

# **Baseline Proposal for CDAUI-8 Chip-to-Chip (c2c)**

For IEEE 802.3bs

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# Purposes

- Present a PAM4 baseline specification proposal for CDAUI-8 c2c electrical interface in support of the 400 GbE to fulfill its objective of:

Support optional 400 Gb/s Attachment Unit Interfaces for chip-to-chip and chip-to-module applications

# Technology Choice Highlights 1

- Channel target/requirement based on that of “informative insertion loss budget” from the electrical interface ad hoc
  - PAM-4 signaling and system is intended to work over existing CAUI-4 c2m and c2c infrastructures
- Channel equalization based on a transceiver having TX FIR, RX CTLE and DFE

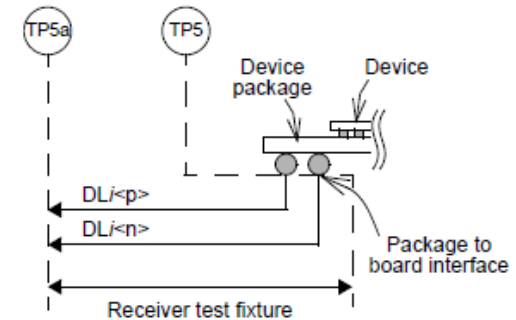
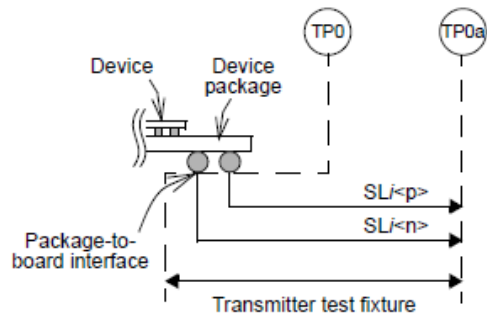
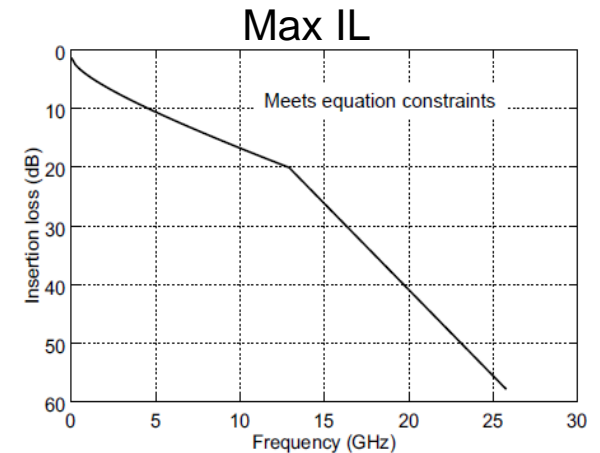
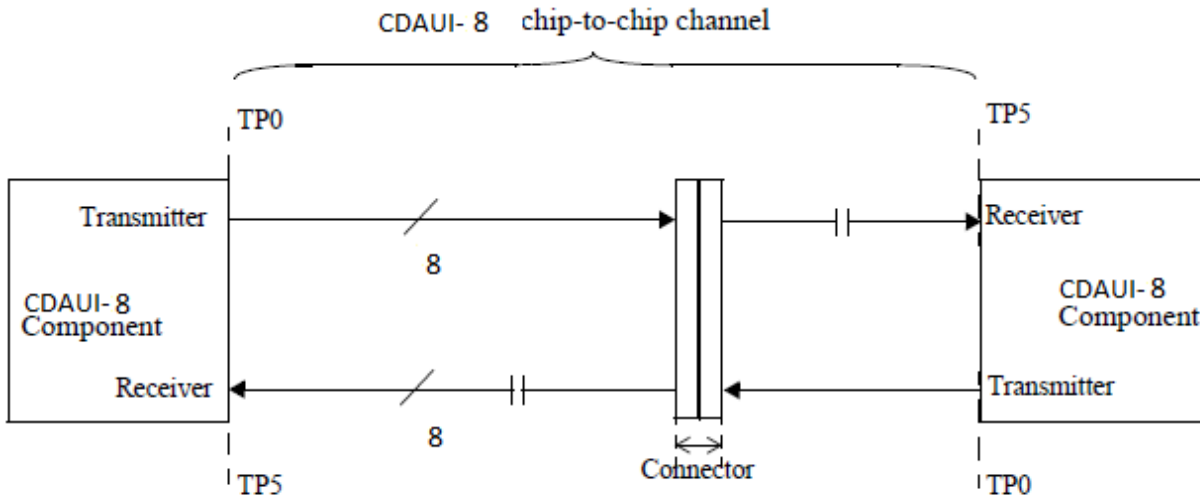
# Technology Choice Highlights 2

- Raw BER of CDAUI-8 link to be  $< 1\text{E-}6$ ; FEC brings link system BER to  $< 1\text{E-}15$

# Technology Choice Highlights 3

- Leverage the 100GBASE-KP4 (i.e., KP4) specification from 13.59 GBd to 25.78 - 28 GBd, and is consistent with CEI-56G-MR specification draft<sup>[1]</sup>
  - Final GBd value depend on the final FEC choice
- Gray-code specified, FEC (capable of bringing raw BER from 1e-6 to  $< 1e-15$  ) assumed. FEC and pre-coding (if needed) specifics be defined by the FEC ad hoc
- Reuse KP4 test patterns, TX and RX methodologies for specifying electrical characteristics and corresponding tests
- Reuse CAUI-4 TX and RX diff and CM RLs, compliance point definitions (i.e., TP0a and TP5a)
- Reuse CAUI-4 link adaptation method (i.e., CL 83D.3.3.2 and 45)
- Reuse 802.3bj COM method channel compliance with PAM-4 signaling

# CDAUI-8 c2c Link Topology and IL Target



- CDAUI-8 c2c compliance point definition is the same as those defined in clause 83D.2 (CAUI-4)

# CDAUI-8 c2c Functional Spec

- CDAUI-8 PMA functional spec will be largely reused, extended/modified from Clauses 94.2.2 (TX), 94.2.3 (RX), including
  - FEC interface
    - Pending on the final choice, with an intent of reducing the overhead to optimize it
  - Gray mapping
  - PAM4 encoding
  - Precoding
    - Pending, the need and specifics ought to be studied and determined in the FEC ad hoc



# CDAUI-8 c2c Test Patterns

- CDAUI-8 PMA will reuse test patterns defined in clause 94.2.9, including:
  - JP03A test pattern
  - JP03B test pattern
  - Quaternary PRBS13 test pattern (if the termination block (i.e., 94.2.2.4) is removed, this will need to be changed accordingly)
  - Transmitter linearity test pattern

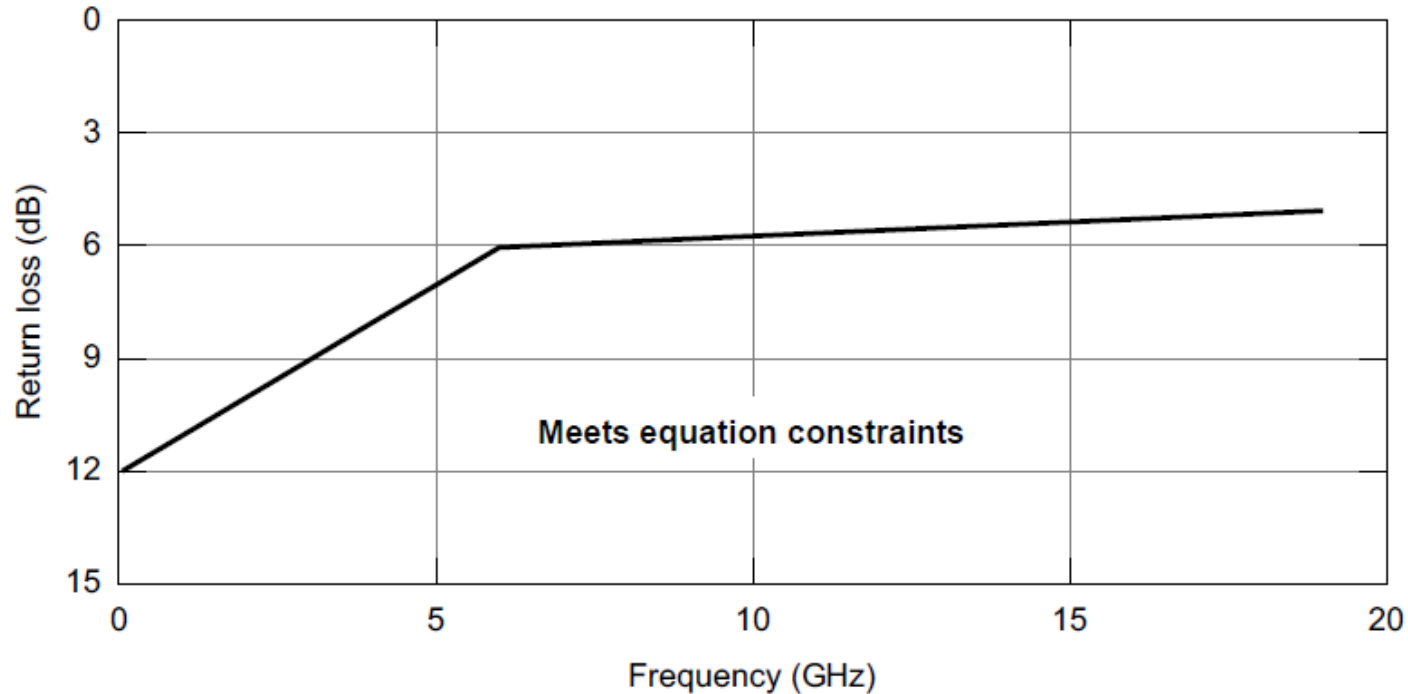
# CDAUI-8 c2c TX Spec

Parameter	Subclause reference	Value	Units
Signaling rate		25.78 - 28	Gsym/s
Differential peak-to-peak output voltage (max.) Transmitter disabled Transmitter enabled		30 1200	mV mV
DC common-mode output voltage (max.)		1.9	V
DC common-mode output voltage (min.)		0	V
AC common-mode output voltage (RMS, max.)		30	mV
Differential output return loss (min.)		Slide 11	dB
Common-mode output return loss (min.)		Slide 12	dB
Output waveform Level separation mismatch ratio, $R_{LM}$ (min.) Steady-state voltage $V_{FS}$ (max.) Steady-state voltage $V_{FS}$ (min.) Linear fit pulse peak (min.) Normalized coefficient step size (min.) Normalized coefficient step size (max.) Pre-cursor full-scale range (min.) Post-cursor full-scale range (min.)		0.92 0.6 0.4 $0.85 \times V_{FS}$ 0.0083 0.05 1.54 4	— V V V — — — —
Output jitter and linearity Clock random jitter, RMS (max.) Clock deterministic jitter, peak-to-peak (max.) Even-odd jitter (max.) Signal-to-noise-and-distortion ratio		0.005 0.05 0.019 31	UI UI UI dB

- TX output waveform definition and test method will reuse clause 94.3.12.5
- TX output jitter definition and test method will reuse clause 94.3.12.6
- TX output noise and distortion definition and test method will reuse clause 94.3.12.7

# CDAUI-8 c2c TX Diff RL Spec

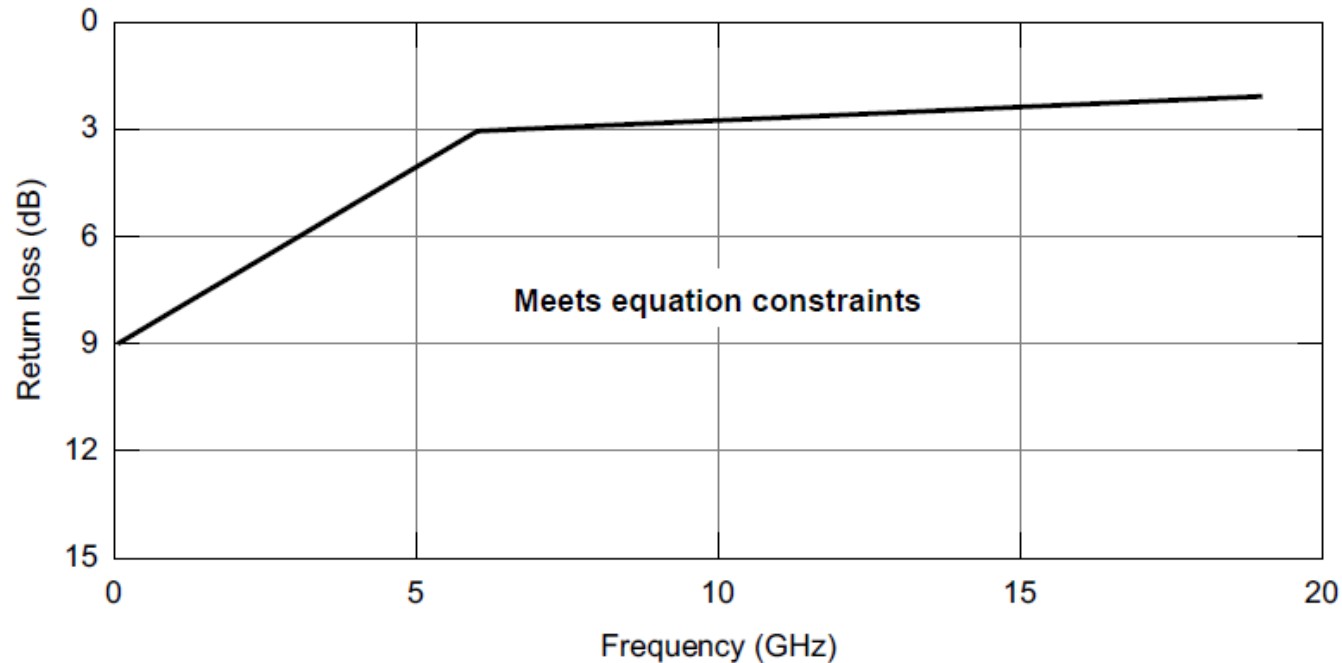
$$RL_d(f) \geq \left\{ \begin{array}{ll} 12.05 - f & 0.05 \leq f \leq 6 \\ 6.5 - 0.075f & 6 < f \leq 19 \end{array} \right\} \text{ dB}$$



- Reuse Eq. (93-3) and Fig (93-7)

# CDAUI-8 c2c TX CM RL Spec

$$RL_{cm}(f) \geq \left\{ \begin{array}{ll} 9.05 - f & 0.05 \leq f \leq 6 \\ 3.5 - 0.075f & 6 < f \leq 19 \end{array} \right\} \text{ dB}$$



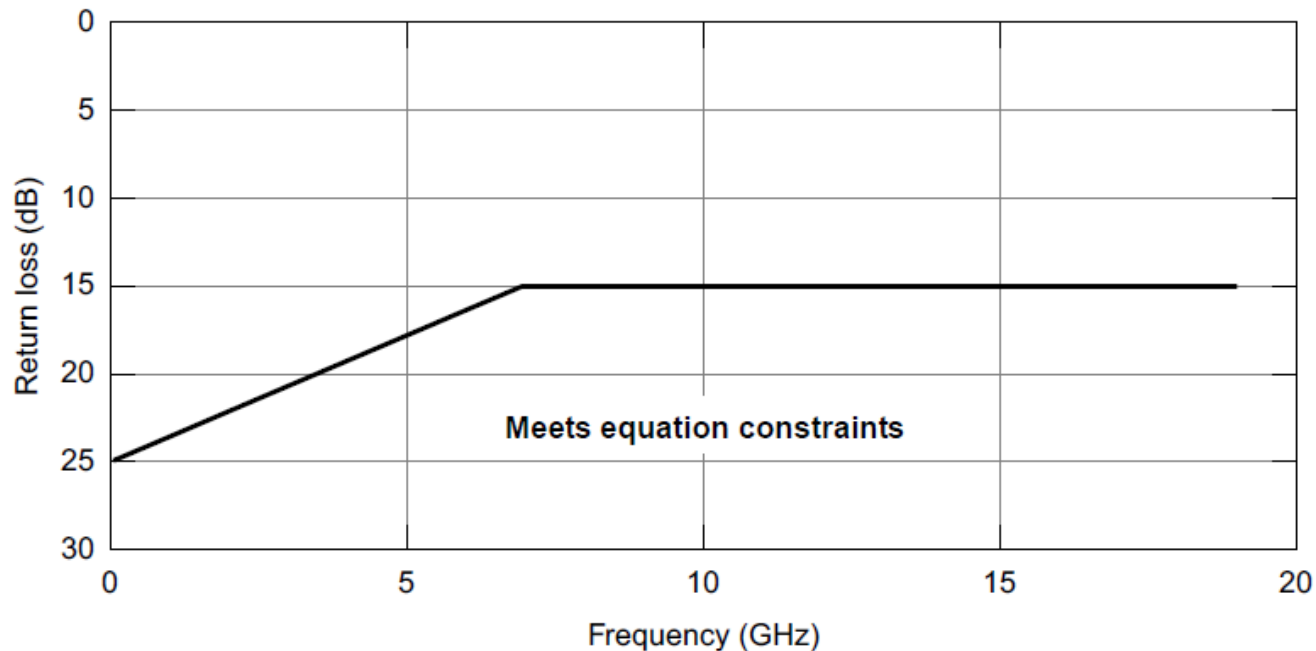
- Reuse Eq. (93-4) and Fig (93-8)

# CDAUI-8 c2c RX Spec

Parameter	Symbol	Value	Units	Conditions
Differential Input Return Loss		Slide 11	dB	
Differential to Common-Mode Return Loss		Slide 14	dB	
Interference Tolerance		Slide 15	-	
Jitter Tolerance		Slide 16	-	

# CDAUI-8 c2c RX D2C RL Spec

$$RL_{cd}(f) = \left\{ \begin{array}{ll} 25 - 1.44f & 0.05 \leq f \leq 6.95 \\ 15 & 6.95 < f \leq 19 \end{array} \right\} \text{ dB}$$



- Reuse Eq. (93-5) and Fig (93-11)

# CDAUI-8 c2c RX Interference Tolerance Parameters

Parameter	Test 1 values		Test 2 values		Units
	Min	Max	Min	Max	
Bit Error Ratio (BER) <sup>1</sup>		10 <sup>-8</sup>		10 <sup>-8</sup>	
COM <sup>2</sup> IL at Nyquist		3 10		3 20	dB dB
a <sub>0</sub> <sup>3</sup>	-1	1.5	-1	2	dB
a <sub>1</sub>	0	9.533	0	14.914	dB/√GHz
a <sub>2</sub>	0	30.855	0	41.228	dB/GHz
a <sub>4</sub>	0	14.162	0	19.728	dB/GHz <sup>2</sup>
RSS_DFE4	0.05	—	0.05	—	—

## NOTES:

1. Measured between Tx and RX package balls.
2. Test channel parameters: COM, including effects of BB noise, Insertion loss at Nyquist
3. Coefficients are determined from insertion loss measured between TX and RX package balls with  $f_{min}$  of 0.05 GHz,  $f_{max}$  of  $f_b/2$ , and maximum  $\Delta f$  of 0.01 GHz.

- Largely re-use of the method in 94.3.13.3

# CDAUI-8 c2c RX Jitter Tolerance Parameters

Parameter	Case A values	Case B values	Units
Max Pre-FEC BER	1e-6	1e-6	
Jitter frequency	$fb/849600$	$fb/8496$	same as $fb$
Jitter Amplitude	5	0.05	UI

- Largely re-use method in 94.3.13.4
- $fb$  is the BAUD rate



# CDAUI-8 c2c Channel Spec: COM (I)

Parameter	Symbol	Value	Units
Signaling rate	$f_s$	25.78-28	GBd
Maximum start frequency	$f_{max}$	0.05	GHz
Maximum frequency step	$\Delta f$	0.01	GHz
Device package model			
Single-ended device capacitance	$C_{**}$	$2.5 \times 10^{-4}$	nF
Transmission line length, Test 1	$Z_{**}$	12	mm
Transmission line length, Test 2	$Z_{**}$	30	mm
Single-ended package capacitance at package-to-board interface	$C_{**}$	$1.8 \times 10^{-4}$	nF
Single-ended reference resistance	$R_{**}$	50	$\Omega$
Single-ended termination resistance	$R_{**}$	55	$\Omega$
Receiver 3 dB bandwidth	$f_b$	$0.75 \times f_s$	
Transmitter equalizer, minimum cursor coefficient	$c(0)$	0.62	—
Transmitter equalizer, pre-cursor coefficient	$c(-1)$		
Minimum value		-0.18	—
Maximum value		0	—
Step size		0.02	—
Transmitter equalizer, post-cursor coefficient	$c(1)$		
Minimum value		-0.38	—
Maximum value		0	—
Step size		0.02	—
Continuous time filter, DC gain	$G_{***}$		
Minimum value		-15	dB
Maximum value		0	dB
Step size		1	dB
Continuous time filter, zero frequency	$f_{z**}$	$f_{max}/4$	GHz
Continuous time filter, pole frequencies	$f_{p***}$ $f_{p***}$	$f_{max}/4$ $f_s$	GHz
Transmitter differential peak output voltage			
Victim	$A_{**}$	0.4	V
Far-end aggressor	$A_{***}$	0.4	V
Near-end aggressor	$A_{***}$	0.6	V

# CDAUI-8 c2c Channel Spec: COM (II)

Number of signal levels	$L$	4	—
Level separation mismatch ratio	$R_{LM}$	0.92	—
Transmitter signal-to-noise ratio	$SNR_{TX}$	31	dB
Number of samples per unit interval	$M$	32	—
Decision feedback equalizer (DFE) length	$N_b$	10	UI
Normalized DFE coefficient magnitude limit for $n = 1$ for $n = 2$ to $N_b$	$d_{max}(n)$	1 0.2	—
Random jitter, RMS	$\sigma_{RJ}$	0.005	UI
Dual-Dirac jitter, peak	$A_{DD}$	0.025	UI
One-sided noise spectral density	$\eta_0$	$5.2 \times 10^{-8}$	V <sup>2</sup> /GHz
Target detector error ratio	$DER_0$	$10^{-6}$	—

# Summary

- A baseline proposal based PAM-4 signaling for CDAUI-8 c2c electrical interface specification has been developed
  - Intent is to support existing CAUI-4 c2c channel and testing infrastructures
  - Reuse/extended/modified from 100GBase-KP4 and CAUI-4 c2c specifications (i.e., clauses 94, 93A, and 83D)
  - Consistent with CEI-56G-MR adopted baseline specification draft

# References

[1] oif2014.245.01, [www.oiforum.com](http://www.oiforum.com)

(That document was provided as an attachment to the October 28, 2014 liaison from OIF to IEEE 802.3. The liaison and its attachments can be found in the IEEE P802.3bs 400 Gb/s Ethernet Task Force private area)