

Consideration on 100Gb/s C2M SerDes Equalizer

IEEE802.3ck

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Socionext Inc.**

Agenda

- 1. Overview**
- 2. Channel Simulation**
 - 2.1 Simulation Conditions**
 - 2.2 Channel for Simulation**
 - 2.3 Simulation Results**
- 3. Conclusion**

1. Overview

- **Feasibility of 100Gb/s C2M transmission with various channels and equalizer configurations.**
 - **modulation : PAM4**

#	vendor	module type	IL (no PKG) @29GHz	note
1	TE	OSFP	-16.9dB	micro-vias L2, bottom, Rx5 *1
2			-13.1dB	micro-vias L2, top, Rx6 *1
3	Yamaichi	"SFP"*	-11.2dB	no BGA footprint/breakout
4	Cisco	QSFP	-11.2dB	"10dB" *2
5			-13.4dB	"12dB" *2
6			-15.4dB	"14dB" *2

* : enhanced characteristics SFP type module

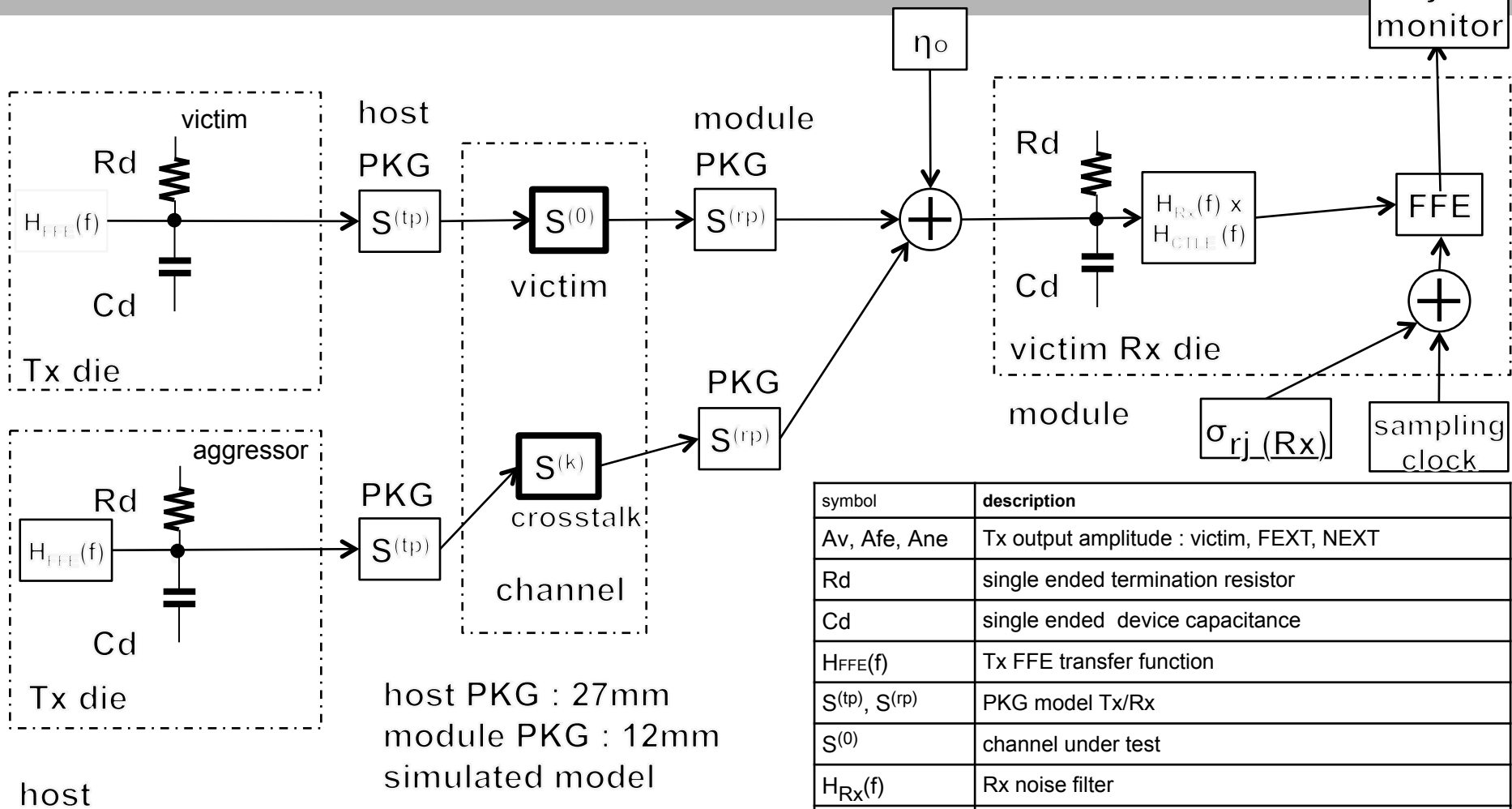
*1 : http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_01a_0118.pdf
http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_02_0118.zip

*2 : http://www.ieee802.org/3/100GEL/public/18_03/lim_100GEL_01b_0318.pdf
http://www.ieee802.org/3/100GEL/public/tools/c2m/lim_100GEL_02_0318.zip

2. Channel simulation

2.1 Simulation Conditions

2.1.1 Simulation Model



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
$S^{(0)}$	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
σ_{rj}	random jitter, RMS Tx : before FFE Rx : considered as eye margin

2.1.2 Simulation Set Up

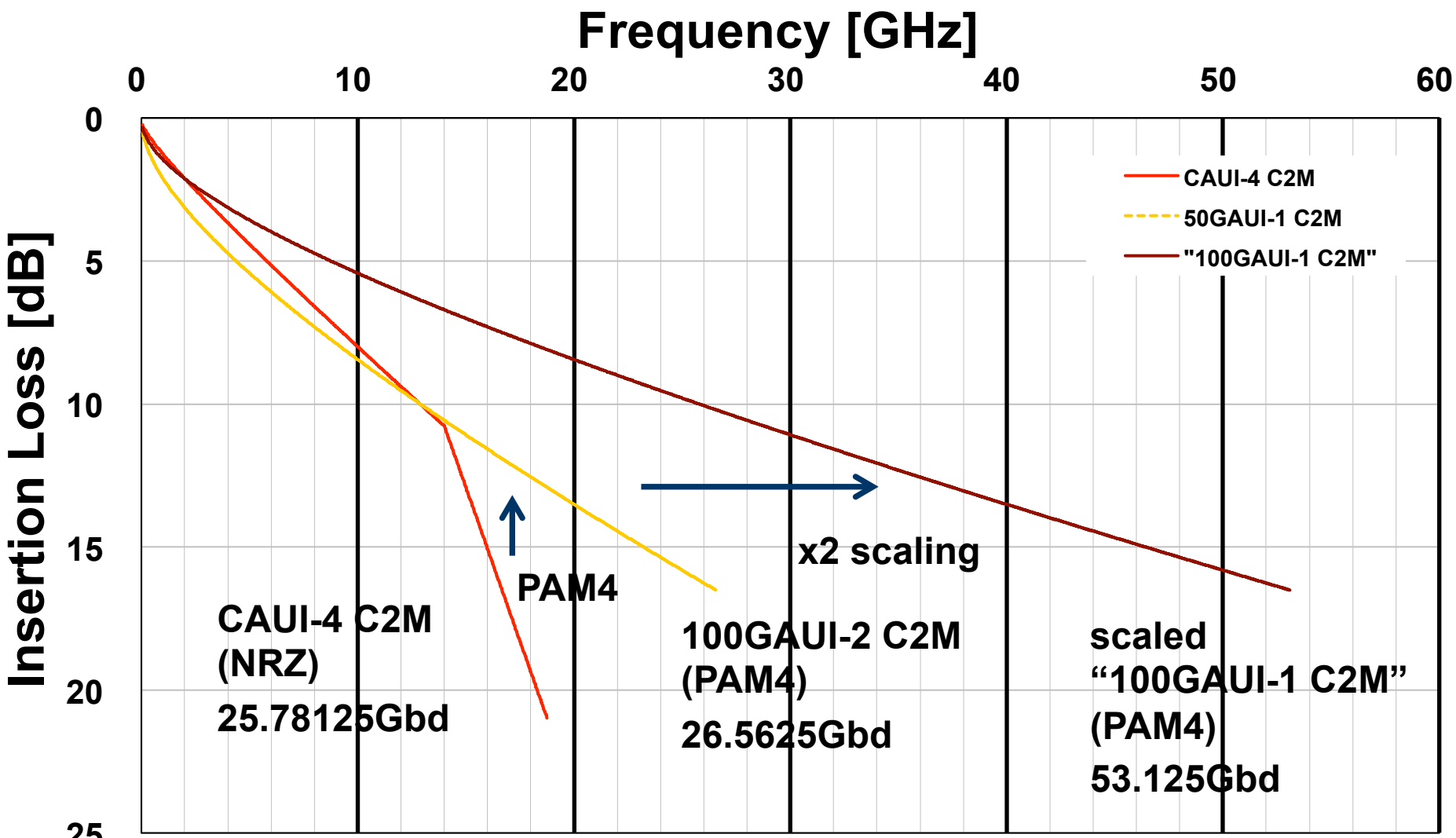
- ✓ **Static Channel Model Simulation**
- ✓ **Behavior model using MatLab**
- ✓ **PAM4 at 58.0Gbd to see margin and other applications. (conservative)**
- ✓ **Jitter, noise and crosstalk are considered.**
- ✓ **Tx jitter, (DJ, RJ) included : Basically RJ is the same as 50G-PAM4 (conservative).**
- ✓ **Rx/CDR jitter (DJ, RJ) are considered as eye opening margin. (EW5, EH5)**
- ✓ **crosstalk noise in channel S-parameter**
- ✓ **Device noise (eta0) is swept to see the effect.**
- ✓ **Device capacitance (Cd) = 100/60/30/0fF**
- ✓ **Impedance are nominal : 50-ohm single ended**
- ✓ **T-spaced FFE**
 - ✓ **Rx FFE parameters are set to minimize ISI.**
 - ✓ **Rx FFE taps are swept to see effect.**
- ✓ **CTLE coefficients are optimized for each channel. (See back up slides.)**
- ✓ **PKG model is based on current design.**

item	value	unit
modulation	PAM4	
pattern	PRBS13Q	
baud rate	58	Gbd
DJ_Tx	60	mUI
RJ_Tx	10	mUI
EOJ_Tx	0	UI
SNR_Tx	32.5	dB
Rt_Tx	50	ohm
Tx_FFE	4/2	tap/pre
Cd_Tx/Rx	100, 60, 30, 0	fF
Cp Tx/Rx	extracted	fF
Rx FFE	5/0, 25/0	tap/pre
Rx fr	3/4 fb	
Av	0.8	Vppd
AVx	1.2	Vppd
BER	1.0E-5	
η_0 eta0	8.2E-09	V ² /GHz
DJ_Rx	0	UI
Rt_Rx	50	ohm

2. Channel simulation

2.2 Channel for Simulation

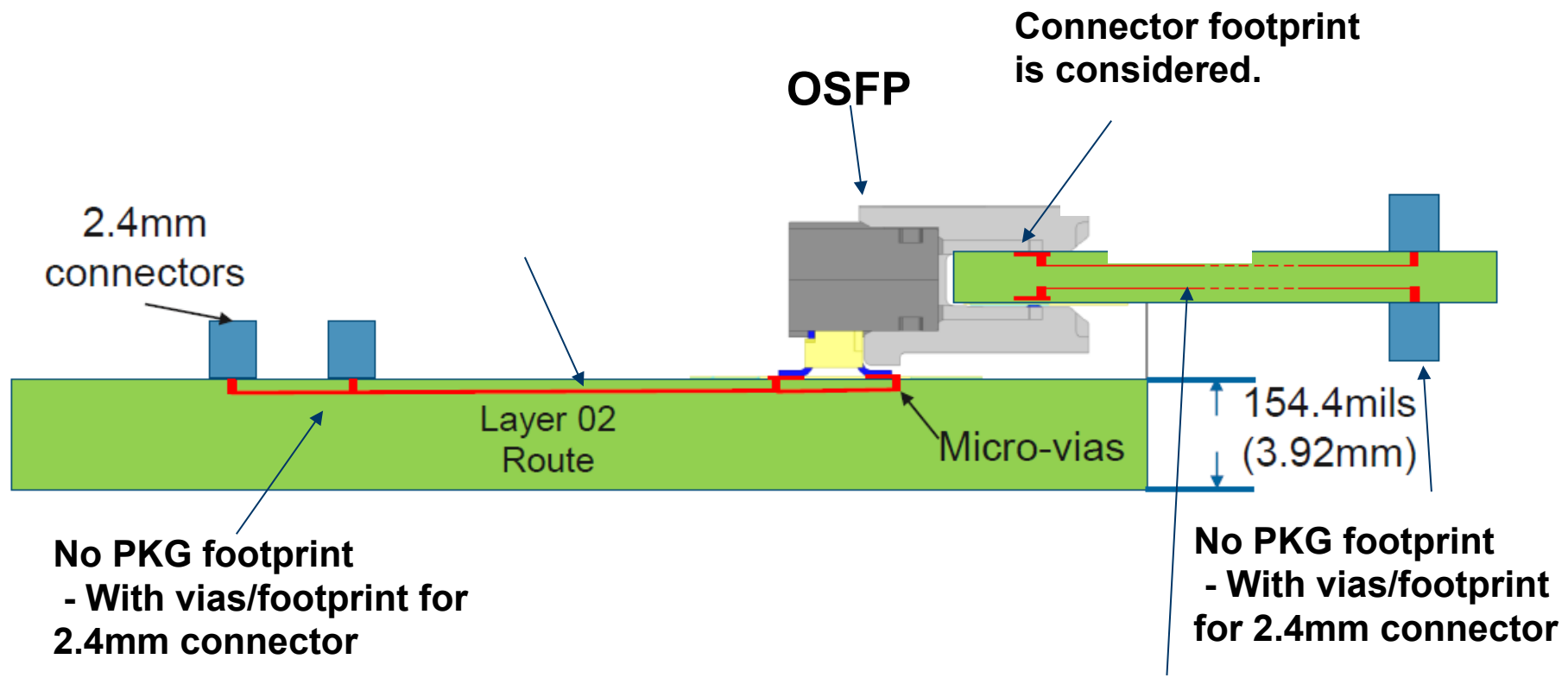
2.2 C2M : channel insertion loss



If PAM4 modulation is selected, 10dB~12dB target insertion loss at Nyquist frequency (26.5625GHz, scaled frequency) is an option.

2.2.1 Channel Configuration (#1/#2 TE Rx5/Rx6)

TE : micro via

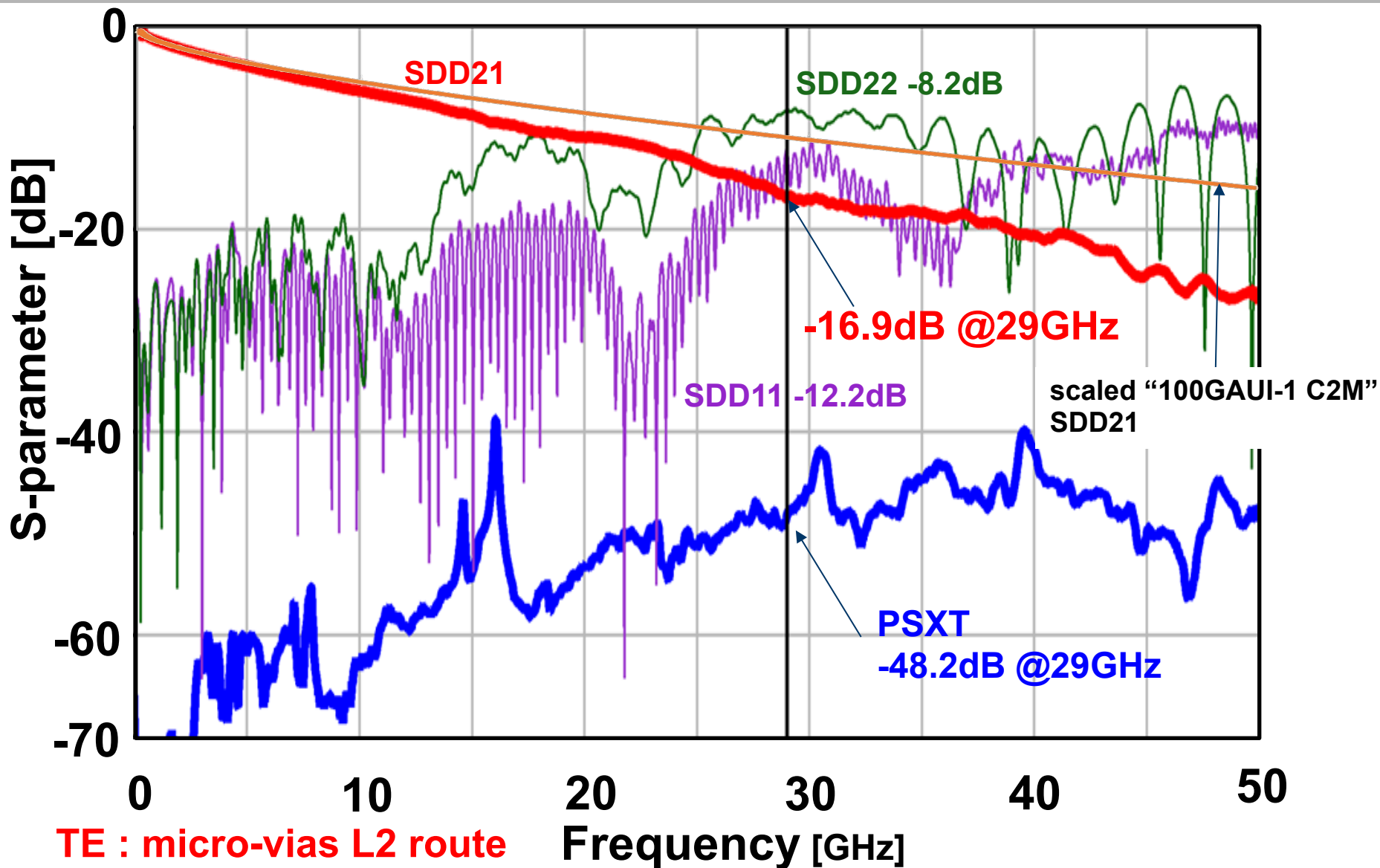


No on-module AC coupling capacitors.

added PKG model
 host (Tx) : 27mm PKG
 module (Rx) : 12mm PKG
 both design extracted

http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_01a_0118.pdf

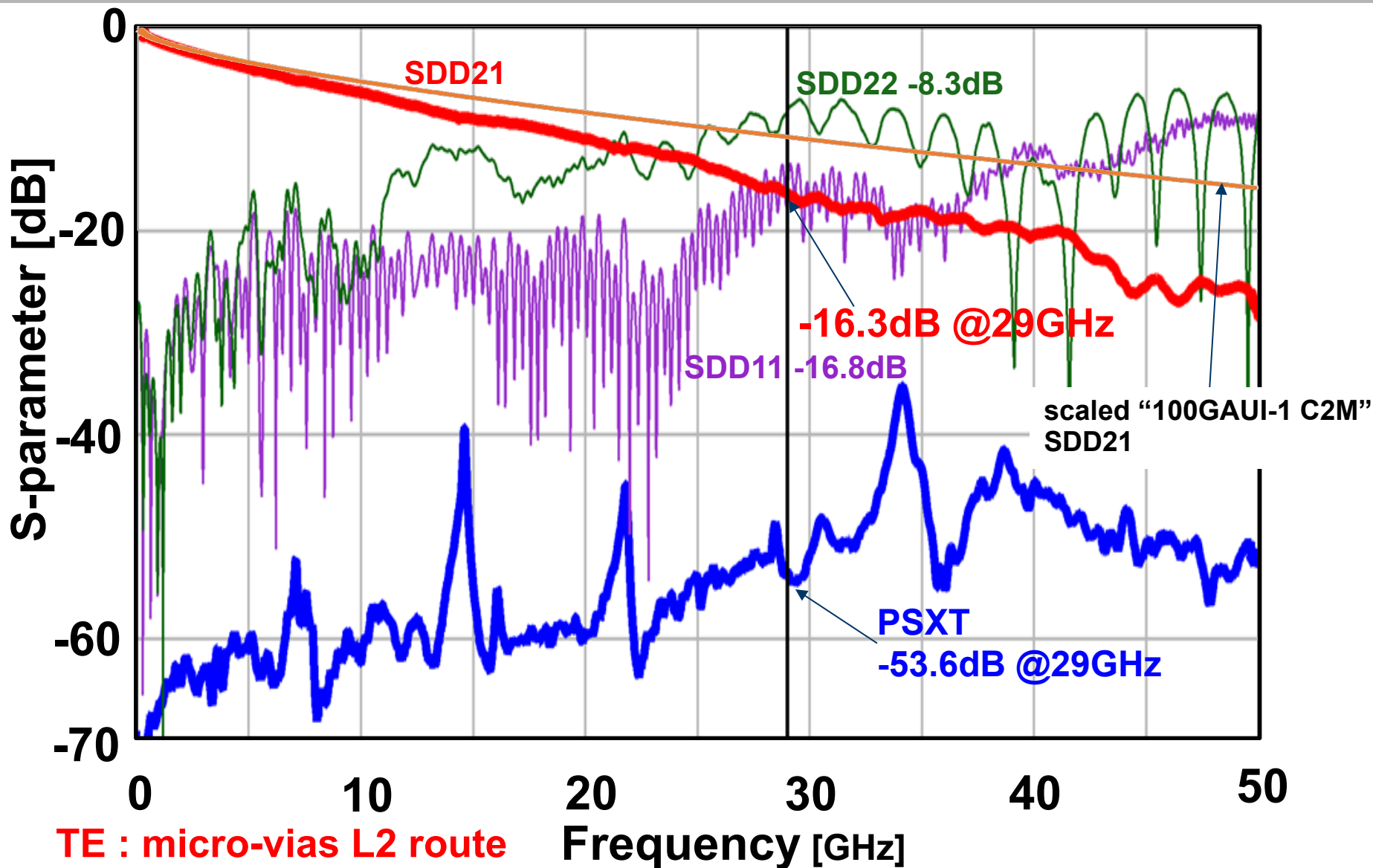
2.2.1 Channel Characteristics (#1, TE Rx5)



**TE : micro-vias L2 route
bottom row victim, Rx5**

http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_01a_0118.pdf
http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip

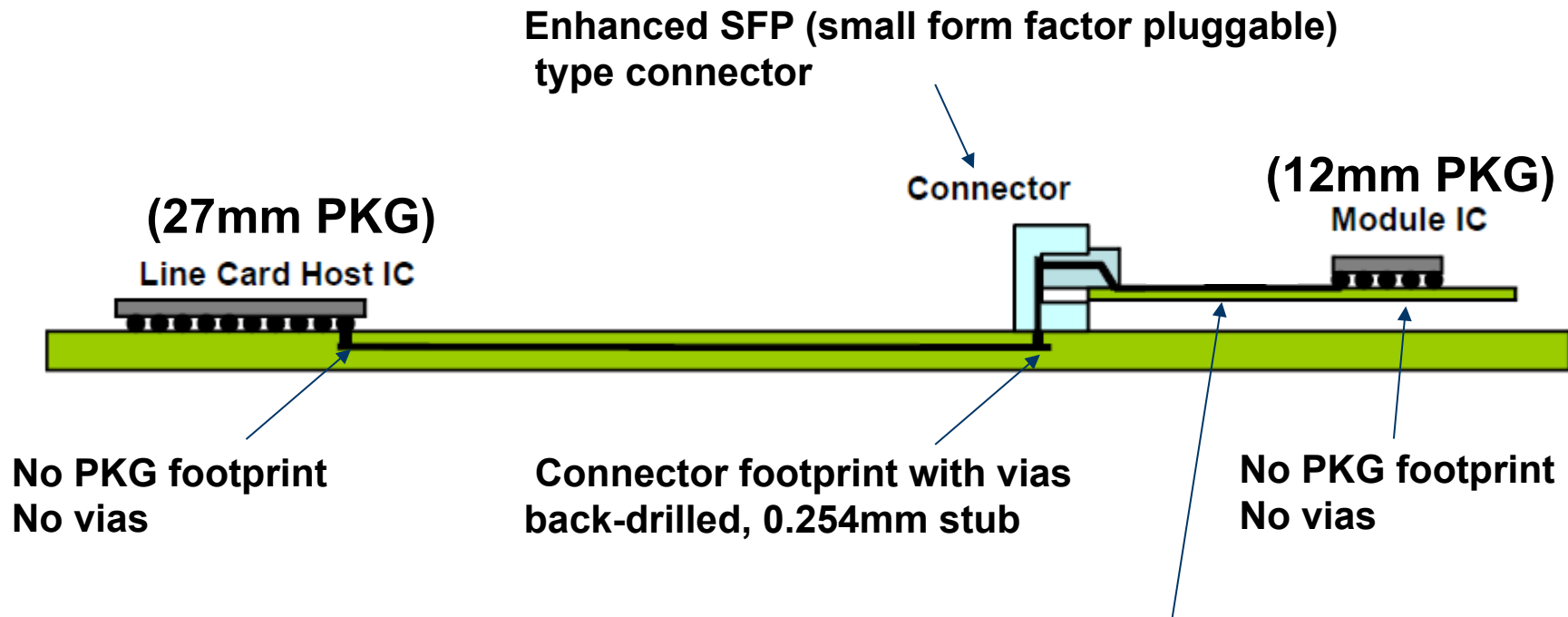
2.2.1 Channel Characteristics (#2, TE Rx6)



**TE : micro-vias L2 route
top row victim, Rx6**

http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_01a_0118.pdf
http://www.ieee802.org/3/100GEL/public/tools/c2m/tracy_100GEL_06_0118.zip

2.2.1 Channel Configuration (#3 Yamaichi)



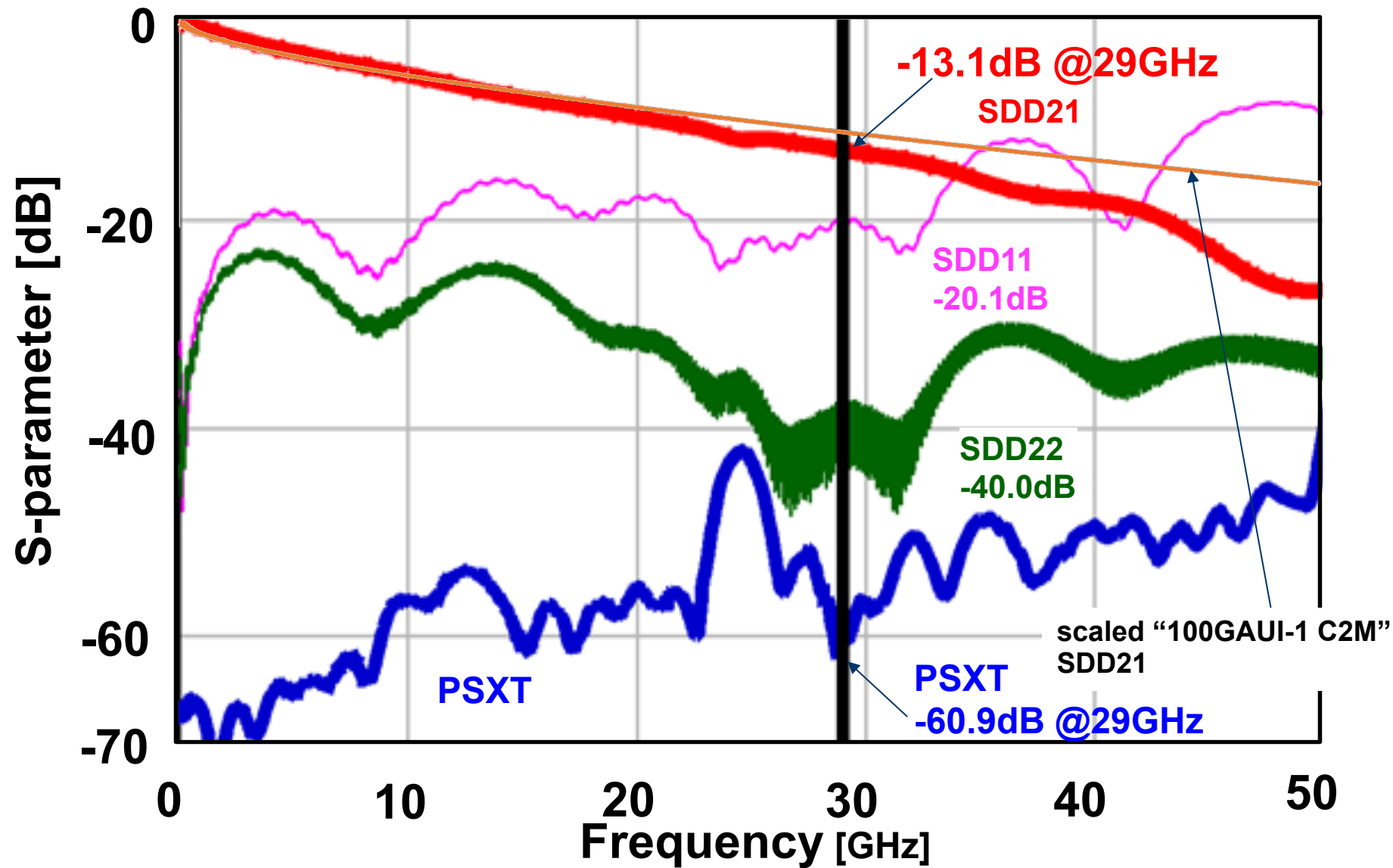
No on-module AC coupling capacitors.
- On-die (receiver) AC coupling capacitors.

added PKG model
host (Tx) : 27mm PKG
module (Rx) : 12mm PKG
both design extracted

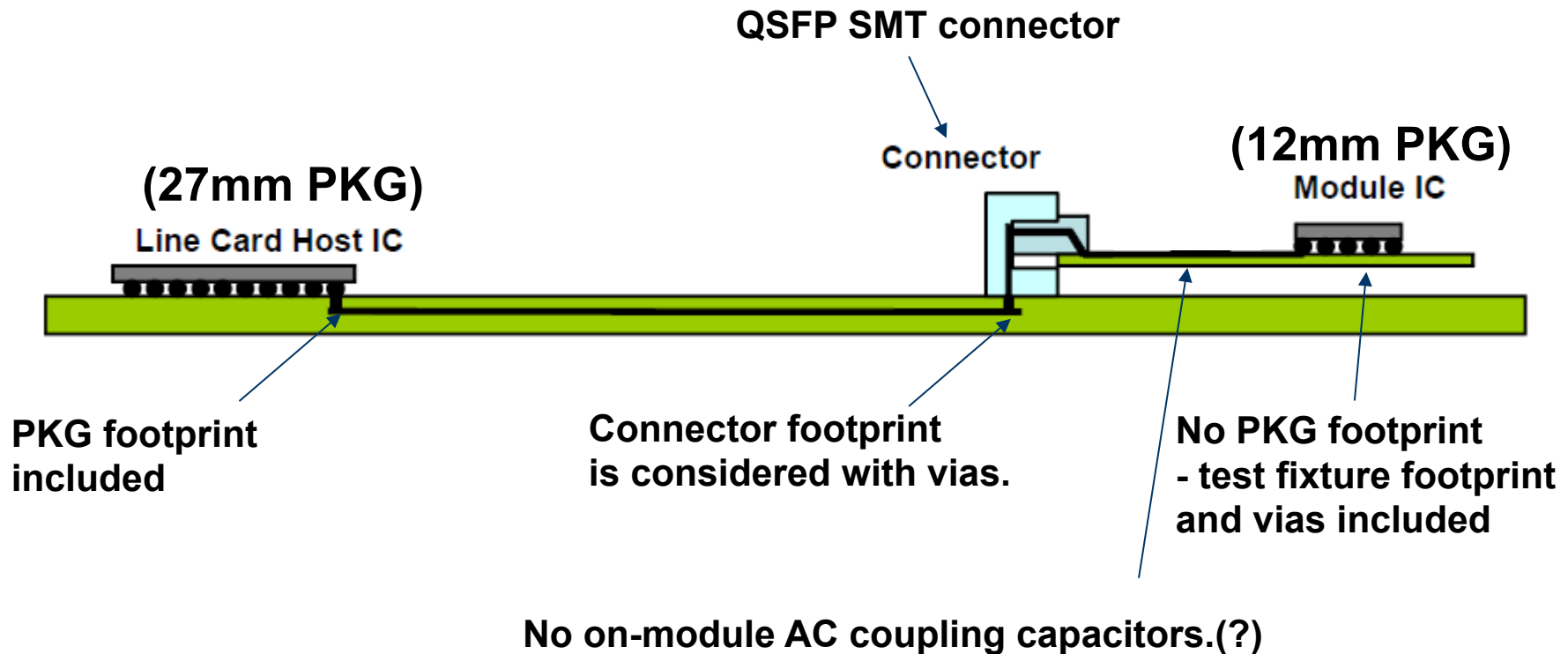
2.2.1 Channel Characteristics (#3 Yamaichi)

- "enhanced SFP"

Courtesy of Yamaichi Electronics Co., Ltd.



2.2.1 Channel Configuration (#4,5,6 Cisco)



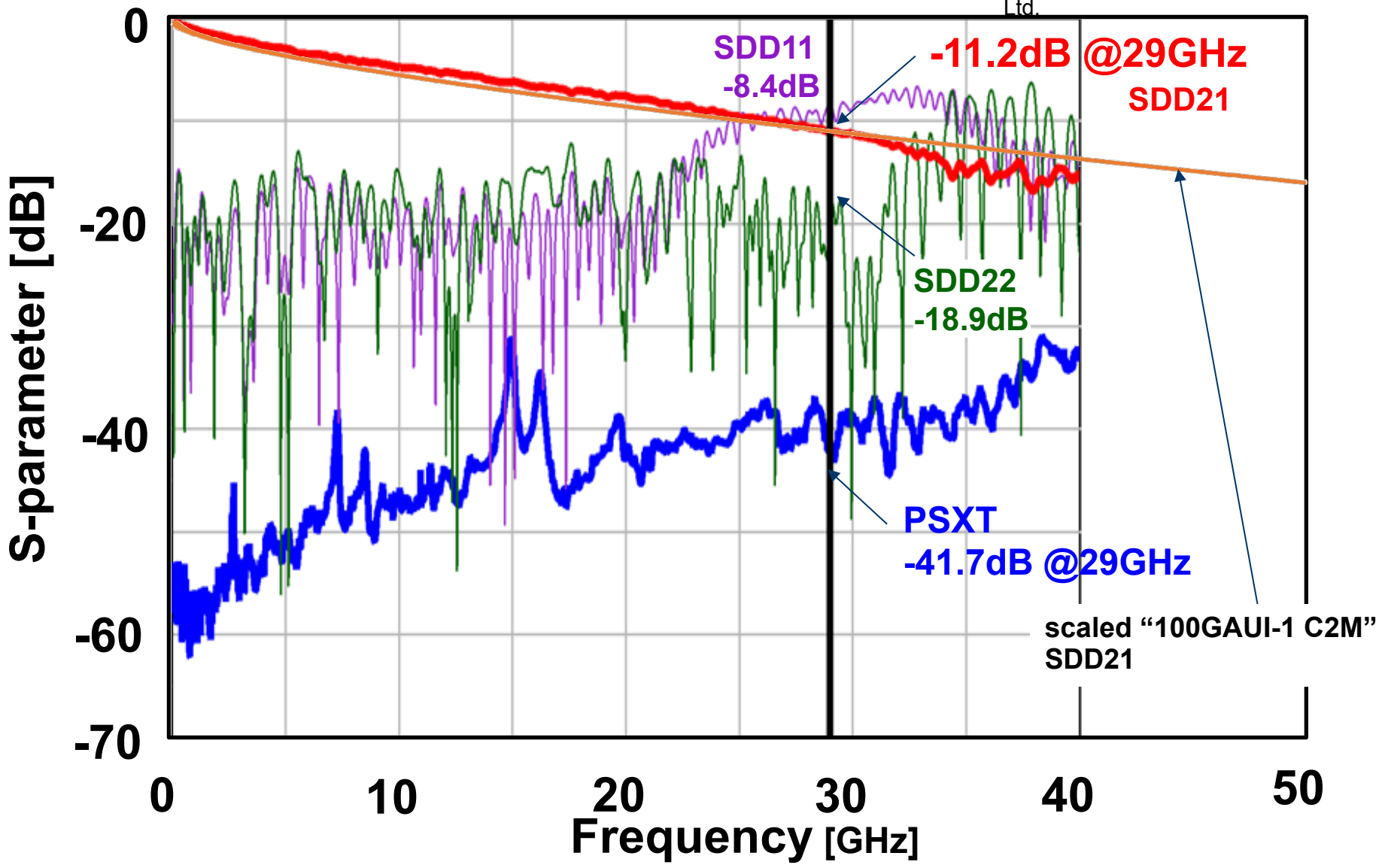
added PKG model
 host (Tx) : 27mm PKG
 module (Rx) : 12mm PKG
 both design extracted

http://www.ieee802.org/3/100GEL/public/18_03/lim_100GEL_01b_0318.pdf
http://www.ieee802.org/3/100GEL/public/tools/c2m/lim_100GEL_02_0318.zip

2.2.1 Channel Characteristics (#4, Cisco_10dB)

QSFP56

Courtesy of Yamaichi Electronics Co., Ltd.

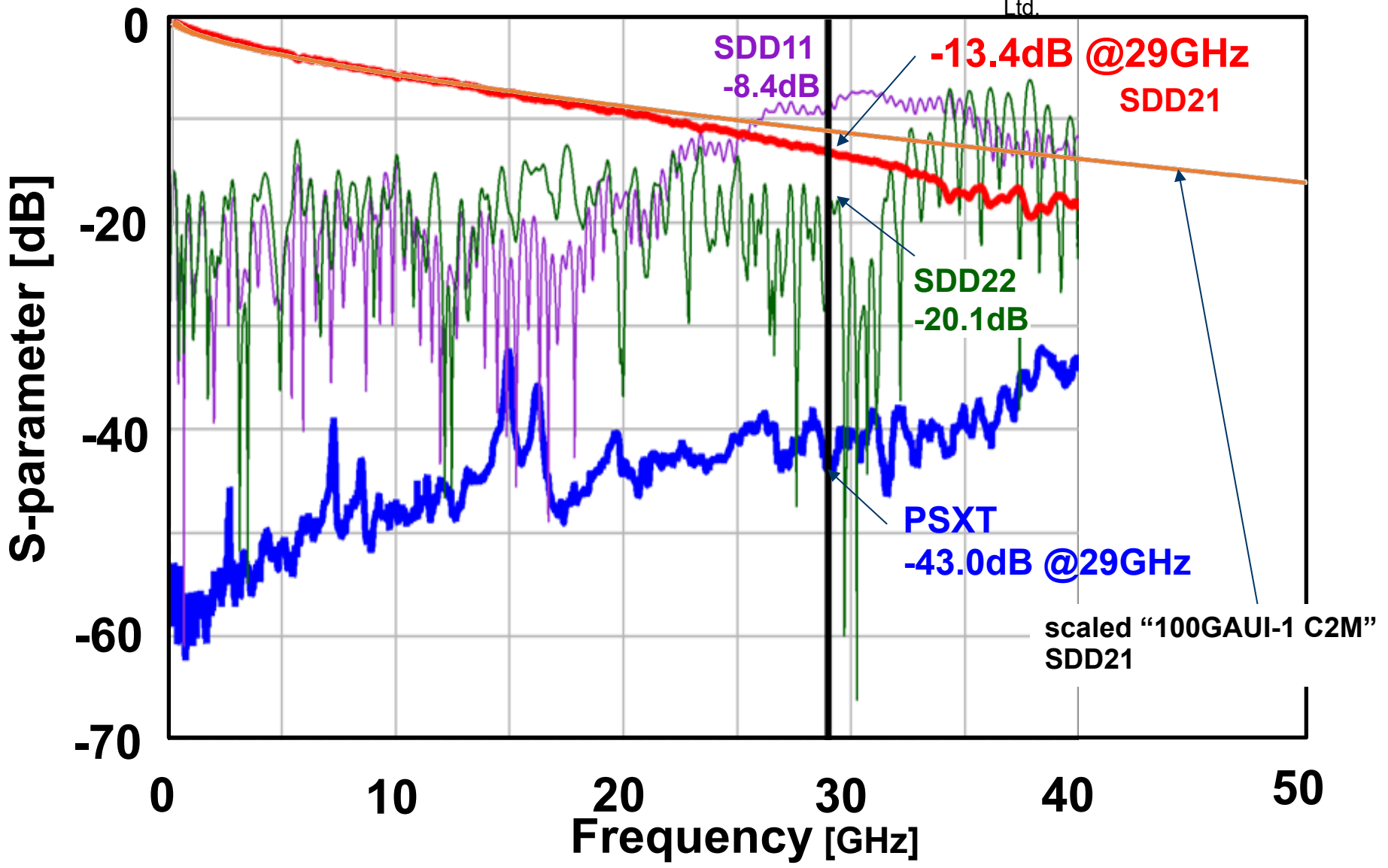


scaled "100GAUI-1 C2M"
SDD21

2.2.1 Channel Characteristics (#5, Cisco_12dB)

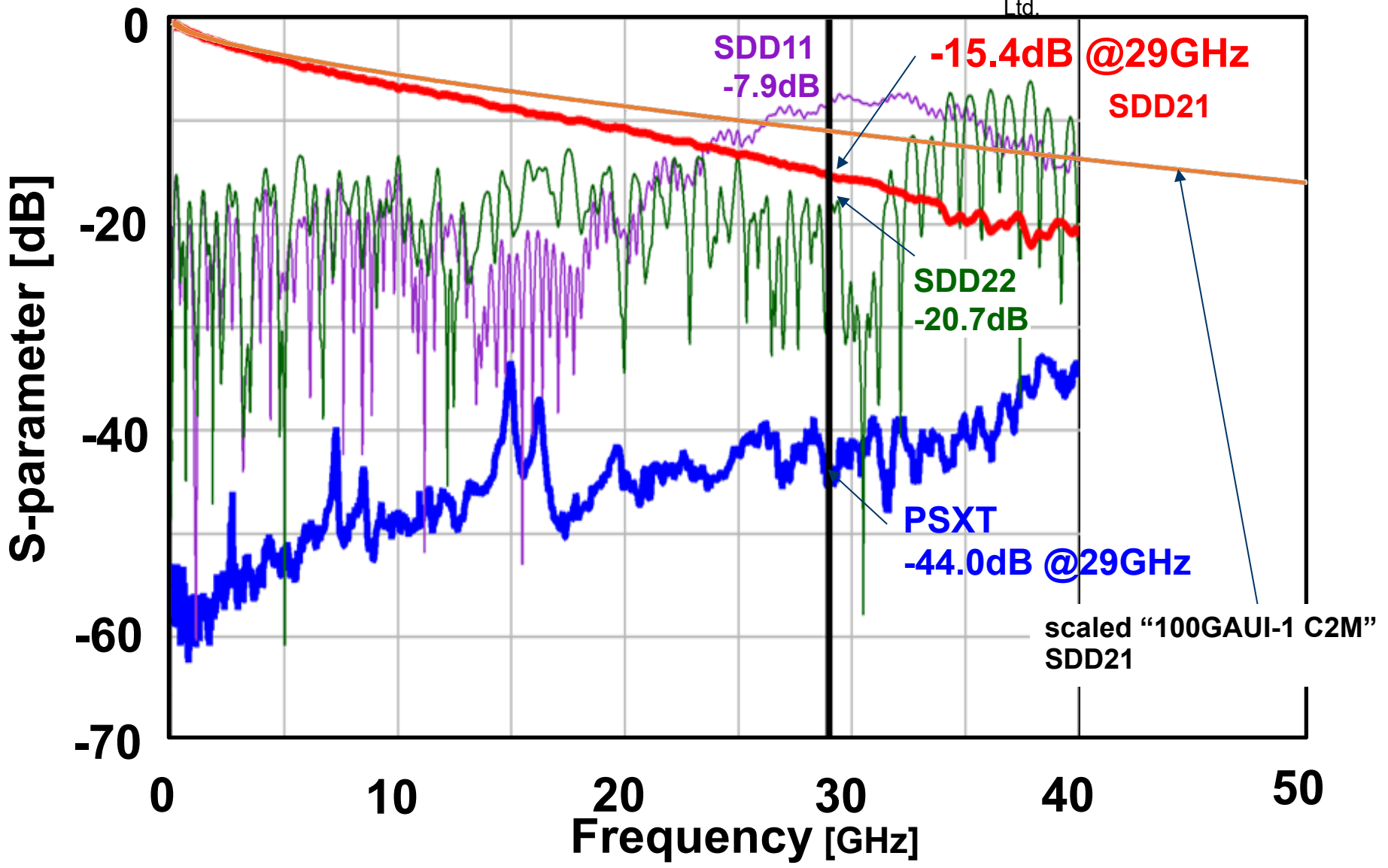
QSFP56

Courtesy of Yamaichi Electronics Co., Ltd.



2.2.1 Channel Characteristics (#6, Cisco_14dB)

Courtesy of Yamaichi Electronics Co., Ltd.



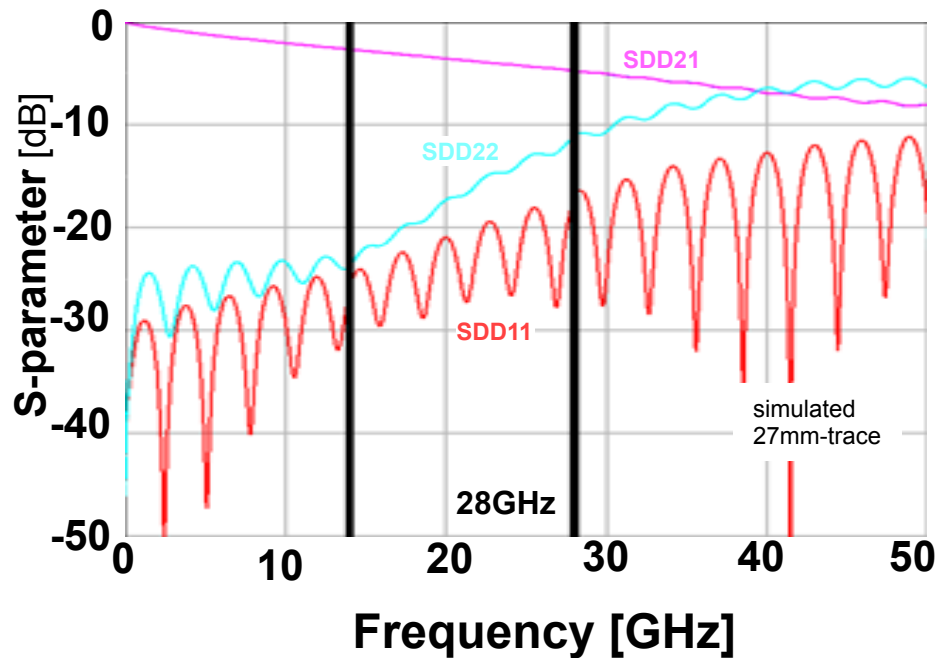
2.2.2 PKG Characteristics

Designed PKG models are used.

27mm PKG (FCBGA, designed)

SDD21: -4.81dB @28GHz

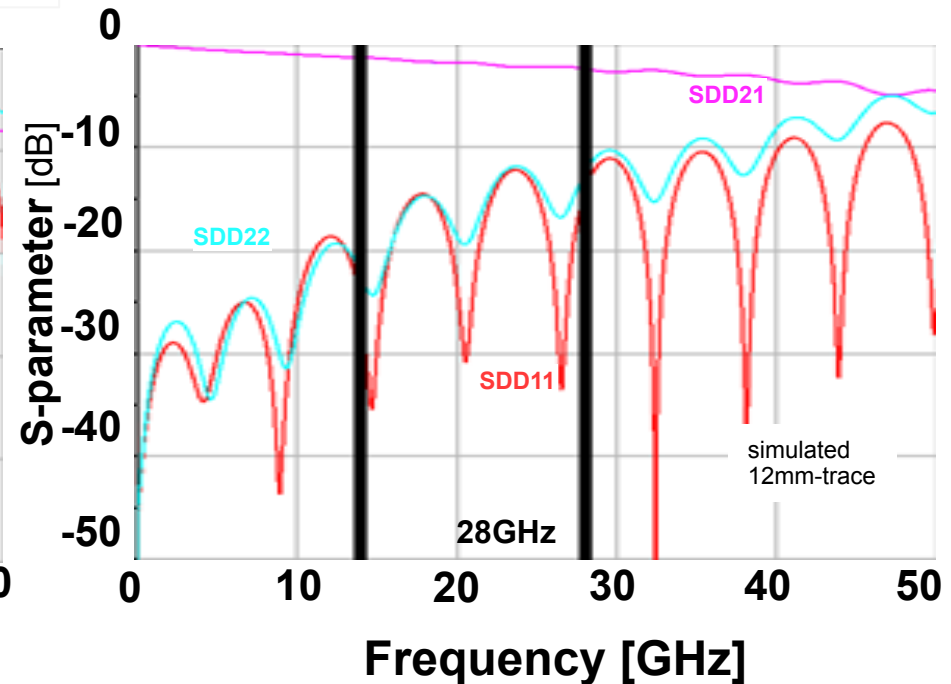
SDD22: -11.1dB @28GHz



12mm PKG (FCBGA, designed)

SDD21: -2.40dB @28GHz

SDD22: -12.5dB @28GHz



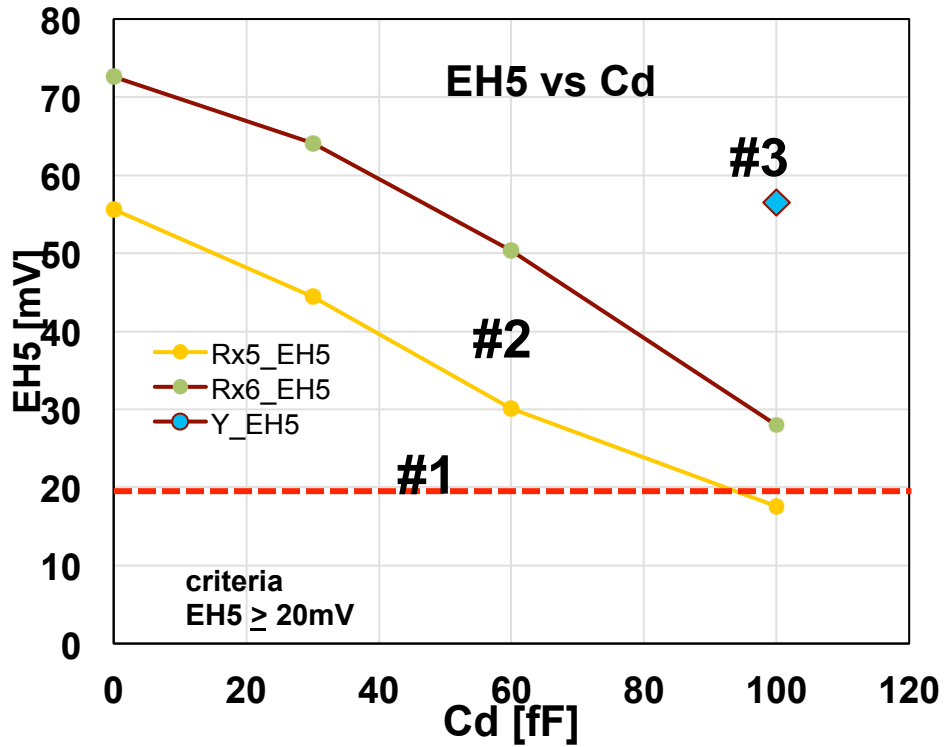
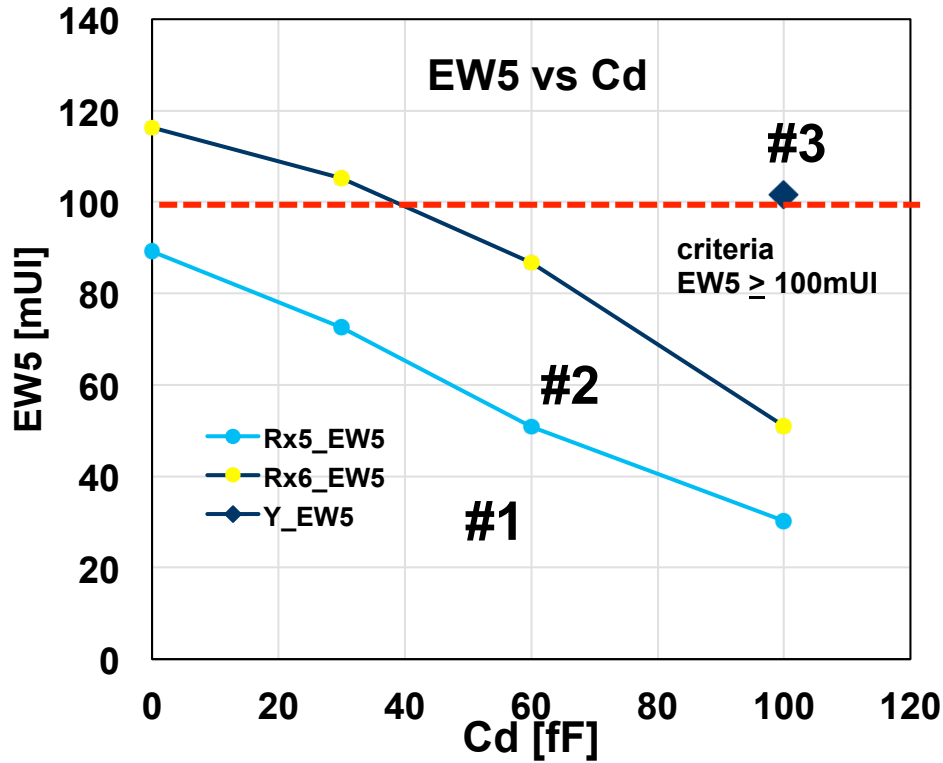
note : No xtalk is considered in these PKG models.

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2. Channel simulation

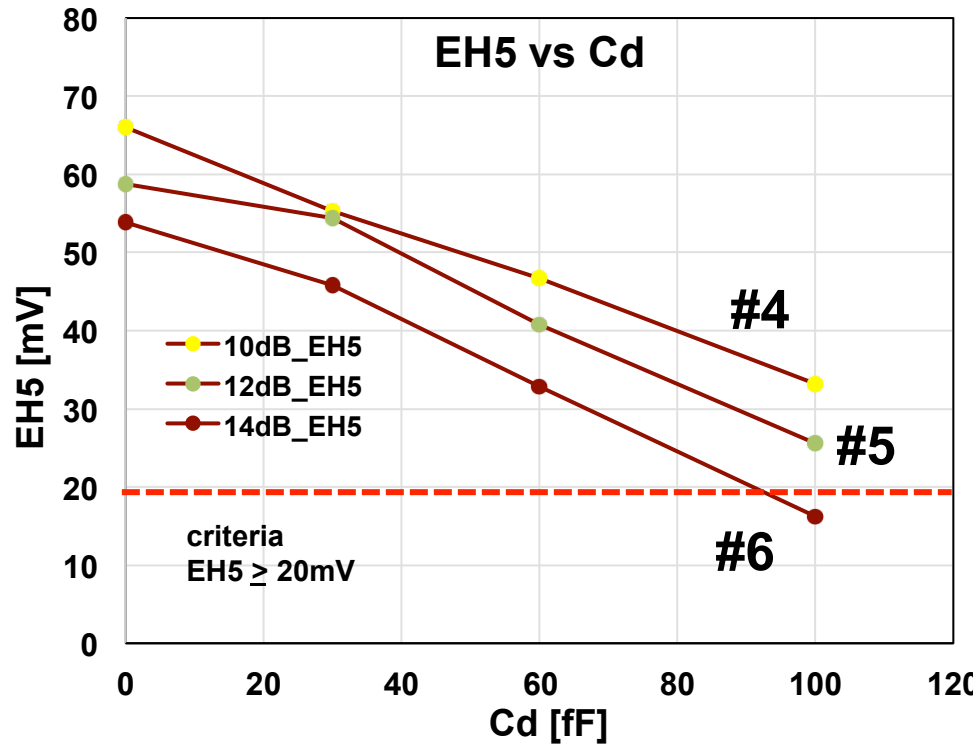
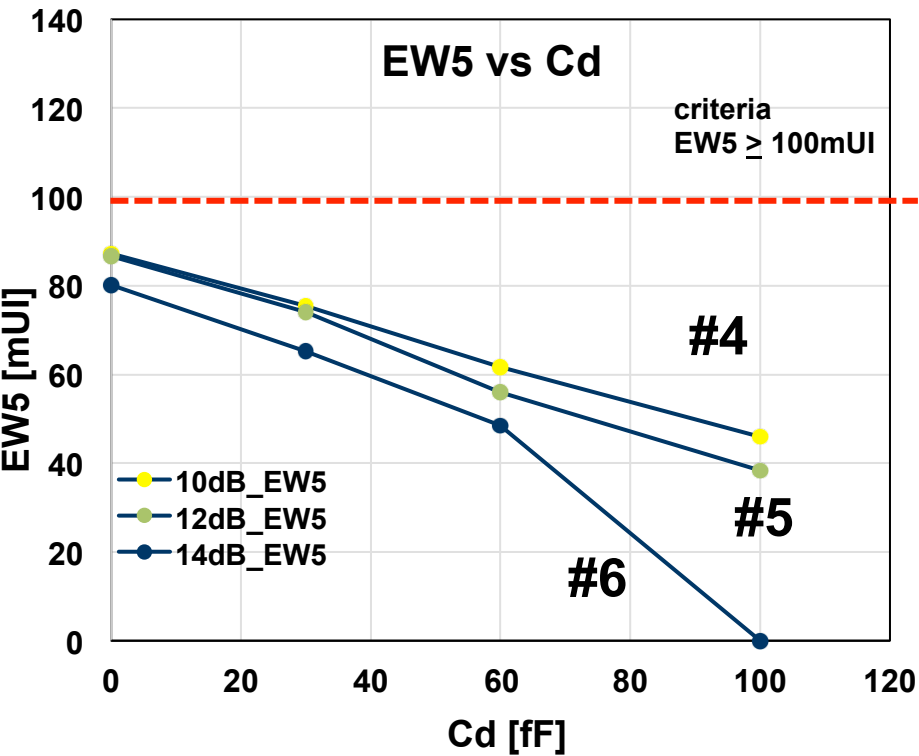
2.3 Simulation Results

2.3.1 Simulation Summary (channel, device cap Cd)



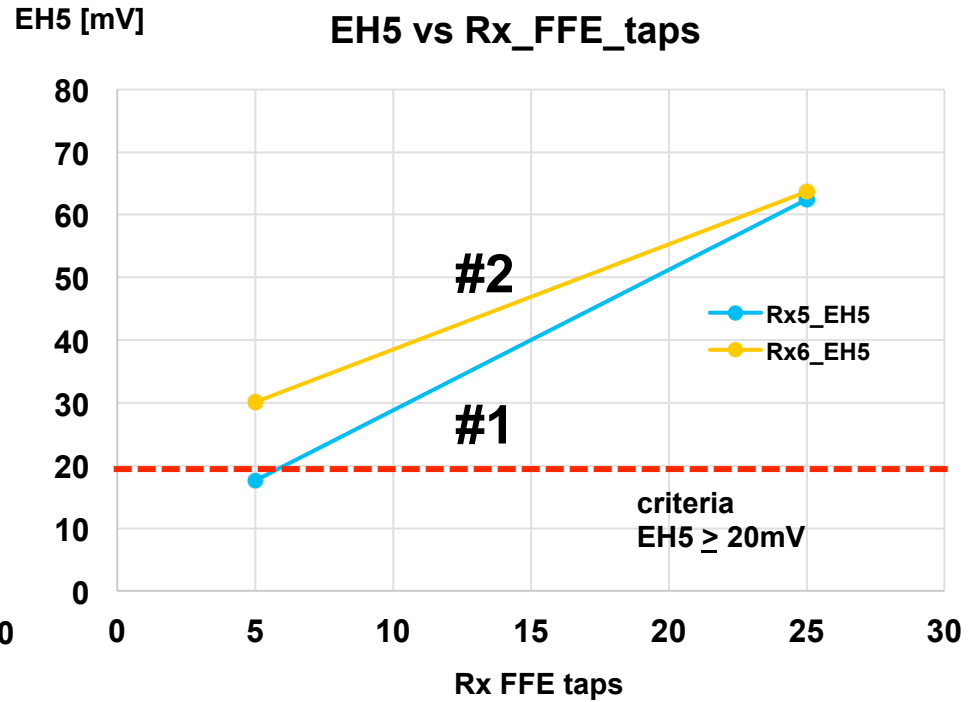
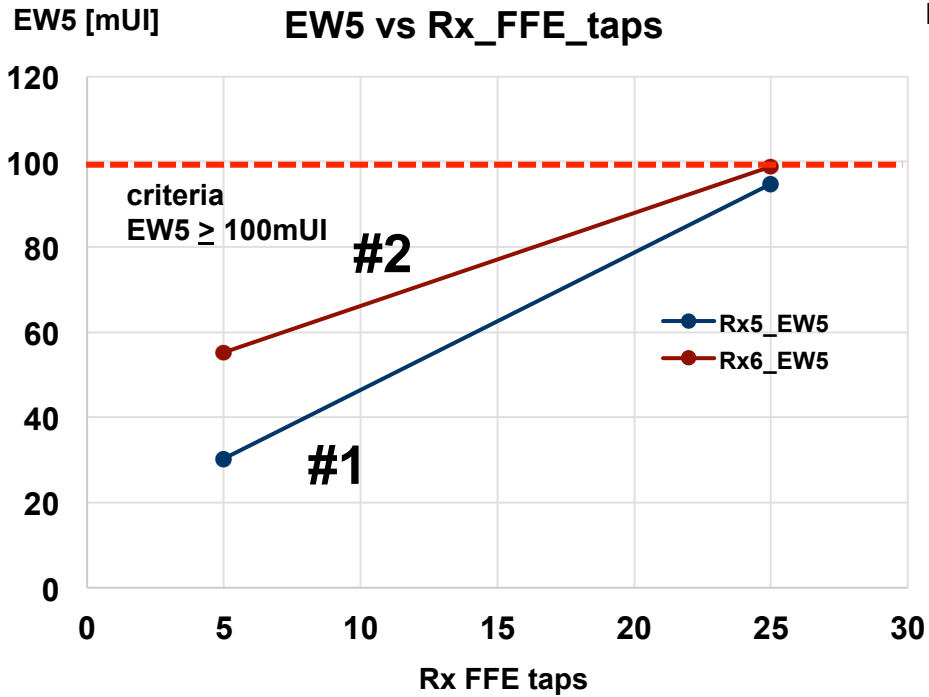
item		unit	#121	#128	#132	#136	#143	#148	#152	#156	#106
channel			#1 TE/Rx5				#2 TE/Rx6				#3 Yamaichi
Tx/Rx		Cd fF	100	60	30	0	100	60	30	0	100
eye	EW5	upp	49	82	98	112	73	80	80	82	110
		mid	60	98	118	129	58	89	96	98	109
		low	30	51	73	89	51	45	48	51	100
	EH5	upp	22	45	58	68	41	45	45	45	64
		mid	24	47	62	73	32	45	46	47	59
		low	18	30	44	56	28	29	30	30	60

2.3.1 Simulation Summary (channel, device cap Cd)

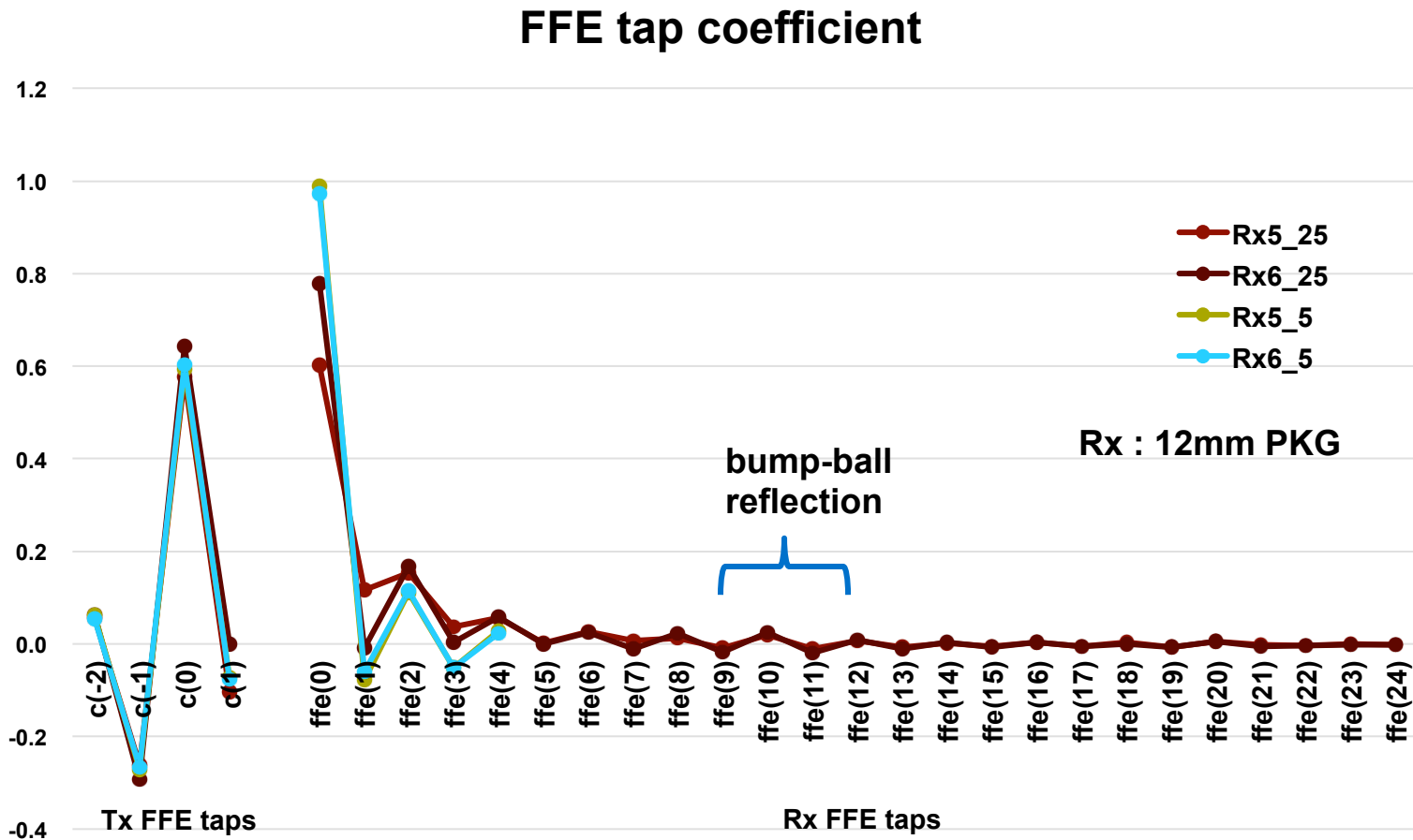


item		unit	#164	#167	#172	#176	#183	#188	#192	#196	#203	#208	#212	#216
channel			#4 Cisco_10dB				#5 Cisco_12dB				#6 Cisco_14dB			
Tx/Rx	Cd	fF	100	60	30	0	100	60	30	0	100	60	30	0
eye	EW 5	upp	55	75	80	92	48	48	48	48	48	49	68	81
		mid	54	69	77	87	46	46	46	46	46	59	74	84
		low	46	62	75	92	38	38	38	38	38	49	65	80
	EH 5	upp	39	53	59	71	32	32	32	32	32	34	48	58
		mid	33	47	55	66	26	26	26	26	26	36	47	54
		low	33	47	56	92	26	26	26	26	26	33	46	56

2.3.1 Simulation Summary (more Rx FFE taps)



item		unit	#137	#138	#139	#140	#157	#158	#159	#160	#121	#122	#123	#124	#141	#142	#143	#144	
Tx/Rx	Cd	fF	100																
channel			#1 TE/Rx5				#2 TE/Rx6				#1 TE/Rx5				#2 TE/Rx6				
Rx	FFE	tap/pre	25/0								5/0								
eye	EW5	upp	mUI	92	95	92	94	96	99	100	100	49	46	50	24	63	70	73	75
		mid		103	108	108	110	97	103	103	104	60	63	66	55	52	56	58	62
		low		101	105	105	108	93	97	97	99	30	0	0	0	47	46	51	55
	EH5	upp	mV	60	62	62	63	62	65	64	65	22	22	24	21	34	41	41	41
		mid		63	68	69	70	63	66	67	68	24	24	26	21	26	31	32	33
		low		66	70	69	70	61	64	63	64	18	9	12	10	25	26	28	30



- No major reflection is seen between bump and ball.
- Reduction of Cd, Cp helps some, but not significant.

3. Conclusion

3. Conclusion (1/2)

1. **With “#3” C2M channel, 58Gbd PAM4 transmission with >13dB @29GHz channel seems feasible using 4-tap Tx FFE and 5-tap Rx FFE. (From host to module direction)**
 - For 802.3ck C2M applications, 12dB @26.5625GHz will have some margin with this channel. Need further investigation.
 - Current model does not include PKG ball breakout effect.
 - From module to host direction, host Rx can have stronger equalizer (eg. more FFE taps), so it will not be a major issue.
 - For C2M module side receiver (Rx), equalization is quite tough, with limited number of taps, considering power and area constraints.
2. **With other channel, eye openings become worse.**
 - Need to reduce crosstalk, mainly.
3. **PKG characteristics affect performance significantly.**
 - IL : 8dB (5dB host, 3dB module), comparing to channel IL (13~15dB)
 - Need to improve.

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3. Conclusion (2/2)

4. Equalizer optimization in simulation is;

1st : host Tx FFE

2nd : module Rx CTLE/FFE

- In actual implementation, following options may be required.

(1) Feedback from module to host, to determine host Tx FFE coefficient.

(2) Preset Tx FFE coefficient based on host channel characteristics, using simulation results

5. Performance, power and area in real Si implementation have to be considered.

- It is a trade off issue both channel (including PKG) and SerDes design.

6. Further investigation needed.

- Device parameters (Cd in COM)

- Equalization

- PKG parameters (Cp in COM)

- Other Channel models, parameters

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Thank you!

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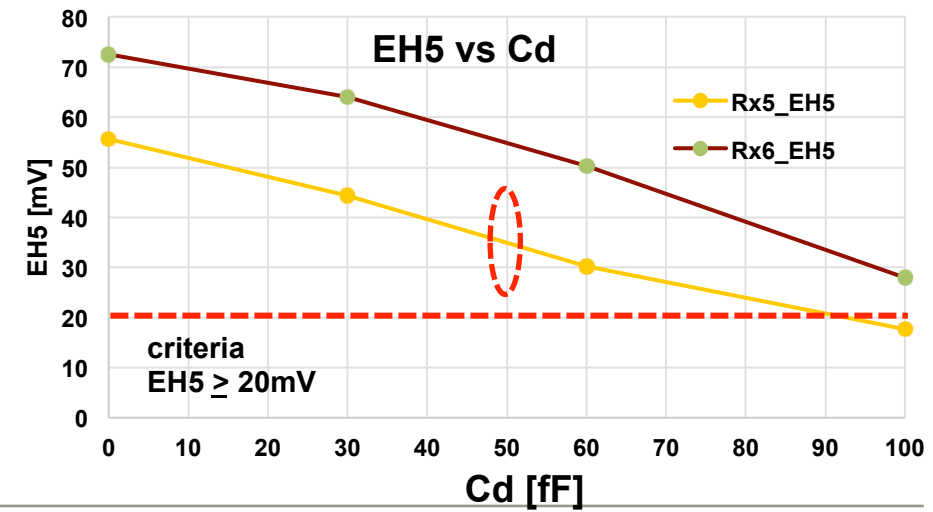
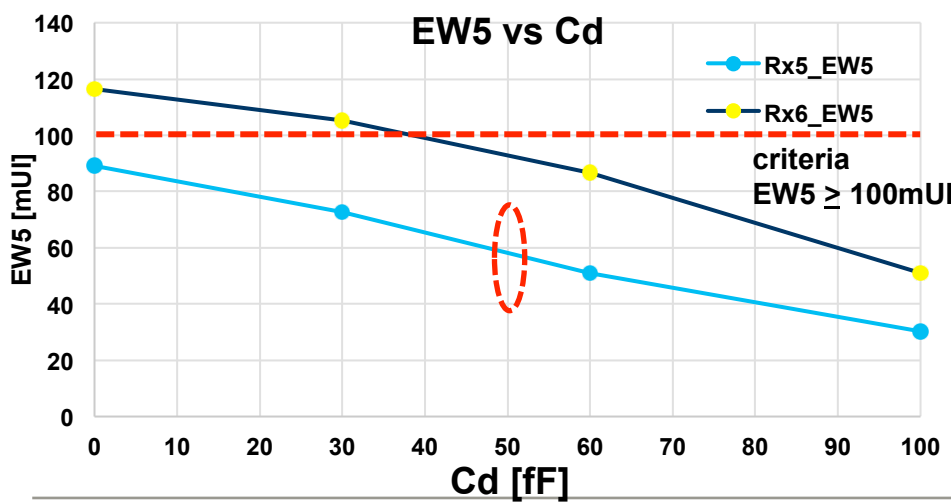
for better quality of experience

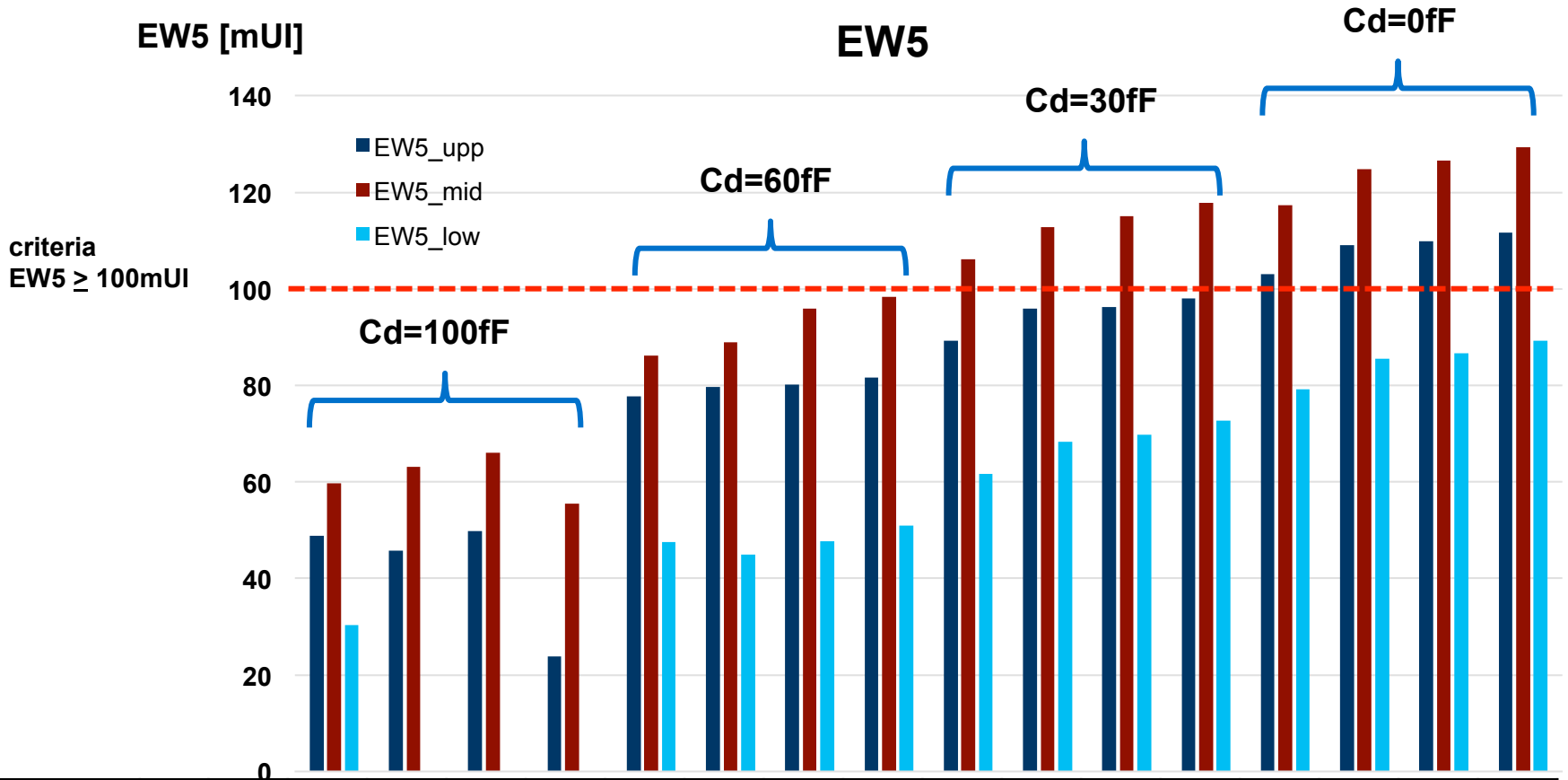
backup slides

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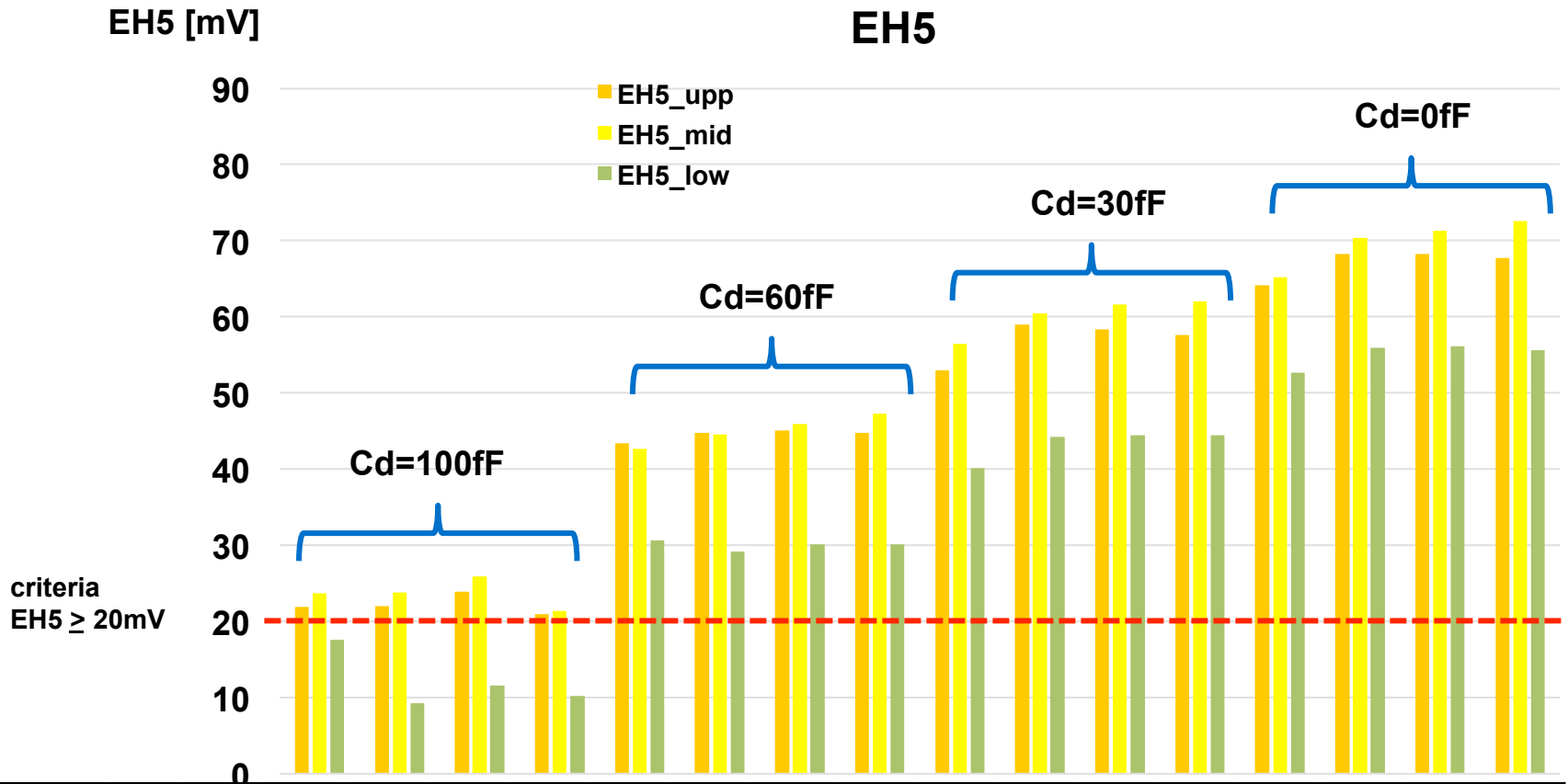
A1.1 Simulation Summary (#1, TE micro-via/Rx5)

item		unit	#121	#122	#123	#124	#125	#126	#127	#128	#129	#130	#131	#132	#133	#134	#135	#136	
Tx	FFE	c(-2)	0.051	0.056	0.061	0.065	0.050	0.054	0.058	0.062	0.044	0.047	0.051	0.054	0.048	0.051	0.054	0.058	
		c(-1)	-0.229	-0.251	-0.272	-0.294	-0.236	-0.255	-0.273	-0.292	-0.231	-0.249	-0.267	-0.284	-0.240	-0.256	-0.272	-0.288	
		c(0)	0.500	0.547	0.594	0.641	0.523	0.564	0.605	0.646	0.537	0.578	0.620	0.661	0.544	0.581	0.617	0.654	
		c(1)	-0.220	-0.146	-0.073	0.000	-0.191	-0.127	-0.064	0.000	-0.188	-0.126	-0.062	-0.001	-0.168	-0.112	-0.057	0.000	
Tx/Rx		Cd	100				60				30				0				
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
		z_HF	0.054	0.036	0.032	0.030	0.045	0.036	0.033	0.031	0.044	0.036	0.033	0.031	0.042	0.036	0.033	0.032	
		p_LF	0.149	0.176	0.125	0.115	0.191	0.152	0.123	0.114	0.323	0.153	0.122	0.114	0.217	0.141	0.121	0.112	
		z_LF	0.042	0.024	0.022	0.021	0.031	0.024	0.023	0.022	0.030	0.025	0.023	0.022	0.028	0.025	0.024	0.023	
	FFE	ffe(0)	0.573	0.937	0.989	1.110	0.735	0.892	0.966	1.042	0.949	0.897	0.952	1.035	0.874	0.872	0.937	0.998	
		ffe(1)	0.179	-0.015	-0.078	-0.227	0.121	0.033	-0.047	-0.136	-0.031	0.031	-0.036	-0.126	0.052	0.056	-0.016	-0.086	
		ffe(2)	0.161	0.101	0.112	0.154	0.116	0.089	0.099	0.117	0.094	0.086	0.098	0.113	0.082	0.081	0.089	0.103	
		ffe(3)	0.044	-0.047	-0.051	-0.074	-0.001	-0.036	-0.044	-0.053	-0.039	-0.037	-0.041	-0.051	-0.031	-0.031	-0.037	-0.042	
		ffe(4)	0.043	0.025	0.028	0.037	0.028	0.023	0.027	0.030	0.028	0.023	0.027	0.030	0.024	0.022	0.026	0.028	
eye	EW5	mUI	upp	49	46	50	24	78	80	80	82	89	96	96	98	103	109	110	112
			mid	60	63	66	55	86	89	96	98	106	113	115	118	117	125	127	129
			low	30	0	0	0	48	45	48	51	62	68	70	73	79	85	87	89
	EH5	mV	upp	22	22	24	21	43	45	45	45	53	59	58	58	64	68	68	68
			mid	24	24	26	21	43	45	46	47	56	60	62	62	65	70	71	73
			low	18	9	12	10	31	29	30	30	40	44	44	44	53	56	56	56





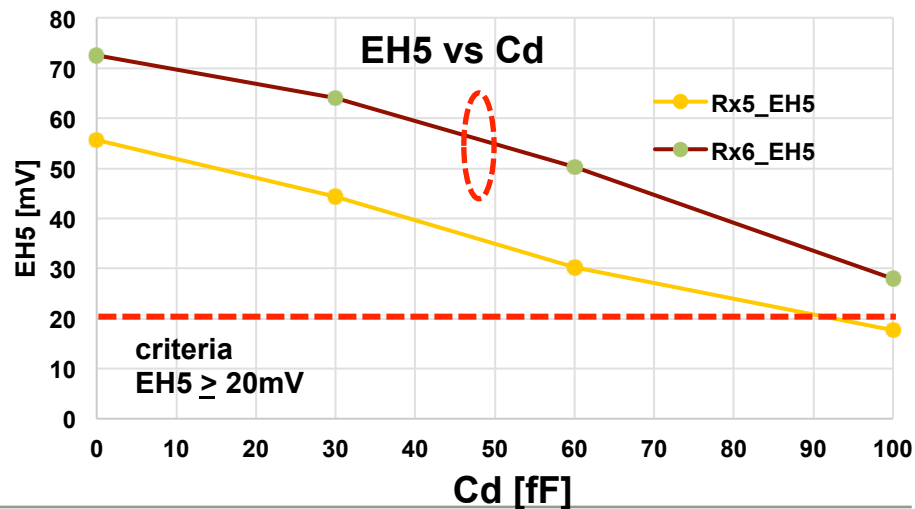
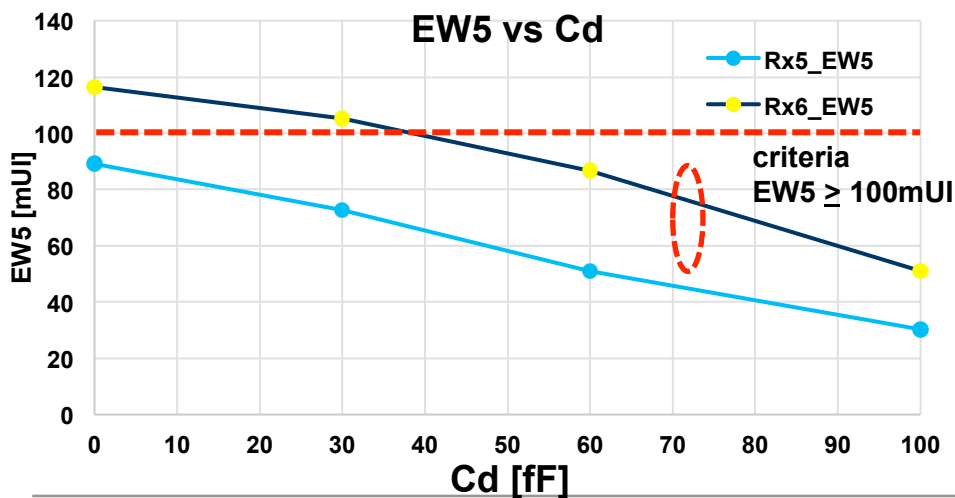
item		unit	#121	#122	#123	#124	#125	#126	#127	#128	#129	#130	#131	#132	#133	#134	#135	#136
Tx/Rx	Cd	fF	100				60				30				0			
eye	EW5	upp	49	46	50	24	78	80	80	82	89	96	96	98	103	109	110	112
		mid	60	63	66	55	86	89	96	98	106	113	115	118	117	125	127	129
		low	30	0	0	0	48	45	48	51	62	68	70	73	79	85	87	89
	EH5	upp	22	22	24	21	43	45	45	45	53	59	58	58	64	68	68	68
		mid	24	24	26	21	43	45	46	47	56	60	62	62	65	70	71	73
		low	18	9	12	10	31	29	30	30	40	44	44	44	53	56	56	56

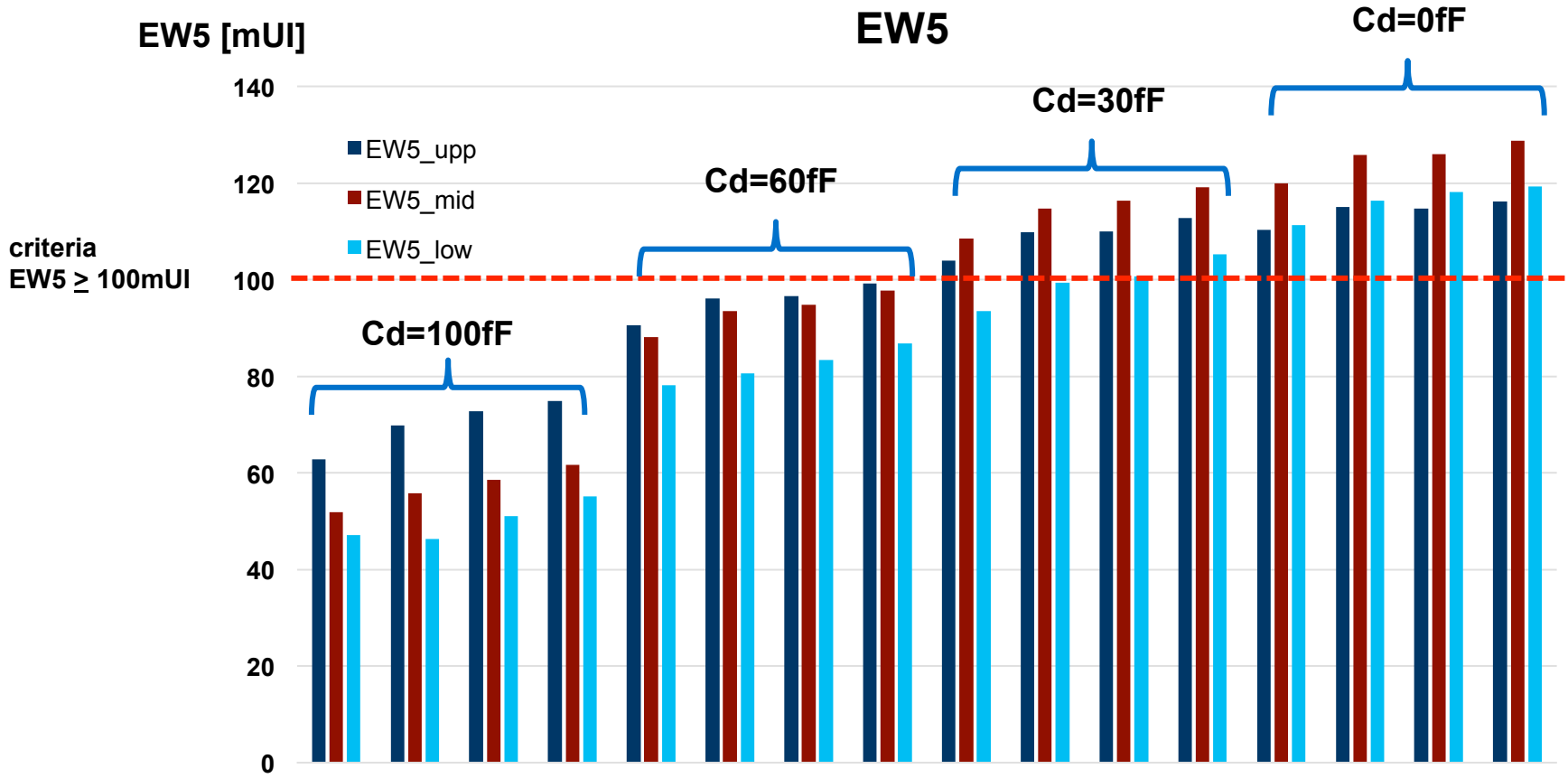


item		unit	#121	#122	#123	#124	#125	#126	#127	#128	#129	#130	#131	#132	#133	#134	#135	#136	
Tx/Rx	Cd	fF	100				60				30				0				
eye	EW5	upp	49	46	50	24	78	80	80	82	89	96	96	98	103	109	110	112	
		mid	60	63	66	55	86	89	96	98	106	113	115	118	117	125	127	129	
		low	30	0	0	0	48	45	48	51	62	68	70	73	79	85	87	89	
	EH5	upp	mV	22	22	24	21	43	45	45	45	53	59	58	58	64	68	68	68
		mid	24	24	26	21	43	45	46	47	56	60	62	62	65	70	71	73	
		low	18	9	12	10	31	29	30	30	40	44	44	44	53	56	56	56	

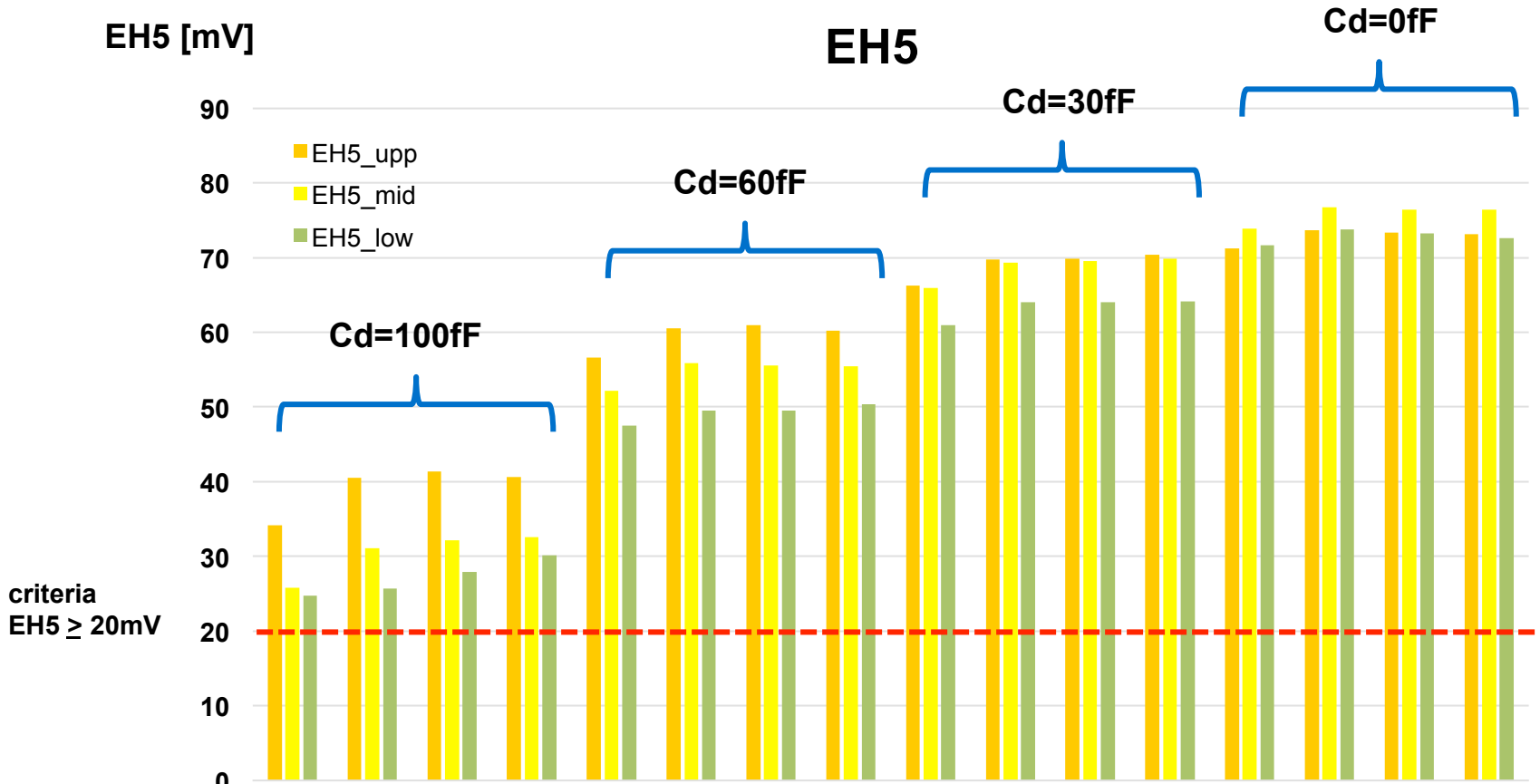
A2.1 Simulation Summary (#2, TE micro-via/Rx6)

item		unit	#141	#142	#143	#144	#145	#146	#147	#148	#149	#150	#151	#152	#153	#154	#155	#156	
Tx	FFE	c(-2)	0.045	0.049	0.054	0.058	0.044	0.048	0.051	0.055	0.047	0.050	0.053	0.057	0.044	0.047	0.050	0.053	
		c(-1)	-0.222	-0.244	-0.266	-0.288	-0.228	-0.247	-0.266	-0.284	-0.238	-0.254	-0.271	-0.287	-0.235	-0.251	-0.267	-0.282	
		c(0)	0.505	0.555	0.604	0.654	0.530	0.574	0.617	0.661	0.544	0.581	0.619	0.656	0.553	0.590	0.627	0.665	
		c(1)	-0.228	-0.152	-0.076	0.000	-0.198	-0.131	-0.066	0.000	-0.171	-0.115	-0.057	0.000	-0.168	-0.112	-0.056	0.000	
Tx/Rx		Cd	100				60				30				0				
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
		z_HF	0.055	0.036	0.031	0.029	0.044	0.035	0.032	0.030	0.040	0.035	0.032	0.031	0.040	0.035	0.033	0.031	
		p_LF	0.155	0.164	0.116	0.107	0.199	0.144	0.114	0.105	0.206	0.134	0.112	0.104	0.195	0.132	0.113	0.106	
		z_LF	0.044	0.024	0.022	0.021	0.030	0.024	0.023	0.022	0.027	0.024	0.023	0.023	0.027	0.024	0.023	0.023	
	FFE	ffe(0)	0.586	0.917	0.972	1.076	0.766	0.889	0.949	1.022	0.872	0.870	0.931	0.991	0.863	0.871	0.936	0.994	
		ffe(1)	0.184	0.007	-0.060	-0.181	0.108	0.042	-0.031	-0.118	0.062	0.064	-0.008	-0.079	0.072	0.063	-0.011	-0.080	
		ffe(2)	0.158	0.104	0.115	0.140	0.115	0.091	0.103	0.121	0.084	0.084	0.094	0.107	0.082	0.083	0.093	0.105	
		ffe(3)	0.039	-0.046	-0.051	-0.066	-0.009	-0.038	-0.043	-0.052	-0.034	-0.033	-0.038	-0.044	-0.033	-0.033	-0.039	-0.045	
		ffe(4)	0.033	0.018	0.024	0.031	0.021	0.016	0.022	0.027	0.016	0.015	0.021	0.025	0.015	0.015	0.021	0.025	
eye	EW5	upp	mUI	63	70	73	75	91	96	97	99	104	110	110	113	110	115	115	116
		mid		52	56	58	62	88	94	95	98	108	115	116	119	120	126	126	129
		low		47	46	51	55	78	81	83	87	94	99	101	105	111	116	118	119
	EH5	upp	mV	34	41	41	41	57	61	61	60	66	70	70	70	71	74	73	73
		mid		26	31	32	33	52	56	56	55	66	69	70	70	74	77	76	76
		low		25	26	28	30	47	50	50	50	61	64	64	64	72	74	73	73



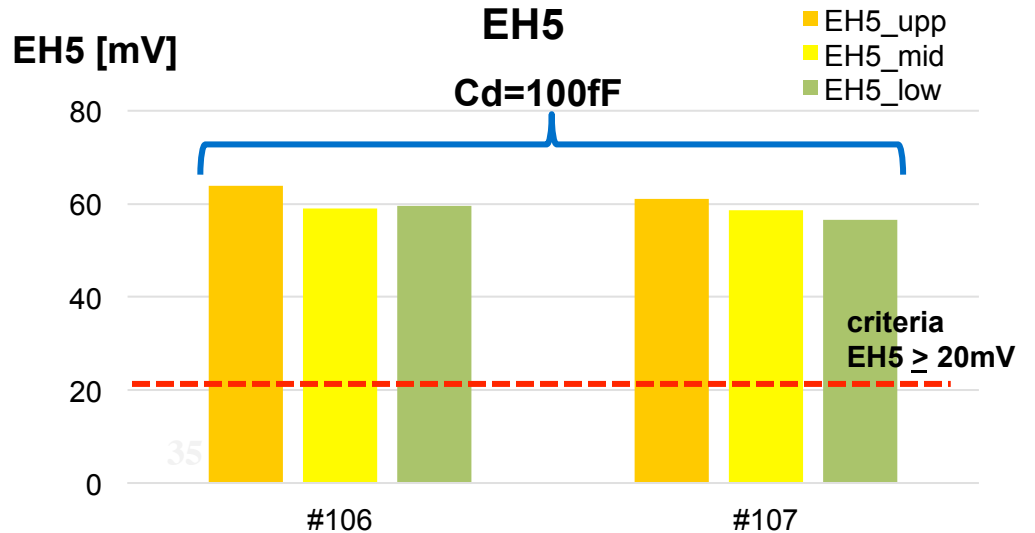
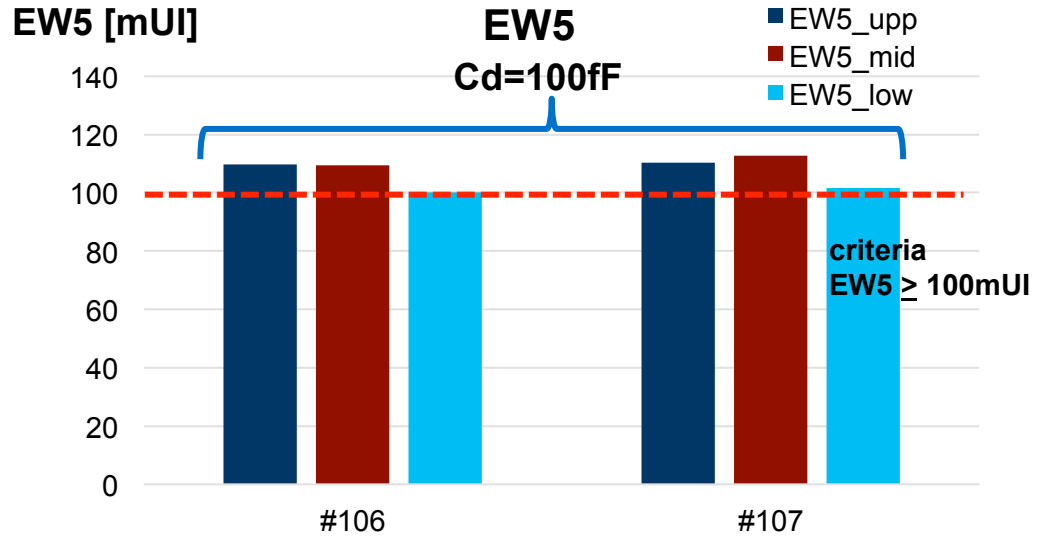


item		unit	#141	#142	#143	#144	#145	#146	#147	#148	#149	#150	#151	#152	#153	#154	#155	#156
Tx/Rx	Cd	fF	100				60				30				0			
eye	EW5	upp	63	70	73	75	91	96	97	99	104	110	110	113	110	115	115	116
		mid	52	56	58	62	88	94	95	98	108	115	116	119	120	126	126	129
		low	47	46	51	55	78	81	83	87	94	99	101	105	111	116	118	119
	EH5	upp	34	41	41	41	57	61	61	60	66	70	70	70	71	74	73	73
		mid	26	31	32	33	52	56	56	55	66	69	70	70	74	77	76	76
		low	25	26	28	30	47	50	50	50	61	64	64	64	72	74	73	73



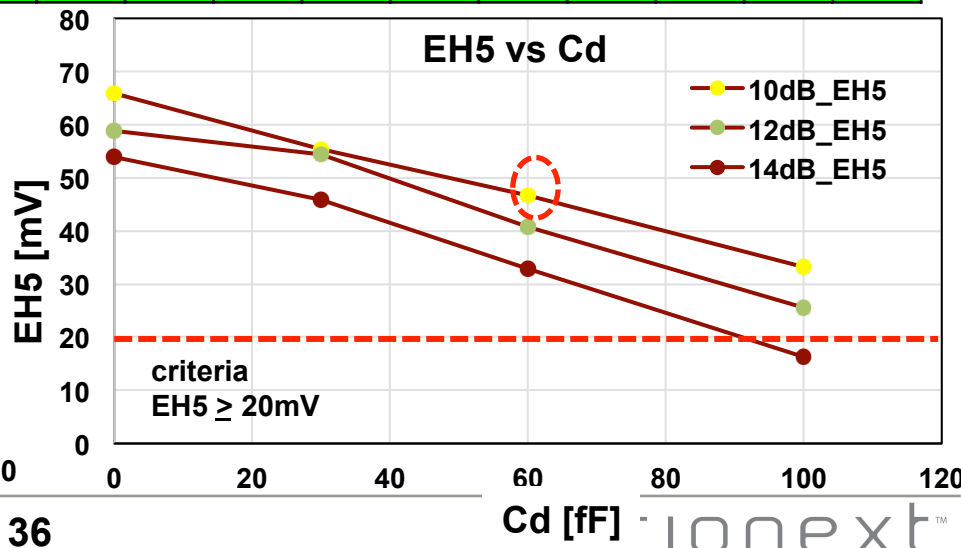
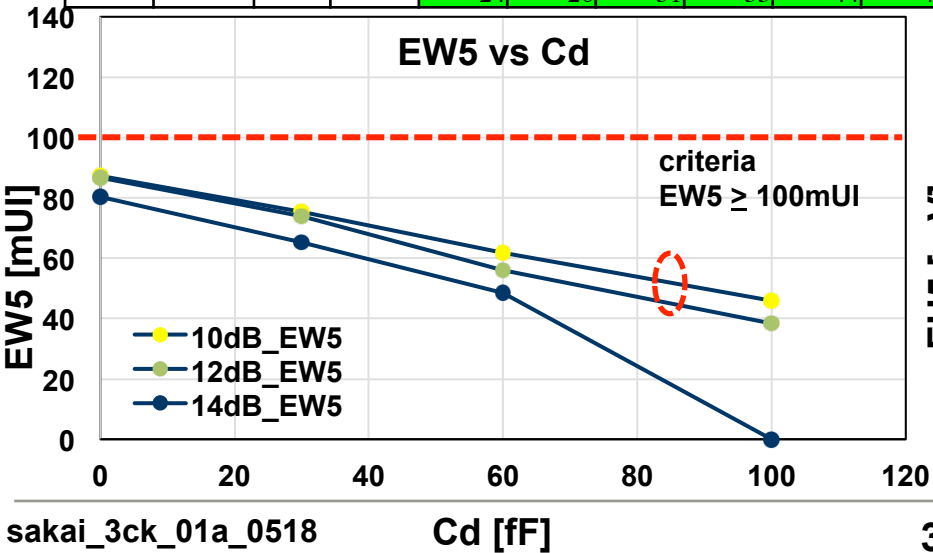
item	unit	#141	#142	#143	#144	#145	#146	#147	#148	#149	#150	#151	#152	#153	#154	#155	#156	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	63	70	73	75	91	96	97	99	104	110	110	113	110	115	115	116
		mid	52	56	58	62	88	94	95	98	108	115	116	119	120	126	126	129
		low	47	46	51	55	78	81	83	87	94	99	101	105	111	116	118	119
	EH5	upp	34	41	41	41	57	61	61	60	66	70	70	70	71	74	73	73
		mid	26	31	32	33	52	56	56	55	66	69	70	70	74	77	76	76
		low	25	26	28	30	47	50	50	50	61	64	64	64	72	74	73	73

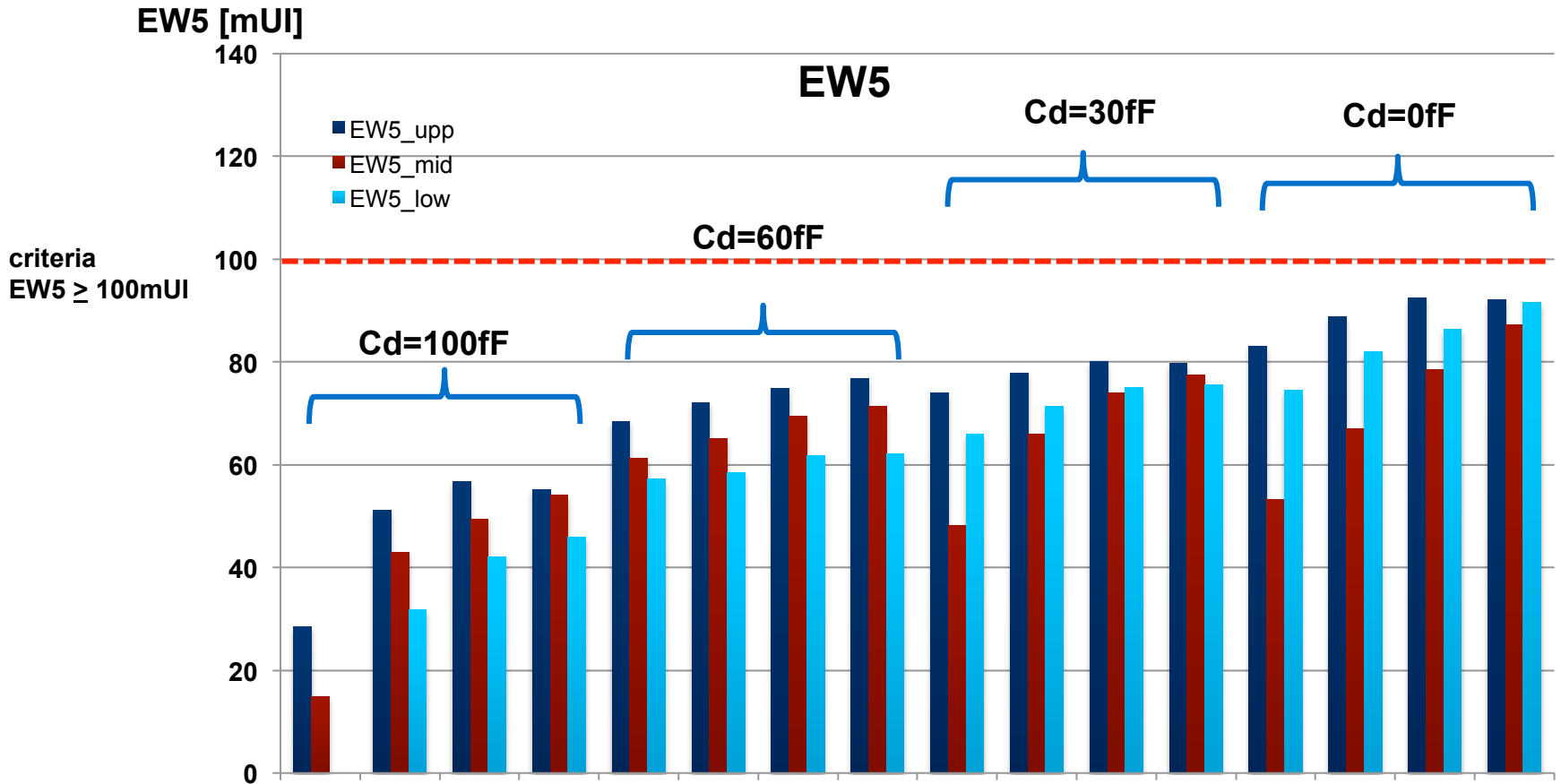
item			unit	#106	#107
Tx	FFE	c(-2)		0.06	0.07
		c(-1)		-0.28	-0.30
		c(0)		0.55	0.60
		c(1)		-0.11	-0.03
Tx/Rx	Cd		fF	100	
Rx	CTLE	p1_HF		1.00	1.00
		p2_HF		0.40	0.40
		z_HF		0.04	0.03
		p_LF		0.12	0.10
		z_LF		0.03	0.03
	FFE	ffe(0)		0.781	0.875
		ffe(1)		0.120	0.021
		ffe(2)		0.091	0.097
		ffe(3)		0.012	0.007
		ffe(4)		-0.004	0.000
eye	EW6	upp	mUI	78	71
		mid	mUI	74	77
		low	mUI	70	72
	EH6	upp	mV	44	40
		mid	mV	40	41
		low	mV	41	39
eye	EW5	upp	mUI	110	110
		mid	mUI	109	113
		low	mUI	100	102
	EH5	upp	mV	64	61
		mid	mV	59	59
		low	mV	60	57
eye	EW4	upp	mUI	150	153
		mid	mUI	153	158
		low	mUI	138	139
	EH4	upp	mV	86	84
		mid	mV	82	80
		low	mV	82	78



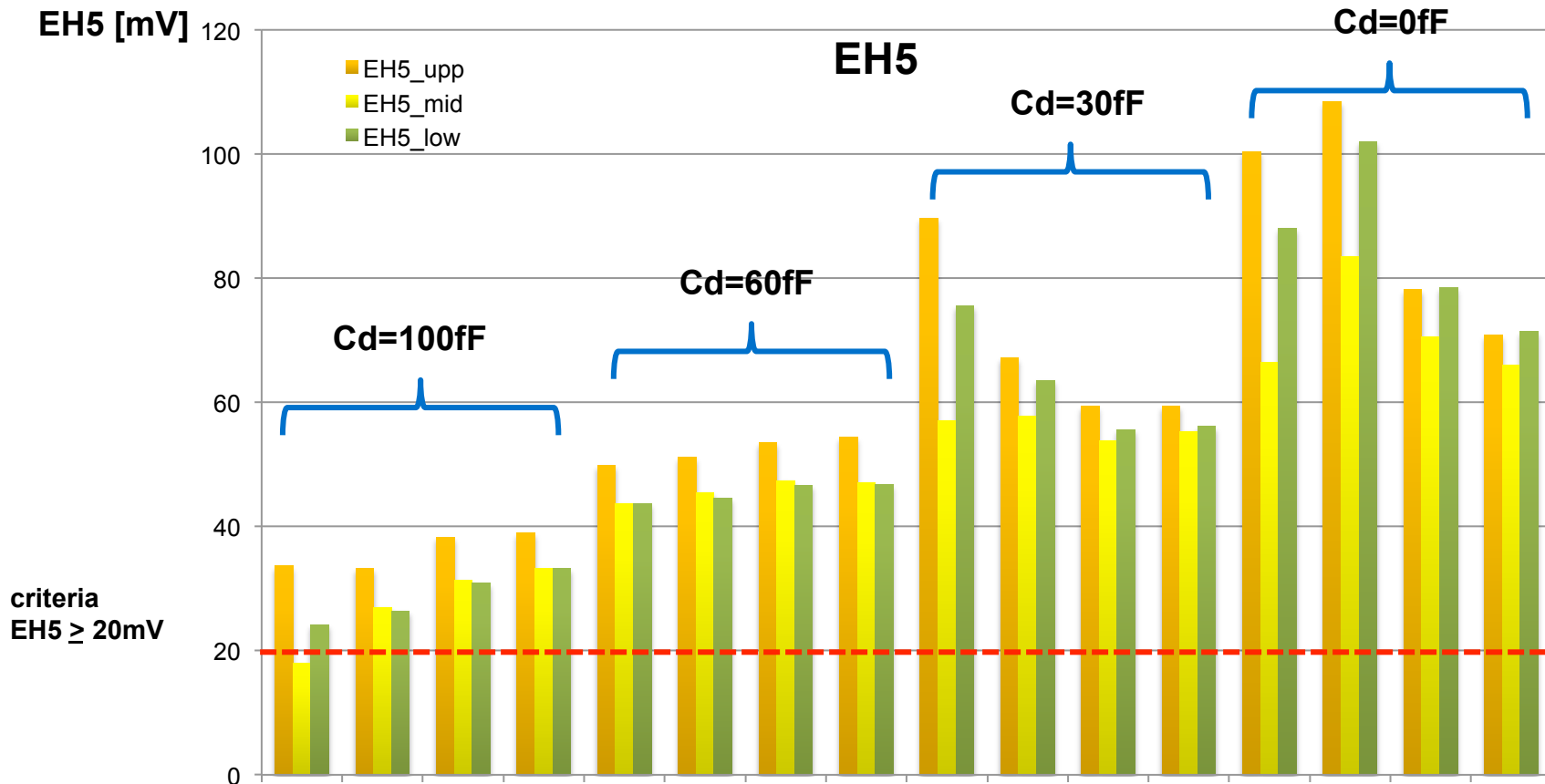
A4.1 Simulation Summary (#4, Cisco 10dB)

item		unit	#161	#162	#163	#164	#165	#166	#167	#168	#169	#170	#171	#172	#173	#174	#175	#176
Tx	FFE	c(-2)	0.075	0.078	0.082	0.085	0.083	0.084	0.086	0.087	0.085	0.087	0.090	0.092	0.081	0.084	0.086	0.089
		c(-1)	-0.285	-0.298	-0.311	-0.324	-0.313	-0.318	-0.323	-0.328	-0.308	-0.316	-0.325	-0.333	-0.301	-0.311	-0.321	-0.331
		c(0)	0.520	0.544	0.567	0.591	0.559	0.568	0.577	0.585	0.532	0.546	0.561	0.575	0.527	0.545	0.562	0.580
		c(1)	-0.120	-0.080	-0.040	0.000	-0.045	-0.030	-0.014	0.000	-0.075	-0.051	-0.024	0.000	-0.091	-0.060	-0.031	0.000
Tx/Rx	Cd	fF	100				60				30				0			
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
		z_HF	0.001	0.003	0.007	0.012	0.002	0.003	0.004	0.005	0.000	0.001	0.002	0.003	0.000	0.000	0.001	0.002
		p_LF	0.111	0.101	0.095	0.095	0.097	0.096	0.092	0.092	0.104	0.097	0.094	0.093	0.107	0.099	0.096	0.094
		z_LF	0.000	0.002	0.006	0.009	0.002	0.002	0.003	0.004	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.001
	FFE	ffe(0)	0.652	0.693	0.737	0.787	0.710	0.727	0.726	0.741	0.663	0.669	0.695	0.734	0.631	0.668	0.695	0.725
		ffe(1)	0.236	0.207	0.156	0.112	0.201	0.188	0.178	0.166	0.256	0.242	0.221	0.185	0.278	0.248	0.226	0.201
		ffe(2)	0.110	0.099	0.101	0.098	0.088	0.085	0.088	0.087	0.088	0.087	0.081	0.079	0.094	0.086	0.080	0.075
		ffe(3)	0.009	0.007	0.005	0.000	0.006	0.005	0.009	0.009	0.006	0.011	0.010	0.007	0.009	0.008	0.007	0.007
		ffe(4)	-0.007	-0.005	0.001	0.003	-0.006	-0.005	-0.002	-0.002	-0.012	-0.008	-0.007	-0.006	-0.012	-0.010	-0.009	-0.008
eye	EW5	upp	28	51	57	55	68	72	75	77	74	78	80	80	83	89	92	92
		mid	15	43	49	54	61	65	69	71	48	66	74	77	53	67	79	87
		low	0	32	42	46	57	59	62	62	66	71	75	75	74	82	86	92
	EH5	upp	34	33	38	39	50	51	53	54	90	67	59	59	100	108	78	71
		mid	18	27	31	33	44	45	47	47	57	58	54	55	66	83	71	66
		low	24	26	31	33	44	45	47	47	76	64	56	56	88	102	79	71





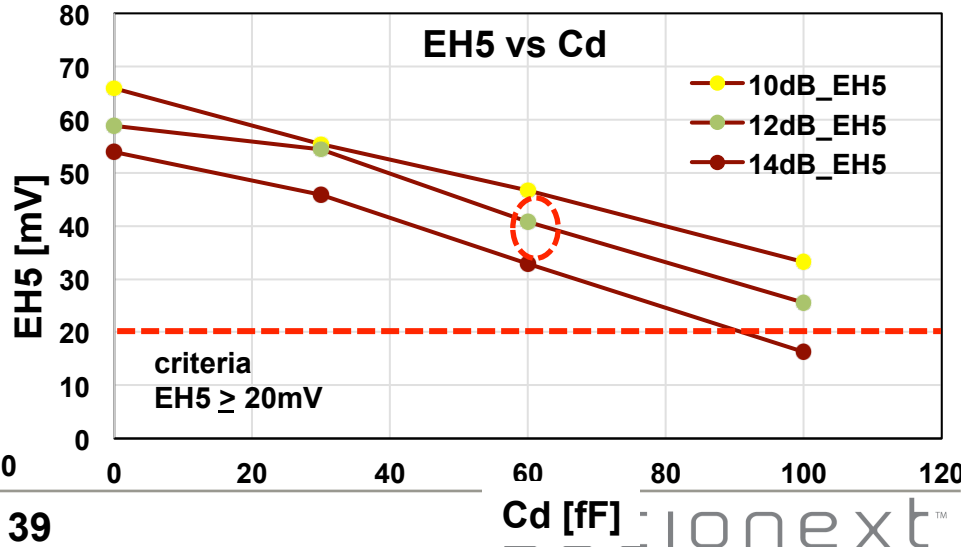
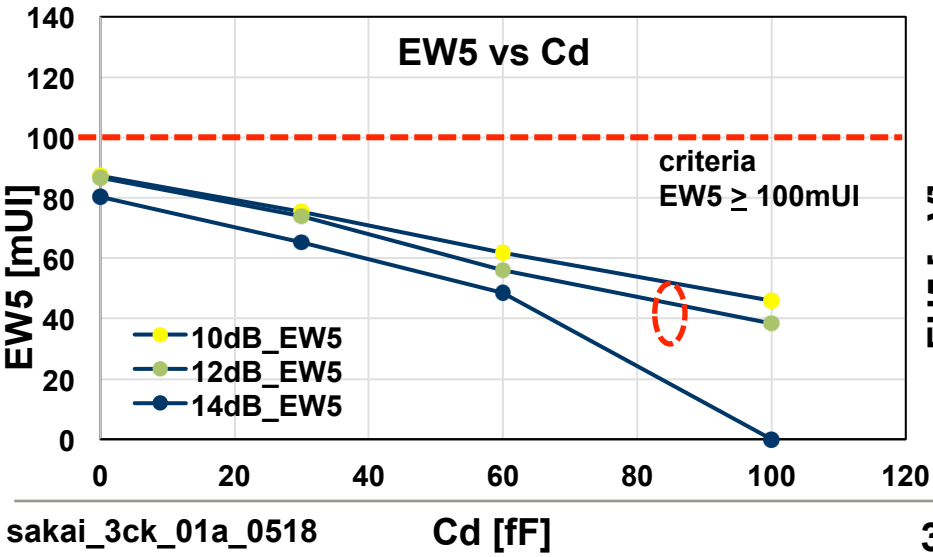
item	unit	#161	#162	#163	#164	#165	#166	#167	#168	#169	#170	#171	#172	#173	#174	#175	#176	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	28	51	57	55	68	72	75	77	74	78	80	80	83	89	92	92
		mid	15	43	49	54	61	65	69	71	48	66	74	77	53	67	79	87
		low	0	32	42	46	57	59	62	62	66	71	75	75	74	82	86	92
	EH5	upp	34	33	38	39	50	51	53	54	90	67	59	59	100	108	78	71
		mid	18	27	31	33	44	45	47	47	57	58	54	55	66	83	71	66
		low	24	26	31	33	44	45	47	47	76	64	56	56	88	102	79	71

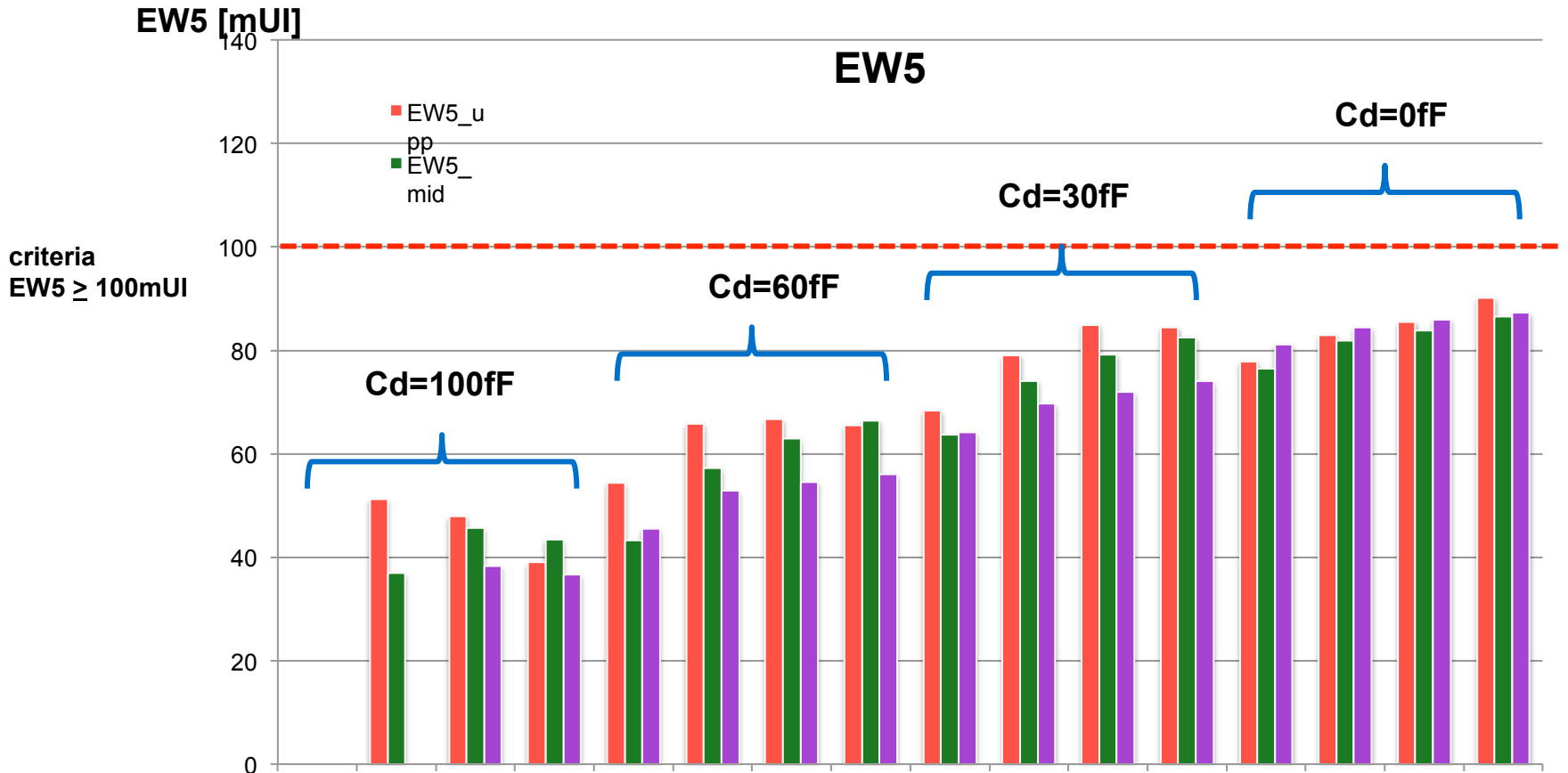


item	unit	#161	#162	#163	#164	#165	#166	#167	#168	#169	#170	#171	#172	#173	#174	#175	#176	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	28	51	57	55	68	72	75	77	74	78	80	80	83	89	92	92
		mid	15	43	49	54	61	65	69	71	48	66	74	77	53	67	79	87
		low	0	32	42	46	57	59	62	62	66	71	75	75	74	82	86	92
	EH5	upp	34	33	38	39	50	51	53	54	90	67	59	59	100	108	78	71
		mid	18	27	31	33	44	45	47	47	57	58	54	55	66	83	71	66
		low	24	26	31	33	44	45	47	47	76	64	56	56	88	102	79	71

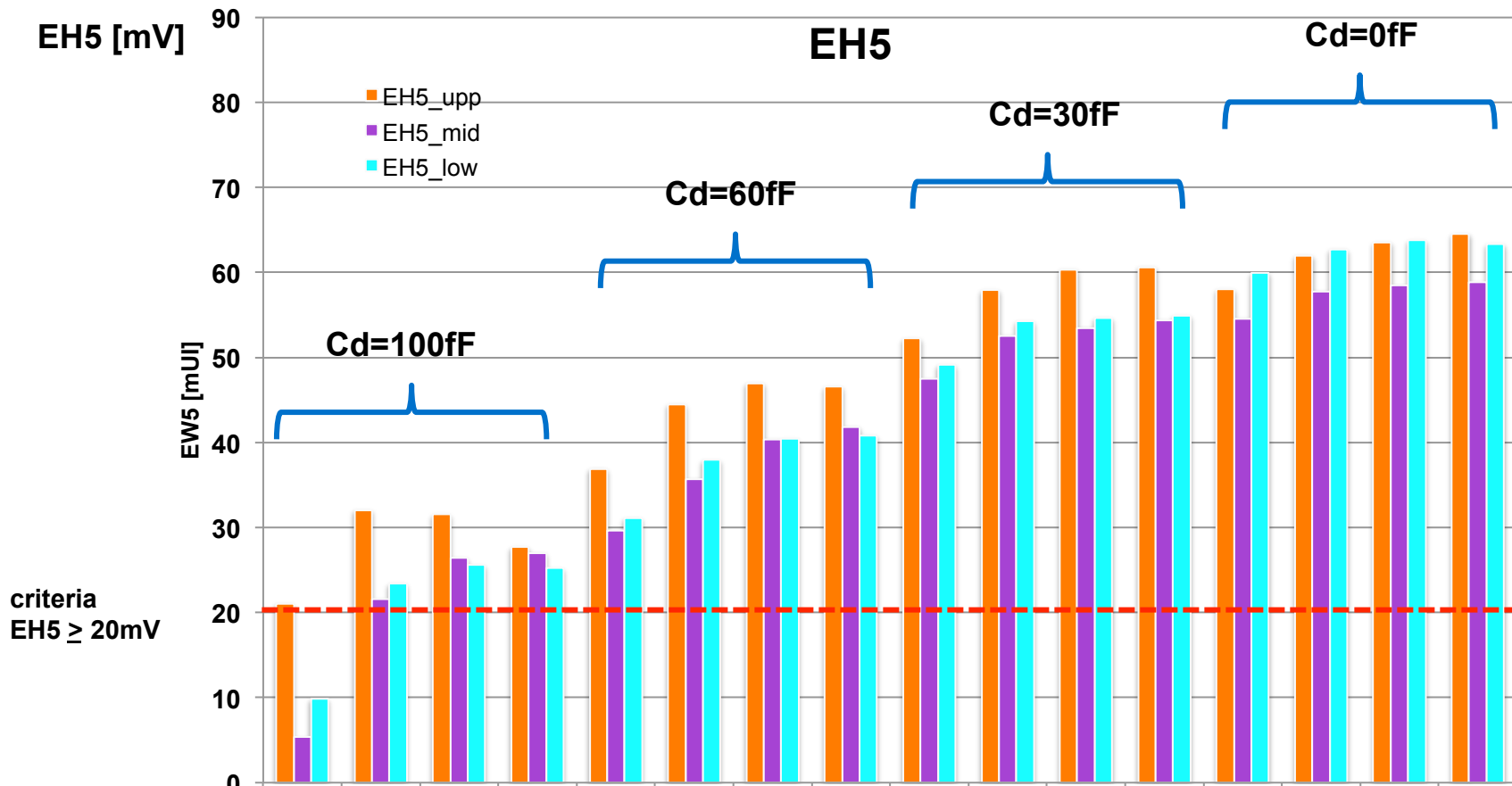
A5.1 Simulation Summary (#5, Cisco 12dB)

item		unit	#181	#182	#183	#184	#185	#186	#187	#188	#189	#190	#191	#192	#193	#194	#195	#196
Tx	FFE	c(-2)	0.073	0.077	0.081	0.085	0.079	0.082	0.085	0.088	0.078	0.080	0.082	0.084	0.087	0.088	0.089	0.091
		c(-1)	-0.278	-0.293	-0.309	-0.324	-0.295	-0.306	-0.316	-0.327	-0.300	-0.308	-0.316	-0.325	-0.318	-0.322	-0.327	-0.331
		c(0)	0.507	0.535	0.563	0.591	0.528	0.547	0.566	0.585	0.546	0.561	0.576	0.591	0.556	0.564	0.571	0.579
		c(1)	-0.142	-0.095	-0.047	0.000	-0.098	-0.065	-0.033	0.000	-0.076	-0.051	-0.026	0.000	-0.039	-0.026	-0.013	0.001
Tx/Rx		Cd	100				60				30				0			
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
		z_HF	0.001	0.008	0.016	0.025	0.003	0.006	0.010	0.015	0.003	0.005	0.008	0.010	0.004	0.005	0.006	0.008
		p_LF	0.110	0.094	0.093	0.096	0.096	0.093	0.089	0.090	0.093	0.088	0.088	0.088	0.090	0.087	0.087	0.087
		z_LF	0.001	0.006	0.013	0.019	0.002	0.005	0.008	0.011	0.002	0.004	0.006	0.008	0.003	0.004	0.005	0.006
	FFE	ffe(0)	0.643	0.694	0.761	0.847	0.671	0.712	0.752	0.795	0.696	0.710	0.740	0.772	0.726	0.725	0.740	0.756
		ffe(1)	0.235	0.187	0.134	0.046	0.227	0.197	0.150	0.112	0.211	0.193	0.168	0.141	0.195	0.187	0.175	0.161
		ffe(2)	0.116	0.110	0.100	0.109	0.100	0.090	0.093	0.090	0.092	0.091	0.086	0.083	0.080	0.082	0.080	0.079
		ffe(3)	0.012	0.009	0.002	-0.011	0.009	0.006	0.005	0.001	0.007	0.010	0.008	0.006	0.006	0.009	0.009	0.008
		ffe(4)	-0.006	0.001	0.003	0.009	-0.007	-0.005	0.000	0.002	-0.006	-0.003	-0.002	-0.001	-0.007	-0.004	-0.004	-0.003
eye	EW5	upp	0	51	48	39	54	66	67	66	68	79	85	84	78	83	86	90
		mid	0	37	46	43	43	57	63	66	64	74	79	82	76	82	84	87
		low	0	0	38	37	46	53	55	56	64	70	72	74	81	84	86	87
	EH5	upp	21	32	32	28	37	44	47	47	52	58	60	61	58	62	64	65
		mid	5	22	26	27	30	36	40	42	47	53	53	54	55	58	58	59
		low	10	23	26	25	31	38	40	41	49	54	55	55	60	63	64	63





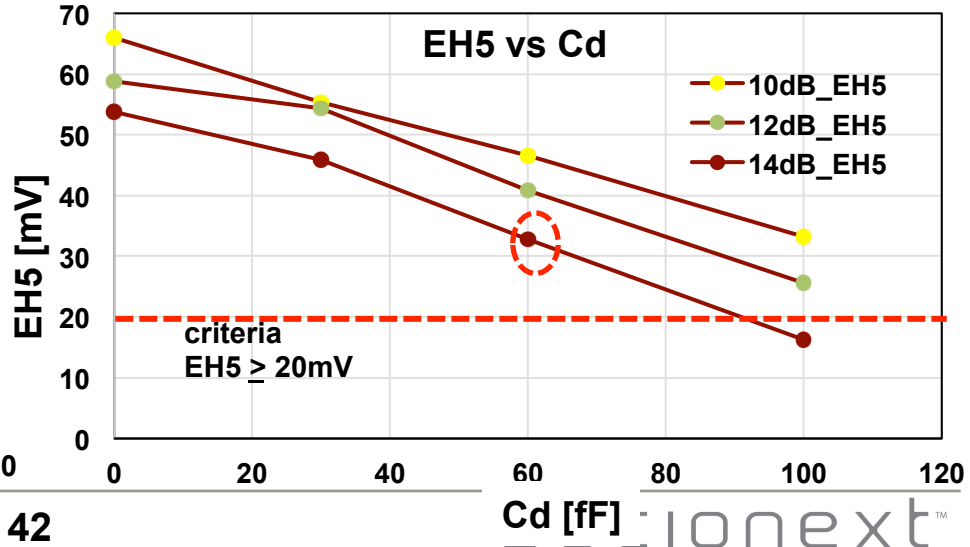
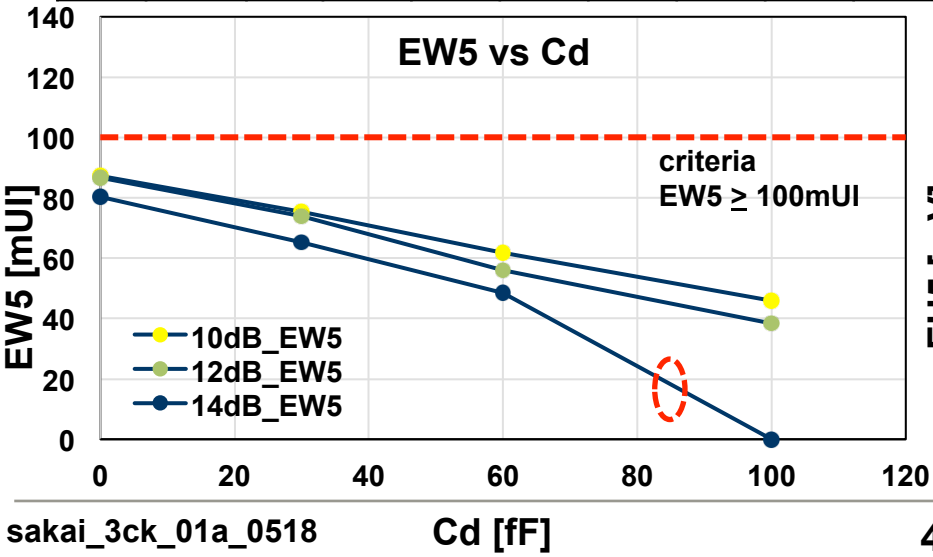
item	unit	#181	#182	#183	#184	#185	#186	#187	#188	#189	#190	#191	#192	#193	#194	#195	#196	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	0	51	48	39	54	66	67	66	68	79	85	84	78	83	86	90
		mid	0	37	46	43	43	57	63	66	64	74	79	82	76	82	84	87
		low	0	0	38	37	46	53	55	56	64	70	72	74	81	84	86	87
	EH5	upp	21	32	32	28	37	44	47	47	52	58	60	61	58	62	64	65
		mid	5	22	26	27	30	36	40	42	47	53	53	54	55	58	58	59
		low	10	23	26	25	31	38	40	41	49	54	55	55	60	63	64	63



item	unit	#181	#182	#183	#184	#185	#186	#187	#188	#189	#190	#191	#192	#193	#194	#195	#196	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	0	51	48	39	54	66	67	66	68	79	85	84	78	83	86	90
		mid	0	37	46	43	43	57	63	66	64	74	79	82	76	82	84	87
		low	0	0	38	37	46	53	55	56	64	70	72	74	81	84	86	87
	EH5	upp	21	32	32	28	37	44	47	47	52	58	60	61	58	62	64	65
		mid	5	22	26	27	30	36	40	42	47	53	53	54	55	58	58	59
		low	10	23	26	25	31	38	40	41	49	54	55	55	60	63	64	63

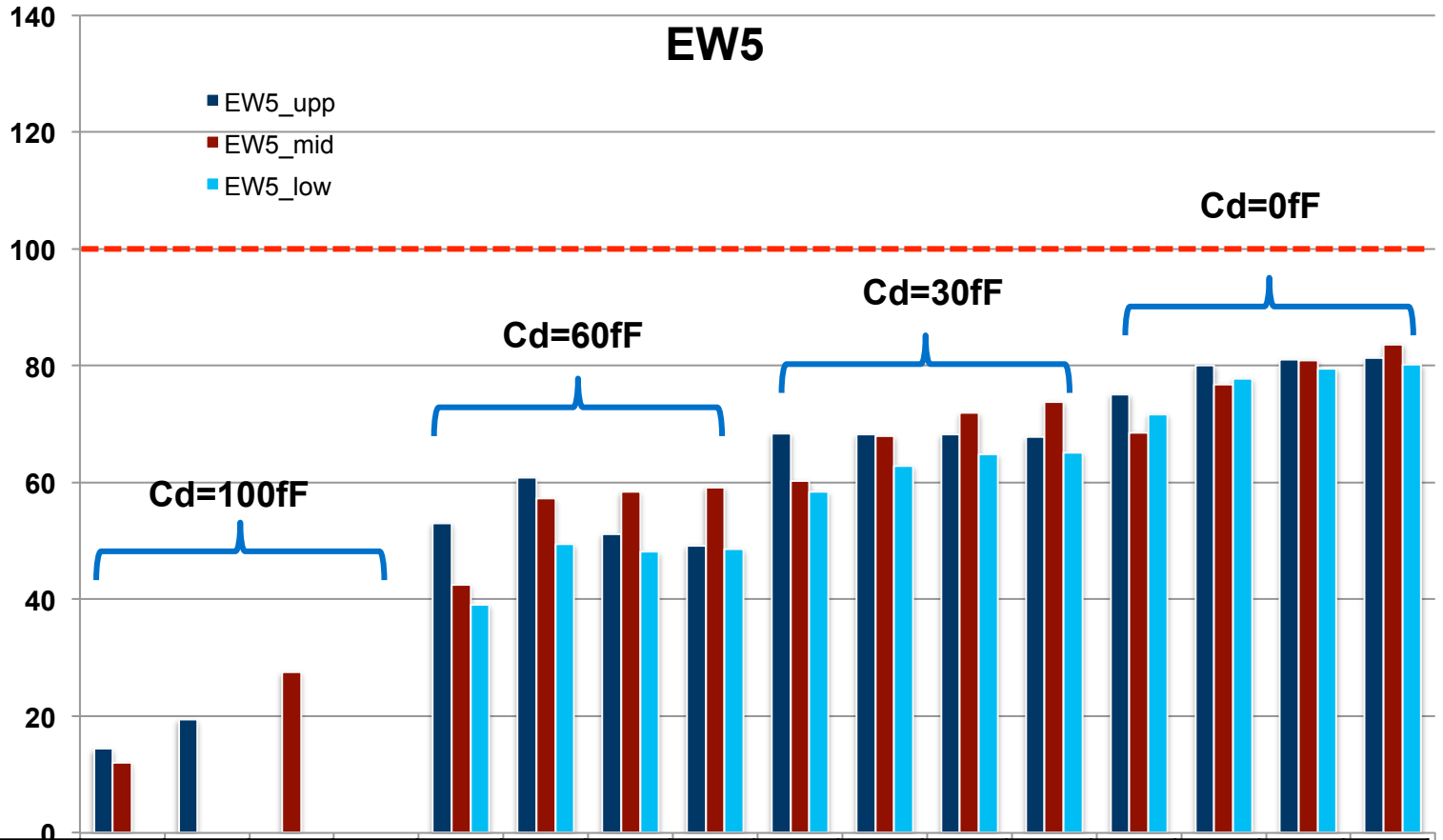
A6.1 Simulation Summary (#6, Cisco 14dB)

item		unit	#201	#202	#203	#204	#205	#206	#207	#208	#209	#210	#211	#212	#213	#214	#215	#216	
Tx	FFE	c(-2)	0.079	0.083	0.087	0.090	0.075	0.078	0.082	0.085	0.078	0.081	0.083	0.086	0.082	0.084	0.086	0.088	
		c(-1)	-0.288	-0.302	-0.316	-0.330	-0.287	-0.300	-0.312	-0.325	-0.297	-0.307	-0.317	-0.327	-0.305	-0.313	-0.321	-0.329	
		c(0)	0.506	0.531	0.555	0.580	0.522	0.545	0.568	0.590	0.534	0.552	0.570	0.587	0.541	0.555	0.569	0.583	
		c(1)	-0.127	-0.084	-0.042	0.000	-0.116	-0.077	-0.038	0.000	-0.091	-0.060	-0.030	0.000	-0.072	-0.048	-0.024	0.000	
Tx/Rx		Cd	100				60				30				0				
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
		z_HF	0.007	0.018	0.029	0.038	0.005	0.012	0.021	0.028	0.006	0.011	0.016	0.021	0.007	0.010	0.014	0.017	
		p_LF	0.099	0.096	0.093	0.098	0.095	0.089	0.090	0.094	0.090	0.086	0.087	0.089	0.089	0.086	0.086	0.086	0.088
		z_LF	0.005	0.014	0.022	0.027	0.004	0.009	0.015	0.020	0.004	0.008	0.012	0.016	0.005	0.007	0.010	0.013	
	FFE	ffe(0)	0.669	0.752	0.813	0.881	0.685	0.722	0.799	0.856	0.697	0.741	0.782	0.825	0.726	0.744	0.776	0.809	
		ffe(1)	0.214	0.148	0.078	0.012	0.209	0.175	0.104	0.051	0.208	0.161	0.126	0.088	0.190	0.168	0.141	0.111	
		ffe(2)	0.110	0.100	0.107	0.110	0.104	0.097	0.096	0.096	0.093	0.093	0.088	0.087	0.086	0.085	0.081	0.079	
		ffe(3)	0.011	0.000	-0.006	-0.014	0.007	0.007	-0.003	-0.008	0.007	0.006	0.002	-0.001	0.004	0.006	0.004	0.002	
		ffe(4)	-0.004	0.000	0.008	0.011	-0.005	-0.001	0.004	0.006	-0.006	0.000	0.001	0.002	-0.006	-0.002	-0.002	-0.001	
eye	EW5	upp	14	19	0	0	53	61	51	49	68	68	68	68	75	80	81	81	
		mid	12	0	28	0	42	57	58	59	60	68	72	74	69	77	81	84	
		low	0	0	0	0	39	49	48	49	58	63	65	65	72	78	79	80	
	EH5	upp	15	20	18	17	35	41	36	34	48	51	49	48	55	58	58	58	
		mid	5	16	19	20	28	35	36	36	40	46	46	47	48	52	53	54	
		low	4	14	16	18	25	33	33	33	41	46	46	46	51	56	56	56	

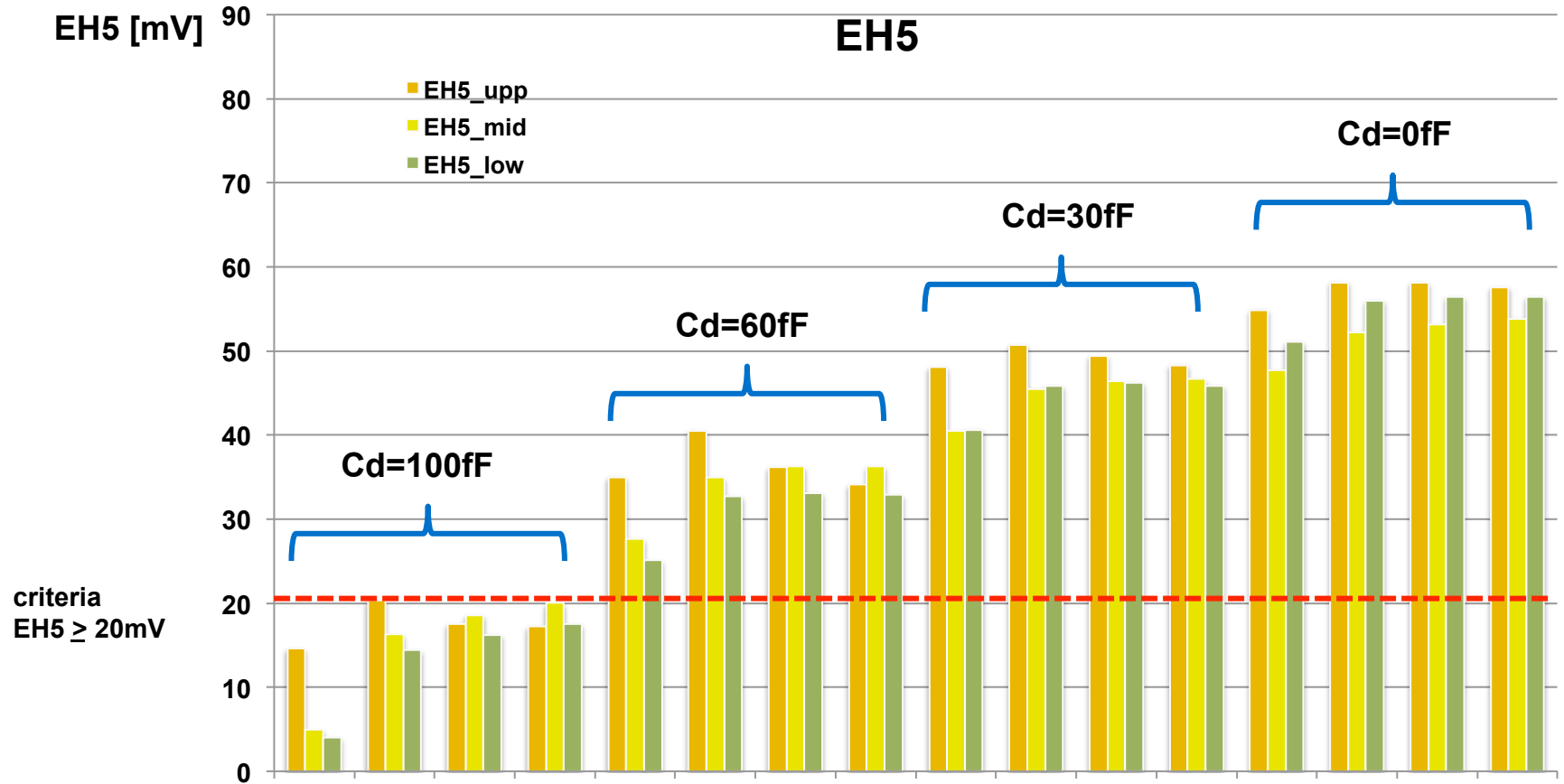


EW5 [mUI]

criteria
EW5 ≥ 100mUI



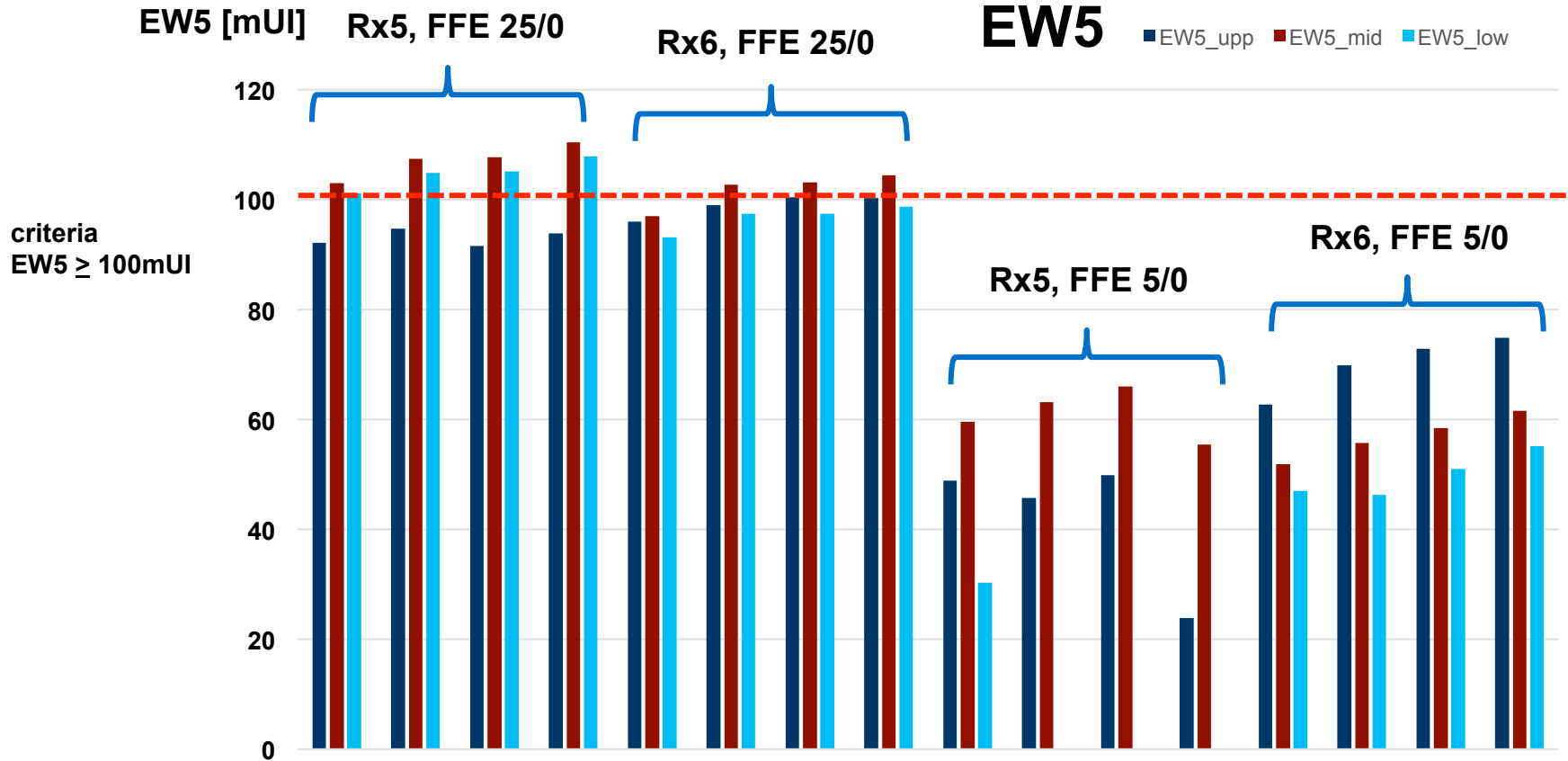
item		unit	#201	#202	#203	#204	#205	#206	#207	#208	#209	#210	#211	#212	#213	#214	#215	#216
Tx/Rx	Cd	fF	100				60				30				0			
eye	EW5	upp	14	19	0	0	53	61	51	49	68	68	68	68	75	80	81	81
		mid	12	0	28	0	42	57	58	59	60	68	72	74	69	77	81	84
		low	0	0	0	0	39	49	48	49	58	63	65	65	72	78	79	80
	EH5	upp	15	20	18	17	35	41	36	34	48	51	49	48	55	58	58	58
		mid	5	16	19	20	28	35	36	36	40	46	46	47	48	52	53	54
		low	4	14	16	18	25	33	33	33	41	46	46	46	51	56	56	56



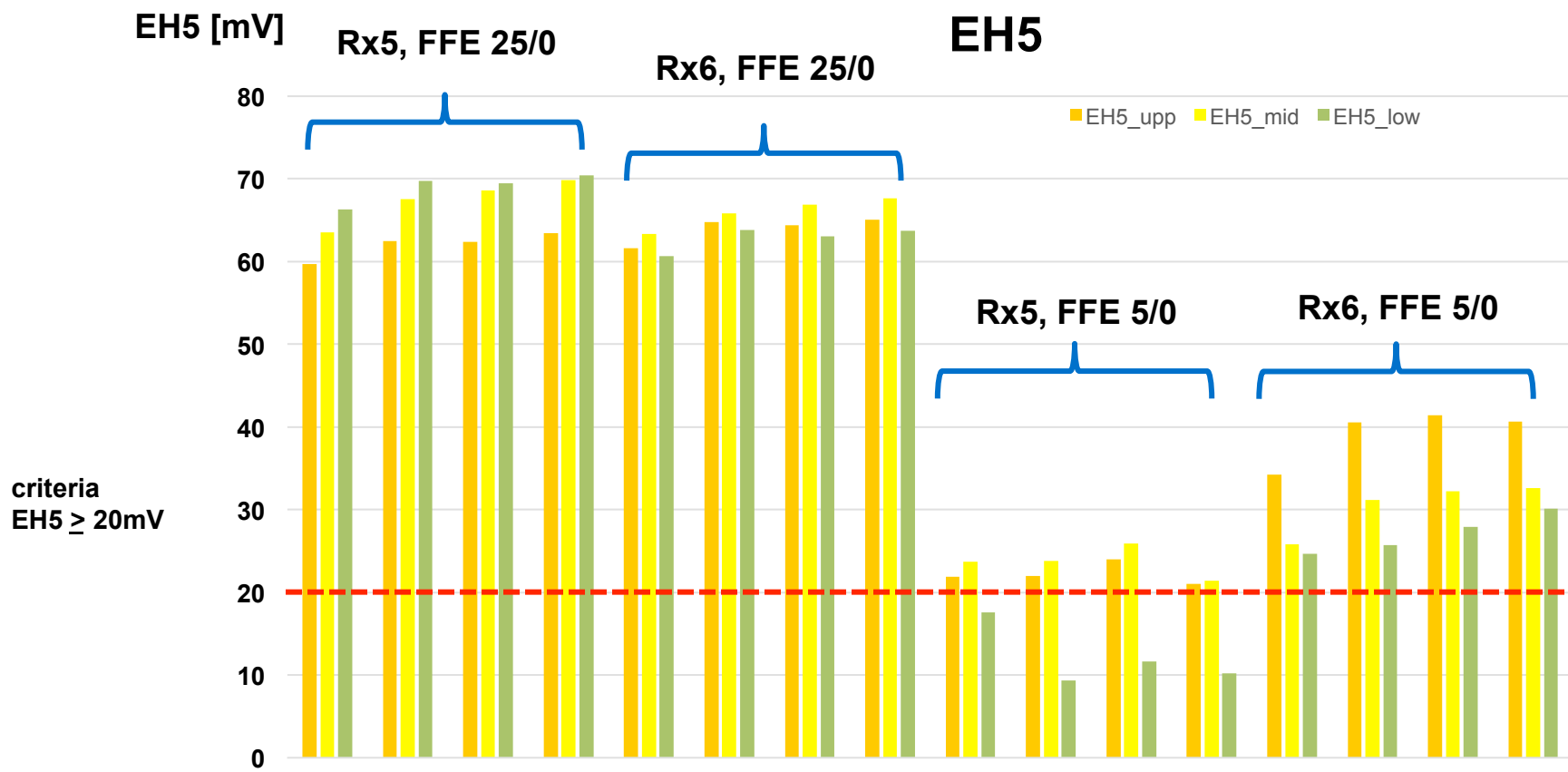
item	unit	#201	#202	#203	#204	#205	#206	#207	#208	#209	#210	#211	#212	#213	#214	#215	#216	
Tx/Rx	Cd	100				60				30				0				
eye	EW5	upp	14	19	0	0	53	61	51	49	68	68	68	68	75	80	81	81
		mid	12	0	28	0	42	57	58	59	60	68	72	74	69	77	81	84
		low	0	0	0	0	39	49	48	49	58	63	65	65	72	78	79	80
	EH5	upp	15	20	18	17	35	41	36	34	48	51	49	48	55	58	58	58
		mid	5	16	19	20	28	35	36	36	40	46	46	47	48	52	53	54
		low	4	14	16	18	25	33	33	33	41	46	46	46	51	56	56	56

A7.1 Simulation Summary (Rx FFE taps, TE micro-via/Rx5/Rx6)

item		unit	#137	#138	#139	#140	#157	#158	#159	#160	#121	#122	#123	#124	#141	#142	#143	#144	
Tx	FFE	c(-2)	0.053	0.056	0.059	0.063	0.054	0.057	0.060	0.063	0.051	0.056	0.061	0.065	0.045	0.049	0.054	0.058	
		c(-1)	-0.247	-0.262	-0.278	-0.293	-0.252	-0.266	-0.280	-0.294	-0.229	-0.251	-0.272	-0.294	-0.222	-0.244	-0.266	-0.288	
		c(0)	0.545	0.578	0.612	0.645	0.551	0.582	0.613	0.643	0.500	0.547	0.594	0.641	0.505	0.555	0.604	0.654	
		c(1)	-0.155	-0.104	-0.051	0.001	-0.143	-0.095	-0.047	0.000	-0.220	-0.146	-0.073	0.000	-0.228	-0.152	-0.076	0.000	
Tx/Rx	Cd	fF	100																
channel			TE/Rx5				TE/Rx6				TE/Rx5				TE/Rx6				
Rx	CTLE	p1_HF	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.051	0.056	0.061	0.065	0.045	0.049	0.054	0.058	
		p2_HF	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-0.229	-0.251	-0.272	-0.294	-0.222	-0.244	-0.266	-0.288	
		z_HF	0.037	0.033	0.031	0.030	0.035	0.032	0.031	0.029	0.500	0.547	0.594	0.641	0.505	0.555	0.604	0.654	
		p_LF	0.046	0.063	0.055	0.051	0.068	0.057	0.047	0.059	-0.220	-0.146	-0.073	0.000	-0.228	-0.152	-0.076	0.000	
		z_LF	0.032	0.025	0.024	0.023	0.025	0.024	0.024	0.024	0.042	0.024	0.022	0.021	0.044	0.024	0.022	0.021	
	FFE	tap/pre	25/0								5/0								
		ffe(0)	0.422	0.603	0.622	0.642	0.534	0.550	0.562	0.779	0.573	0.937	0.989	1.110	0.586	0.917	0.972	1.076	
		ffe(1)	0.167	0.116	0.058	0.015	0.157	0.120	0.076	-0.009	0.179	-0.015	-0.078	-0.227	0.184	0.007	-0.060	-0.181	
		ffe(2)	0.166	0.154	0.159	0.166	0.155	0.147	0.152	0.168	0.161	0.101	0.112	0.154	0.158	0.104	0.115	0.140	
		ffe(3)	0.079	0.036	0.030	0.025	0.049	0.044	0.042	0.003	0.044	-0.047	-0.051	-0.074	0.039	-0.046	-0.051	-0.066	
		ffe(4)	0.074	0.057	0.066	0.071	0.053	0.057	0.066	0.058	0.043	0.025	0.028	0.037	0.033	0.018	0.024	0.031	
		ffe(5)	0.035	0.026	0.035	0.039	0.022	0.027	0.034	0.024	---	---	---	---	---	---	---	---	
		ffe(6)	0.019	0.007	0.009	0.010	0.002	0.005	0.007	-0.011	---	---	---	---	---	---	---	---	
		ffe(7)	0.017	0.012	0.016	0.018	0.018	0.022	0.026	0.023	---	---	---	---	---	---	---	---	
		ffe(8)	0.000	-0.009	-0.008	-0.007	-0.005	-0.004	-0.003	-0.018	---	---	---	---	---	---	---	---	
		ffe(9)	0.016	0.020	0.024	0.027	0.017	0.020	0.023	0.024	---	---	---	---	---	---	---	---	
		ffe(10)	-0.004	-0.011	-0.012	-0.013	-0.007	-0.006	-0.007	-0.019	---	---	---	---	---	---	---	---	
		ffe(11)	0.005	0.007	0.011	0.013	0.005	0.007	0.009	0.008	---	---	---	---	---	---	---	---	
		ffe(12)	-0.004	-0.006	-0.006	-0.007	-0.005	-0.004	-0.004	-0.011	---	---	---	---	---	---	---	---	
		ffe(13)	0.000	0.001	0.003	0.004	0.002	0.003	0.004	0.003	---	---	---	---	---	---	---	---	
		ffe(14)	-0.004	-0.005	-0.004	-0.004	-0.003	-0.003	-0.003	-0.006	---	---	---	---	---	---	---	---	
		ffe(15)	0.000	0.003	0.004	0.005	0.002	0.003	0.003	0.003	---	---	---	---	---	---	---	---	
		ffe(16)	-0.005	-0.005	-0.005	-0.006	-0.003	-0.003	-0.003	-0.006	---	---	---	---	---	---	---	---	
		ffe(17)	0.001	0.003	0.004	0.005	0.000	0.001	0.001	0.001	---	---	---	---	---	---	---	---	
		ffe(18)	-0.006	-0.008	-0.008	-0.008	-0.005	-0.004	-0.004	-0.007	---	---	---	---	---	---	---	---	
ffe(19)	0.002	0.005	0.006	0.007	0.004	0.005	0.004	0.006	---	---	---	---	---	---	---	---			
ffe(20)	-0.002	-0.003	-0.002	-0.003	-0.002	-0.003	-0.003	-0.005	---	---	---	---	---	---	---	---			
ffe(21)	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002	-0.002	-0.004	---	---	---	---	---	---	---	---			
ffe(22)	-0.001	-0.001	0.000	0.000	-0.002	-0.002	-0.002	-0.003	---	---	---	---	---	---	---	---			
ffe(23)	-0.001	-0.002	-0.002	-0.002	-0.001	0.000	-0.001	-0.001	---	---	---	---	---	---	---	---			
ffe(24)	0.035	0.026	0.035	0.039	0.022	0.027	0.034	0.024	---	---	---	---	---	---	---	---			
eye	EW5	upp	mUI	92	95	92	94	96	99	100	100	49	46	50	24	63	70	73	75
		mid	103	108	108	110	97	103	103	104	60	63	66	55	52	56	58	62	
		low	101	105	105	108	93	97	97	99	30	0	0	0	47	46	51	55	
	EH5	upp	mV	60	62	62	63	62	65	64	65	22	22	24	21	34	41	41	41
		mid	63	68	69	70	63	66	67	68	24	24	26	21	26	31	32	33	
		low	66	70	69	70	61	64	63	64	18	9	12	10	25	26	28	30	



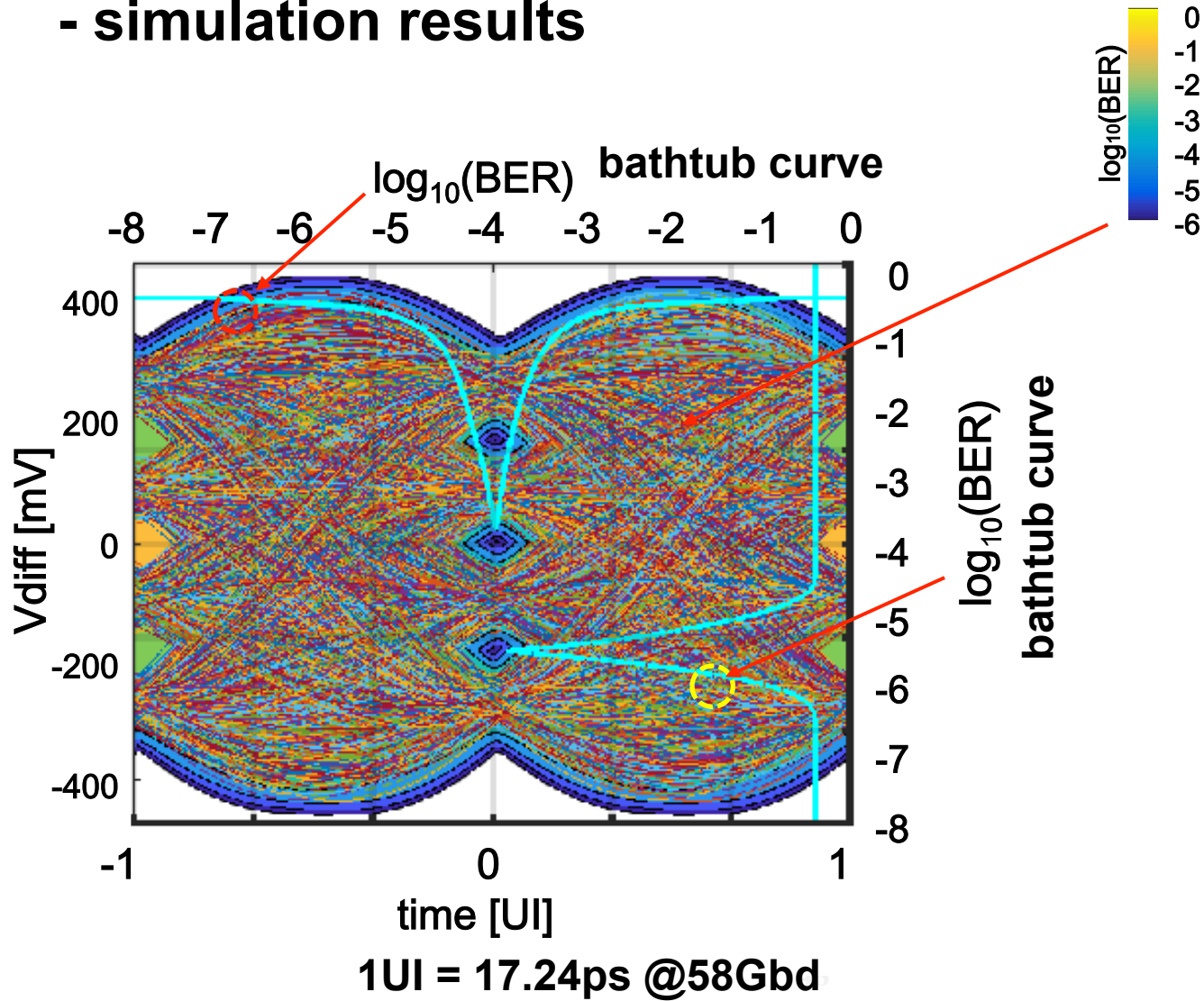
item	unit	#137	#138	#139	#140	#157	#158	#159	#160	#121	#122	#123	#124	#141	#142	#143	#144		
channel		TE/Rx5				TE/Rx6				TE/Rx5				TE/Rx6					
Rx	FFE	25/0								5/0									
eye	EW5	upp	mUI	92	95	92	94	96	99	100	100	49	46	50	24	63	70	73	75
		mid	mUI	103	108	108	110	97	103	103	104	60	63	66	55	52	56	58	62
		low	mUI	101	105	105	108	93	97	97	99	30	0	0	0	47	46	51	55
	EH5	upp	mV	60	62	62	63	62	65	64	65	22	22	24	21	34	41	41	41
		mid	mV	63	68	69	70	63	66	67	68	24	24	26	21	26	31	32	33
		low	mV	66	70	69	70	61	64	63	64	18	9	12	10	25	26	28	30



item	channel	Rx	FFE	tap/pre	unit	#137	#138	#139	#140	#157	#158	#159	#160	#121	#122	#123	#124	#141	#142	#143	#144
						TE/Rx5				TE/Rx6				TE/Rx5				TE/Rx6			
						25/0								5/0							
eye	EW5	mUI	upp		92	95	92	94	96	99	100	100	49	46	50	24	63	70	73	75	
			mid		103	108	108	110	97	103	103	104	60	63	66	55	52	56	58	62	
			low		101	105	105	108	93	97	97	99	30	0	0	0	47	46	51	55	
	EH5	mV	upp		60	62	62	63	62	65	64	65	22	22	24	21	34	41	41	41	
			mid		63	68	69	70	63	66	67	68	24	24	26	21	26	31	32	33	
			low		66	70	69	70	61	64	63	64	18	9	12	10	25	26	28	30	

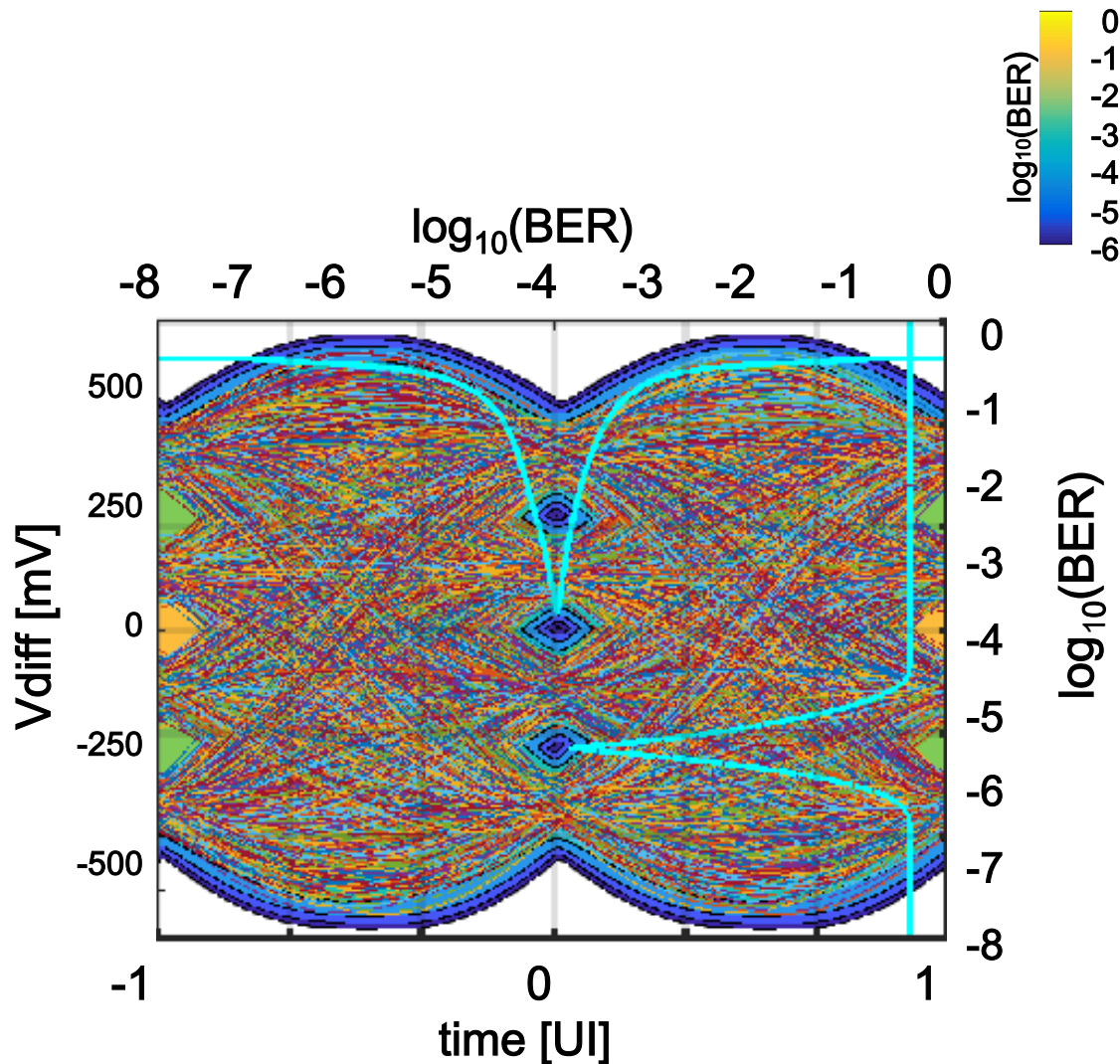
B-0 Rx FFE output eye

- simulation results



“Colors” are corresponding to each line BER.

B-1 Simulation Result (#121)

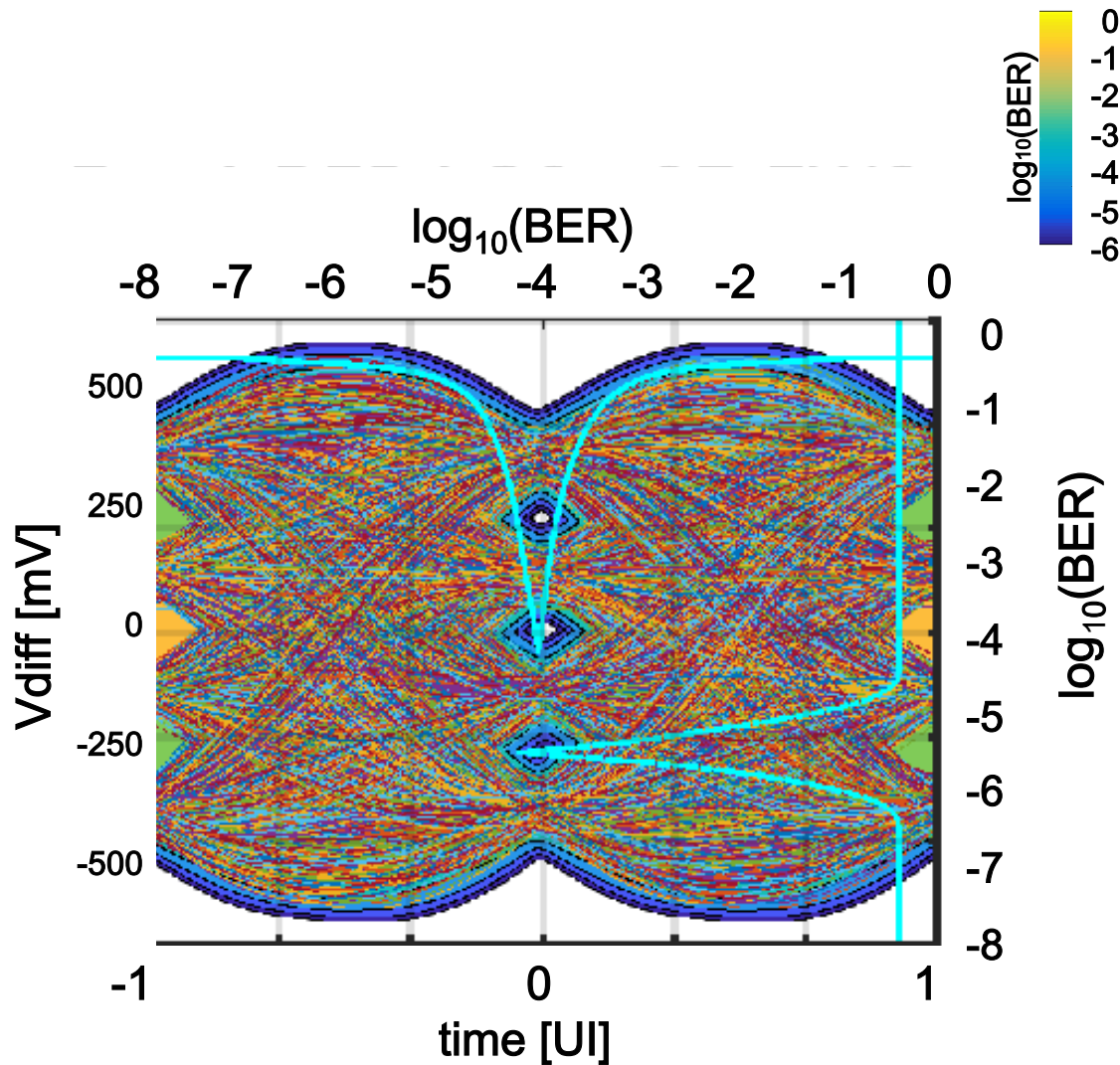


item		unit	#121	#128	#132	#136
baud rate		Gbd	58			
channel	type		#1, TE/Rx5			
	IL	no PKG ^{*1}	16.9 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.62	0.66	0.69	0.70
Tx	FFE	tap/pre	4/2			
	RJrms	mUI	10			
	SNR	dB	32.5			
Tx/ Rx	PKG	trace	27/12			
	Cd	fF	100	60	30	0
	Cp	fF	extracted			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0	V ² /GHz	8.2E-9			
	fr	x fb	3/4			
	FFE	tap/pre	5/0			
	RJrms	mUI	10			
eye	EW5	upp	49	82	98	112
		mid	60	98	118	129
		low	30	51	73	89
	EH5	upp	22	45	57	68
		mid	24	47	62	73
		low	18	30	44	56

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted

B-2 Simulation Result (#128)

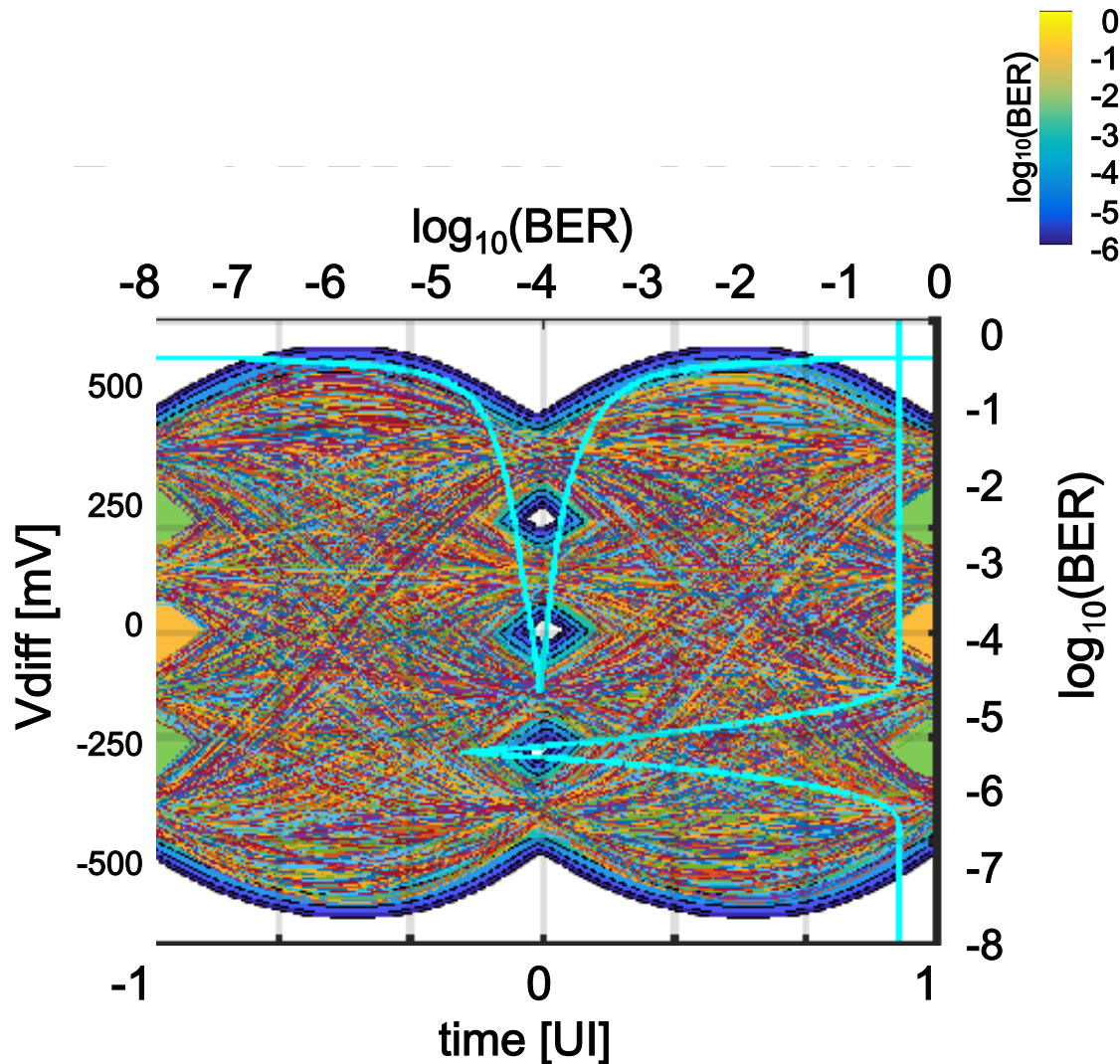


item	unit	#121	#128	#132	#136	
baud rate	Gbd	58				
channel	type	#1, TE/Rx5				
	IL	no PKG ^{*1}	16.9 @29GHz			
		w/ PKG ^{*2}	26.3	25.2	24.5	24.1
ICN	mV	0.62	0.66	0.69	0.70	
Tx	FFE	tap/pre	4/2			
	RJrms	mUI	10			
	SNR	dB	32.5			
Tx/Rx	PKG	trace	27/12			
	Cd	fF	100	60	30	0
	Cp	fF	extracted			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0	V ² /GHz	8.2E-9			
	fr	x fb	3/4			
	FFE	tap/pre	5/0			
	RJrms	mUI	10			
eye	EW5	upp	49	82	98	112
		mid	60	98	118	129
		low	30	51	73	89
	EH5	upp	22	45	57	68
		mid	24	47	62	73
		low	18	30	44	56

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted

B-3 Simulation Result (#132)

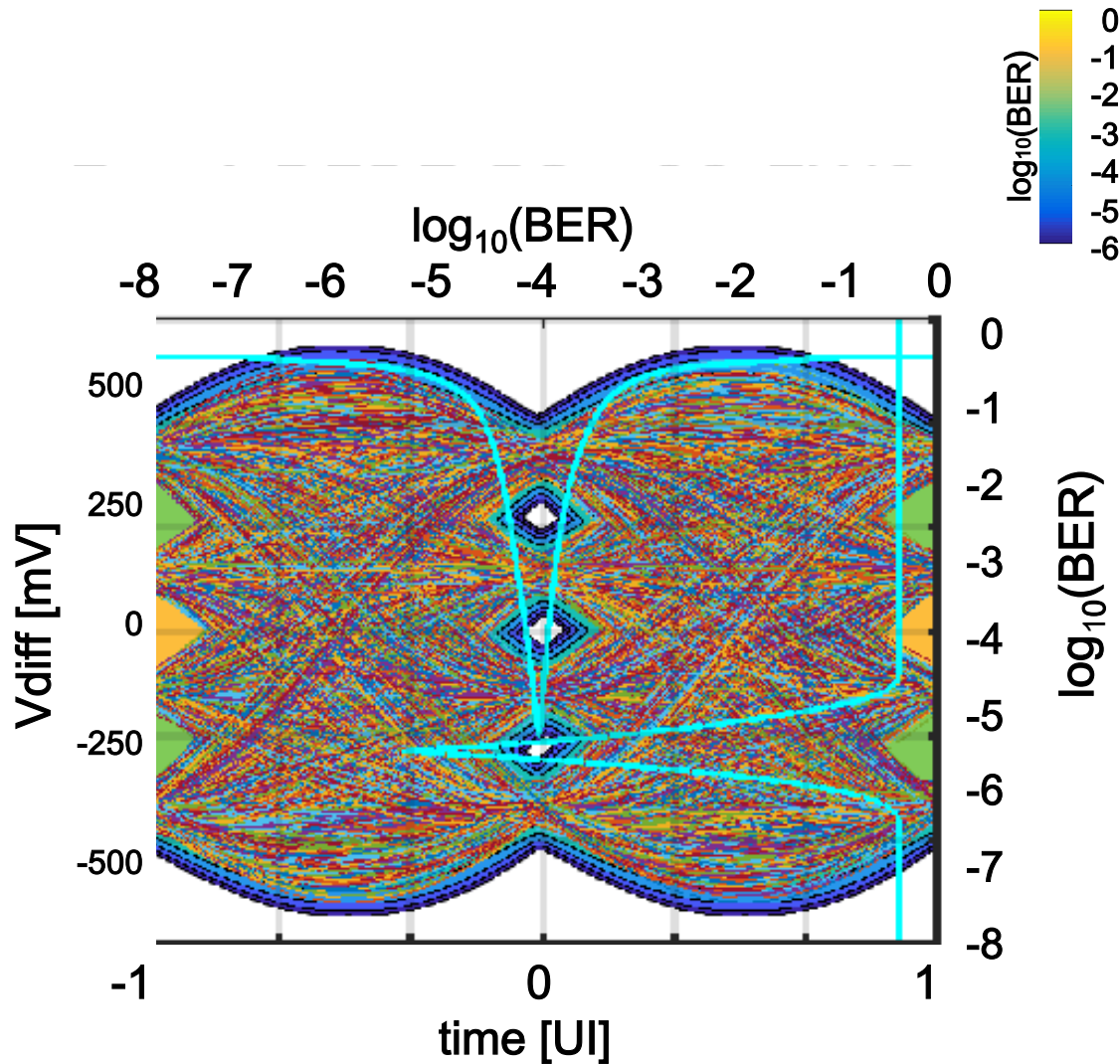


item	unit	#121	#128	#132	#136	
baud rate	Gbd	58				
channel	type		#1, TE/Rx5			
	IL	no PKG ^{*1}	16.9 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.62	0.66	0.69	0.70
Tx	FFE	tap/pre	4/2			
	RJrms		mUI			
	SNR		dB			
Tx/ Rx	PKG	trace	mm			
	Cd		100	60	30	0
	Cp		fF			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0		V ² /GHz			
	fr	x fb	GHz			
	FFE	tap/pre	5/0			
	RJrms		mUI			
eye	EW5	upp	49	82	98	112
		mid	60	98	118	129
		low	30	51	73	89
	EH5	upp	22	45	57	68
		mid	24	47	62	73
		low	18	30	44	56

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted

B-4 Simulation Result (#136)



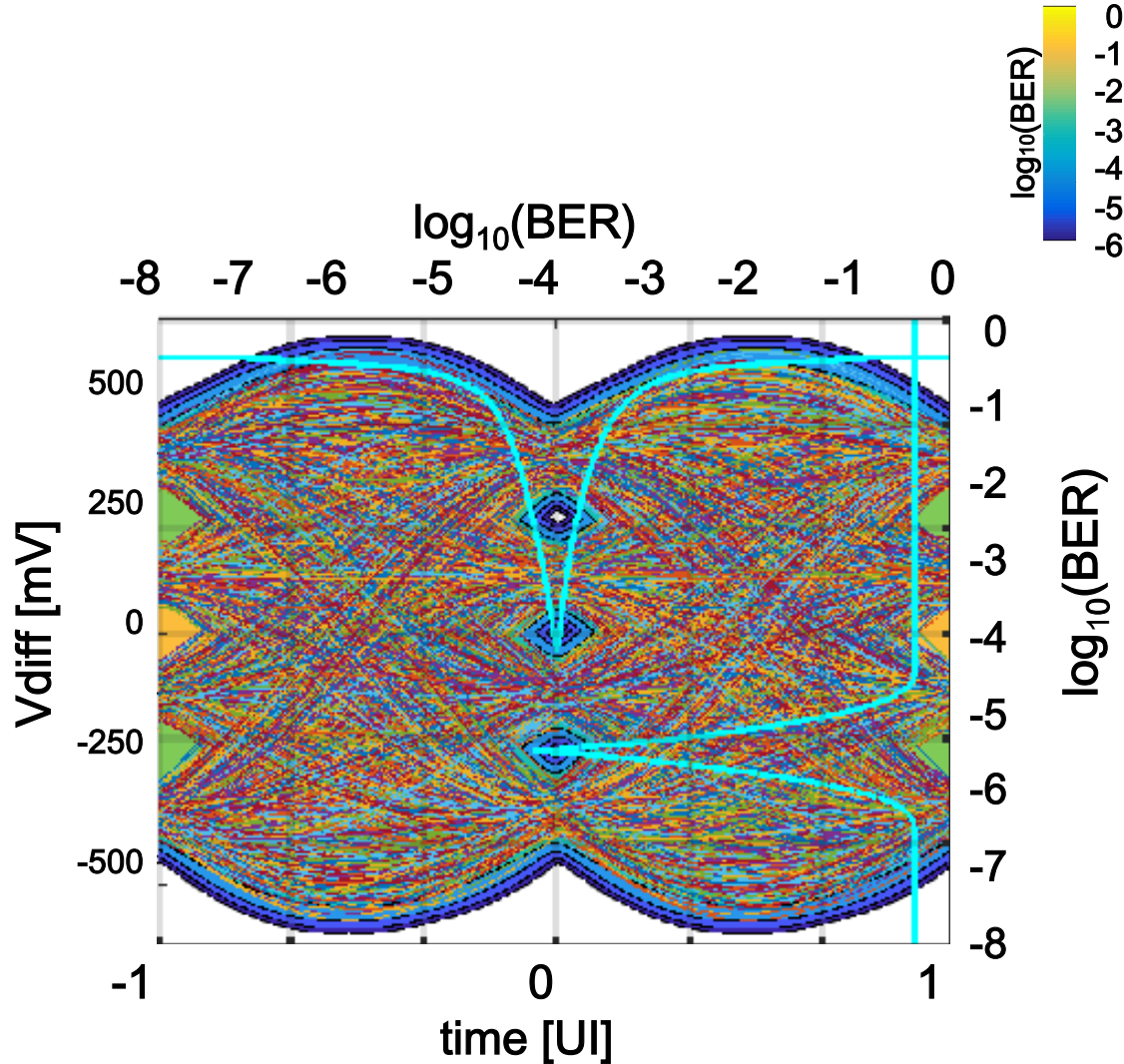
item		unit	#121	#128	#132	#136	
baud rate		Gbd	58				
channel	type		#1, TE/Rx5				
	IL	no PKG ^{*1}	16.9 @29GHz				
		w/ PKG ^{*2}	dB	26.3	25.2	24.5	24.1
ICN		mV	0.62	0.66	0.69	0.70	
Tx	FFE	tap/pre	4/2				
	RJrms	mUI	10				
	SNR	dB	32.5				
Tx/ Rx	PKG	trace	27/12				
	Cd	fF	100	60	30	0	
	Cp	fF	extracted				
Rx	CTLE	HF/LF	2p-1z/1p-1z				
	eta0	V ² /GHz	8.2E-9				
	fr	x fb	3/4				
	FFE	tap/pre	5/0				
	RJrms	mUI	10				
eye	EW5	upp	mUI	49	82	98	112
		mid	mUI	60	98	118	129
		low	mUI	30	51	73	89
	EH5	upp	mV	22	45	57	68
		mid	mV	24	47	62	73
		low	mV	18	30	44	56

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted



B-5 Simulation Result (#143)



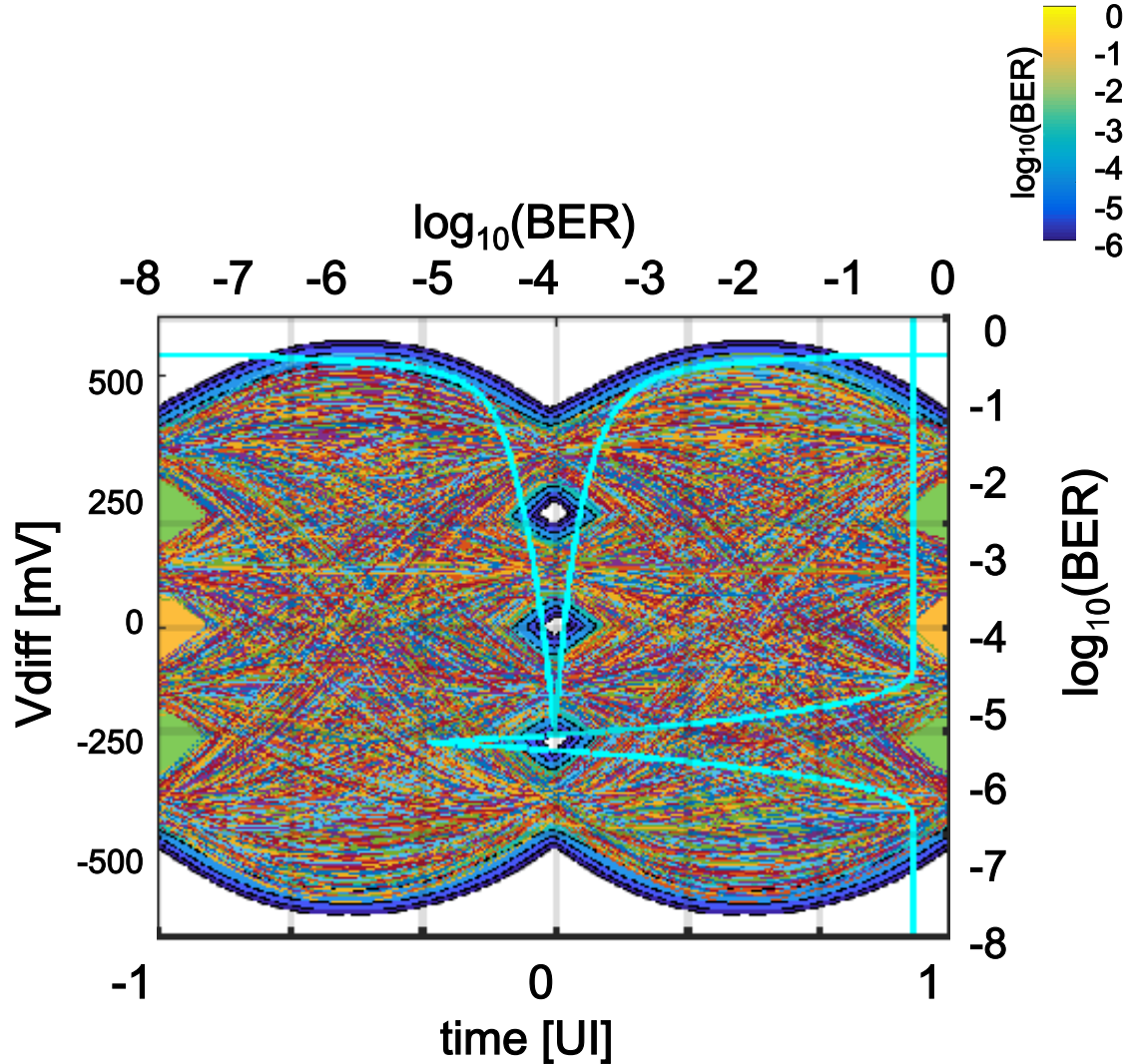
item	unit	#143	#148	#152	#156	
baud rate	Gbd	58				
channel	type		#2, TE/Rx6			
	IL	no PKG ^{*1}	16.3 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.55	0.59	0.61	0.62
Tx	FFE	tap/pre	4/2			
	RJrms		mUI			
	SNR		dB			
Tx/ Rx	PKG	trace	mm			
	Cd		100	60	30	0
	Cp		fF			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0		V ² /GHz			
	fr	x fb	GHz			
	FFE	tap/pre	5/0			
	RJrms		mUI			
eye	EW5	upp	73	99	113	116
		mid	58	98	119	129
		low	51	87	105	119
	EH5	upp	41	60	70	73
		mid	32	55	70	76
		low	28	50	64	73

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted



B-6 Simulation Result (#148)

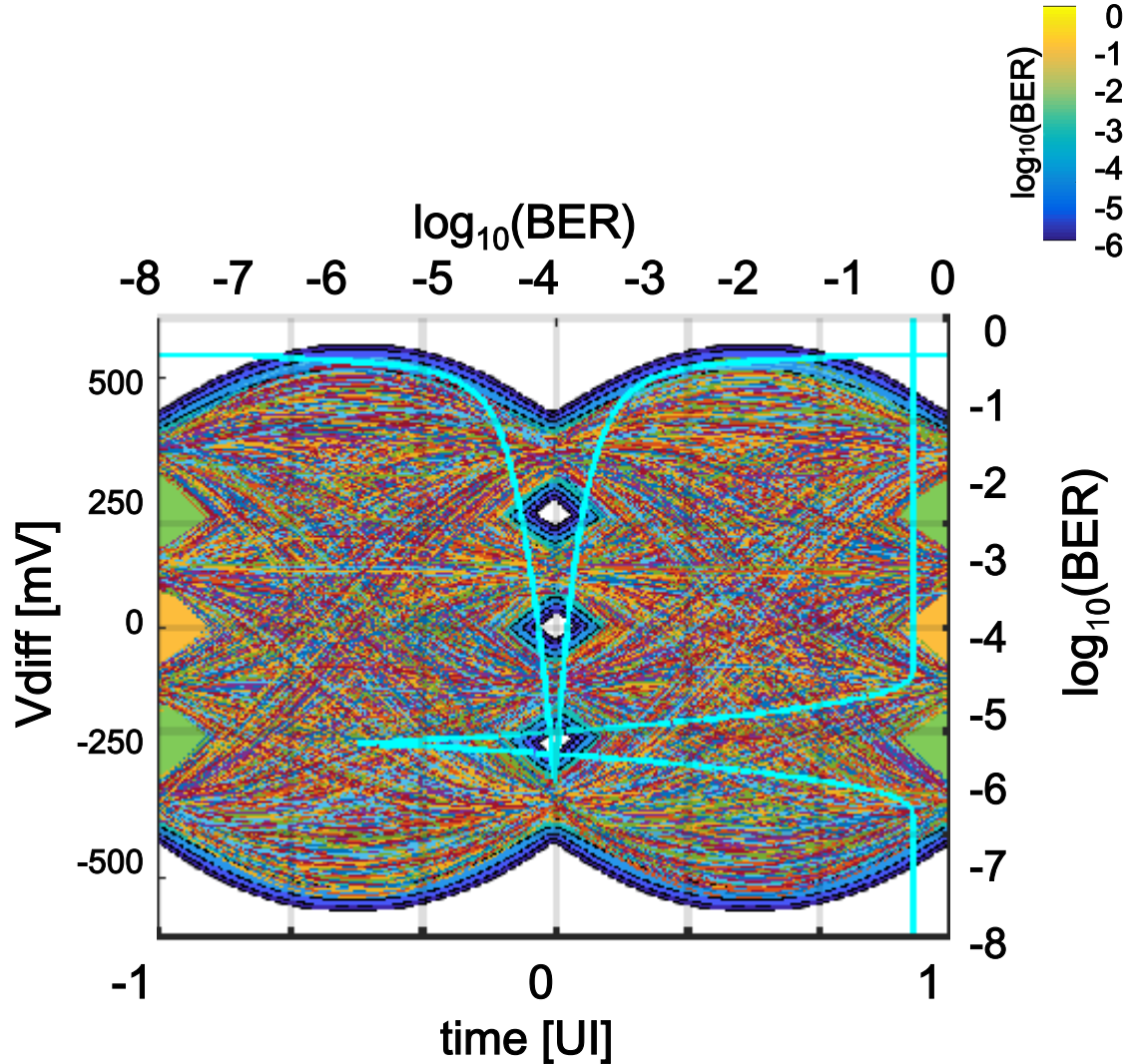


item	unit	#143	#148	#152	#156	
baud rate	Gbd	58				
channel	type		#2, TE/Rx6			
	IL	no PKG ^{*1}	16.3 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.55	0.59	0.61	0.62
Tx	FFE	tap/pre	4/2			
	RJrms		mUI			
	SNR		dB			
Tx/ Rx	PKG	trace	mm			
	Cd		100	60	30	0
	Cp		fF			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0		V ² /GHz			
	fr	x fb	GHz			
	FFE	tap/pre	5/0			
	RJrms		mUI			
eye	EW5	upp	73	99	113	116
		mid	58	98	119	129
		low	51	87	105	119
	EH5	upp	41	60	70	73
		mid	32	55	70	76
		low	28	50	64	73

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted

B-7 Simulation Result (#152)

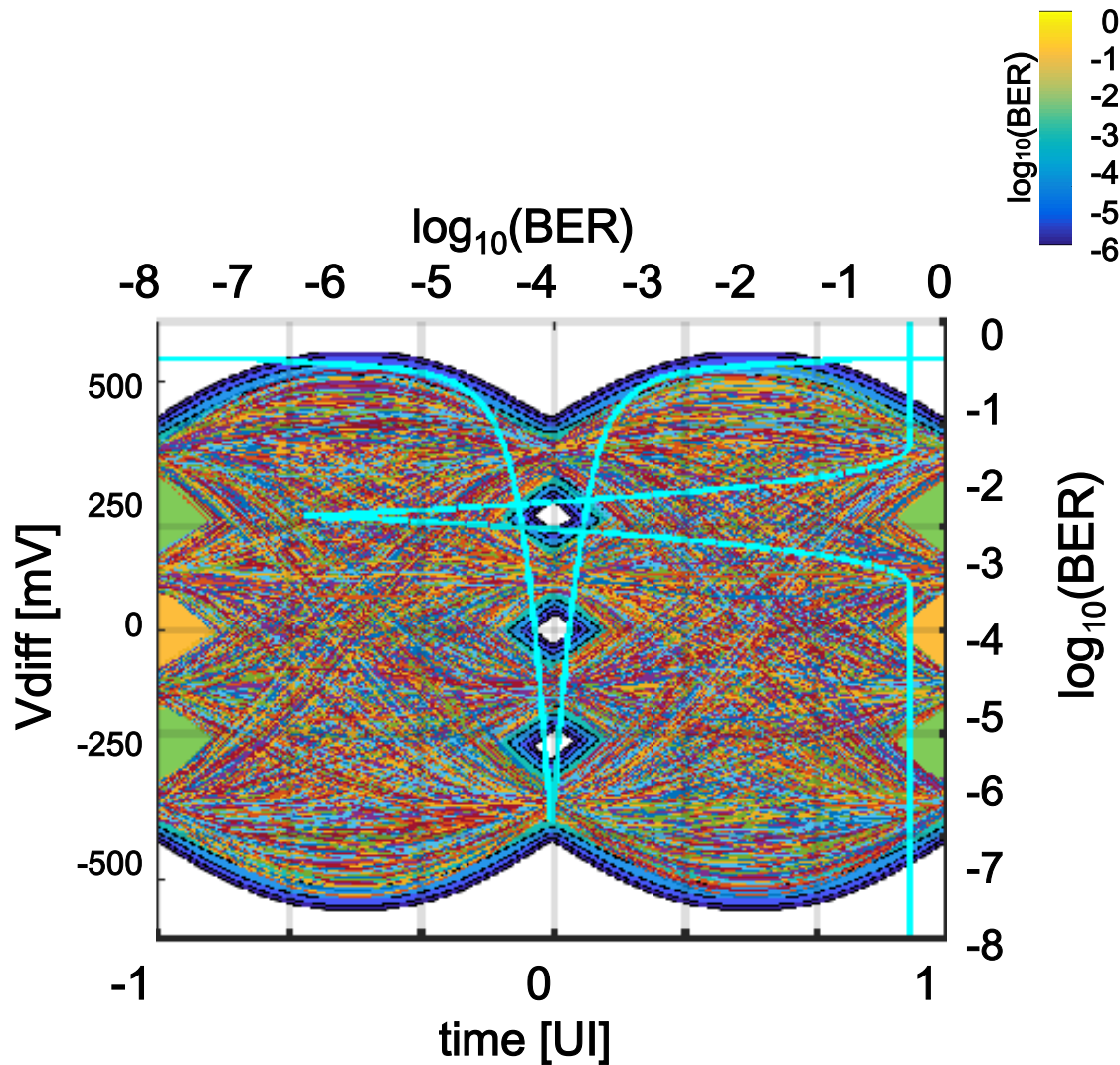


item	unit	#143	#148	#152	#156	
baud rate	Gbd	58				
channel	type		#2, TE/Rx6			
	IL	no PKG ^{*1}	16.3 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.55	0.59	0.61	0.62
Tx	FFE	tap/pre	4/2			
	RJrms		mUI			
	SNR		dB			
Tx/ Rx	PKG	trace	mm			
	Cd		100	60	30	0
	Cp		fF			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0		V ² /GHz			
	fr	x fb	GHz			
	FFE	tap/pre	5/0			
	RJrms		mUI			
eye	EW5	upp	73	99	113	116
		mid	58	98	119	129
		low	51	87	105	119
	EH5	upp	41	60	70	73
		mid	32	55	70	76
		low	28	50	64	73

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted

B-8 Simulation Result (#156)



item		unit	#143	#148	#152	#156
baud rate		Gbd	58			
channel	type		#2, TE/Rx6			
	IL	no PKG ^{*1}	16.3 @29GHz			
		w/ PKG ^{*2}	dB	26.3	25.2	24.5
ICN		mV	0.55	0.59	0.61	0.62
Tx	FFE	tap/pre	4/2			
	RJrms	mUI	10			
	SNR	dB	32.5			
Tx/ Rx	PKG	trace	27/12			
	Cd	fF	100	60	30	0
	Cp	fF	extracted			
Rx	CTLE	HF/LF	2p-1z/1p-1z			
	eta0	V ² /GHz	8.2E-9			
	fr	x fb	3/4			
	FFE	tap/pre	5/0			
	RJrms	mUI	10			
eye	EW5	upp	73	99	113	116
		mid	58	98	119	129
		low	51	87	105	119
	EH5	upp	41	60	70	73
		mid	32	55	70	76
		low	28	50	64	73

criteria
 EW5 ≥ 100mUI
 EH5 ≥ 20mV

*1 : raw
 *2 : fitted



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