz					1.64E-8		
	fr	x fb GHz					3/8		
	FFE	tap/pre	33/6	32/5	31/4	30/3	29/2	28/1	27/0
	DFE	tap	1						
		RJrms	mUI					10	
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

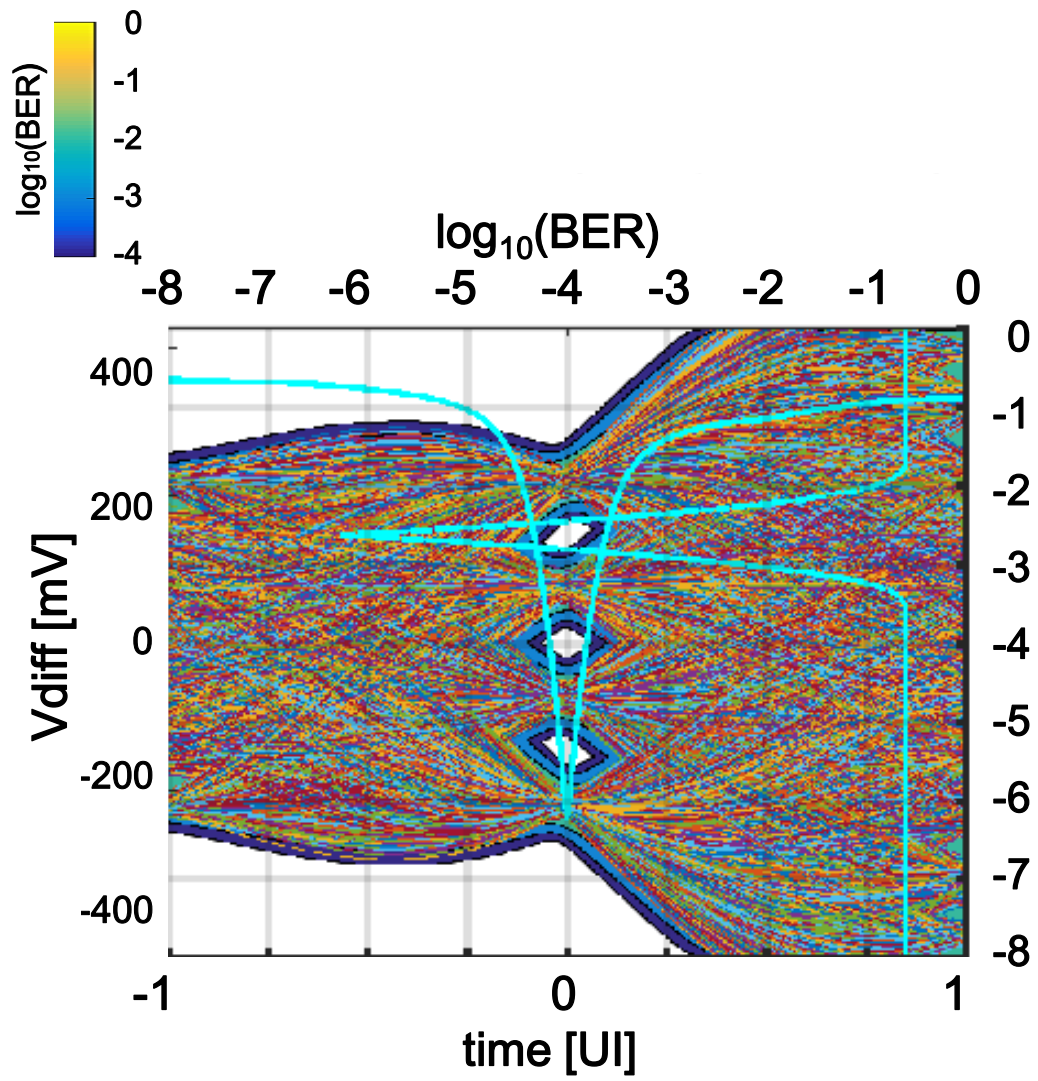


B-1 DFE output eye (#23)



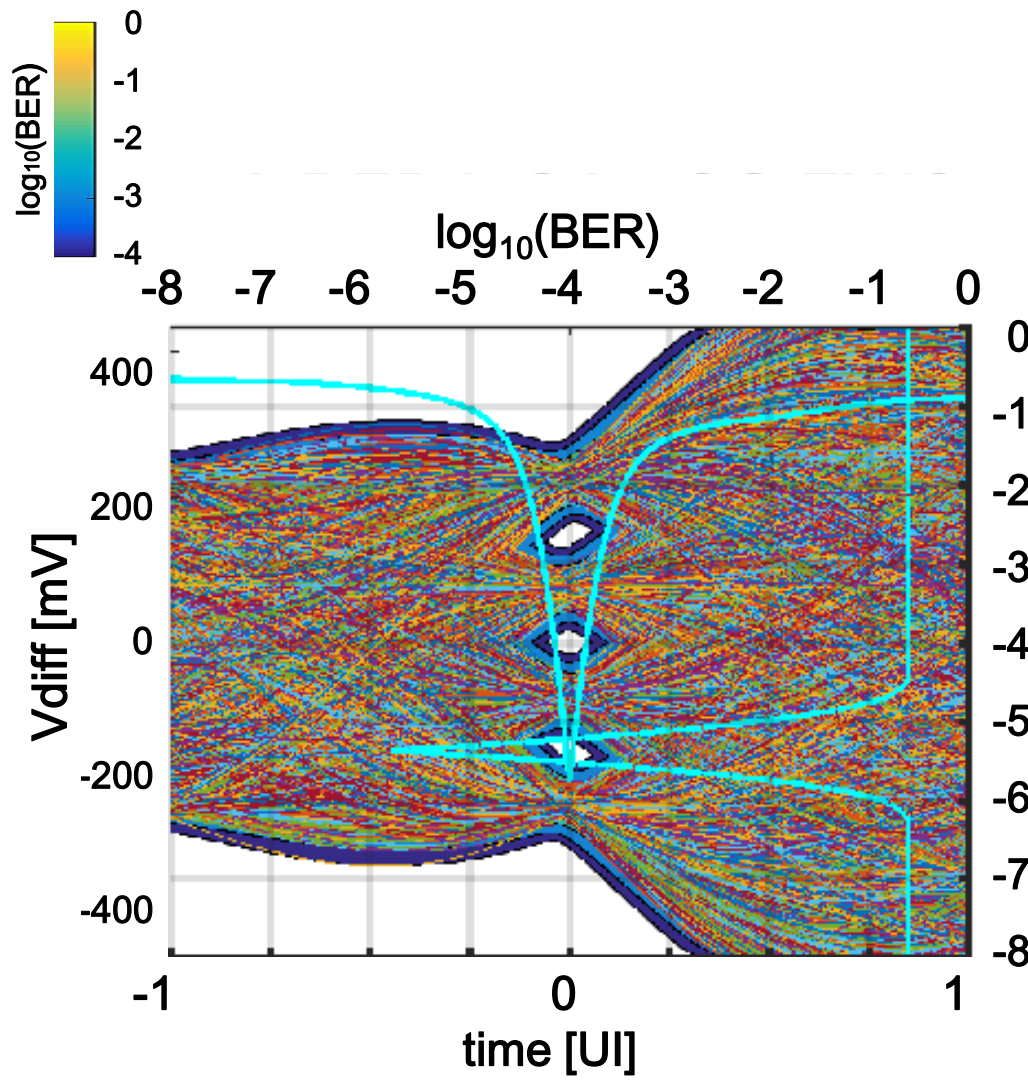
item	unit	#18	#16	#19	#20	#21	#22	#23	
baud rate	Gbd	58							
channel	type	cabled BP							
	IL	no PKG	dB						30.5
		w/ PKG	dB						40.4
Tx	FFE	tap/pre						1/0	
	RJrms	mUI						10	
	SNR	dB						32.5	
Tx/ Rx	PKG trace	mm						27	
	Cd	fF						160	
	Cp	fF						no Cp (S-parameter)	
Rx	CTL E	HF/LF						2p-1z/1p-1z	
	eta0	V ² /GHz						1.64E-8	
	fr	x fb						GHz	3/8
	FFE	tap/pre	33/6	32/5	31/4	30/3	29/2	28/1	27/0
	DFE	tap							1
		RJrms	mUI						10
eye	width EW4	upp	92	92	87	85	69	0	0
		mid	128	128	124	125	117	26	0
		low	91	91	86	84	70	0	0
	height EH4	upp	38	38	34	33	26	0	0
		mid	41	41	37	36	29	2	0
		low	38	38	34	33	26	0	0

B-1 DFE output eye (#41)



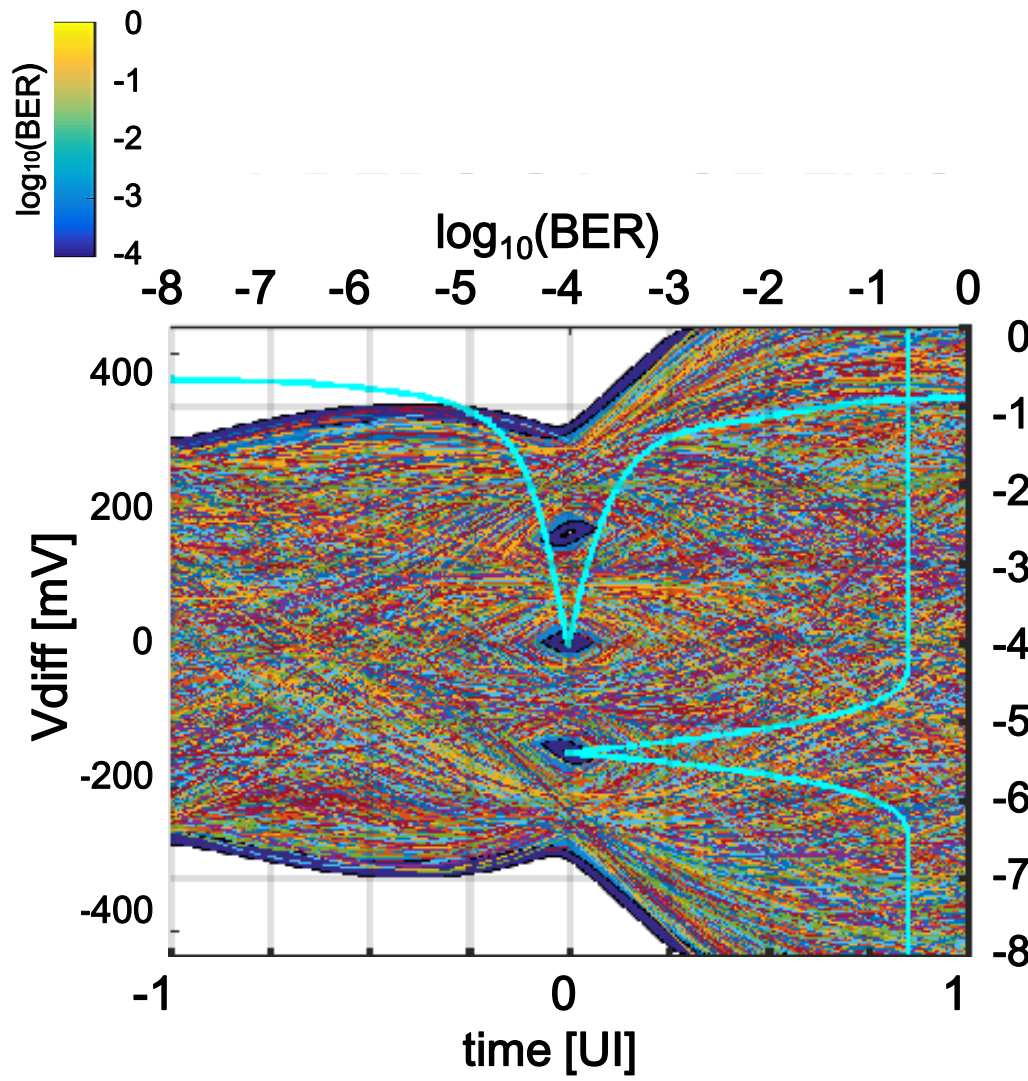
item	unit	#10	#41	#42	#43	#44		
baud rate	Gbd	58						
channel	type	2m(B), cabled BP						
	IL	no PKG	dB				30.5	
w/ PKG		dB	40.4	39.2				
Tx	FFE	tap/pre	1/0					
	RJrms	mUI	10					
	SNR	dB	32.5					
Tx/Rx	PKG	trace	mm	27	30 (COM PKG)			
	Cd	fF	160					
	Cp	fF	---	110				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz	3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap	1					
	RJrms	mUI	10					
eye	EW4	upp		93	93	82	14	14
		mid	mUI	131	126	113	21	20
		low		93	93	79	3	3
	EH4	upp		38	38	32	4	4
		mid	mV	40	40	33	3	3
		low		38	38	32	1	1

B-1 DFE output eye (#42)



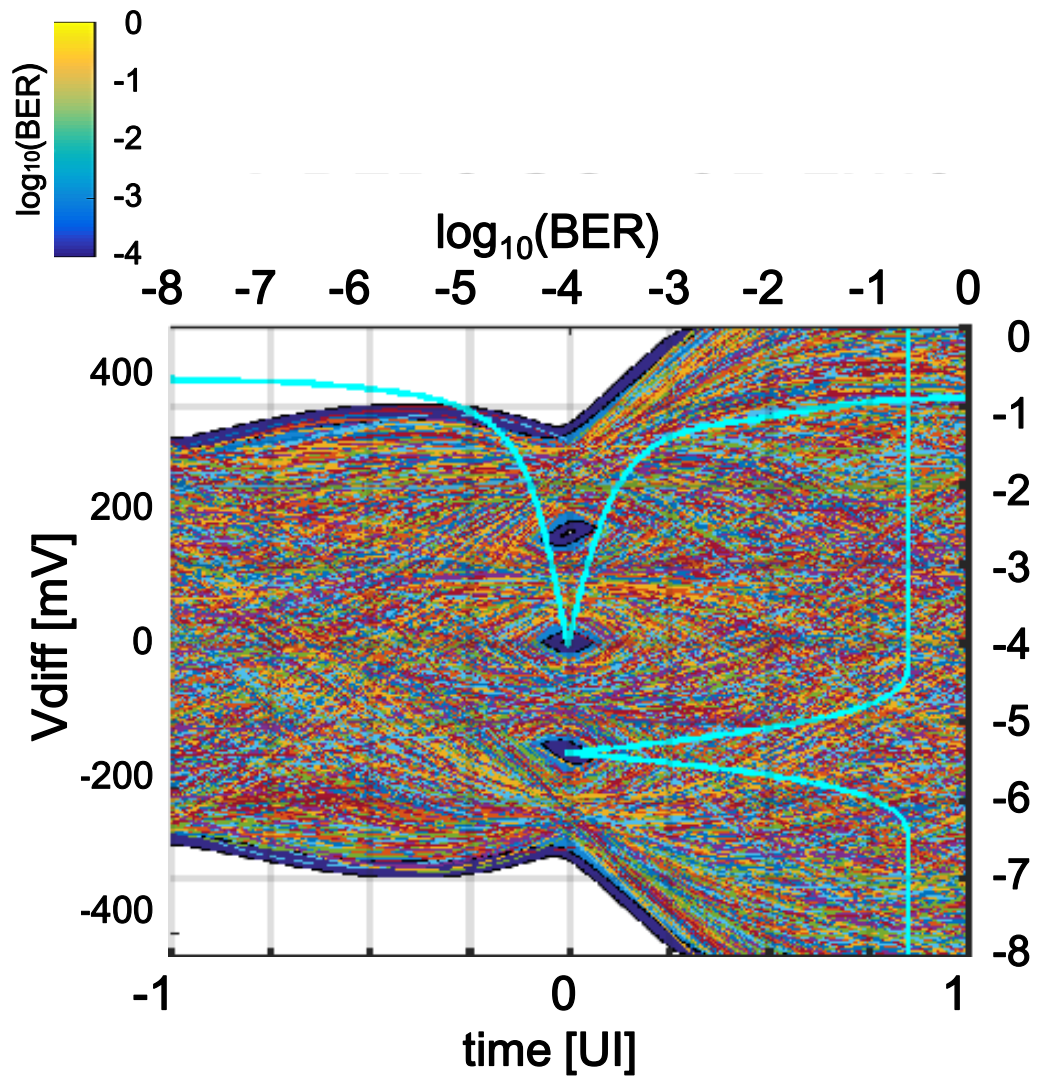
item	unit	#10	#41	#42	#43	#44	
baud rate	Gbd	58					
channel	type		2m(B), cabled BP				
	IL	no PKG	dB				30.5
		w/ PKG	dB	40.4	39.2		
Tx	FFE	tap/pre	1/0				
	RJrms	mUI	10				
	SNR	dB	32.5				
Tx/Rx	PKG	trace	mm	27	30 (COM PKG)		
	Cd	fF	160				
	Cp	fF	---	110			
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	1.64E-8				
	fr	x fb	GHz	3/8			
	FFE	tap/pre	54/5	32/5	24/5	18/5	
	DFE	tap	1				
	RJrms	mUI	10				
eye	EW4	upp	93	93	82	14	14
		mid	131	126	113	21	20
		low	93	93	79	3	3
	EH4	upp	38	38	32	4	4
		mid	40	40	33	3	3
		low	38	38	32	1	1

B-1 DFE output eye (#43)



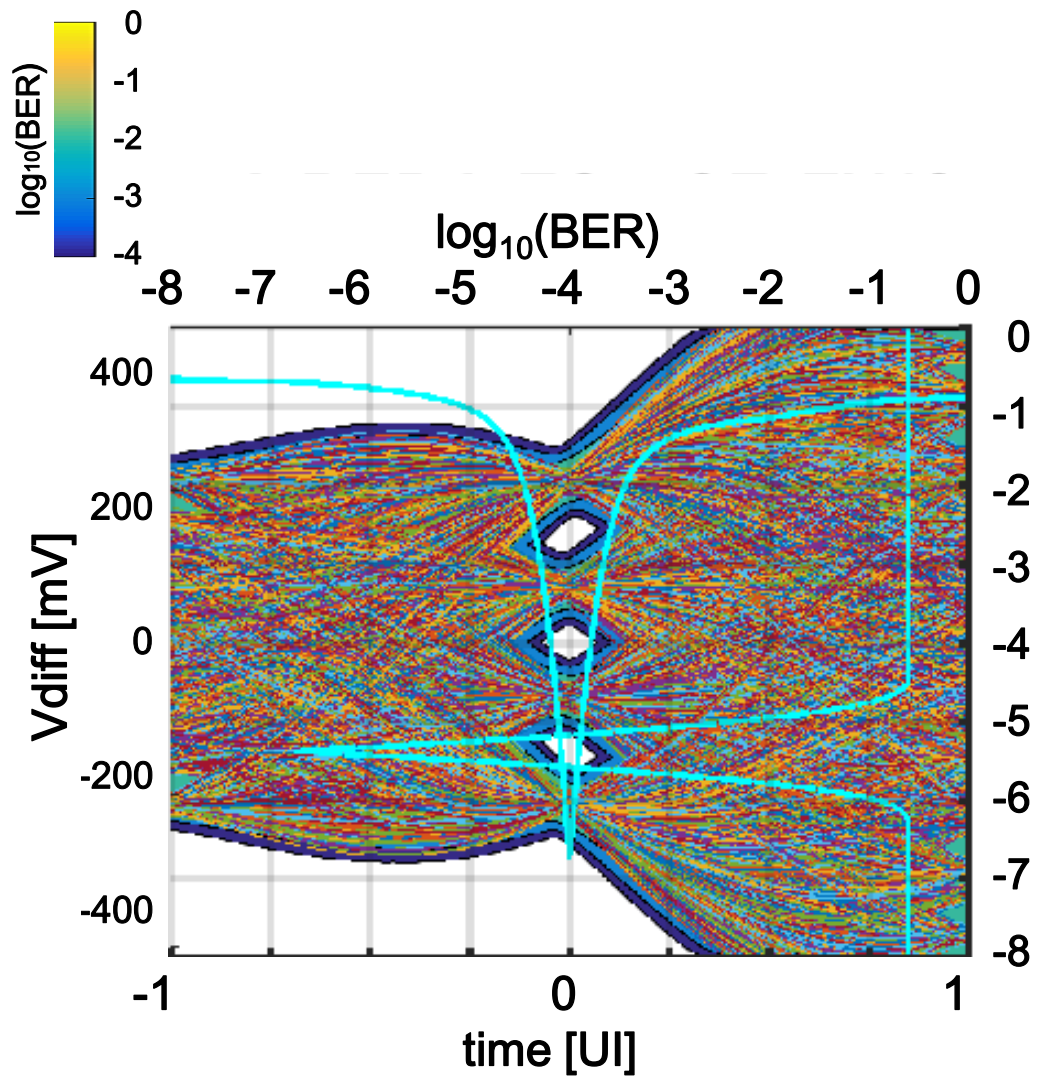
item	unit	#10	#41	#42	#43	#44						
baud rate	Gbd	58										
channel	type		2m(B), cabled BP									
	IL	no PKG	dB				30.5					
		w/ PKG	dB	40.4	39.2							
Tx	FFE	tap/pre		1/0								
	RJrms	mUI		10								
	SNR	dB		32.5								
Tx/ Rx	PKG	trace	mm	27	30 (COM PKG)							
	Cd	fF		160								
	Cp	fF		---	110							
Rx	CTLE	HF/LF	2p-1z/1p-1z									
	eta0	V ² /GHz		1.64E-8								
	fr	x fb	GHz	3/8								
	FFE	tap/pre		54/5	32/5	24/5	18/5					
	DFE	tap		1								
	RJrms	mUI		10								
eye	EW4	upp	mUI					93	93	82	14	14
		mid	mUI					131	126	113	21	20
		low	mUI					93	93	79	3	3
	EH4	upp	mV					38	38	32	4	4
		mid	mV					40	40	33	3	3
		low	mV					38	38	32	1	1

B-1 DFE output eye (#44)



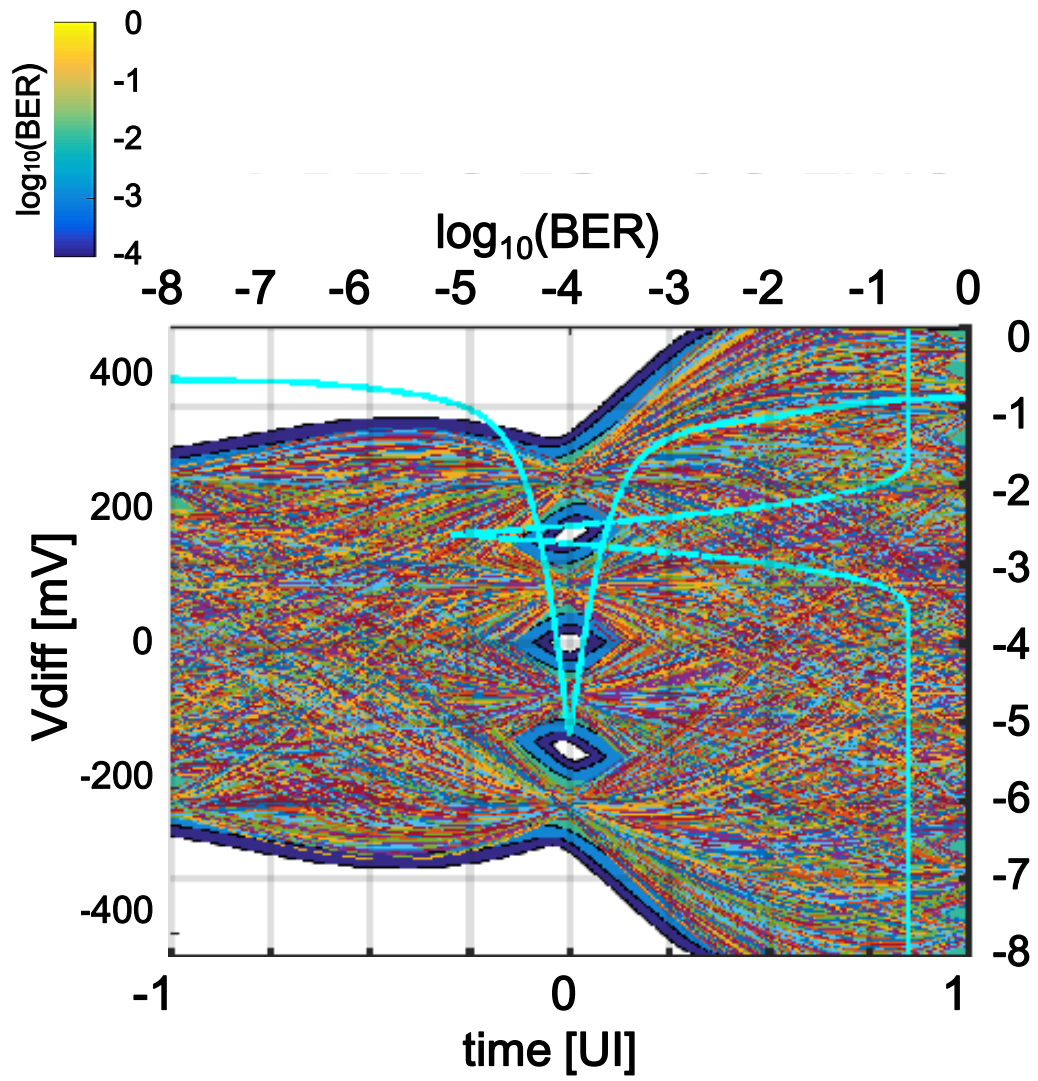
item	unit	#10	#41	#42	#43	#44		
baud rate	Gbd	58						
channel	type		2m(B), cabled BP					
	IL	no PKG	dB					
		w/ PKG	dB	40.4	39.2			
Tx	FFE	tap/pre	1/0					
	RJrms	mUI	10					
	SNR	dB	32.5					
Tx/ Rx	PKG	trace	mm	27	30 (COM PKG)			
	Cd	fF	160					
	Cp	fF	---	110				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz	1.64E-8					
	fr	x fb	GHz	3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap	1					
	RJrms	mUI	10					
eye	EW4	upp		93	93	82	14	14
		mid	mUI	131	126	113	21	20
		low		93	93	79	3	3
	EH4	upp		38	38	32	4	4
		mid	mV	40	40	33	3	3
		low		38	38	32	1	1

B-1 DFE output eye (#45)



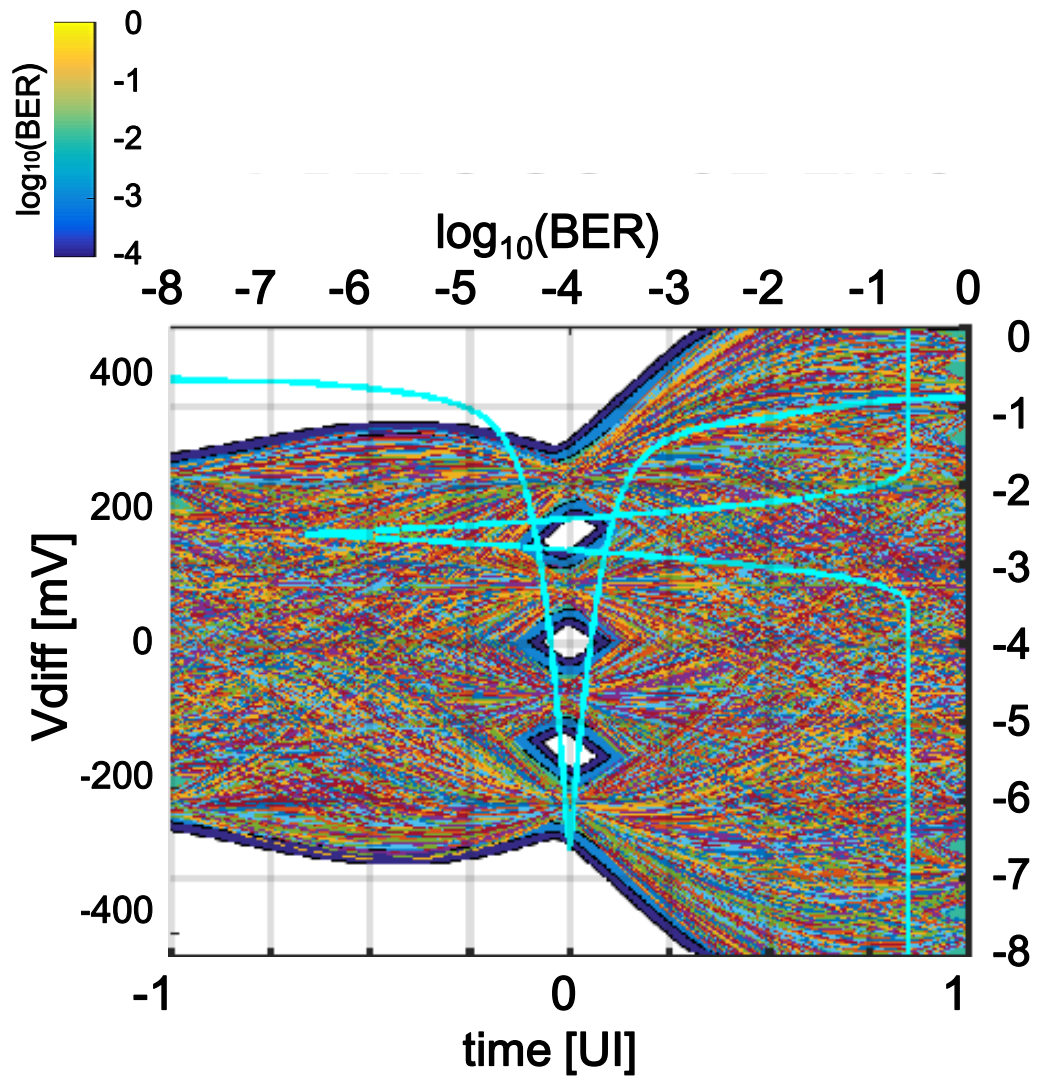
item		unit	#41	#45	
baud rate		Gbd	58		
chann el	type		2m(B), cabled BP		
	IL	no PKG	dB	30.5	
		w/ PKG	dB	39.2	
Tx	FFE	tap/pre	1/0		
	RJrms	mUI	10		
	SNR	dB	32.5		
Tx/ Rx	PKG	trace	mm	30 (COM PKG)	
	Cd		fF	160 100	
	Cp		fF	110	
Rx	CTLE	HF/LF	2p-1z/1p-1z		
	eta0	V ² /GHz	1.64E-8		
	fr	x fb	GHz	3/8	
	FFE	tap/pre	54/5		
	DFE	tap	1		
		RJrms	mUI	10	
eye	EW4	upp	mUI	93	102
		mid	mUI	131	138
		low	mUI	93	102
	EH4	upp	mV	38	42
		mid	mV	40	45
		low	mV	38	42

B-1 DFE output eye (#46)



item	unit	#41	#46	#47		
baud rate	Gbd	58				
channel	type		2m(B), cabled BP			
	IL	no PKG	dB			
		w/ PKG	dB			
Tx	FFE	tap/pre	1/0			
	RJrms	mUI	10			
	SNR	dB	32.5			
Tx/ Rx	PKG	trace	mm			
	Cd	fF	160			
	Cp	fF	110			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0	V ² /GHz	1.64E-8	8.2E-9	2.3E-9	
	fr	x fb	GHz	3/8	3/4	
	FFE	tap/pre	54/5			
	DFE	tap	1			
	RJrms	mUI	10			
eye	EW4	upp	mUI	93	66	100
		mid	mUI	126	99	135
		low	mUI	93	66	100
	EH4	upp	mV	38	24	43
		mid	mV	40	26	45
		low	mV	38	24	43

B-1 DFE output eye (#47)

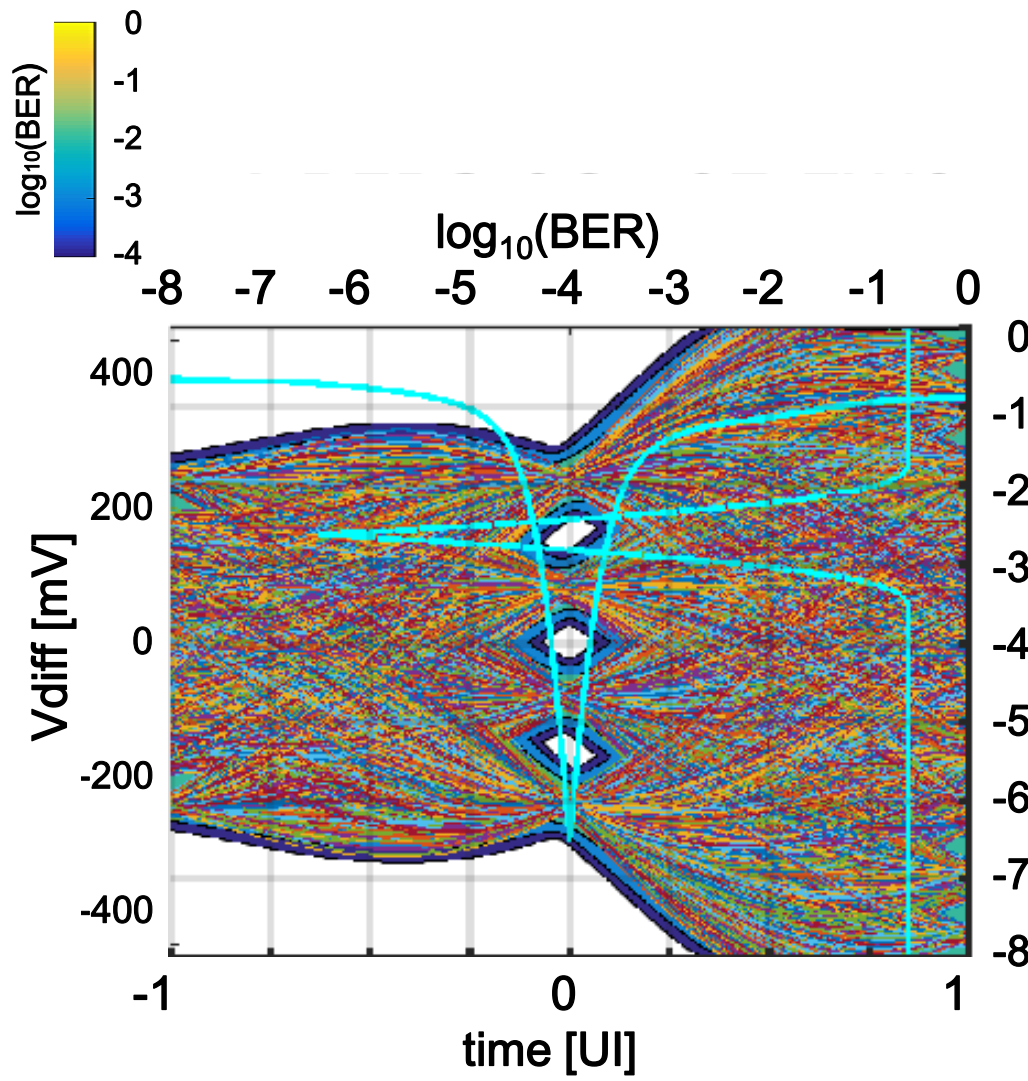


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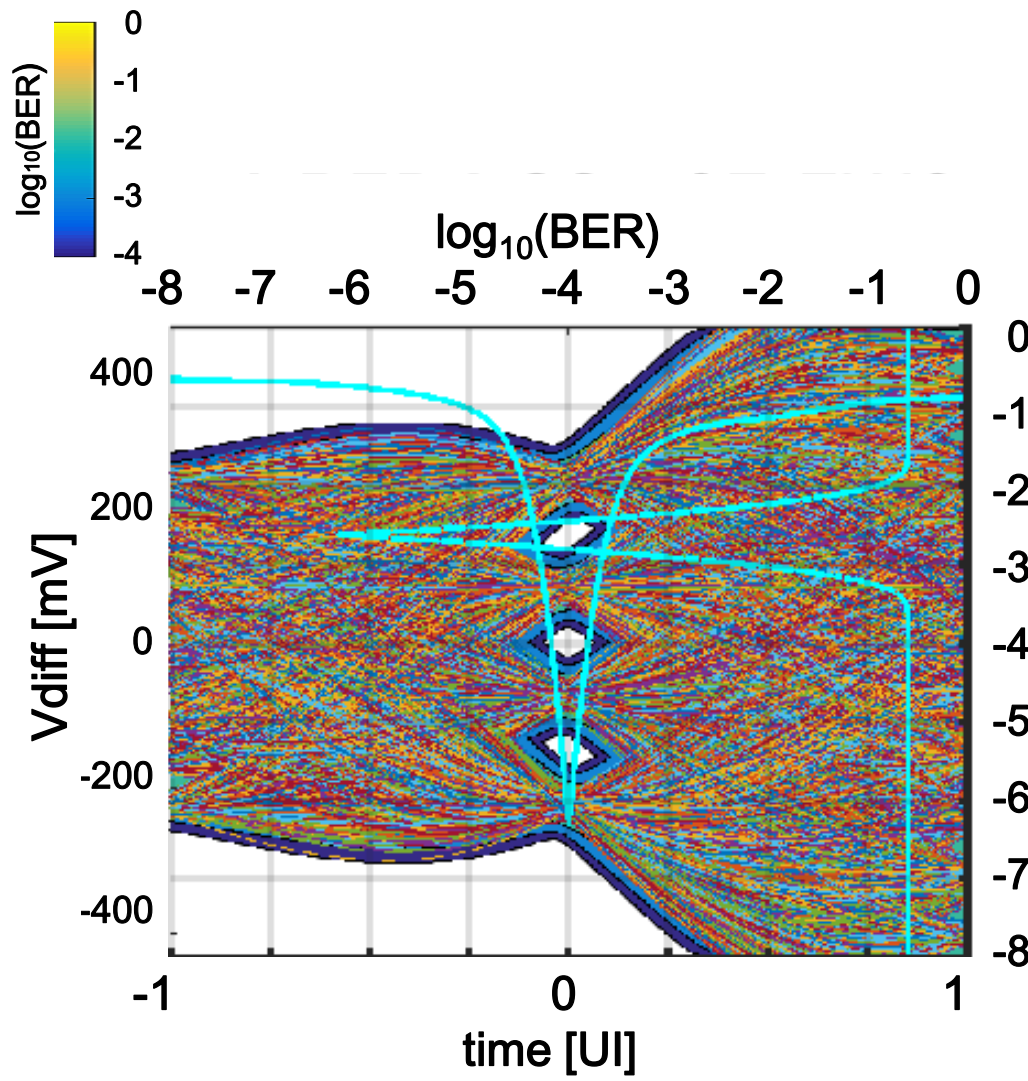
item	unit	#41	#46	#47		
baud rate	Gbd	58				
channel	type		2m(B), cabled BP			
	IL	no PKG	dB			
		w/ PKG	dB			
Tx	FFE	tap/pre	1/0			
	RJrms	mUI	10			
	SNR	dB	32.5			
Tx/ Rx	PKG	trace	mm			
	Cd	fF	160			
	Cp	fF	110			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0	V ² /GHz	1.64E-8	8.2E-9	2.3E-9	
	fr	x fb	GHz	3/8	3/4	
	FFE	tap/pre	54/5			
	DFE	tap	1			
	RJrms	mUI	10			
eye	EW4	upp	mUI	93	66	100
		mid	mUI	126	99	135
		low	mUI	93	66	100
	EH4	upp	mV	38	24	43
		mid	mV	40	26	45
		low	mV	38	24	43

B-1 DFE output eye (#48)



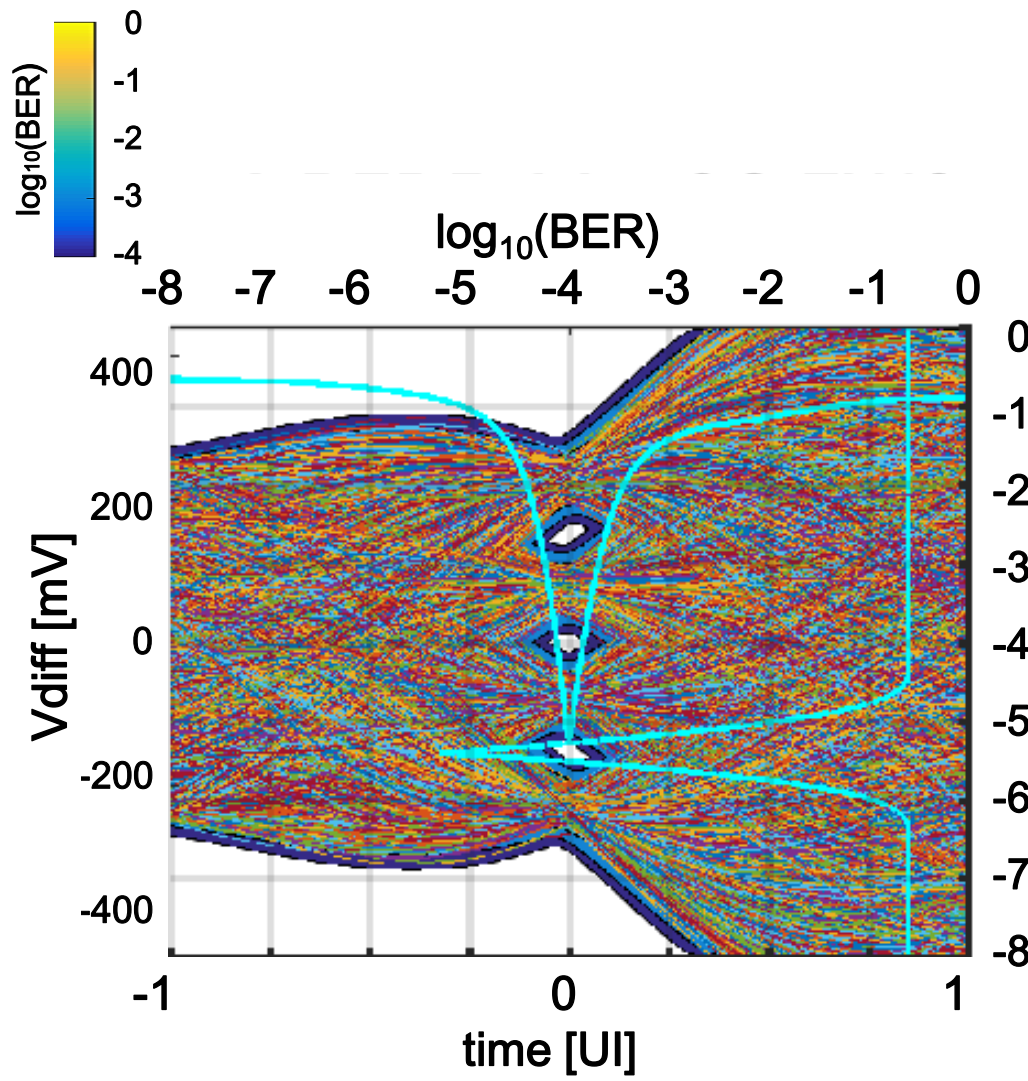
item	unit	#41	#48	#49	#50	#51	
baud rate	Gbd	58					
channel	type	2m(B), cabled BP					
	IL	no PKG	dB				30.5
w/ PKG		dB	39.2	38.1			
Tx	FFE	tap/pre	1/0				
	RJrms	mUI	10				
	SNR	dB	32.5				
Tx/Rx	PKG	trace	mm				30 (COM PKG)
	Cd	fF	160				
	Cp	fF	110	60			
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	1.64E-8				
	fr	x fb	GHz				3/8
	FFE	tap/pre	54/5	32/5	24/5	18/5	
	DFE	tap	1				
	RJrms	mUI	10				
eye	EW4	upp	93	98	94	69	69
		mid	126	134	128	95	95
		low	93	98	93	67	67
	EH4	upp	38	40	39	27	27
		mid	40	43	41	26	26
		low	38	40	39	26	25

B-1 DFE output eye (#49)



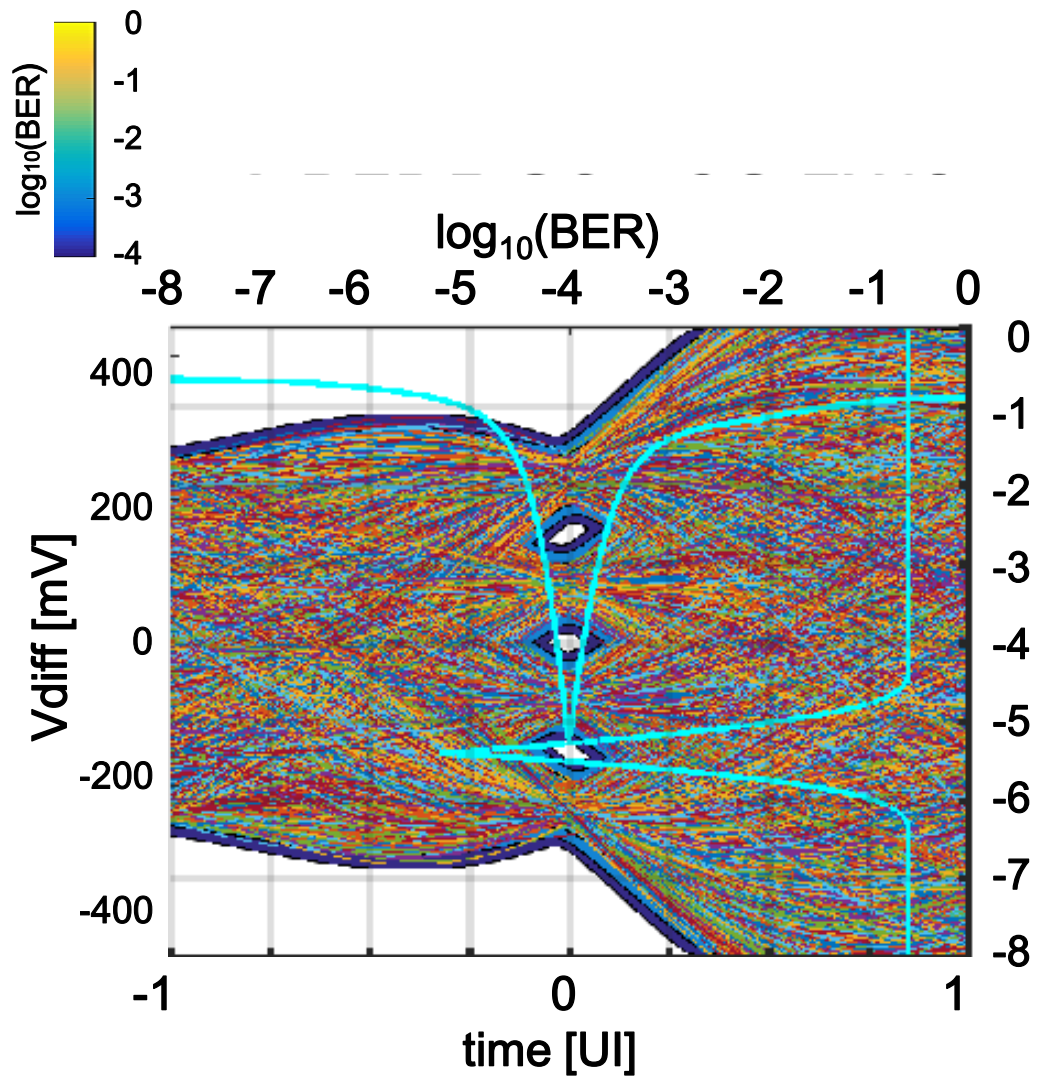
item	unit	#41	#48	#49	#50	#51			
baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB		30.5				
w/ PKG		dB		39.2	38.1				
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/ Rx	PKG	trace	mm		30 (COM PKG)				
	Cd	fF		160					
	Cp	fF		110	60				
Rx	CTLE	HF/LF		2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz		3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	98	94	69	69
		mid	mUI		126	134	128	95	95
		low	mUI		93	98	93	67	67
	EH4	upp	mV		38	40	39	27	27
		mid	mV		40	43	41	26	26
		low	mV		38	40	39	26	25

B-1 DFE output eye (#50)



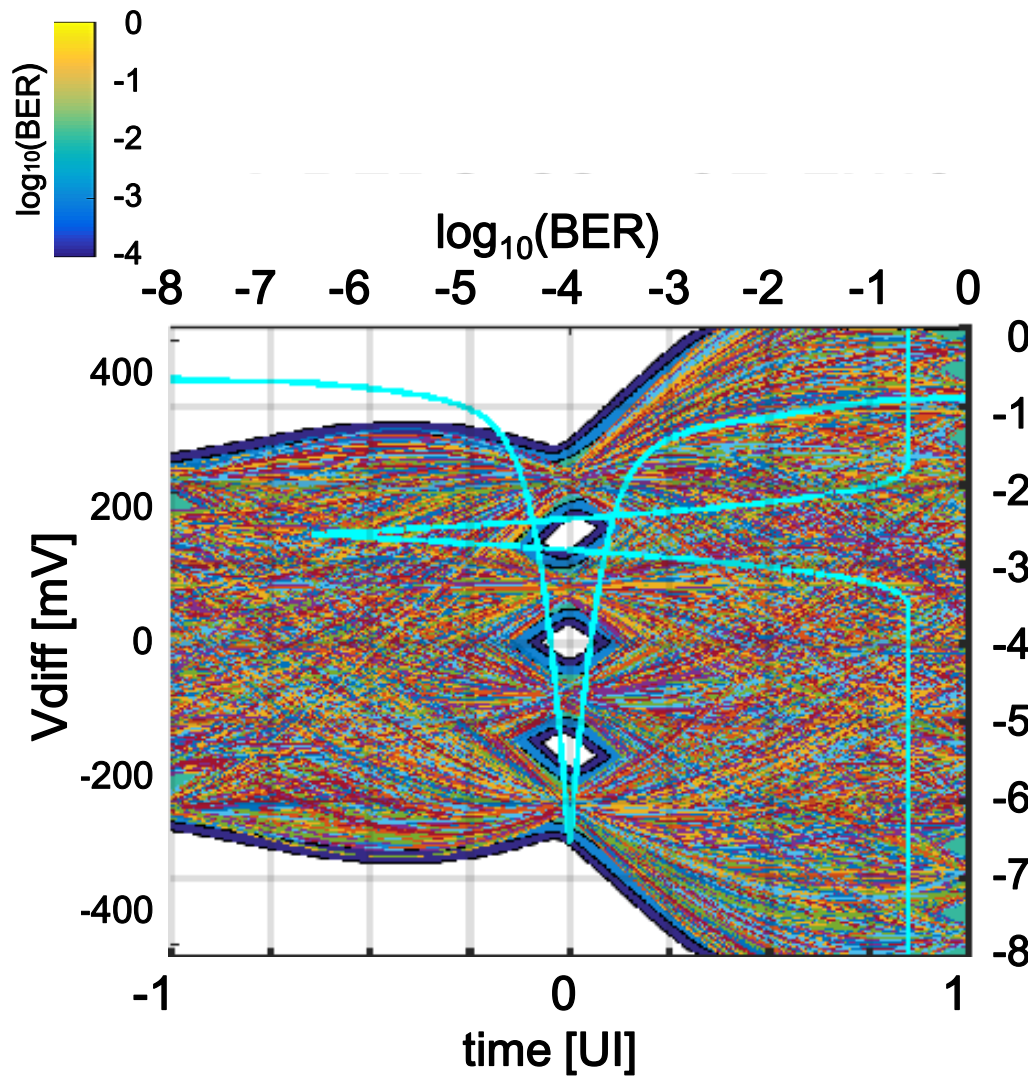
item	unit	#41	#48	#49	#50	#51	
baud rate	Gbd	58					
channel	type	2m(B), cabled BP					
	IL	no PKG	dB				30.5
		w/ PKG	dB	39.2	38.1		
Tx	FFE	tap/pre	1/0				
	RJrms	mUI	10				
	SNR	dB	32.5				
Tx/Rx	PKG	trace	mm				30 (COM PKG)
	Cd	fF	160				
	Cp	fF	110	60			
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	1.64E-8				
	fr	x fb	GHz				3/8
	FFE	tap/pre	54/5	32/5	24/5	18/5	
	DFE	tap	1				
	RJrms	mUI	10				
eye	EW4	upp	93	98	94	69	69
		mid	126	134	128	95	95
		low	93	98	93	67	67
	EH4	upp	38	40	39	27	27
		mid	40	43	41	26	26
		low	38	40	39	26	25

B-1 DFE output eye (#51)



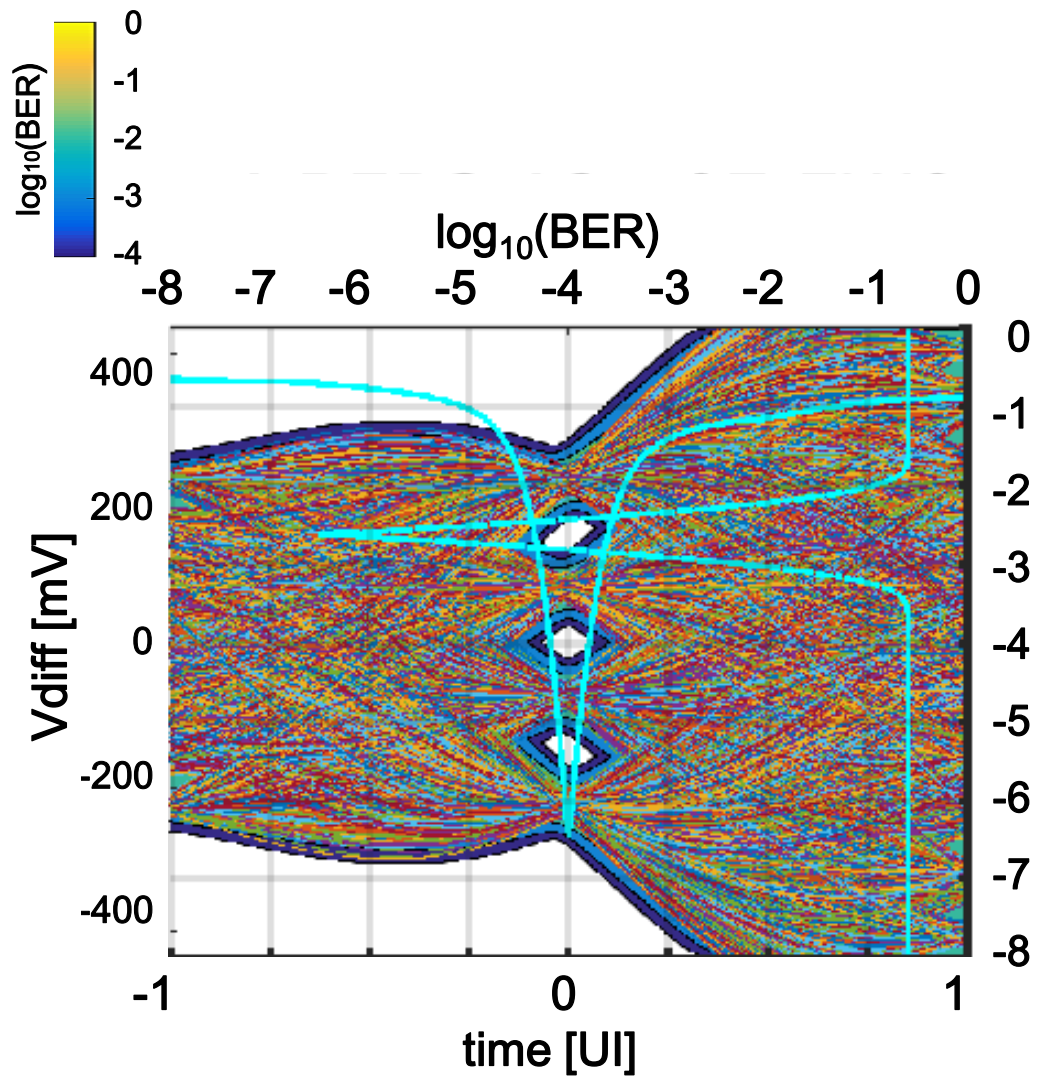
item	unit	#41	#48	#49	#50	#51			
baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB				30.5		
		w/ PKG	dB	39.2	38.1				
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/Rx	PKG	trace	mm				30 (COM PKG)		
	Cd	fF		160					
	Cp	fF		110	60				
Rx	CTLE	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz		3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	98	94	69	69
		mid	mUI		126	134	128	95	95
		low	mUI		93	98	93	67	67
	EH4	upp	mV		38	40	39	27	27
		mid	mV		40	43	41	26	26
		low	mV		38	40	39	26	25

B-1 DFE output eye (#52)



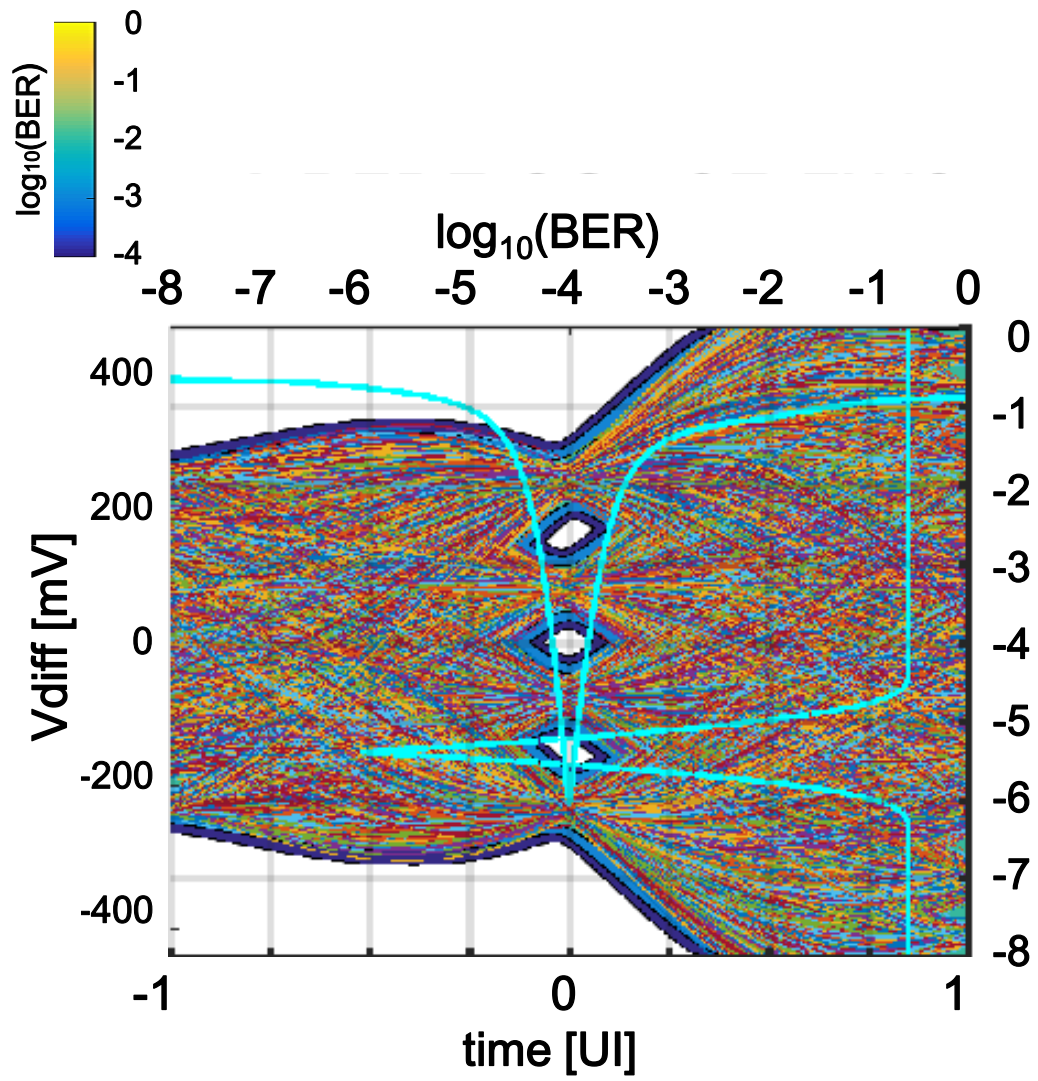
item	unit	#41	#52	#53	#54	#55			
5baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB				30.5		
w/ PKG		dB		39.2	38.1				
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/ Rx	PKG	trace	mm		30 (COM PKG)				
	Cd	fF		160					
	Cp	fF		110	30				
Rx	CTLE	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz		3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	100	98	90	89
		mid	mUI		126	137	134	123	123
		low	mUI		93	101	98	90	89
	EH4	upp	mV		38	41	42	37	37
		mid	mV		40	44	44	38	38
		low	mV		38	41	42	37	36

B-1 DFE output eye (#53)



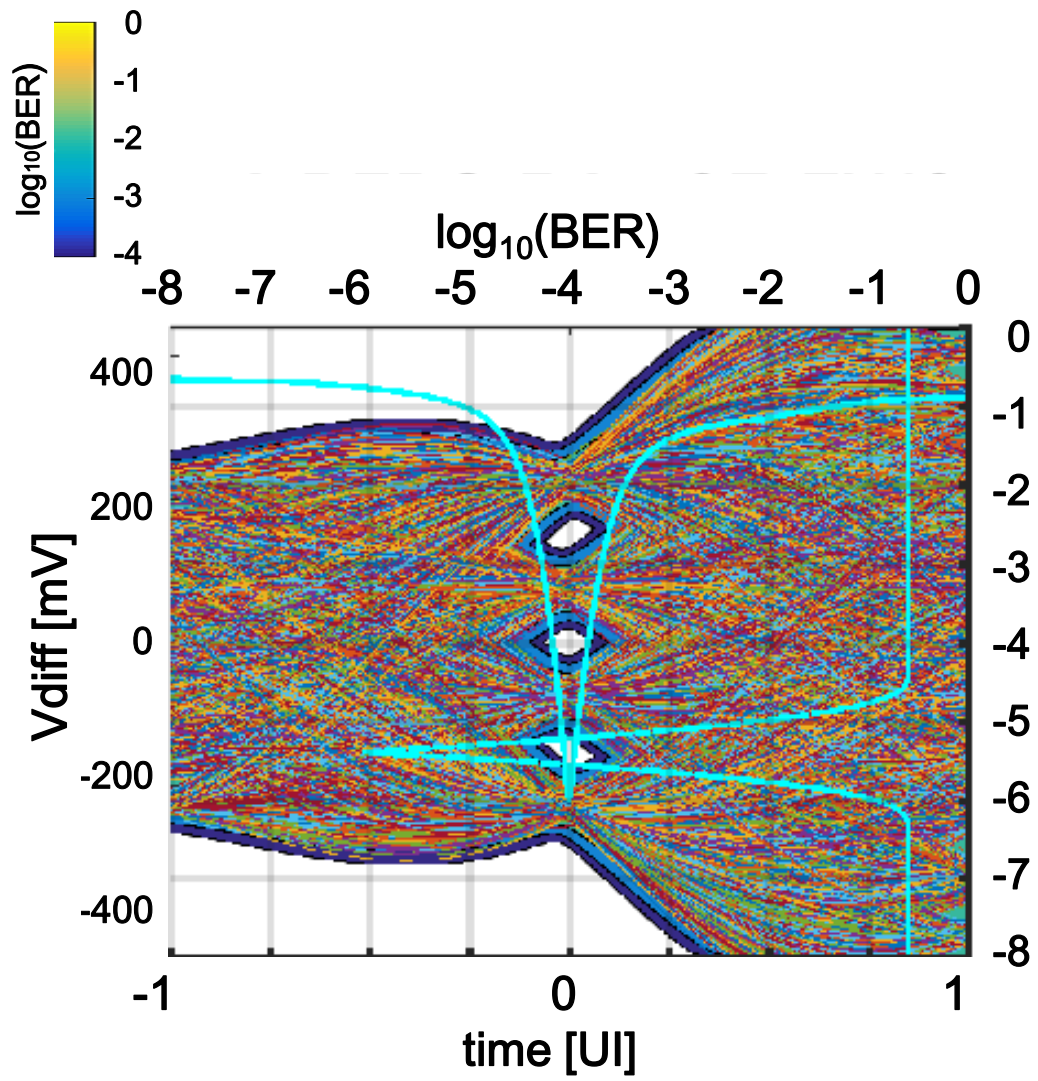
item	unit	#41	#52	#53	#54	#55		
5baud rate	Gbd	58						
channel	type		2m(B), cabled BP					
	IL	no PKG	dB		30.5			
w/ PKG		dB	39.2	38.1				
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm		30 (COM PKG)			
	Cd	fF		160				
	Cp	fF	110	30				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz		3/8			
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap		1				
		RJrms	mUI		10			
eye	EW4	upp	mUI	93	100	98	90	89
		mid	mUI	126	137	134	123	123
		low	mUI	93	101	98	90	89
	EH4	upp	mV	38	41	42	37	37
		mid	mV	40	44	44	38	38
		low	mV	38	41	42	37	36

B-1 DFE output eye (#54)



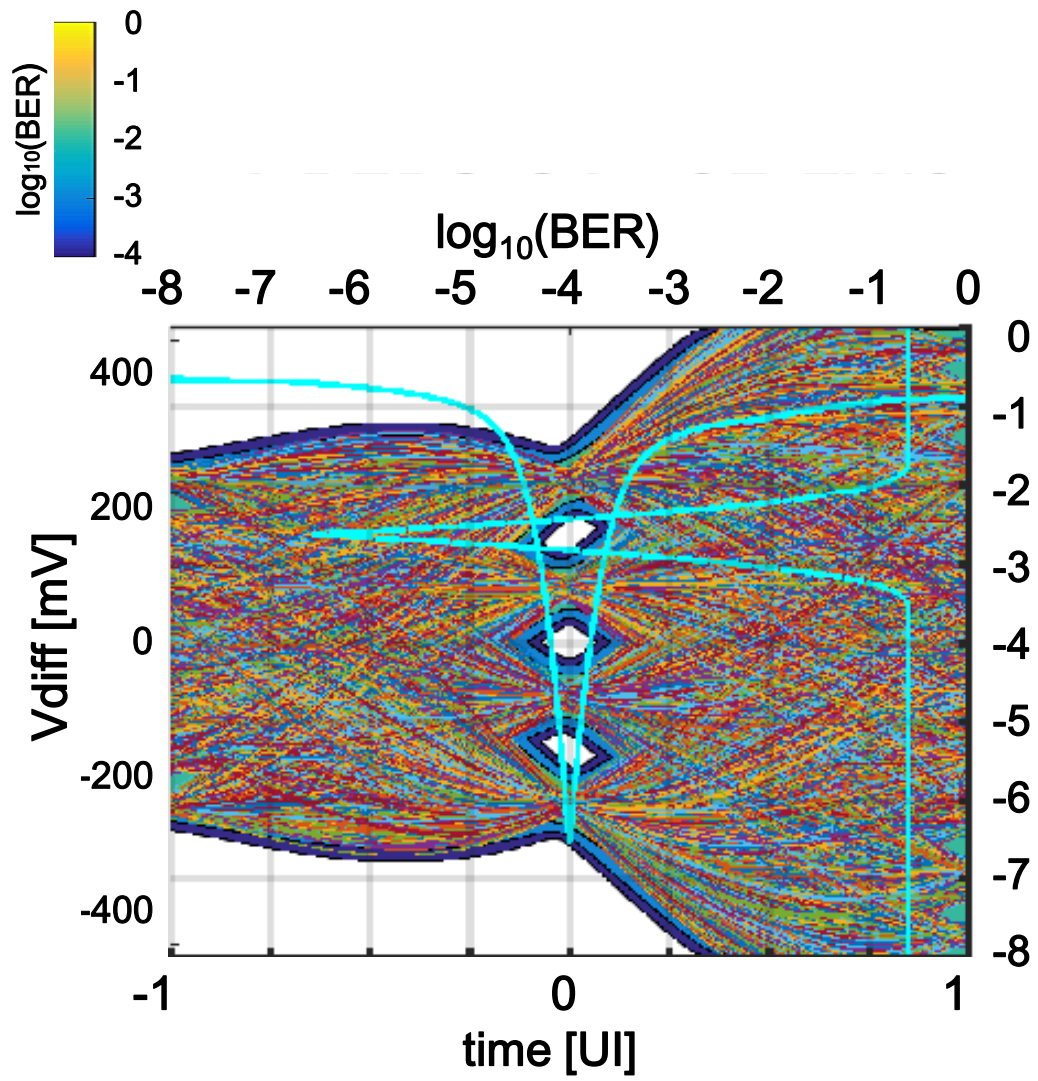
item	unit	#41	#52	#53	#54	#55		
5baud rate	Gbd	58						
channel	type		2m(B), cabled BP					
	IL	no PKG	dB				30.5	
		w/ PKG	dB	39.2	38.1			
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm		30 (COM PKG)			
	Cd	fF		160				
	Cp	fF	110	30				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz		3/8			
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap		1				
		RJrms	mUI		10			
eye	EW4	upp	mUI	93	100	98	90	89
		mid	mUI	126	137	134	123	123
		low	mUI	93	101	98	90	89
	EH4	upp	mV	38	41	42	37	37
		mid	mV	40	44	44	38	38
		low	mV	38	41	42	37	36

B-1 DFE output eye (#55)



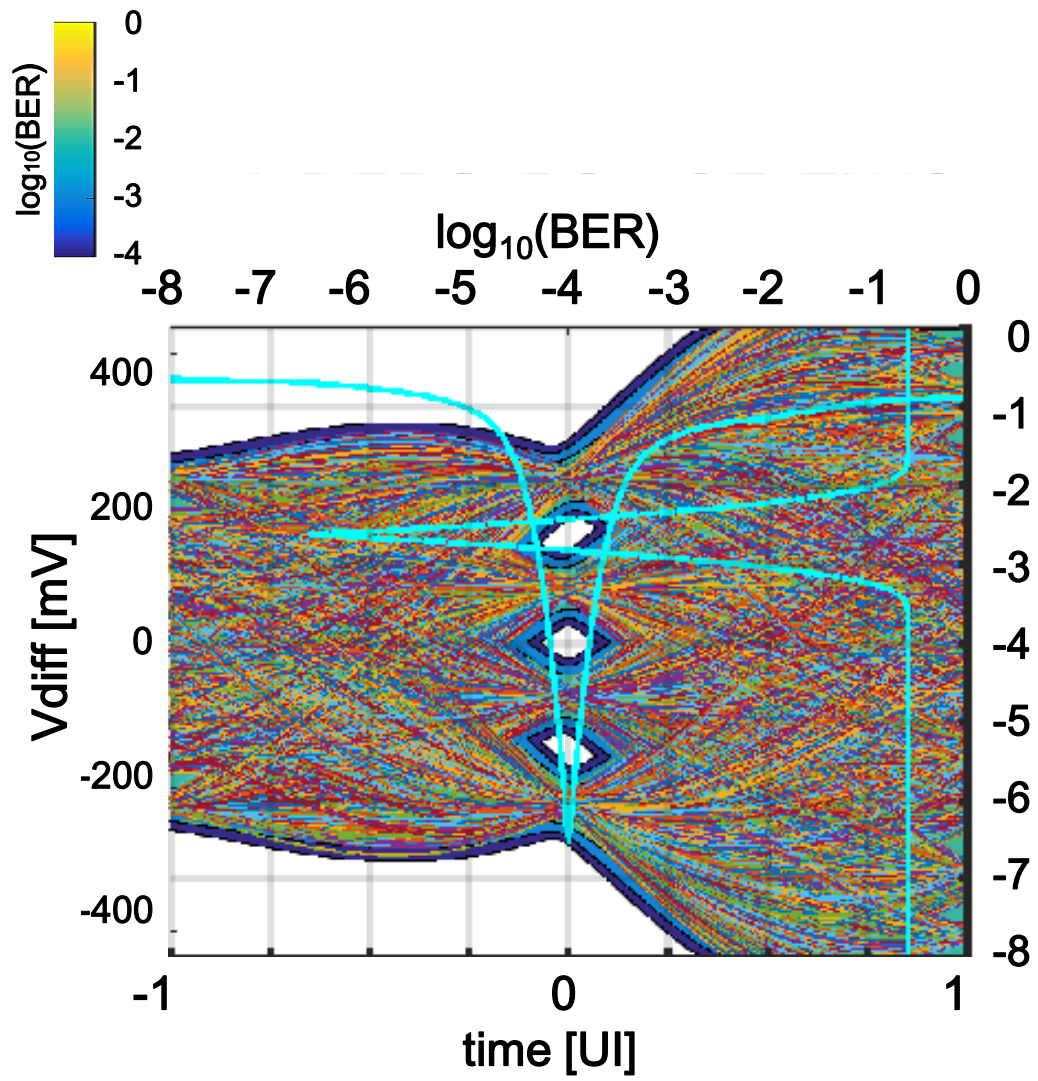
item	unit	#41	#52	#53	#54	#55			
5baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB				30.5		
		w/ PKG	dB	39.2	38.1				
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/Rx	PKG	trace	mm				30 (COM PKG)		
	Cd	fF		160					
	Cp	fF		110	30				
Rx	CTLE	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz				3/8		
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	100	98	90	89
		mid	mUI		126	137	134	123	123
		low	mUI		93	101	98	90	89
	EH4	upp	mV		38	41	42	37	37
		mid	mV		40	44	44	38	38
		low	mV		38	41	42	37	36

B-1 DFE output eye (#56)



item	unit	#41	#56	#57	#58	#59	
5baud rate	Gbd	58					
channel	type		2m(B), cabled BP				
	IL	no PKG	dB				30.5
		w/ PKG	dB	39.2	38.1		
Tx	FFE	tap/pre		1/0			
	RJrms	mUI		10			
	SNR	dB		32.5			
Tx/Rx	PKG	trace	mm				30 (COM PKG)
	Cd	fF		160			
	Cp	fF		110	0		
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz		1.64E-8			
	fr	x fb	GHz		3/8		
	FFE	tap/pre		54/5	32/5	24/5	18/5
	DFE	tap		1			
		RJrms	mUI		10		
eye	EW4	upp	93	100	99	99	98
		mid	126	140	138	137	137
		low	93	101	100	99	99
	EH4	upp	38	41	43	42	42
		mid	40	44	45	45	44
		low	38	41	43	42	42

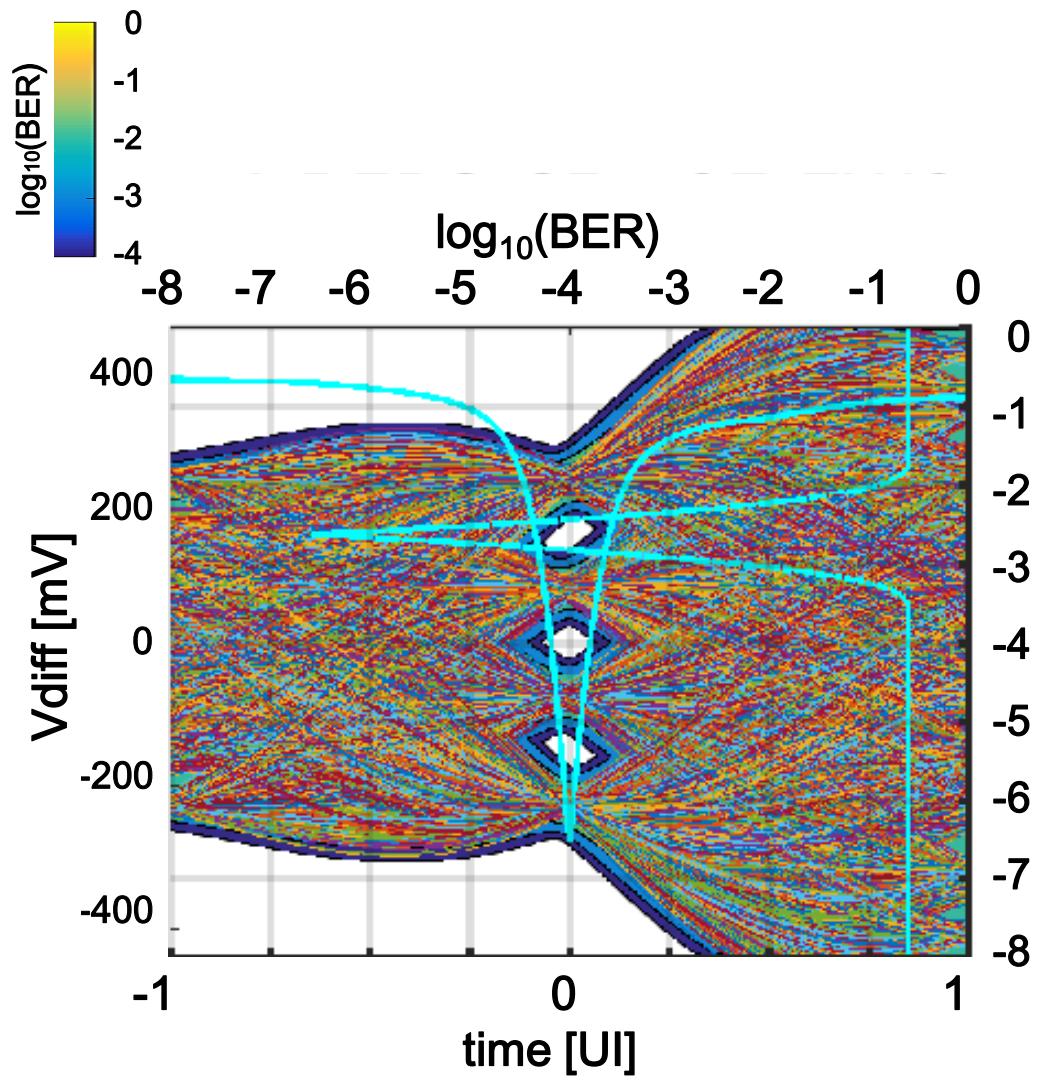
B-1 DFE output eye (#57)



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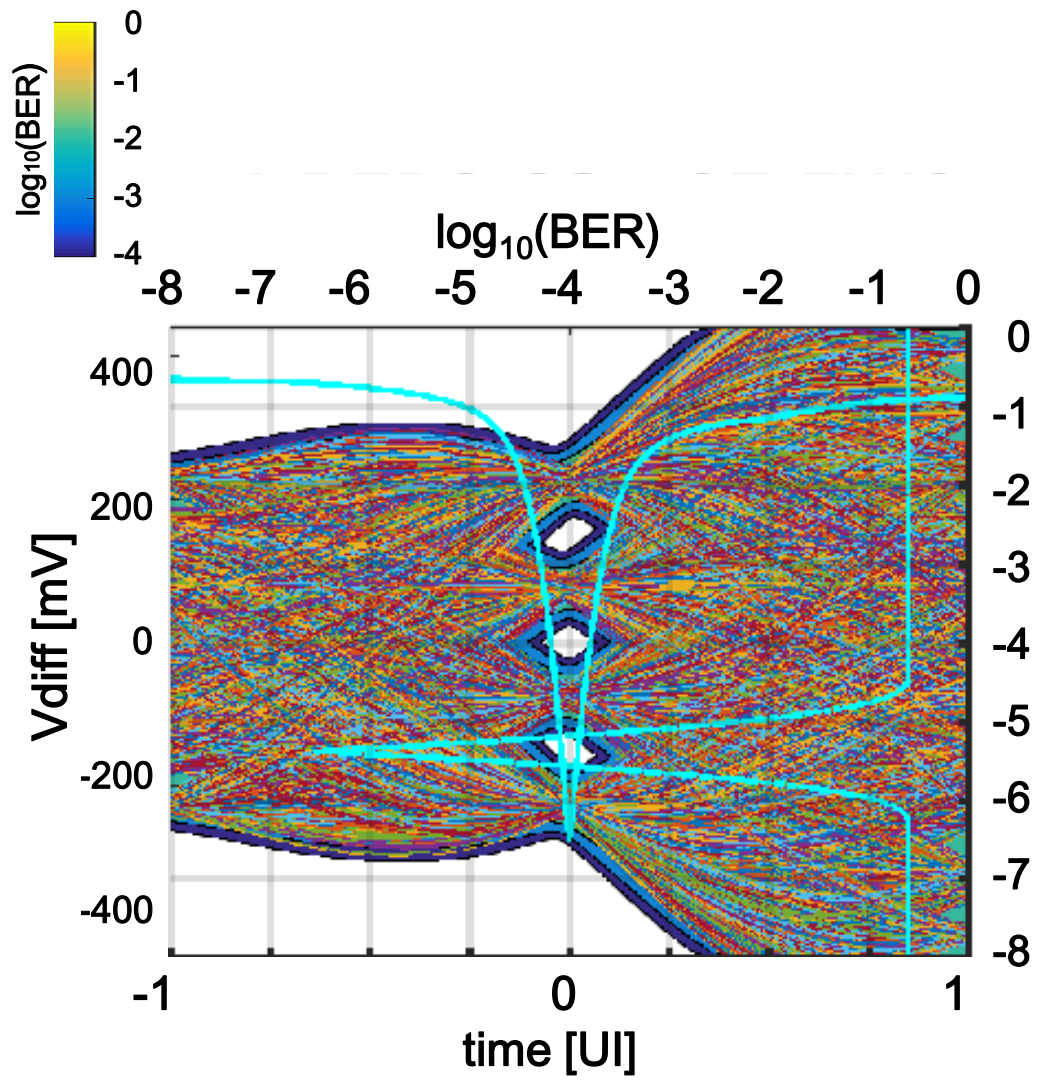
item	unit	#41	#56	#57	#58	#59		
5baud rate	Gbd	58						
channel	type		2m(B), cabled BP					
	IL	no PKG	dB				30.5	
		w/ PKG	dB	39.2	38.1			
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm		30 (COM PKG)			
	Cd	fF		160				
	Cp	fF	110	0				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz		3/8			
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap		1				
		RJrms	mUI		10			
eye	EW4	upp	mUI	93	100	99	99	98
		mid	mUI	126	140	138	137	137
		low	mUI	93	101	100	99	99
	EH4	upp	mV	38	41	43	42	42
		mid	mV	40	44	45	45	44
		low	mV	38	41	43	42	42

B-1 DFE output eye (#58)



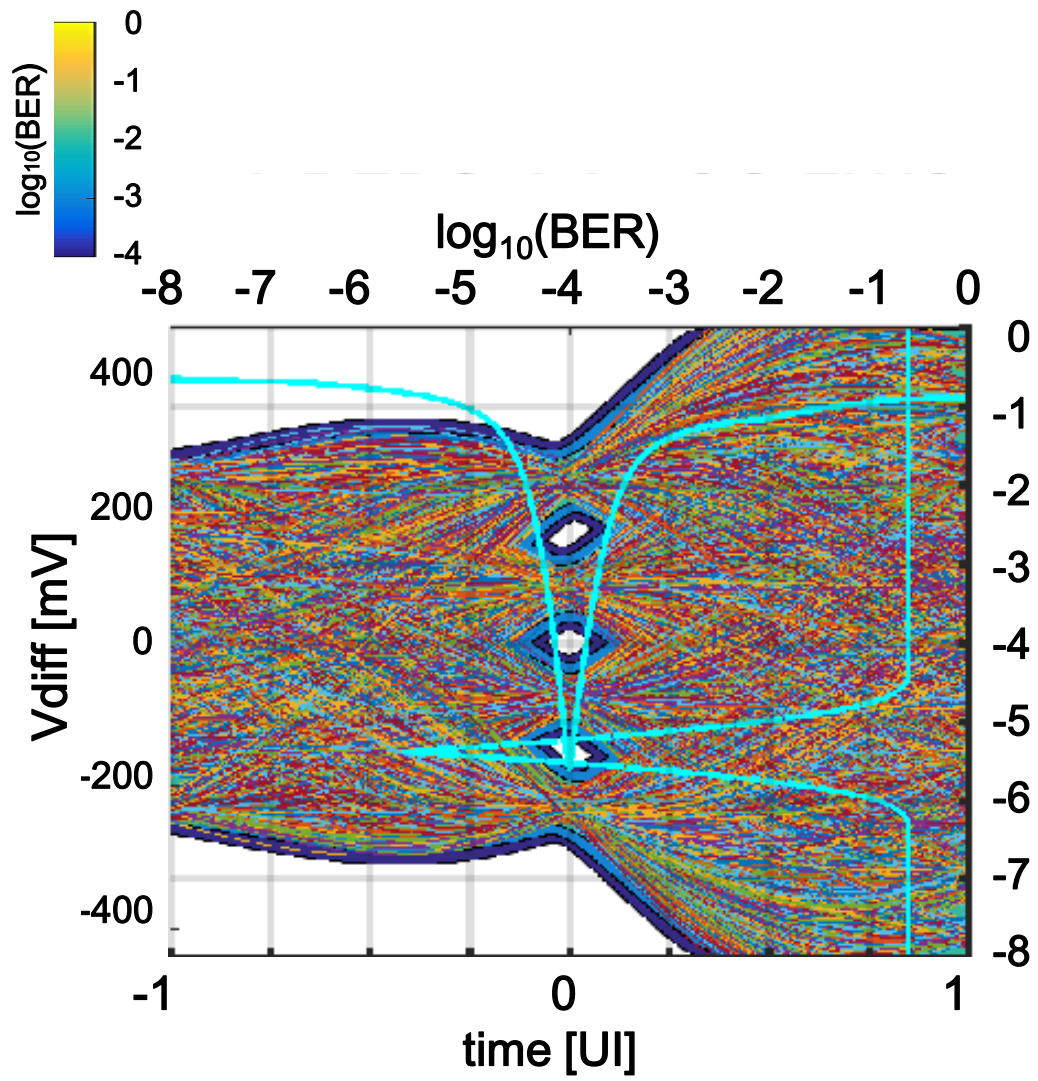
item	unit	#41	#56	#57	#58	#59			
5baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB		30.5				
		w/ PKG	dB		39.2	38.1			
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/ Rx	PKG	trace	mm		30 (COM PKG)				
	Cd	fF		160					
	Cp	fF		110	0				
Rx	CTLE	HF/LF		2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz		3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	100	99	99	98
		mid	mUI		126	140	138	137	137
		low	mUI		93	101	100	99	99
	EH4	upp	mV		38	41	43	42	42
		mid	mV		40	44	45	45	44
		low	mV		38	41	43	42	42

B-1 DFE output eye (#59)



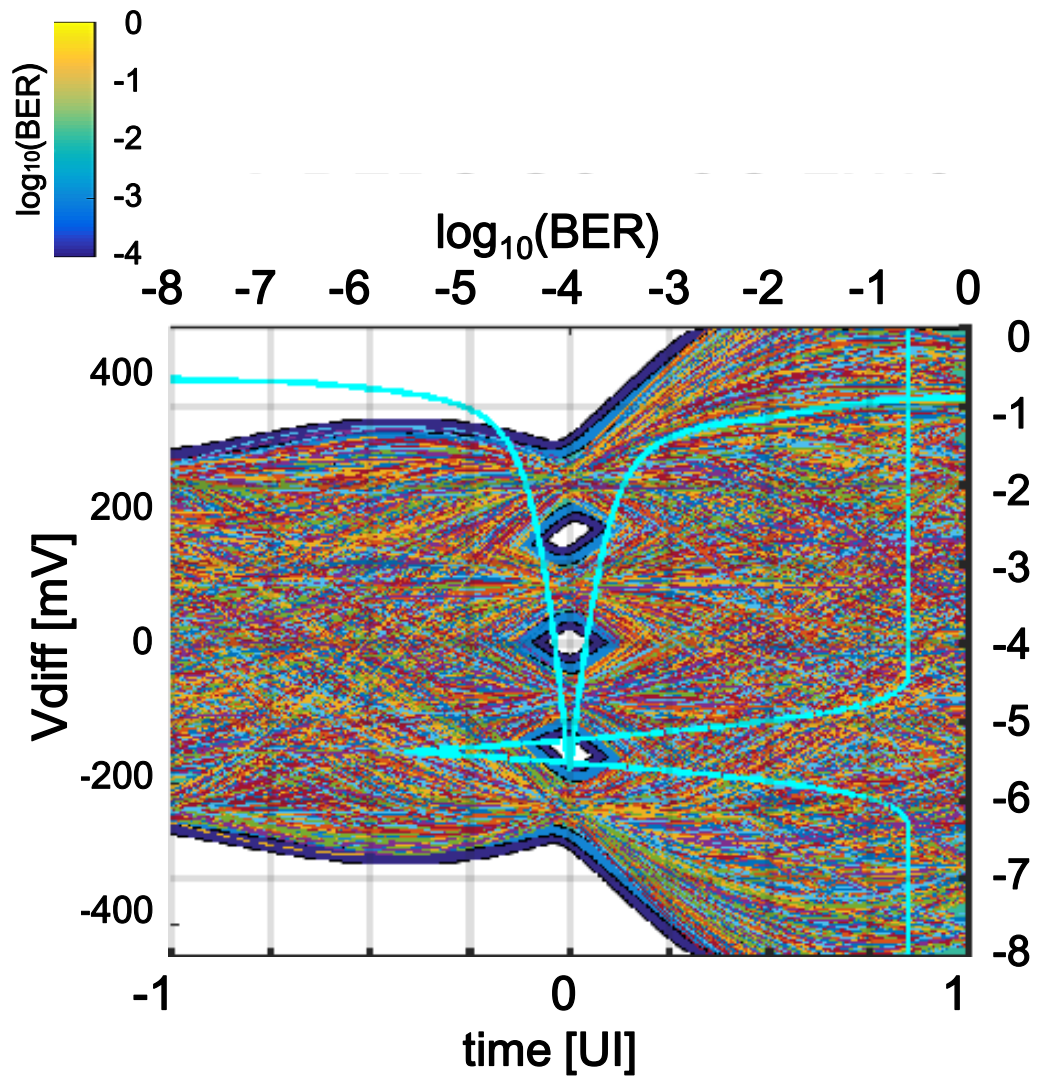
item	unit	#41	#56	#57	#58	#59			
5baud rate	Gbd	58							
channel	type		2m(B), cabled BP						
	IL	no PKG	dB				30.5		
		w/ PKG	dB	39.2	38.1				
Tx	FFE	tap/pre		1/0					
	RJrms	mUI		10					
	SNR	dB		32.5					
Tx/ Rx	PKG	trace	mm		30 (COM PKG)				
	Cd	fF		160					
	Cp	fF	110	0					
Rx	CTLE	HF/LF	2p-1z/1p-1z						
	eta0	V ² /GHz		1.64E-8					
	fr	x fb	GHz		3/8				
	FFE	tap/pre		54/5	32/5	24/5	18/5		
	DFE	tap		1					
		RJrms	mUI		10				
eye	EW4	upp	mUI		93	100	99	99	98
		mid	mUI		126	140	138	137	137
		low	mUI		93	101	100	99	99
	EH4	upp	mV		38	41	43	42	42
		mid	mV		40	44	45	45	44
		low	mV		38	41	43	42	42

B-1 DFE output eye (#60)



item	unit	#10	#16	#60	#61			
5baud rate	Gbd	58						
chan nel	type		2m(B), cabled BP					
	IL	no PKG	dB			30.5		
		w/ PKG	dB			40.4		
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm			27mm		
	Cd	fF			160			
	Cp	fF			--- (S-param)			
Rx	CTLE	HF/LF				2p-1z/1p-1z		
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz			3/8		
	FFE	tap/pre		54/5	32/5	24/5	18/5	
	DFE	tap		1				
		RJrms	mUI		10			
eye	EW4	upp	mUI		93	92	80	79
		mid	mUI		131	128	115	114
		low	mUI		93	91	80	79
	EH4	upp	mV		38	38	33	32
		mid	mV		40	41	35	35
		low	mV		38	38	32	32

B-1 DFE output eye (#61)



item	unit	#10	#16	#60	#61			
5baud rate	Gbd	58						
chan nel	type		2m(B), cabled BP					
	IL	no PKG	dB					
		w/ PKG	dB					
Tx	FFE	tap/pre		1/0				
	RJrms	mUI		10				
	SNR	dB		32.5				
Tx/ Rx	PKG	trace	mm					
	Cd	fF		160				
	Cp	fF		--- (S-param)				
Rx	CTLE	HF/LF	2p-1z/1p-1z					
	eta0	V ² /GHz		1.64E-8				
	fr	x fb	GHz					
	FFE	tap/pre	54/5	32/5	24/5	18/5		
	DFE	tap	1					
	RJrms	mUI		10				
eye	EW4	upp	mUI		93	92	80	79
		mid	mUI		131	128	115	114
		low	mUI		93	91	80	79
	EH4	upp	mV		38	38	33	32
		mid	mV		40	41	35	35
		low	mV		38	38	32	32

C-1 CTLE parameters

parameter	freq.	symbol	unit	#10	#11	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22	#23
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.008	0.008	0.004 0.021	---	0.004 0.021	0.008	---	0.008	0.008	0.008	0.008	0.008	0.008
zero	HF	fz	fb	0.029	0.015	0.036	0.019	0.048	0.039	0.033	0.040	0.032	0.033	0.034	0.030	0.030
	LF	fLF		0.006	0.006	0.003 0.016	---	0.003 0.014	0.005	---	0.005	0.006	0.006	0.006	0.006	0.006

parameter	freq.	symbol	unit	#41	#42	#43	#44	#45	#46	#47	#48	#49	#50	#51
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.4	0.4	0.2	0.2	0.2	0.2
	LF	fLF		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
zero	HF	fz	fb	0.033	0.039	0.039	0.039	0.037	0.038	0.038	0.037	0.039	0.039	0.039
	LF	fLF		0.005	0.005	0.005	0.005	0.006	0.005	0.005	0.005	0.006	0.005	0.005

parameter	freq.	symbol	unit	#52	#53	#54	#55	#56	#57	#58	#59	#10	#16	#60	#61
pole	HF	fp1	fb	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		fp2		0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	LF	fLF		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
zero	HF	fz	fb	0.037	0.039	0.039	0.039	0.027	0.039	0.039	0.039	0.029	0.039	0.040	0.040
	LF	fLF		0.006	0.005	0.005	0.005	0.006	0.005	0.005	0.005	0.006	0.005	0.005	0.005

- Since the parameters are "optimized" at no noise condition, the parameters are the same for with and no noise.
- The assumption is that noise is random and average is "0".

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