

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

For IEEE 802.3bs

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Purposes

- Present a baseline specification proposal for CDAUI-8 c2c electrical interface in support 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

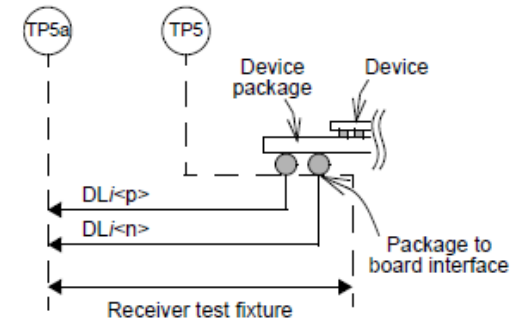
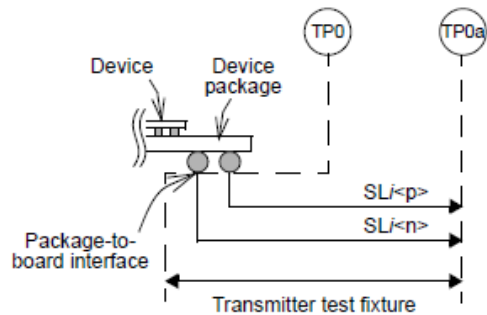
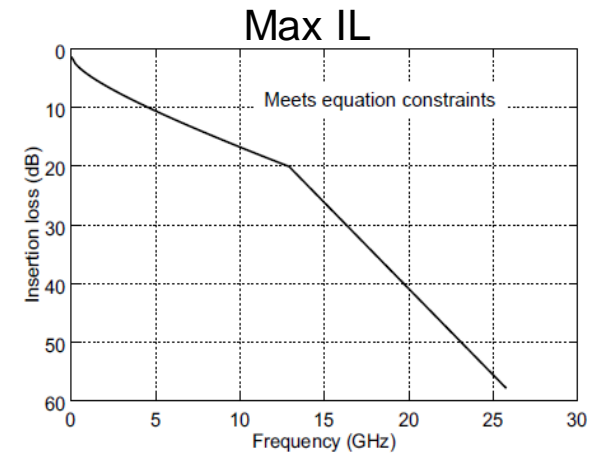
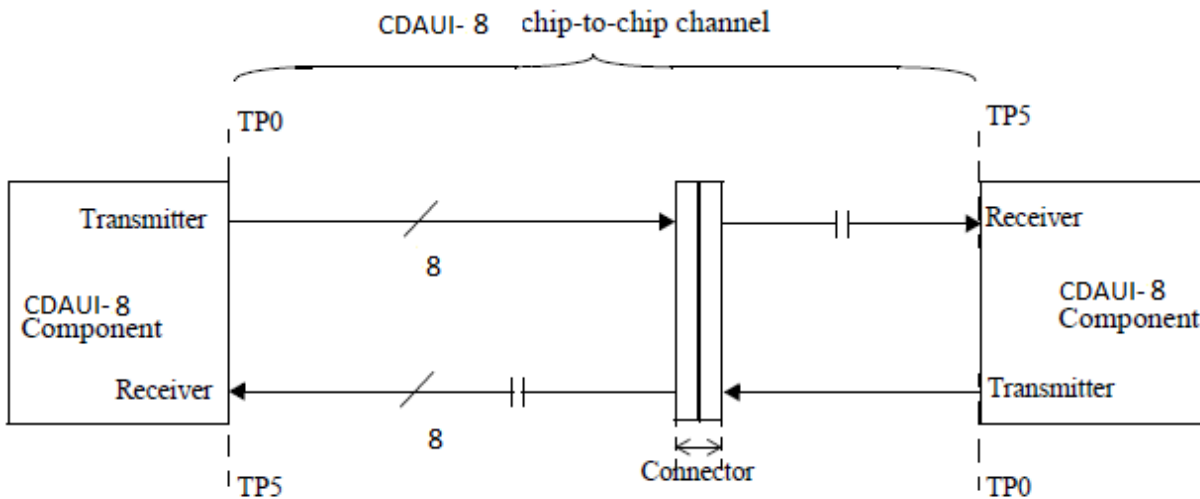
Technology Choice Highlights 2

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

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^[1]
 - 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, but not specified, pre-coding TBD
- 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 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 (TBD)

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

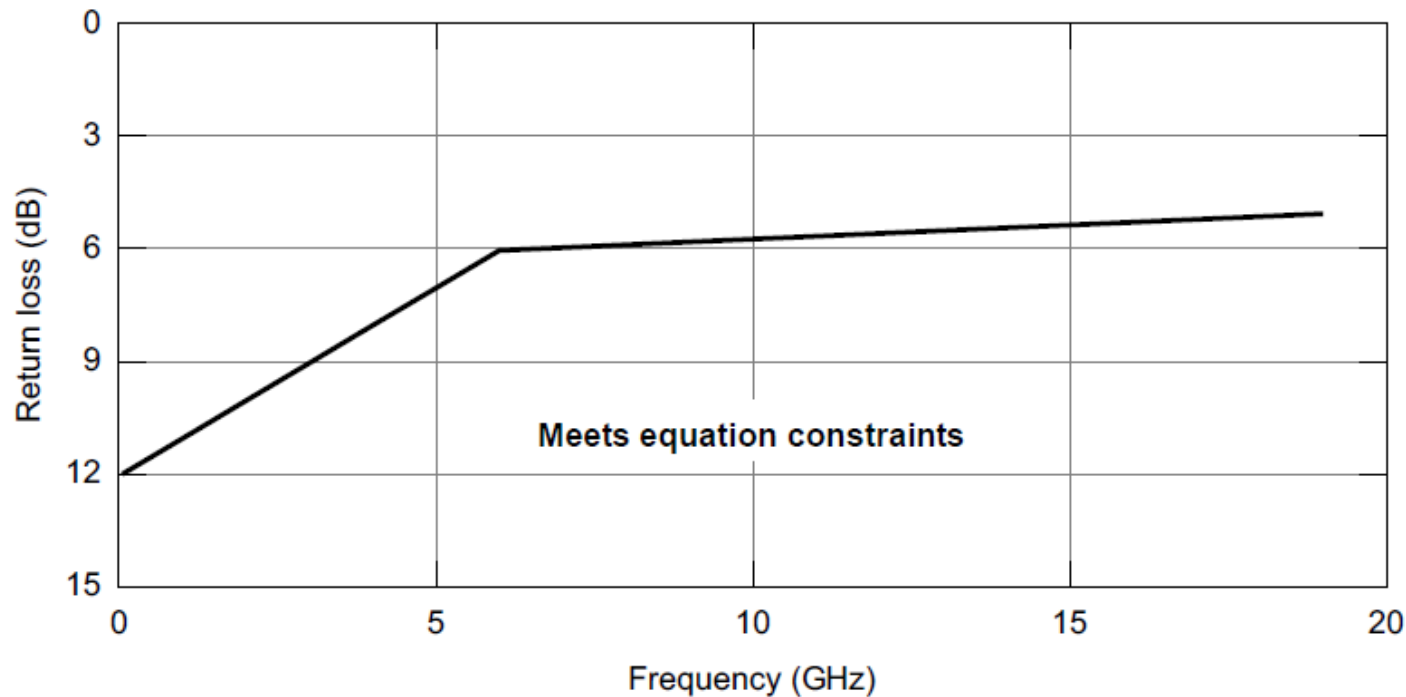
CDAUI-8 c2c TX Spec

| 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_{avg} (max.) Steady-state voltage V_{avg} (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 $0.85 \times V_{\text{avg}}$ 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

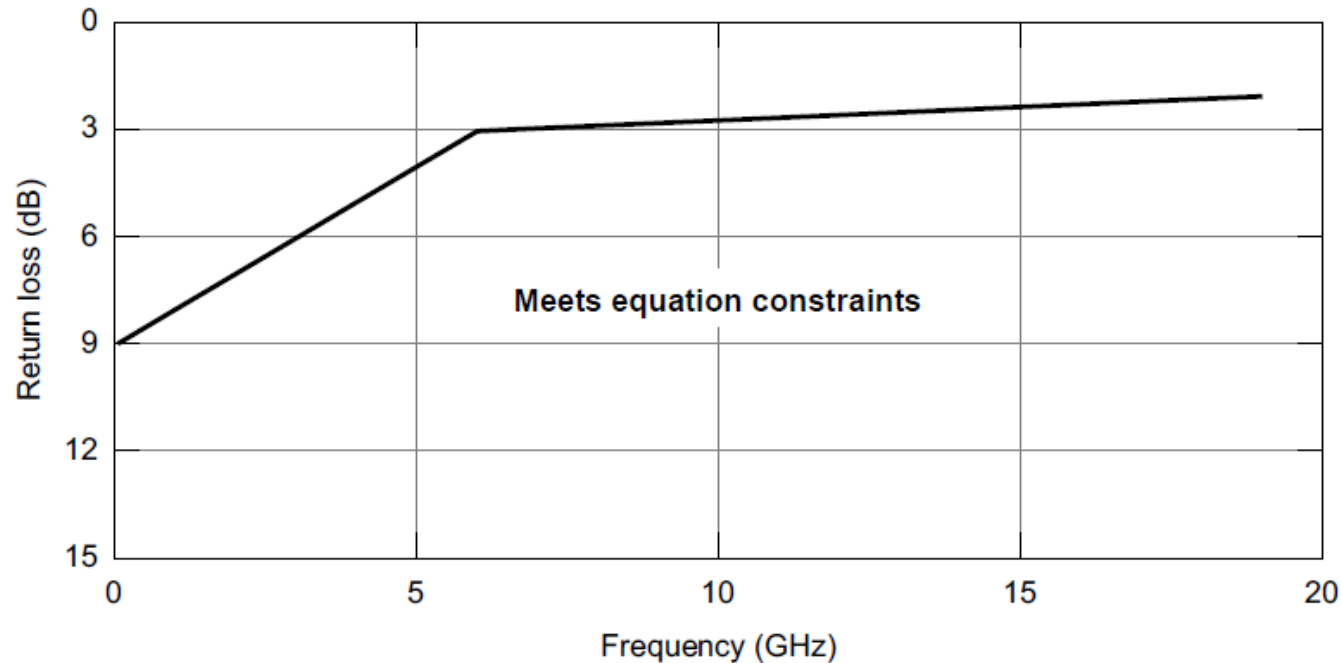
$$RL_d(f) \geq \left\{ \begin{array}{ll} 12.05 - f & 0.05 \leq f \leq 6 \\ 6.5 - 0.075f & 6 < f \leq 19 \end{array} \right\} \text{ dB}$$



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

CDAUI-8 c2c TX CM RL Spec

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



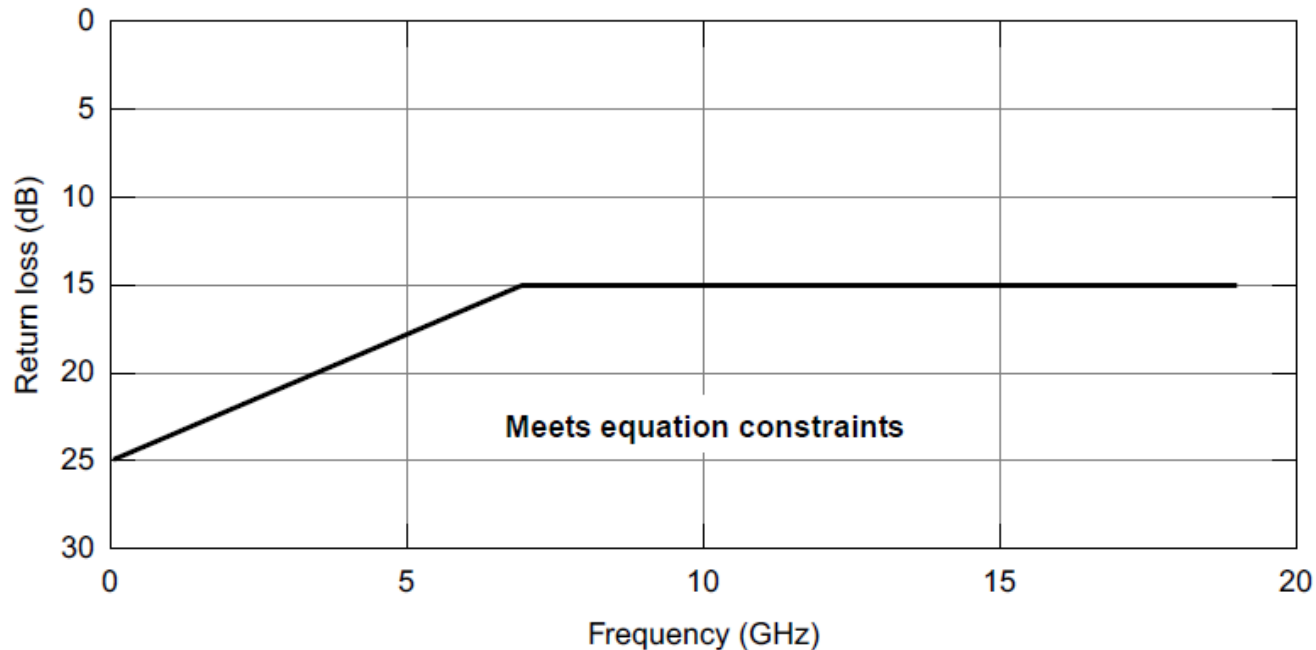
- Reuse Eq. (93-4) and Fig (93-8)

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) ¹ | | 10 ⁻⁸ | | 10 ⁻⁸ | |
| COM ² IL at Nyquist | | 3 10 | | 3 20 | dB dB |
| a ₀ ³ | -1 | 1.5 | -1 | 2 | dB |
| a ₁ | 0 | 9.533 | 0 | 14.914 | dB/√GHz |
| a ₂ | 0 | 30.855 | 0 | 41.228 | dB/GHz |
| a ₄ | 0 | 14.162 | 0 | 19.728 | dB/GHz ² |
| 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 Δf 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 | Δf | 0.01 | GHz |
| Device package model | | | |
| Single-ended device capacitance | C_{in} | 2.5×10^{-4} | nF |
| Transmission line length, Test 1 | Z_{TL1} | 12 | mm |
| Transmission line length, Test 2 | Z_{TL2} | 30 | mm |
| Single-ended package capacitance at package-to-board interface | C_{out} | 1.8×10^{-4} | nF |
| Single-ended reference resistance | R_{ref} | 50 | Ω |
| Single-ended termination resistance | R_{term} | 55 | Ω |
| 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_{DC} | | |
| Minimum value | | -15 | dB |
| Maximum value | | 0 | dB |
| Step size | | 1 | dB |
| Continuous time filter, zero frequency | f_{z0} | $f_{max}/4$ | GHz |
| Continuous time filter, pole frequencies | f_{p1} f_{p2} | $f_{max}/4$ f_s | GHz |
| Transmitter differential peak output voltage | | | |
| Victim | A_{vict} | 0.4 | V |
| Far-end aggressor | A_{far} | 0.4 | V |
| Near-end aggressor | A_{near} | 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 | σ_{RJ} | 0.005 | UI |
| Dual-Dirac jitter, peak | A_{DD} | 0.025 | UI |
| One-sided noise spectral density | η_0 | 5.2×10^{-8} | V ² /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

References

[1] oif2014.245.00, www.oiforum.com

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