

Channel Operating Margin (COM) for CDAUI-8 chip-to-chip interfaces

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Introduction

- Table 120D-7 is incomplete (comment #53)
- This presentation contains a proposal to complete the table

Overview of proposed changes

- Define TBD device package and termination parameters
 - Begin with $R_d = 40 \Omega$, $C_d = 280 \text{ fF}$, $C_p = 110 \text{ fF}$
 - In addition, change transmission line Z_c (Table 93A–3) to 90Ω
- Change $b_{\max}(1)$ from 1 to 0.5
 - Larger values appear to be unnecessary
- 2-stage receiver equalizer (replaces Equation 93A–22)

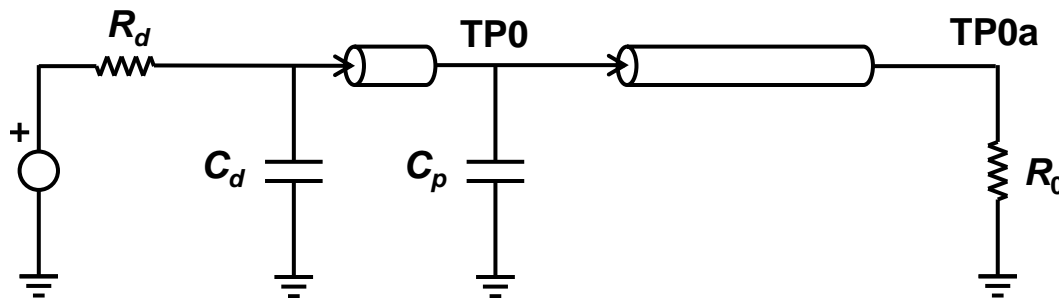
$$H_{ctf}(f) = \left[\frac{10^{g_{DC}/20} + j f / f_z}{1 + j f / f_{p1}} \right] \left[\frac{10^{g_{DC2}/20} + j f / f_{z2}}{1 + j f / f_{p2}} \right]$$

- $f_z = f_{p1} = f_b / 2.5$, $g_{DC} = -15$ to 0 in 1 dB steps
- $f_{z2} = f_{p2} = f_b / 40$, $g_{DC2} = -4$ to 0 in 1 dB steps

Overview of proposed changes, continued

- Cut η_0 in half (to approximately -155 dBm/Hz)
- Change R_{LM} from 0.92 to 0.95
- Increase N_b from 5 to 10 (to mitigate package reflection)

Transmitter differential peak voltage calibration



- Set A_v and A_{fe} to achieve minimum steady voltage v_f
 - 0.4 V per Table 120D-1
- Set A_{ne} to achieve maximum steady-state voltage
 - 0.6 V per Table 120D-1
- TP0 to TP0a test fixture is 38 mm of host transmission line
 - Refer to Table 92-12
- Use $D_p = 2$ and $N_p = D_p + 1 + N_b$ to calculate linear fit pulse

Proposal

Parameter	Symbol	Baseline	Proposal	Units
Signaling rate	f_b	26.5625	26.5625	GBd
Device package model				
Single-ended device capacitance	C_p	TBD	280	nF
Transmission line length, test 1	Z_p	12	12	mm
Transmission line length, test 2	Z_p	30	30	mm
Single-ended package capacitance	C_p	TBD	110	nF
Transmission line characteristic impedance *	Z_c	78.2	90	Ω
Single-ended reference resistance	R_0	50	50	Ω
Single-ended termination resistance	R_d	TBD	40	Ω
Receiver 3 dB bandwidth	f_r	$0.75 \times f_b$	$0.75 \times f_b$	GHz
Transmitter equalizer, minimum cursor coefficient	$c(0)$	0.6	0.6	—
Transmitter equalizer, pre-cursor coefficient	$c(-1)$			
Minimum value		-0.15	-0.15	—
Maximum value		0	0	—
Step size		0.05	0.05	—
Transmitter equalizer, post-cursor coefficient	$c(1)$			
Minimum value		-0.25	-0.25	—
Maximum value		0	0	—
Step size		0.05	0.05	—

* This parameter is defined in Table 93A-3.

Proposal, continued

Parameter	Symbol	Baseline	Proposal	Units
Continuous time filter, DC gain Minimum value Maximum value Step size	g_{DC}	-15 0 1	-15 0 1	dB dB dB
Continuous time filter, DC gain 2 Minimum value Maximum value Step size	g_{DC2}	n/a n/a n/a	-4 0 1	dB dB dB
Continuous time filter, zero frequencies	f_z f_{z2}	$f_b / 4$ n/a	$f_b / 2.5$ $f_b / 40$	GHz GHz
Continuous time filter, pole frequencies	f_{p1} f_{p2}	$f_b / 4$ f_b	$f_b / 2.5$ $f_b / 40$	GHz GHz
Transmitter differential peak output voltage Victim Far-end aggressor Near-end aggressor	A_v A_{fe} A_{ne}	0.4 0.4 0.6	0.38* 0.38* 0.55*	V V V

* Calibrated to yield $v_f = 0.4$ (for victim and far-end aggressors) or $v_f = 0.6$ (for near-end aggressors).

Proposal, continued

Parameter	Symbol	Baseline	Proposal	Units
Number of signal levels	L	4	4	—
Level separation mismatch ratio	R_{LM}	0.92	0.95	—
Transmitter signal-to-noise ratio	SNR_{TX}	31	31	dB
Number of samples per unit interval	M	32	32	—
Decision feedback equalizer (DFE) length	N_b	5	10	UI
Normalized DFE coefficient magnitude limit	$b_{max}(n)$			
$n = 1$		1	0.5	—
$n = 2$ to N_b		0.2	0.2	—
Random jitter, RMS	σ_{RJ}	0.01	0.01	UI
Dual-Dirac jitter, peak	A_{DD}	0.02	0.02	UI
One-sided noise spectral density	η_0	5.2E-8	2.6E-8	V ² /GHz
Target detector error ratio	DER_0	1E-6	1E-6	—
Channel operating margin, min.	COM	2	2	dB

Summary of results

Test case	1	2	3	4	5	6	7	8	9	10
IL at 13.28 GHz, dB	19.6	14.7	6.9	19.5	17.4	11	9.2	18.6	19.1	17.4
Baseline + 30 mm package	0.47	0.88	0.98	0.38	0.09	1.08	0.89	1.45	-0.25	0.87
+ change $b_{\max}(1)$ to 0.5	0.28	0.88	0.99	0.19	0.04	1.08	0.89	1.34	-0.29	0.92
+ add 2-stage receiver equalizer	0.62	1.24	1.54	0.44	0.36	1.63	1.53	1.90	0	1.13
+ reduce η_0 by 3 dB	1.03	1.41	1.59	0.80	0.60	1.72	1.59	2.35	0.28	1.41
+ change R_{LM} to 0.95	1.31	1.69	1.87	1.08	0.88	2	1.87	2.62	0.56	1.69
+ change N_b to 10	2.55	3.3	3.33	2.35	1.83	3.23	3.14	4.19	1.3	2.47

- Test cases 1 through 7 are from [mellitz_3bs_01_0714.pdf](#)
- Test case 8 is from [shanbhag_02_0914.pdf](#)
- Test cases 9 and 10 are from [mellitz_3bs_01_0315.pdf](#)

Addendum to results

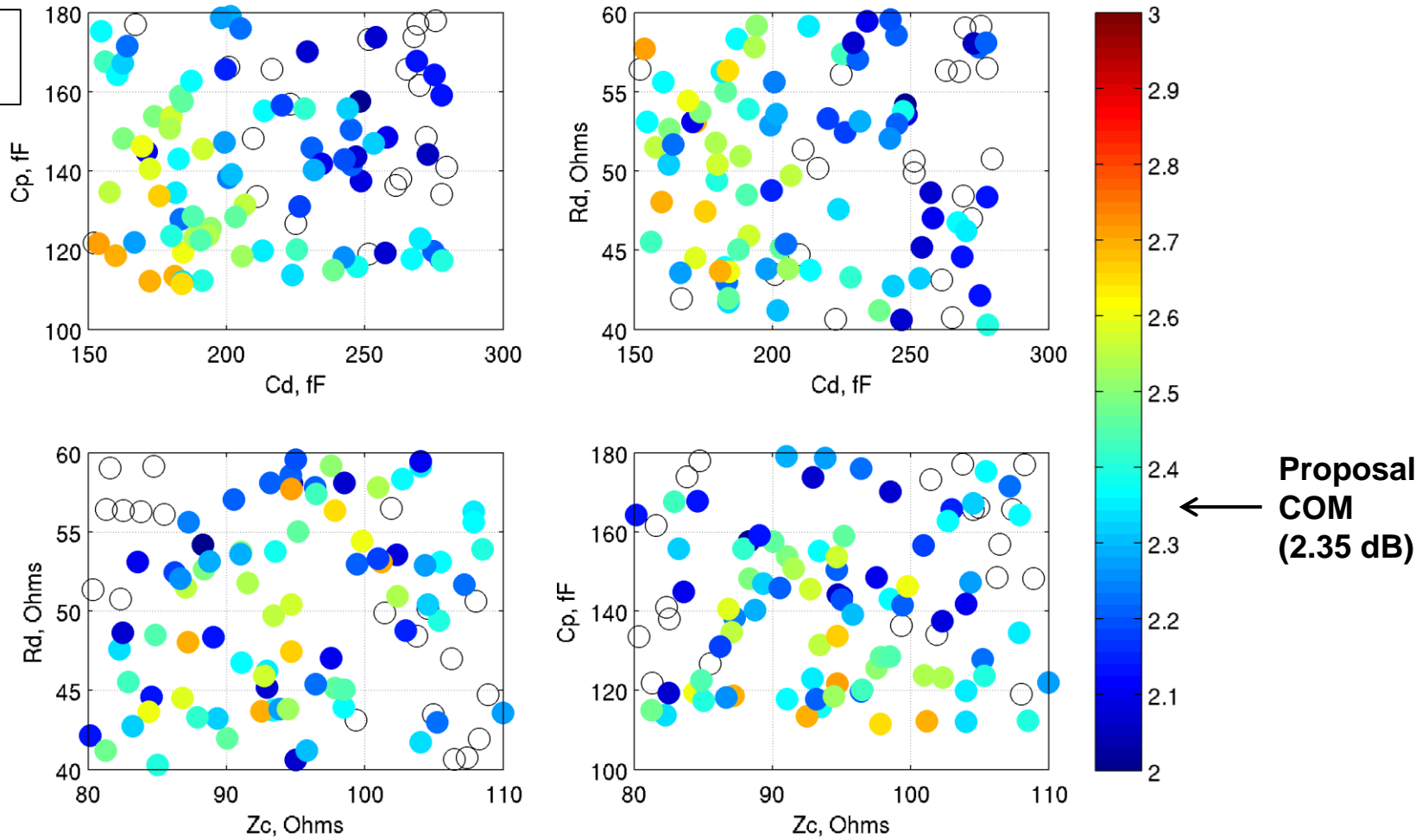
Test case	1	2	3	4	5	6	7	8	9	10
IL at 13.28 GHz, dB	19.6	14.7	6.9	19.5	17.4	11	9.2	18.6	19.1	17.4
This proposal with N_b set to 5	1.31	1.69	1.87	1.08	0.88	2	1.87	2.62	0.56	1.69
Change R_d to 47 Ω , C_d to 200 fF, C_p to 100 fF, a_2 to 4 x 1.455E-4 ns/mm, Z_c to 78.2 Ω , z_p to 18 mm	1.36	1.9	2.55	1.29	1.36	2.51	2.40	3.19	0.06	2.24
This proposal with N_b set to 10	2.55	3.3	3.33	2.35	1.83	3.23	3.14	4.19	1.3	2.47
Change R_d to 47 Ω , C_d to 200 fF, C_p to 100 fF, a_2 to 4 x 1.455E-4 ns/mm, Z_c to 78.2 Ω , z_p to 18 mm	2.85	3.41	3.42	2.61	2.17	3.49	3.26	4.55	1.74	2.99

NOTE: a_2 is a parameter of the package transmission line model (see Table 93A-3).

- Substitute device package and termination parameters proposed by Mellitz
 - z_p set to 7 mm for near-end aggressors
- $[A_v, A_{fe}, A_{ne}]$ values recalibrated to [0.42, 0.42, 0.6] V

Device package and termination parameters

Channel #4
 $z_p = 30$ mm



- 100 trials with uniformly distributed R_d , C_d , C_p , and Z_c values
- Many combinations result in COM similar to or better than proposal

Summary and conclusions

- COM greater than 2 dB for a number of interesting channels using proposed values
- Other combinations of device package and termination parameters yield same or better results
 - Not necessary to reduce package transmission line length