# Quantization Noise in COM – Direct Model or Proxy?

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# Background

- In contribution <u>shakiba 3dj 02 2405.pdf</u> the impact of quantization noise on COM channel compliance verification was analyzed and a direct method for modeling it was proposed
- Contribution <u>healey 3dj 01b 2405.pdf</u> considered using existing means (e.g. scaling eta\_0) as a proxy to represent quantization noise
- At the time, there was more support for using the simpler proxy method
  - Still considerable Y's and a lot of undecideds
- The "N" outcome was mostly motivated by the argument of "reference receiver trap"
- Eta\_0 was elevated to 1E-8V<sup>2</sup>/GHz to include the effect of quantization noise
- While the argument of proxy is generally understandable and in many cases applicable, quantization noise is too important to be ignored or represented by a simple proxy
- Also, it would have helped if the theoretical basis of the direct modeling approach and its calculation overhead were better understood, justified, and quantified May 2025

May 2024
Straw Poll #1
I support adding a new noise term (such as 'eta_1' in healey_3dj_01a_2405, slide 6) to the COM reference received
Results (all) Y: 13, , N: 37 , A: 31

### **Facts to Consider**

- A big part of the "reference receiver trap" was to avoid features that are implementationspecific and could cause unreasonable complication
- Vast majority to almost all receiver implementations nowadays use ADC, making this architecture generic and de-facto, and the natural baseline for the reference receiver
- Shift in paradigm to consider the non-ADC-based receiver implementation-specific
- Direct modeling of quantization noise stands on a solid theoretical foundation and can be simply embedded with reasonable overhead
- Quantization noise has some unique and specific attributes that makes it not a good candidate to be replaced by a proxy as simple as a fix scaled and uncorrelated eta\_0 noise term
- Several other attributes of the current reference receiver and existing noise terms are likely less important and arguably more implementation-specific
- Uncertainty around TxFFE optimization in the absence of a realistic quantization noise

# Motivation

- Some observations and developments since then:
  - There was a lack of enough data and clarity on the extend of the overhead of adding the quantization noise model to the COM flow
  - \* Noticeable ongoing interests and requests to further follow up on this topic
  - ✤ Several direct requests for having access to the COM Matlab function with the capability
  - More data have been generated and some presented by others since then
  - \* Recent changes in the COM code motivates an attempt to re-quantify the effect of quantization noise
  - \* The latest released version (480) of the COM Matlab function incorporates the feature
    - Demonstrates a reasonable run time overhead for the added value
    - Provides a wider access
    - There are few COM commit requests in recent COM ad hoc meetings that affect the COM results (bug fixes)
- Hopefully consensus will be built and a move in the right direction will be made:
  - 1) Enough support for adding quantization noise to the COM flow
  - 2) ... or use the presented material as a reference for people who wish to use the feature for further exploration

# **Quantization Noise Model**

• Quantization noise is a new noise term added between CTLE and RxFFE



Quantization Noise

• It can be modeled by a white random noise with uniform distribution over –LSB/2 to +LSB/2 at the injection point



- Quantization clip level can be calculated from the desired probability of signal clipping
- LSB, quantization step size, can be calculated from the desired number of bits and clip level
- Note that modeling quantization functionality is outside the scope, it is only its noise May 2025

# Impact of Quantization Noise on CTLE Utilization

• Quantization noise has a prominent impact on the equalizer distribution and optimization



• CTLE high-frequency gain (gDC) utilization increases with increasing quantization noise

- \* CTLE search range can not be generally reduced (fixing gDC to speed up optimization is not a choice)
- CTLE high-frequency utilization is unrealistically minimal when eta\_0 is used as a proxy
- As expected, CTLE low-frequency boost (gDC2) utilization is not impacted May 2025 IEEE 802.3 Interim

# Impact of Quantization Noise on COM

• With direct modeling, the impact of quantization noise on COM can be quantified accurately, predictively, and realistically



- For the test channels, at least 6 bits is needed to contain the quantization noise
- Even with 6 bits, the test channels suffer anywhere between 0.47dB to 1.86dB of COM penalty May 2025 IEEE 802.3 Interim 7

# The Concern with eta\_0 Proxy Approach

- For three different values of eta\_0 scale and for all test channels COM was calculated
- For each individual channel and using data from the plot on the previous slide, the calculated COM was mapped to an equivalent number of bits that would result in the same COM



• Ideally, it is expected that the equivalent number of bits be independent of channel loss

• The variation and dependency/correlation to channel loss is evident

### **COM Results Comparison**

- As a result, the best estimate of the equivalent number of bits that each scale value reflects is its average over channels
- These averages are used to calculate COM that direct model of quantization noise yields
- COM values obtained from two methods (eta\_0 proxy and direct model) now can be compared for the test channels



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# **COM Difference**

#### • Closer observations:

- ✤ For channels with IL >~ 40dB the proxy method generally under-estimates COM
- ✤ For channels with IL < ~40dB the proxy method generally over-estimates COM</p>
- ✤ Many channels with similar IL can exhibit large COM differences (even more than 1dB)
- Correlation in general is not tight enough
- ✤ Depending on the number of quantization bits (even in a practical range), channel, and insertion loss, the difference could be as much as ±1.5dB, which is unacceptable and could flip pass/fail cases





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# **Pass/Fail and Flipping Cases**

• The difference between COMs from two methods causes some cases to flip the pass/fail test



# **CTLE Utilization Comparison**

#### • A noticeable population of cases do not properly utilize CTLE with the proxy method



- The trend of CTLE under-utilization as quantization noise increases is against expectation
  - Percentage of cases that utilize more than 16dB (out of 20dB or more than 80%) of CTLE:



# **On the COM Simulation Run Time**

- A recent review of one of the changes in COM version 480 revealed that a part of one of the earlier commit requests was not properly implemented
- This change has to do with the method for calculating quantization noise during optimization iterations
  - Method 1 is less accurate, but runs faster (3% run time overhead)
  - Method 2 is more accurate but runs slower (106% run time overhead or 2X slower that method 1)
- Currently, due to a bug both methods are executed but ultimately method 1 overrides the new method
- Consequently, less accurate result of method 1 is yielded with slow run time of method 2 🙁
- A COM commit request will be presented this week to address this issue

# **On the COM Simulation Run Time**

• Run time results without quantization noise and with quantization noise and for both methods across 112 test cases and 3 number of quantization bits:

Average Run Time [s] without Quantization Noise	Average Run Time [s] with Quantization Noise (Method 1)	Average Run Time [s] with Quantization Noise (Method 2)
195	201 (3% Overhead)	401 (106% Overhead)

• The penalty in COM for the above test cases is less than a fraction of a dB except for two cases



# **Summary and Conclusion**

- Same study and data generation and analysis process was carried on a set of 110 C2C and a set of 208 C2M channels and similar results and trends were observed (see Appendix)
- To include the direct model of quantization noise in the COM flow, a candidate proposal could look like the following:
  - ✤ Scale back eta\_0 from 1E-8V<sup>2</sup>/GHz to 5E-9V<sup>2</sup>/GHz
  - \* Add direct model of quantization noise based on this presentation
  - Set probability of clip, P\_qc, to its default value of 2\*DER0
  - Choose number of quantization bits, N\_qb, to match the average COM obtained when eta\_0 was 1E-8V<sup>2</sup>/GHz

Channel	eta_0 [V²/GHz]	P_qc ( = 2*DER0)	N_qb
CR / KR	5E-9	2 x 2E-4	5.62
C2C	5E-9	2 x 0.67E-5	6.31
C2M	5E-9	2 x 2E-5	6.56

### Thank You ©

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# Appendix

**C2C and C2M Test Case Results** 

### Impact of Quantization Noise on CTLE Utilization



18

### Impact of Quantization Noise on COM



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12

12

### The Concern with eta\_0 Proxy Approach



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#### **COM Results Comparison**





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### **COM Difference**





# **Pass/Fail and Flipping Cases**



# **Pass/Fail and Flipping Cases**



# **CTLE Utilization Comparison**



# **CTLE Utilization Comparison**



### **Backup Slides**

**Channel and COM Info** 

# **CR/KR Test Channels**

Channel #	Channel Source
1	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_03_230629.zip
2	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_04_230629.zip
3 – 7	https://www.ieee802.org/3/dj/public/tools/CR/kocsis_3dj_02_2305.zip
8-34	https://www.ieee802.org/3/dj/public/tools/KR/mellitz_3dj_02_elec_230504.zip
35 – 40	https://www.ieee802.org/3/dj/public/tools/CR/shanbhag_3dj_01_2305.zip
41 - 44	https://www.ieee802.org/3/dj/public/tools/KR/shanbhag_3dj_02_2305.zip
45 – 80	https://www.ieee802.org/3/dj/public/tools/KR/weaver_3dj_02_2305.zip
81 - 88	https://www.ieee802.org/3/dj/public/tools/KR/weaver_3dj_elec_01_230622.zip
89	https://www.ieee802.org/3/dj/public/tools/CR/lim_3dj_07_2309.zip
90 – 96	https://www.ieee802.org/3/dj/public/tools/KR/akinwale_3dj_01_2310.zip
97 – 100	https://www.ieee802.org/3/dj/public/tools/CR/akinwale_3dj_02_2311.zip
101 – 112	https://www.ieee802.org/3/dj/public/tools/CR/weaver_3dj_02_2311.zip

### **C2C Test Channels**

Channel #	Channel Source
1 – 72	https://www.ieee802.org/3/dj/public/tools/c2c/heck_3dj_02_2405.zip
73 – 85	https://www.ieee802.org/3/dj/public/tools/c2c/heck_3dj_02_2403.zip
86 - 110	https://www.ieee802.org/3/dj/public/tools/c2c/mellitz_3dj_03_elec_230504.zip

### **C2M Test Channels**

Channel #	Channel Source
1 - 4	https://www.ieee802.org/3/dj/public/tools/c2m/mellitz_3dj_02_2409.zip
5 - 64	https://www.ieee802.org/3/dj/public/tools/c2m/kareti_3dj_elec_02_240111.zip
65 – 82	https://www.ieee802.org/3/dj/public/tools/c2m/gore_3dj_elec_02_231026.zip
83 – 85	https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_01_230629.zip https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_02_230629.zip https://www.ieee802.org/3/dj/public/tools/c2m/lim_3dj_06_2309.zip
86 - 101 102 - 117	https://www.ieee802.org/3/dj/public/tools/c2m/weaver_3dj_elec_02_230831.zip
118 – 123	https://www.ieee802.org/3/dj/public/tools/c2m/shanbhag_3dj_03_2305.zip
124 – 206	https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_02_2307.zip https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_03_2307.zip https://www.ieee802.org/3/dj/public/tools/c2m/akinwale_3dj_04_2307.zip
207- 208	https://www.ieee802.org/3/dj/public/tools/c2m/rabinovich_3dj_02_230116.zip https://www.ieee802.org/3/dj/public/tools/c2m/rabinovich_3dj_03_230116.zip

# **CR/KR COM Config**

#### • COM version 480\_hs2p3 (customization \_hs2p3 applies commit requests 4p8\_1 to 4p8\_5)

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	filter and Eq.			1	beta_x	0			samples_for_C2M	100				2 bp WIEKT	32	mm
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c(-4)	0	0	[mintsteptmax]	-	1	Valse, itter			Local Search	2		0-full grid search, 2-	local search	Seletions (rec	tangle, gaussian, dual ravielg	h triangle
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START	PKG_LowR_CLASSA	[2.44 5.7] db			Ĩ
-	Table 93A-3 parameters				
Parameter	Setting	Units	Information		
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package_t_tau	0.006141	ns/mm	1	d1.0	1
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0	ī
R_d	[ 46.25 46.25 ]	Ohm	[TX RX]	d1.0 cmt 396	ī
z_p (TX)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 :0000 ;0000 ]	mm	[test cases]	d1.0	1
z_p (NEXT)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8; 0000 ; 0000 ]	mm	[test cases]	d1.0	ī
z_p (FEXT)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 :0000 ;0000 ]	• mm	[test cases]	d1.0	ī
z_p (RX)	[33 12 33 33 : 1.8 1.8 1.8 1.8 : 0000 : 0000 ]	mm	[test cases]	d1.0	Ĩ
C_p	[0.4e-4 0.4e-4]	ηF	[TX RX]	d1.0	1
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0,400	d1.2	
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2	
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2	
END					ĩ

START	PKG_HIR_CLASSB	[2.8 5.6 6.7 9	9.4] db	
	Table 93A-3 parameters			
Parameter	Setting	Units	Information	
package_tl_gamma0_a1_a2	[ 0.0005 0.00065 0.000293 ]		1	d1.0
package_tl_tau	0.006141	ns/mm	1 1	d1.0
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm	1	d1.0
R_d	[ 46.25 46.25 ]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[45 30 8 24 2 2 2 2 13 13 13 13 13 15 15 15 15 15	mm	[test cases]	d1.0
z_p (NEXT)	[ 44 29 8 24 : 2 2 2 2 ; 1.3 1.3 1.3 1.3 : 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0
z_p (FEXT)	[45 30 8 24 2 2 2 2 13 13 13 13 13 15 15 15 15 15	mm	[test cases]	d1.0
z_p (RX)	[ 44 29 8 24 : 2 2 2 2 : 1.3 1.3 1.3 1.3 1.3 : 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_V	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	d1.0 cmt 434
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434
END				

# **C2C COM Config**

#### • COM version 480\_hs2p3 (customization \_hs2p3 applies commit requests 4p8\_1 to 4p8\_5)

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Deits_f	0.01	GHz			RESULT_DIR	Vew Its VC2M_date/S			package Z c	42:70 70:80 80:100 X	Ohm	1 m			CN p arameters	
C_d	[0.4e-4 0.9e-4 1.1e-4 0.4e-4 0.9e-4 1.1e-4]	ITE	[TX RX]	d1.0	SAVE_FIGURES	0	logical		2.0 [0]	41111111105	mm	[test cases to run].		1.0	0.278	Fb
13	[0.13 0.15 0.14: 0.13 0.15 0.14]	nH	TX RX	d1.0	Port Oider	[1324]	input fi	1	17(3)() a _ 1	4 1 11:11 1 1:05	min	[test cases]	-	0.	0.278	Fb
⊃C_b	[0.3e4 0.3e4]	ITE	TX RX	d1.0	RU/JTAG	C2M_	-		E D(FENT)	4 1 11:11 11:05	mm	[test cases]		f.n	0.278	Fb
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PKG_NAME	PWG HIR CLASSE PHG LOWR CLASSA	1	TX RX		DR	and ERL options	1		-	Operational				Ant	0.450	V
AN	0.387	v			TDR	1	lagia)		ERL Pass the shold	10	de	a				
At	0.387	V			ERL	1	lagical		CDM Pass threshold	3	db	1.11		Parameter	Setting	
And	0.482	v			ERL DONY	6	laria)		DERO	6.70=05				boad ti camma0 at a2	10 9 996-4 2 66-051	1.4 db/in @ 53.125
z o select	[1]	1	-		TR TOR	0.005	115	-	T.c.	0.00400	ins.	Participant and a second		board til tau	5.790Ed3	ris/mm
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.M.	32	0	1	1	TDR_Butterworth	i	1		EM.D_type	CIC		1		z_bp (1X)	32	mm
1.	filter and Eq	-		1	bes x	0			samples for C2M	100				2 bp (VIEXT)	32	(1911)
15	0.550	fb *fb		d1.0 cmt60 (60 GHz)	mo_x	0.618			0.5	50				z bp (FEXT)	32	(film)
c[0)	0.54		min	d1.0 cmt 37	TOR W TXPNG	1	UI	ER L computed at TP 1a	BW	1				r bo (RX)	32	mm
c[-1]	0	6.34:0.02	[# [ministepomak]	d1.0 max value -0.34	NLbx	16	UI.		MUSE	1 4	logical	2		C.0	(0.29e-40)	'nF
x(-2)	0	. 01.0240.14	a) [ministepomak]	d1.0 max value 0.14	fixture delay time	(00)	5		ts_archor	1		The second se		C_1	[0.1e-4 0]	nF.
c(-3)	0	0	[min:step.max]		Tulky_Window	1		-	sample_adjustment	(-15 16)				Include PCB	0	logical
c(-4)	0	0	[minister.max]			Nalse, itter			Local Search	2		0-full prid search, 2-	local search	Seletions (rec	tangle, gaussian, dual raviely	ghimlangle
c[1]	0	+0.20.02:	Annt caternin 0	d1.0 cm 37	signa_RJ	0.01	UI.					MLSE trunction leng	th 8-16 not adopted yet	Histogom_Window_Weight	ន្ទារេន sion	selection
N_B	4	01		d1.0	A_DD	0.02	U			Filter:	RaffE		and the second s	Dy	0.02	- UI
0_max(1)	0.85		As/dfe1	d1.0 cm 279	da_0	1.005-08	V^2/GHz		if pre to en	2	Ú.					
b_mac(2_N b)	9		As/d/e2_N_B		34R_T8	33.5	dB		it nos tap len	B			· · · · · · · · · · · · · · · · · · ·	1		1
(1) niin (1)	Q.		As/dile1	d1.0 cmt 279	R LM	0.95			fie pre_tap1_max	0.7	-++-	COM to change to W	max/min	4		
b min(2_N b)	-0.15	- 104	Z+dth lFAIr	- oc					fit_post_tap1_max	0.7	interpreted as +/-	COM to change to W	nak/min	4		
E.DC	(-20:1:0)	de de	[min:Step max]	d1.0 [May value-20]					ffe_tabn_max	0.7	mendinged as +/-	COM to citange to W	nav/min	1		
12	42.50	GHz		d1.0	manin perinter	1.1	incer.		FFE OFT METHOD	MMS		IV-UMS or MMSE	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	1		
1.01	42.50	GHz	-	d1.0	29.029	1,00200			num ui RXFF noise	2048				1		
[_p2	106.25	GHZ		d1.0	£1 GB	4				Floating Ta	ap Control					
E DE HP	[-6:10]		[mm.step.max]	d1.0	al code see	104690			n br	2	0 1 2 or 3 goups	14 C		1		
LHP_PZ	1.328125	GHz		d1.0	tranc.	101			N_H	- 1	pos per goup	1. I				
Butterworth	1	logical	include in fr	1	1.5	206			11.3	04	UT span for floating taps	(1)(				
					ald_st_mess	1			bmag	0.2	mar DFE value for floating tass.				l	
									E_float_RSS_MAX	1 1	as call cap limit	1. 1. I.I.				
	1. A second s	-							W_tal_start	19	UII start of tail tass limit	/				

START	PKG_LowR_CLASSA	[2.44 5.7] db			1
-	Table 93A-3 parameters				
Parameter	Setting	Units	Information		
padkage_tl_gamma0_a1_a2	[ 0.0005 0.00089 0.0002 ]			d1.0	
package_t_tau	0.006141	ns/mm	1	d1.0	ī
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0	ī
R_d	[ 46.25 46.25 ]	Ohm	[TX RX]	d1.0 cmt 396	
z_p (TX)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 :0000 ;0000 ]	mm	[test cases]	d1.0	
z_p (NEXT)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8; 0000 ; 0000 ]	mm	[test cases]	d1.0	
z_p (FEXT)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 :0000 ;0000 ]	mm	[test cases]	d1.0	1
z_p (RX)	[33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0000 ; 0000 ]	mm	[test cases]	d1.0	
C_p	[0.4e-4 0,4e-4]	nF	[TX RX]	d1.0	1
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0,400	d1.2	
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2	
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2	
END					ī

START	PKG_HiR_CLASSB	[2.8 5.6 6.7	.4] db		
Table 93A-3 parameters					
Parameter	Setting	Units	Information		
package_tl_gamma0_a1_a2	[ 0.0005 0.00065 0.000293 ]	1	1	d1.0	
package_tl_tau	0.006141	ns/mm	1 1	d1.0	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm	1	d1.0	
R_d	[ 46.25 46.25 ]	Ohm	[TX RX]	d1.0 cmt 396	
z_p (TX)	[45 30 8 24 2 2 2 2 1.3 1.3 1.3 1.3 1.5 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0	
z_p (NEXT)	[44 29 8 24 : 2 2 2 2 : 1.3 1.3 1.3 1.3 : 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0	
z_p (FEXT)	[45 30 8 24 2 2 2 2 1.3 1.3 1.3 1.3 1.5 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0	
z_p (RX)	[44 29 8 24 : 2 2 2 2 : 1.3 1.3 1.3 1.3 1.3 : 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0	
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0	
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434	
A_fe	[0.385 0.385 0.385 0.385]	v	Vf=0.399	d1.0 cmt 434	
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434	
.END			1.20		

# **C2M COM Config**

#### • COM version 480\_hs2p3 (customization \_hs2p3 applies commit requests 4p8\_1 to 4p8\_5)

Table 93A 1 parameters				stds ief.	1/O combrol			stats ref.	Table 93A-3 parameters (Table Not Used with ClassA and BPacalages)			stis ref	SAVE_CONFIG2MAT	0		
Parameter	Setting	Units	Information		DIAGNOSTICS	0	logical		Pasarodar	Setting	Units	Homain	ar		Receiver testing	
f_b	106.25	GBd			DISPLAY_WILLDOW	0	logical		padrag f gamma0_a1_a2	5=4 0.00065 0.00	003]			RX_CALIBRATION	0	logical
f_min	0.05	GHZ		1	CSV_REPORT	0	lopial		madiage 1 bu	0.006141	rs /mm			SigniaBBP) step	5.00E03	V.
Dielta_f	0.01	GHz		and the second se	RESULT_DIR	Year Its VC2M_Idate/s			package Z.c	#2:70 70:80 80:1	oo x Ohm	I I I I I I I I I I I I I I I I I I I			CNp arameters	
C_d	[0.4e4 0.9e4 1.1e4 0.4e4 0.9e4 1.1e4]	rtF	TX RX	d1.0	SAWE_FIGURES	a	logical		2.0 (73)	4 1 11; 11 1 1;	0.5 mm	[lest cases to run]		f_9	0.278	Fb
1.3	[0,13 0.15 0.14; 0.13 0.15 0.14]	nH	TX RX	d1.0	Port Ordes	1324	import fi		2_0.((IENT)	1111;1111;	0.5• mini	(test cases)		- UF	0.278	Fb
C_D	[0.3e4 0.3e4]	rtF	TX RX	d1.0	RUMINAG	C2M_			E_D ( FENT)	1111;1111;	0.5 mm	[test cases]		(jn	0.278	Fb
R_Q	50	Ofim	TX RX	d1.0 cmt 396	COM_CONTRIBUTION	1	logical.		2,3 (50)	1111;1111;	0.5• mm	[test cases]		f_2	58.438	GHz
Rud	46.25.46.25	(Oftra)	TX RX				1		6.0	0.4=4 0.4=4]	цЕ	[test cases]		A_ft	0.450	V
PNG_/(AME	PKG_HiR_CLASS&P.KG_Madule		TX RX	1 P. 1	TDR	and ERL options			1	Operational		10		Ant	0.450	V
A_#	0.387	V		1	TDR	4	logial		ERL Pass the shold	10	dB				p	1.0
AF	0.187	V		1.0	ERE	4	lopial		COM Pass threshold	3	db			Parameter	Setting	ALC: NAME OF A
Ane	0.482	V			ERL_OHLY	a	logical		0.80	2.00603				board_ti_samma0_a1_a2	0 3.95e4 2.6e 05	1.4 db/in @ 53.125
z p select	(2)				TR_TDR	0.005	ins		Tr	0.00400	ns			board til tau	1.790E03	TEL/TOPT
4	4			1.	N N	7000	UI		HORCE_TR	1	logical	required for backva	comp.tability	boad Z.c	92:5	Ohm
.M.	32	0	1	11.	TDR_Bute worth	i	1		EMID_type	CIC		and the second second		z_bp (1X)	32	mm
filter and Eq				beta x	0			samples_for_C2M	100				2_bp (1EXT)	32	mim	
ter.	0.550	*fb		dL.0 cmt 60 (60 GHz)	rhe_x.	0.619			0,5	50	1	10		z_tan (FEXT)	32	mm
c[0)	0.54		inin	d1.0 cmt 37	TDR_W_DXPNG	1	101	ER L computed at TP 1a	EV/	1				z_bo (RX)	32	mm
<i>x</i> [−1]	0	0.34:0.02	[min:stearma]	d1.0 may value -0.34	11_bx	16	101		MLSE	1	<ul> <li>lagical</li> </ul>			0.0	(0.29e-4 0]	n.F
c(-2)	0	0.02/0.14	[ [minestearmax]	d1.0 machalae 0.14	fixture delay time	(6a)	5		ts_anchor	1				1.0	[0.1e=4 0]	InF
c(+3)	.0	0	[min:step:max]		Tukey_Window	1			sample_adjustment	[-16 16]				Include PCB	0	logical
£[=4]	0 0 ministearnal Noise, Mier				Local Search	2		0-full grid search, 2	local search	Selebons tre	tangle; gaussian.dual_myleig	h,triangle				
c(1)	0	-0.2:0.021	D [mintsteptmax]	d1.0 cmt 37	signa_RJ	10.0	10					MUSE tranction len	the B-16 not adopted yet	Histogram_Window_Weight	pus sian	selection
N_B	1	UL.		d1.0	A_DD	0.02	01	2		FI	ter: Rx FFE	III III IIII IIII		Qe	0.02	. vi
b_max(1)	680		As/dffe1	d1.0 cm 279	da_0	1.00508	V"2/GHz		fib.p.m.tap.km	3	UI		- 11	I I	A	1.
b_max(2_N_b)	0		As/dfe2_11_b	i and in the second	SIR_TX	33,5	dB		ff post_tap_len	8		· · · · · · · · · · · · · · · · · · ·		-		
b_min(1)	0		As/dffe1	d1.0 cm 279	R_UM	0.95			ffe_pre_tap1_max	0.7	interpreted as +/-	COM to change to V	nao/min	1		T
b_min(2_N_b)	-0.15	1.0	HATFILD+L	a second s			1		ffe_post_tap1_max	0.7	interpreted as +/-	COM to change to V	nao/min			1
E_DC	(-20:1:0)	dB	[min:step.max]	d1.0 (Max value -20)			1		ffe_tapn_max	0.7	interpreted as +/-	COM to change to V	navinin			1
12	42.50	GHz	· · · · · ·	d1.0	SREAD_CRUMPS	1.	1000		FFE OPT METHOD	MME		PV-UM S or MMSE				1
f_p1	42.50	GHz		d1.0	0.60,008	1.00507			num_uiRX#_nose	2048				1		
£ف£	106.25	GHz		0.16	C1.08	1. O				Floats	ng Tap Combol	1				1
E_DC_HP	[-6:1:0]	1.00	ministerma	- dt.o		100603			- N.bo	2	0 1 2 or 3 gours	-		4		
EHP PZ	1.328125	GHz		d10	tranc	123				4	tates ber troub			1		
Butterwort h	1	logical	include in fr	A	3.5	122	1		NJ	50	Utspan for floating taps					
	-	-			altication	10 B	1	4	binakg	0.2	max DFE value for floating taps	-	-			
									B_float_RS5_MAX	1	es bil be imit					
									N tai start	-9	UII start of tail taps limit	-				

START	PKG_LowR_CLASSA	[2.44 5.7] db		
	Table 93A-3 parameters			
Parameter	Setting	Units	Information	
padkage_tl_gamma0_a1_a2	[ 0.0005 0.00089 0.0002 ]			d1.0
package_t_tau	0.006141	ns/mm	1	d1.0
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm		d1.0
R_d	[ 46.25 46.25 ]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 :0000 ;0000 ]	mm	[test cases]	d1.0
z_p (NEXT)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8; 0000 ; 0000 ]	mm	[test cases]	d1.0
z_p (FEXT)	[ 33 12 33 33 : 1.8 1.8 1.8 1.8 : 0000 : 0000 ]	mm	[test cases]	d1.0
z_p (RX)	[ 33 12 33 33 ; 1.8 1.8 1.8 1.8 ; 0000 ; 0000 ]	mm	[test cases]	d1.0
C_p	[0.4e-4 0,4e-4]	nF	[TX RX]	d1.0
A_v	[0.385 0.385 0.385 0.385]	V	Vf=0,400	d1.2
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	D1.2
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	D1.2
END				

START	PKG_HIR_CLASSB	2.8 5.6 6.7	4] db	
Table 93A-3 parameters				
Parameter	Setting	Units	Information	
package_tl_gamma0_a1_a2	[ 0.0005 0.00065 0.000293 ]	1		d1.0
package_tl_tau	0.006141	ns/mm	1 1	d1.0
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 78 78]	Ohm	In the second se	d1.0
R_d	[46.2546.25]	Ohm	[TX RX]	d1.0 cmt 396
z_p (TX)	[45 30 8 24 2 2 2 2 1.3 1.3 1.3 1.3 1.5 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0
z_p (NEXT)	[ 44 29 8 24 : 2 2 2 2 : 1.3 1.3 1.3 1.3 : 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0
z_p (FEXT)	[45 30 8 24 ; 2 2 2 2 ; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5 ]	mm	[test cases]	d1.0
z_p (RX)	[ 44 29 8 24 : 2 2 2 2 : 1,3 1,3 1,3 1,3 1,3 : 1.5 1,5 1,5 1,5 ]	mm	[test cases]	d1.0
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]	d1.0
A_V	[0.385 0.385 0.385 0.385]	V	Vf=0.400	d1.0 cmt 434
A_fe	[0.385 0.385 0.385 0.385]	V	Vf=0.399	d1.0 cmt 434
A_ne	[0.481 0.481 0.481 0.481]	V	Vf=0.400	d1.0 cmt 434
END				