# Baseline proposals for copper twinaxial cable specifications

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# Purpose

- Baseline proposals for 802.3cd copper twinaxial cable specifications consistent with adopted objectives
  - Tx/Rx receiver PCB insertion loss specifications
  - Test fixtures PCB insertion loss specifications
  - Host channel insertion loss specifications
  - Channel insertion loss specifications
  - Cable assembly specifications
  - Test fixture specifications
  - MDI specifications

# Supporters

- Scott Sommers, Chris Roth, Tom Palkert – Molex
- Rich Mellitz – Intel
- Jon Lewis – Dell
- Ron Nordin, Brett Lane – Panduit
- Nathan Tracy – TE Connectivity
- Erdem Matoglu, Andrew Zambell – Amphenol
- Ali Ghiasi – Ghiasi Quantum LLC

# 802.3cd Objectives

## Objectives 1 of 3

- Support full-duplex operation only
- Preserve the Ethernet frame format utilizing the Ethernet MAC
- Preserve minimum and maximum FrameSize of current IEEE 802.3 stanc
- Support optional Energy-Efficient Ethernet operation
- Provide appropriate support for OTN
- Support a MAC data rate of 50 Gb/s and 100 Gb/s
- Support a BER of better than or equal to $10^{-12}$ at the MAC/PLS service interface (or the frame loss ratio equivalent) for 50 Gb/s and 100 Gb/s operation
- Support a MAC data rate of 200 Gb/s
- Support a BER of better than or equal to $10^{-13}$ at the MAC/PLS service interface (or the frame loss ratio equivalent) for 200 Gb/s operation

*Source: http://www.ieee802.org/3/50G/public/objectives_50G_NGOATH_01a_0316.pdf*

# 802.3cd Objectives

## Objectives 2 of 3

- Define single-lane 50 Gb/s PHYs for operation over
  - copper twin-axial cables with lengths up to at least 3m.
  - printed circuit board backplane with a total channel insertion loss of <= 30dB at 13.28125 GHz.
  - MMF with lengths up to at least 100m
  - SMF with lengths up to at least 2km
  - SMF with lengths up to at least 10km
- Define a two-lane 100 Gb/s PHY for operation over copper twin-axial cables with lengths up to at least 3m.
- Define a two-lane 100 Gb/s PHY for operation over a printed circuit board backplane with a total channel insertion loss of <= 30dB at 13.28125 GHz.
- Define a two-lane 100 Gb/s PHY for operation over MMF with lengths up to at least 100m

*Source: http://www.ieee802.org/3/50G/public/objectives_50G_NGOATH_01a_0316.pdf*

# Tx/Rx receiver PCB IL - Baseline

- Use transmitter and receiver differential printed circuit board trace loss min and max (with IL @ 13.28GHz)
  - Specified in 92A.4 EQ(92A-1 (max) and 92A-2 (min))– referenced 110A.4

# Transmitter and receiver differential PCB IL

- IL @ 13.28 GHz

$$IL_{PCB}(f) \le IL_{PCBmax}(f) = 0.5(0.0694 + 0.4248\sqrt{f} + 0.9322f) \quad \text{(dB)}$$

for 0.01 GHz $\le f \le$ 19 GHz.

where

$f$ is the frequency in GHz
$IL_{PCB}(f)$ is the insertion loss for the transmitter and receiver PCB
$IL_{PCBmax}(f)$ is the recommended maximum insertion loss for the transmitter and receiver PCB

IL @ 12.89 GHz = 6.81 dB
IL @ 13.28 GHz = 7.00 dB

$$IL_{PCB}(f) \ge IL_{PCBmin}(f) = 0.086(0.0694 + 0.4248\sqrt{f} + 0.9322f) \quad \text{(dB)}$$

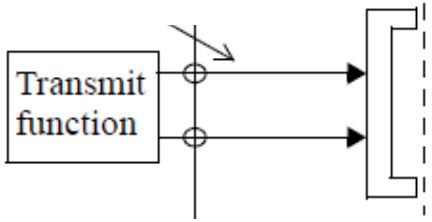
for 0.01 GHz $\le f \le$ 19 GHz.

where

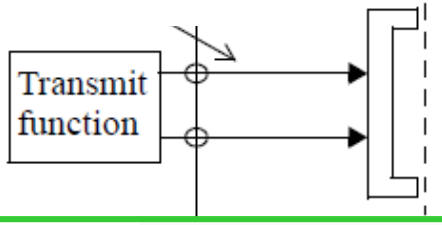
$f$ is the frequency in GHz
$IL_{PCB}(f)$ is the insertion loss for the transmitter and receiver PCB
$IL_{PCBmin}(f)$ is the minimum insertion loss for the transmitter and receiver PCB

IL @ 12.89 GHz = 1.17 dB
IL @ 13.28 GHz = 1.20 dB

IL @ 12.89 GHz = Max 6.81 dB
= Min 1.17 dB



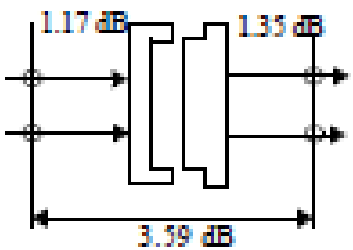

IL @ 13.28 GHz = Max 7.00 dB
= Min 1.20 dB



# Test Fixture PCB IL - Baseline

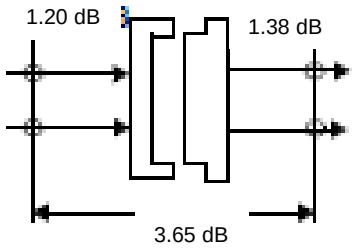
- Use TP2 or TP3 (HCB) test fixture printed circuit board reference insertion loss with IL @ 13.28 GHz specified in
  - 802.3bj 92.11.1.2 Test fixture insertion loss equation (92-34)
    - Referenced in 802.3by 110B.1.1 SFP28 TP2 or TP3 test fixture
- Use Cable assembly (MCB) test fixture printed circuit board reference insertion loss with IL @ 13.28 GHz specified in
  - 802.3bj 92.11.1.2 Test fixture insertion loss equation (92-34)
    - Referenced in 802.3by 110B.1.1 SFP28 TP2 or TP3 test fixture

IL @ 12.89 GHz




Mated cable assembly and test point test fixture

IL @ 13.28 GHz




Mated cable assembly and test point test fixture

# Test fixtures PCB IL

$$IL_{tfref}(f) = -0.00144 + 0.13824\sqrt{f} + 0.06624\,f \quad \text{(dB)}$$

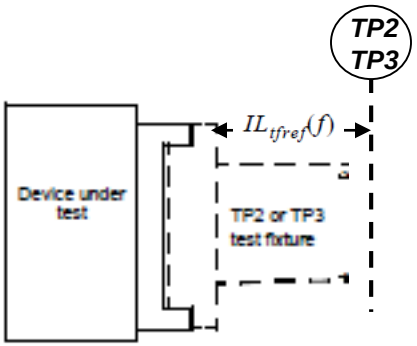
for $0.01 \le f \le 25$ GHz

where

$f$ is the frequency in GHz

$IL_{tfref}(f)$ is the reference test fixture PCB insertion loss at frequency $f$

IL @ 12.89 GHz = 1.35 dB
IL @ 13.28 GHz = 1.38 dB




$$IL_{catf}(f) = -0.00125 + 0.12\sqrt{f} + 0.0575f \quad \text{(dB)}$$

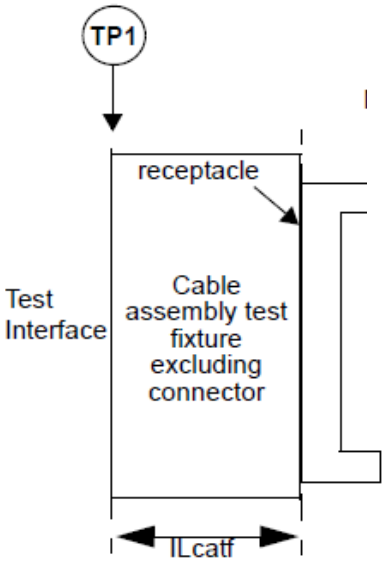
for 0.01 GHz $\le f \le$ 25 GHz

where

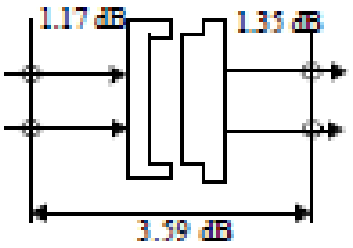
$f$ is the frequency in GHz

$IL_{catf}(f)$ is the reference test fixture printed circuit board insertion loss at frequency $f$

IL @ 12.89 GHz = 1.17 dB
IL @ 13.28 GHz = 1.20 dB

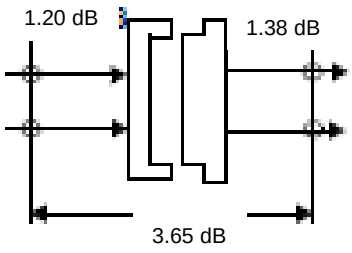



IL @ 12.89 GHz




Mated cable assembly and test point test fixture

IL @ 13.28 GHz



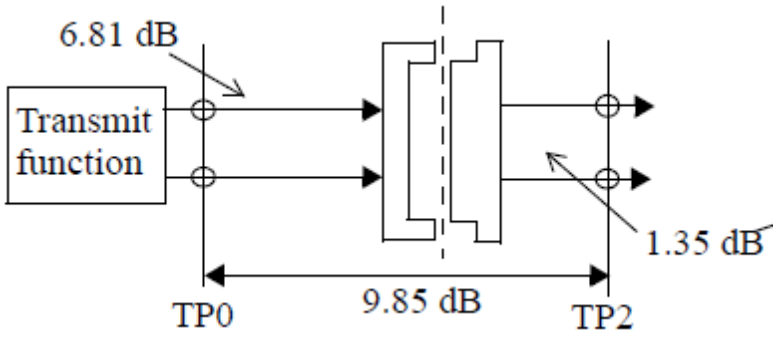

Mated cable assembly and test point test fixture

NOTE—The connector insertion loss is 1.07 dB for the mated test fixture. The host connector is allocated 0.62 dB of additional margin.

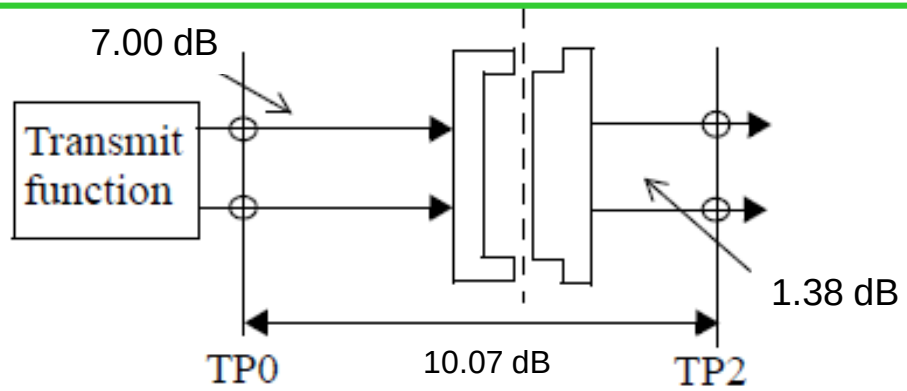
# Host Channel – Baseline

- Use transmitter and receiver differential printed circuit board trace loss max (with IL @ 13.28GHz) max
  - Specified in 92A.4 EQ(92A-1 – referenced 110A.4

NOTE—The connector insertion loss is 1.07 dB for the mated test fixture. The host connector is allocated 0.62 dB of additional margin. IL host connector @ 12.89 GHz = 9.85-6.81-1.35= 1.69 dB



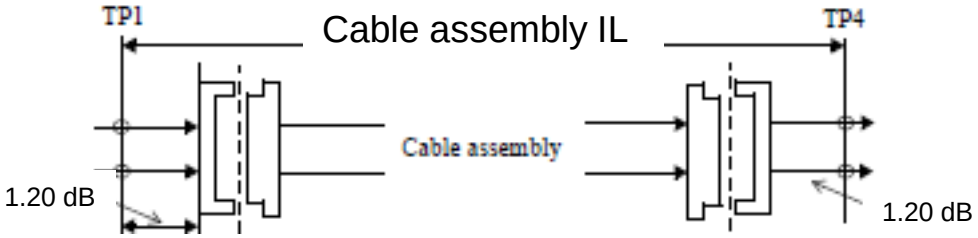

**Host Loss budget at 12.8906 GHz**



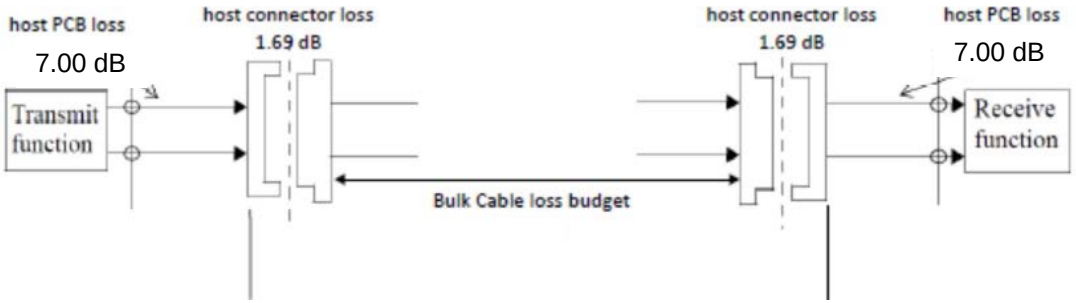

**Host Loss budget at 13.2815 GHz**

# Cable assembly IL max and min – Baseline

- Use 16.06 dB @ 13.28 as maximum cable assembly IL
- Use 802.3bj 92.10.2 Cable assembly insertion loss min equation (92–26) @ 13.28 GHz – referenced 110.10.2 – calculated as 8.3 dB @ 13.28 GHz




Bulk cable assumed @13.28 GHz = Cable assembly IL-(2*1.20)+(2*1.07)




Bulk cable assumed @13.28 GHz = Channel IL- (2*7)+(2*1.69)

NOTE—The connector insertion loss is 1.07 dB for the mated test fixture. The host connector is allocated 0.62 dB of additional margin.

$$IL_{Cabmin}(f) = 0.7\sqrt{f} + 0.3f + 0.01f^2 \quad \text{(dB)}$$

Equation 92-26

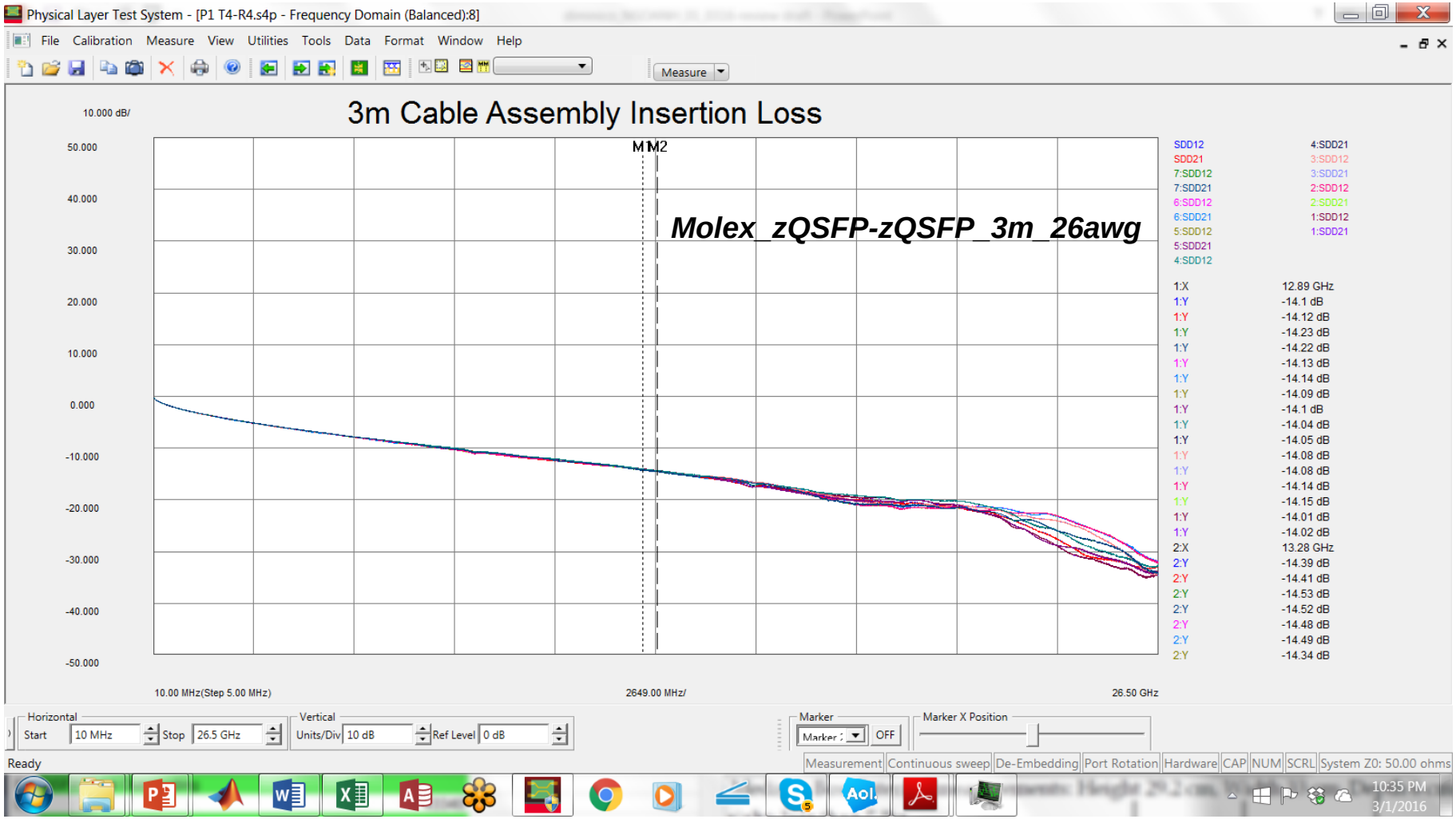
where

$f$ is the frequency in GHz

$IL_{Cabmin}(f)$ is the minimum cable assembly insertion loss at frequency $f$

| Channel IL (dB)@ 13.28 GHz | Max Cable assembly IL (db)@ 13.28 GHz | Bulk cable dB @ 13.28 GHz |
|---|---|---|
| 28.0 | 15.16 | 10.62 |
| 28.1 | 15.26 | 10.72 |
| 28.2 | 15.36 | 10.82 |
| 28.3 | 15.46 | 10.92 |
| 28.4 | 15.56 | 11.02 |
| 28.5 | 15.66 | 11.12 |
| 28.6 | 15.76 | 11.22 |
| 28.7 | 15.86 | 11.32 |
| 28.8 | 15.96 | 11.42 |
| 28.9 | 16.06 | 11.52 |
| 29.0 | 16.16 | 11.62 |
| 29.1 | 16.26 | 11.72 |
| 29.2 | 16.36 | 11.82 |
| 29.3 | 16.46 | 11.92 |
| 29.4 | 16.56 | 12.02 |
| 29.5 | 16.66 | 12.12 |
| 29.6 | 16.76 | 12.22 |
| 29.7 | 16.86 | 12.32 |
| 29.8 | 16.96 | 12.42 |
| 29.9 | 17.06 | 12.52 |
| 30.0 | 17.16 | 12.62 |

# NGOATH Contributed Channel Data

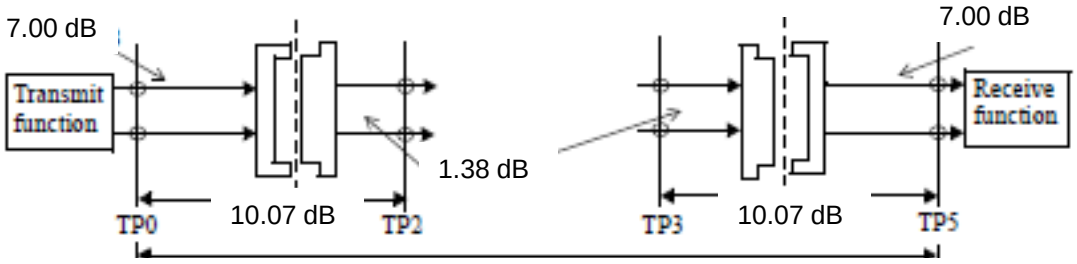



http://www.ieee802.org/3/50G/public/channel/index.html

*Molex_zQSFP-zQSFP_3m_26awg*

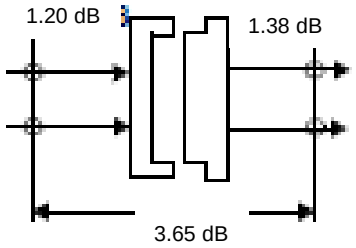
# Channel Insertion Loss – Baseline

- Use form of channel insertion loss equations max and min with IL @ 13.28 GHz
  - Specified in 802.3bj Equation (92A–3) max and Equation (92A–5) min
  - Specified in 802.3by 110A.5 Channel insertion loss
    - Where frequency @ 13.28 GHz
      - + ILChmax = 28.90 dB, ILCamax = 16.06 dB
      - + ILChmin = 21.14 dB, ILCamin = 8.3 dB
      - + ILHost = 10.07 dB
      - + ILMatedTF = 3.65 dB




Channel IL @13.28 GHz = Cable assembly IL+(2*10.07)-(2*3.65)

IL @ 13.28 GHz




Mated cable assembly and test point test fixture

NOTE—The connector insertion loss is 1.07 dB for the mated test fixture. The host connector is allocated 0.62 dB of additional margin.

# Cable Assembly – Baseline

- Cable assembly - consistent with CL92 and CL110 – referenced parameters @ 13.28 GHz
- Use 16.06 dB @ 13.28 GHZ as maximum cable assembly IL
- Use 8.3 dB @ 13.28 GHz as minimum cable assembly IL

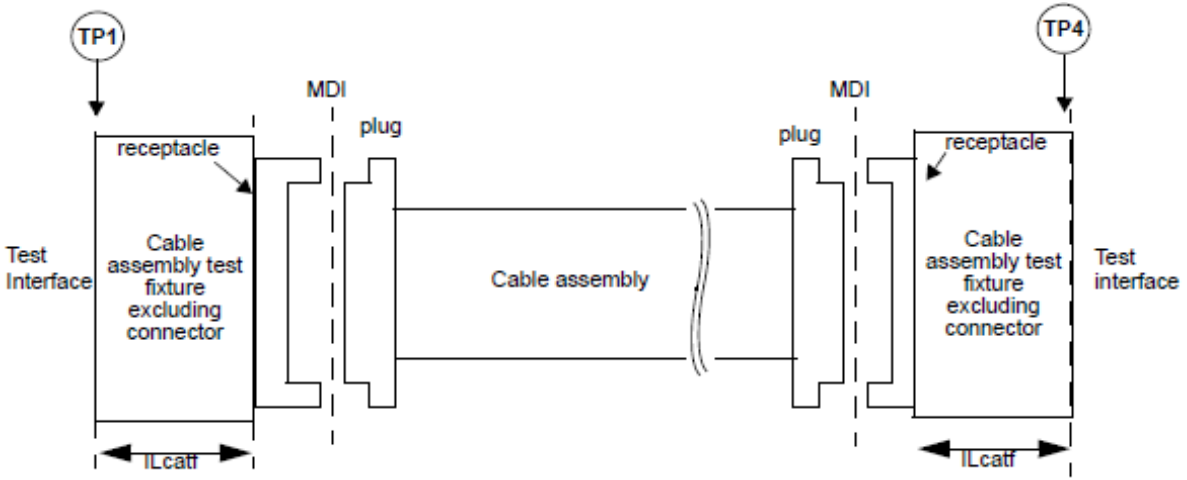
**Table 92–10—Cable assembly differential characteristics summary**

| Description | Reference | Value | Unit |
|---|---|---|---|
| Maximum insertion loss at 12.8906 GHz | 92.10.2 | 22.48 | dB |
| Minimum insertion loss at 12.8906 GHz | 92.10.2 | 8 | dB |
| Minimum return loss at 12.8906 GHz | 92.10.3 | 6 | dB |
| Differential to common-mode return loss | 92.10.4 | Equation (92–28) | dB |
| Differential to common-mode conversion loss | 92.10.5 | Equation (92–29) | dB |
| Common-mode to common-mode return loss | 92.10.6 | Equation (92–30) | dB |

**Table 110–10—Cable assembly characteristics summary**

| Description | Reference | CA-25G-L | CA-25G-S | CA-25G-N | Unit |
|---|---|---|---|---|---|
| Maximum insertion loss at 12.8906 GHz | 110.10.2 | 22.48 | 16.48 | 15.5 | dB |
| Minimum insertion loss at 12.8906 GHz | 110.10.2 | 8 | | | dB |
| Minimum differential return loss at 12.8906 GHz | 110.10.3 | 6 | | | dB |
| Differential to common-mode return loss | 110.10.4 | Equation (92–28) | | | dB |
| Differential to common-mode conversion loss | 110.10.5 | Equation (92–29) | | | dB |
| Common-mode to common-mode return loss | 110.10.6 | Equation (92–30) | | | dB |
| COM | 110.10.7 | See Table 110–11 | | | dB |

from [0.01/0.05/0.2] ≤ f ≤ 19 GHz




# COM- Baseline

- COM - consistent with methodology CL92 and CL110 – signaling rate 25.78125 GBd
- COM parameter values TBD

**Table 110–11—COM parameter values**

| Parameter | Symbol | CA-25G-N | CA-25G-S | CA-25G-L[a] | Units |
|---|---|---|---|---|---|
| Signaling rate | $f_b$ | 25.78125 | | | GBd |
| Maximum start frequency | $f_{min}$ | 0.05 | | | GHz |
| Maximum frequency step[b] | $\Delta f$ | 0.01 | | | GHz |
| Device package model | | | | | |
| Single-ended device capacitance | $C_d$ | $2.5 \times 10^{-4}$ | | | nF |
| Transmission line length, Test 1 | $z_p$ | 12 | | | mm |
| Transmission line length, Test 2 | $z_p$ | 30 | | | mm |
| Single-ended package capacitance at package-to-board interface | $C_p$ | $2.5 \times 10^{-4}$ | | | nF |
| Single-ended reference resistance | $R_0$ | 50 | | | Ω |
| Single-ended termination resistance | $R_d$ | 55 | | | Ω |
| Receiver 3 dB bandwidth | | $0.75 \times f_b$ | | | GHz |
| 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 | | −16 | −12 | −12 | dB |
| Maximum value | | 0 | 0 | 0 | dB |
| Step size | | 1 | 1 | 1 | dB |
| Continuous time filter, zero frequency | $f_z$ | $f_b / 4$ | | | GHz |
| Continuous time filter, pole frequencies | $f_{p1}$ | $f_b / 4$ | | | GHz |
| | $f_{p2}$ | $f_b$ | | | GHz |

TBD

**Table 110–11—COM parameter values *(continued)***

| Parameter | Symbol | CA-25G-N | CA-25G-S | CA-25G-L[a] | Units |
|---|---|---|---|---|---|
| Transmitter differential peak output voltage | | | | | |
| Victim | $A_v$ | 0.4 | | | V |
| Far-end aggressor | $A_{fe}$ | 0.6 | | | V |
| Near-end aggressor | $A_{ne}$ | 0.6 | | | V |
| Number of signal levels | $L$ | 2 | | | |
| Level separation mismatch ratio | $R_{LM}$ | 1 | | | |
| Transmitter signal-to-noise ratio | $SNR_{TX}$ | 28 | 27 | 27 | dB |
| Number of samples per unit interval | $M$ | 32 | | | |
| Decision feedback equalizer (DFE) length | $N_b$ | 5 | | | |
| Normalized DFE coefficient magnitude limit, for $n = 1$ to $N_b$ | $b_{max}(n)$ | 0.35 | 0.5 | 1 | — |
| Random jitter, RMS | $\sigma_{RJ}$ | 0.01 | | | UI |
| Dual-Dirac jitter, peak | $A_{DD}$ | 0.05 | | | UI |
| One-sided noise spectral density | $\eta_0$ | $5.2 \times 10^{-8}$ | | | $V^2$/GHz |
| Target detector error ratio | $DER_0$ | $10^{-12}$ | $10^{-8}$ | $10^{-5}$ | — |
| Channel Operating Margin (min.) | $COM$ | 3[c] | 3 | 3 | dB |

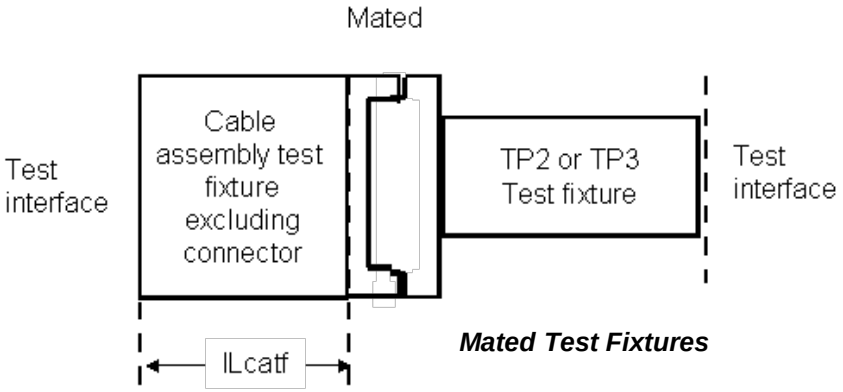
[a] The parameters for CA-25G-L are the same as those for 100GBASE-CR4 (Table 93–8), except for $A_{fe}$.
[b] For cable lengths greater than 4 m, a frequency step ($\Delta f$) no larger than 5 MHz is recommended.
[c] For CA-25G-N cable assemblies with insertion loss at 12.8906 GHz greater than 12 dB, the minimum COM is relaxed to 2.2 dB.

TBD

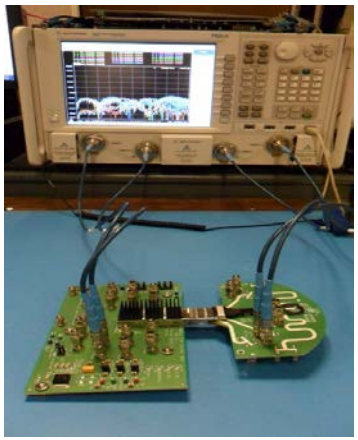
*Consider: http://www.ieee802.org/3/bs/public/adhoc/elect/index.shtml*
*COM update for Annex 120D (CDAUI-8 C2C) 12-Jan-16 (2157k)*
*config_com_ieee8023_93a=CDAUI-8-C2C_D1p1_mellitz_01_0116.xls*

# Test Fixtures

- Test Fixture specifications - consistent with CL92 and CL110
- Test fixtures specified in a mated state used for testing the transmitter, the receiver and cable assembly measurements
- The TP2/TP3 test fixture also known in the industry as Host Compliance Board (HCB) is required for measuring the transmitter specifications at TP2 and the receiver return loss at TP3.
- The cable assembly test fixture also known in the industry as Module Compliance Board (MCB) is required for measuring the cable assembly specifications at TP1 and TP4.




***Mated Test Fixtures***



# Test Fixtures - Baseline

- Test Fixture specifications – Adopt CL92 and CL110 – referenced parameters @ 13.28 GHz (signaling rate 25.78125 GBd).

**Mated test fixtures parameters**

| Parameter description | Reference | f(GHz) | Unit |
|---|---|---|---|
| Maximum insertion Loss | 92.11.3.1 | 0.01≤f≤25 | dB |
| Minimum Insertion Loss | 92.11.3.1 | 0.01≤f≤25 | dB |
| Figure of Merit(FOM) ILD | 92.11.3.1 | 0.01≤f≤25 | dB |
| Minimum Return Loss | 92.11.3.2 | 0.01≤f≤25 | dB |
| Common-mode conversion insertion loss | 92.11.3.3 | 0.01≤f≤25 | dB |
| Common-mode return loss | 92.11.3.4 | 0.01≤f≤25 | dB |
| Common-mode to differential –mode return loss | 92.11.3.5 | 0.01≤f≤25 | dB |
| Integrated crosstalk noise | 92.11.3.5 (QSFP28)<br>110B.1.3.6 (SFP28) | | |

# MDI/plug connector - Baseline

- MDI/Plug connector - Single-lane 50 Gb/s PHYs for operation – copper twin-axial cables (reference)
  - 110.11.1 Single-lane MDI connectors
    + The single-lane MDI uses the SFP+ 28 Gb/s 1X Pluggable (SFP28) plug and receptacle as defined in SFF-8402 and SFF-8432.

- MDI/Plug connector – Two-lane 100 Gb/s PHY – copper twin-axial cables (reference two lanes)
  - 92.12.1.1 Style-1 100GBASE-CR4 MDI connectors
    + The plug connector for each end of the cable assembly QSFP+ 28 Gb/s 4X Pluggable (QSFP28) plugs defined in SFF-8665.
    + The MDI connector shall be the QSFP+ 28 Gb/s 4X Pluggable (QSFP28) receptacle with the mechanical mating interface defined in SFF-8665.

# BACKUP

# IEEE 802.3bj: 100GBASE-CR4 Specifications

## Host Tx and Rx PCB losses

- Transmitter and receiver differential printed circuit board trace loss

| GHz | dB/in |
|---|---|
| 1 | 0.1856 |
| 6.5 | 0.8971 |
| 7 | 0.9557 |
| 12.89 | 1.5924 |
| 14 | 1.702 |

| Attenuation* (dB/in) at: | 1 GHz | 6.5 GHz | 7 GHz | 12.89 GHz | 14 GHz |
|---|---|---|---|---|---|
| Meg6_LowSR – Wide | 0.0951 | 0.4159 | 0.4433 | 0.7562 | 0.8127 |
| Meg6_LowSR – Narrow | 0.1466 | 0.5849 | 0.6205 | 1.0152 | 1.0847 |
| Meg6_HighSR – Wide | 0.1175 | 0.5960 | 0.6367 | 1.0891 | 1.1688 |
| Meg6_HighSR – Narrow | 0.1856 | 0.8971 | 0.9557 | 1.5924 | 1.7020 |
| ImpFR4_LowSR – Wide | 0.1202 | 0.6096 | 0.6541 | 1.1772 | 1.2734 |
| ImpFR4_LowSR – Narrow | 0.1717 | 0.7794 | 0.8323 | 1.4410 | 1.5512 |
| ImpFR4_HighSR – Wide | 0.1427 | 0.7904 | 0.8484 | 1.5158 | 1.6367 |
| ImpFR4_HighSR – Narrow | 0.2106 | 1.0930 | 1.1692 | 2.0283 | 2.1813 |

*using Algebraic Model v2.02a – see backup slides for values entered in Model

PROPOSED PARAMETERS; GRAPHS ON PREVIOUS SLIDE

| | | |
|---|---|---|
| Proposal for Defining Material Loss<br>26-Jan 12 | Elizabeth Kochuparambil<br>Joel Goergen | Cisco |

http://www.ieee802.org/3/bj/public/jan12/kochuparambil_01a_0112.pdf

12

802.3bj Cu specifications

*http://www.ieee802.org/3/bj/public/may12/diminico_01a_0512.pdf*

# Channel Insertion Loss

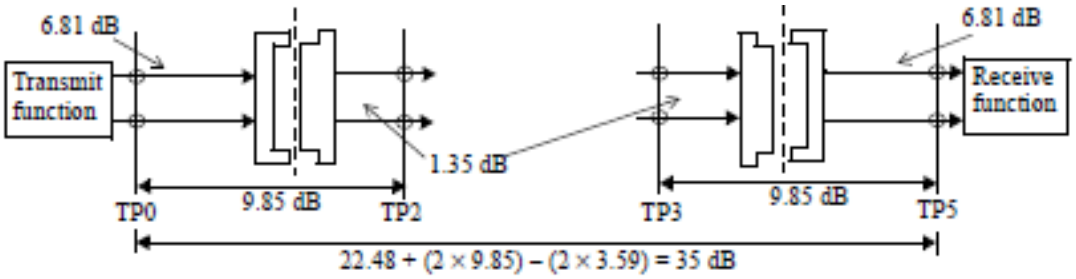
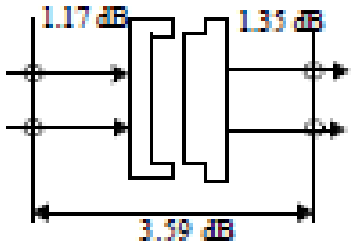



Table 110A–1—Cable insertion loss budget values at 12.8906 GHz

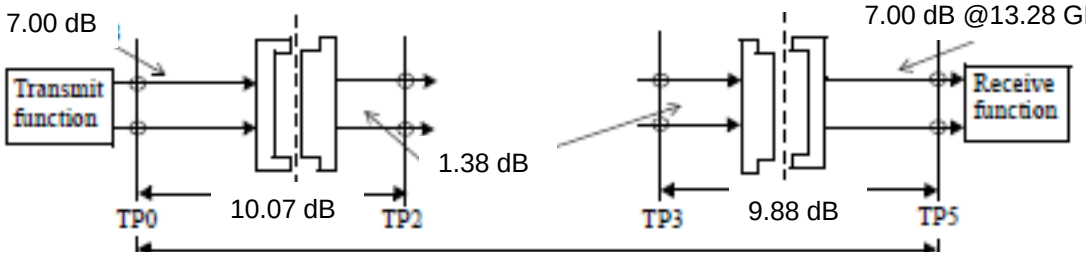
| Parameter | CA-25G-L | CA-25G-S | CA-25G-N | Units |
|---|---|---|---|---|
| $IL_{Chmax}$ | 35 | 29 | 28.02 | dB |
| $IL_{Camax}$ | 22.48 | 16.48 | 15.50 | dB |
| $IL_{Ch0.5m}$ | 20.52 | | | dB |
| $IL_{Camin}$ | 8 | | | dB |
| $IL_{Host}$ | 9.85 | | | dB |
| $IL_{MatedITF}$ | 3.59 | | | dB |

Channel IL @12.89 GHz = Cable assembly IL+(2*9.85)-(2*3.59)

IL @ 12.89 GHz

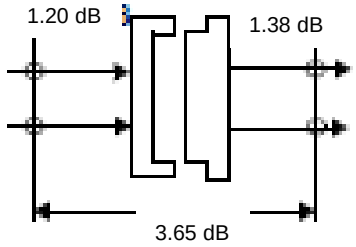



Mated cable assembly and test point test fixture




Channel IL @13.28 GHz = Cable assembly IL+(2*10.07)-(2*3.65)

IL @ 13.28 GHz

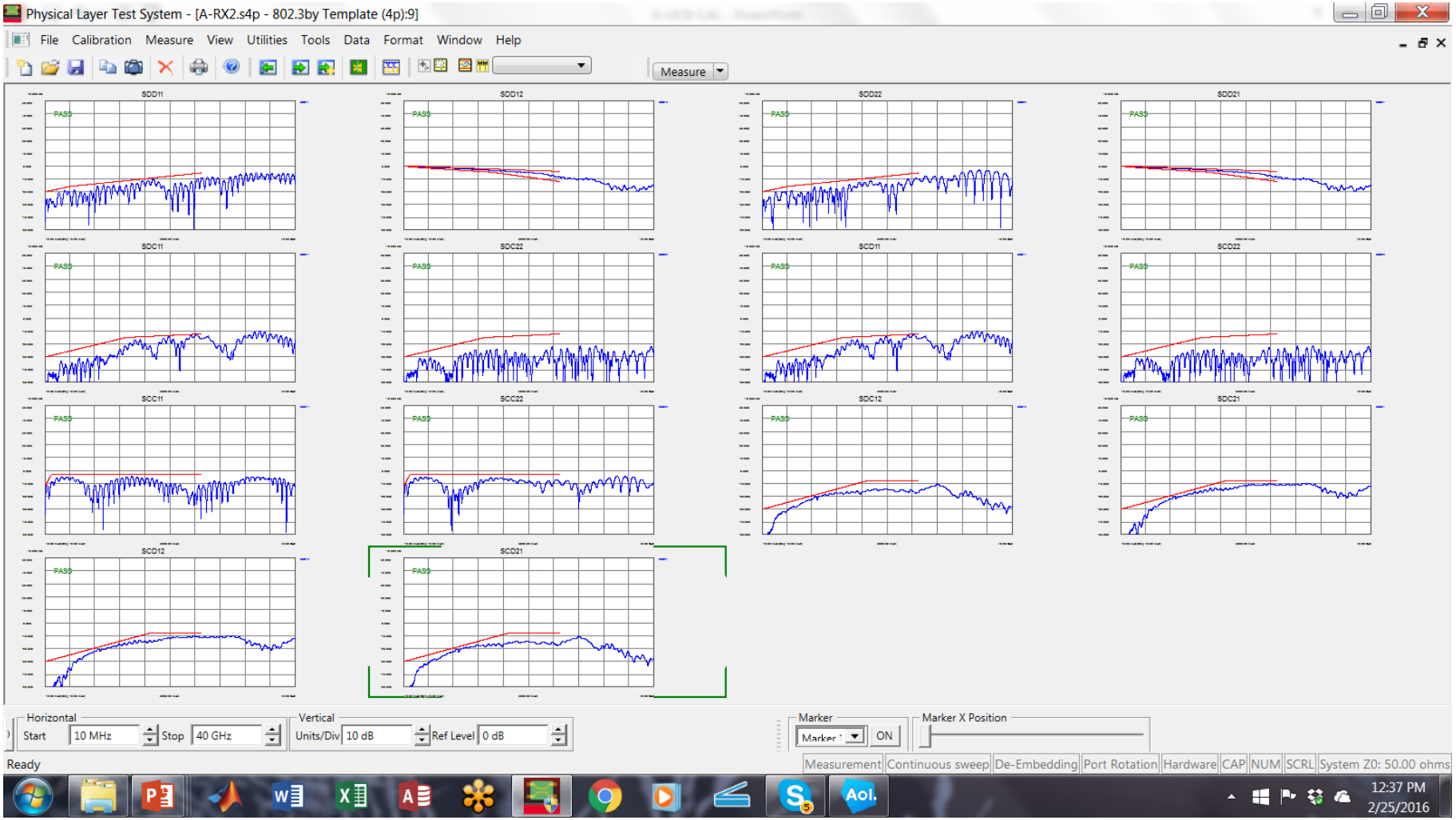



Mated cable assembly and test point test fixture

NOTE—The connector insertion loss is 1.07 dB for the mated test fixture. The host connector is allocated 0.62 dB of additional margin.

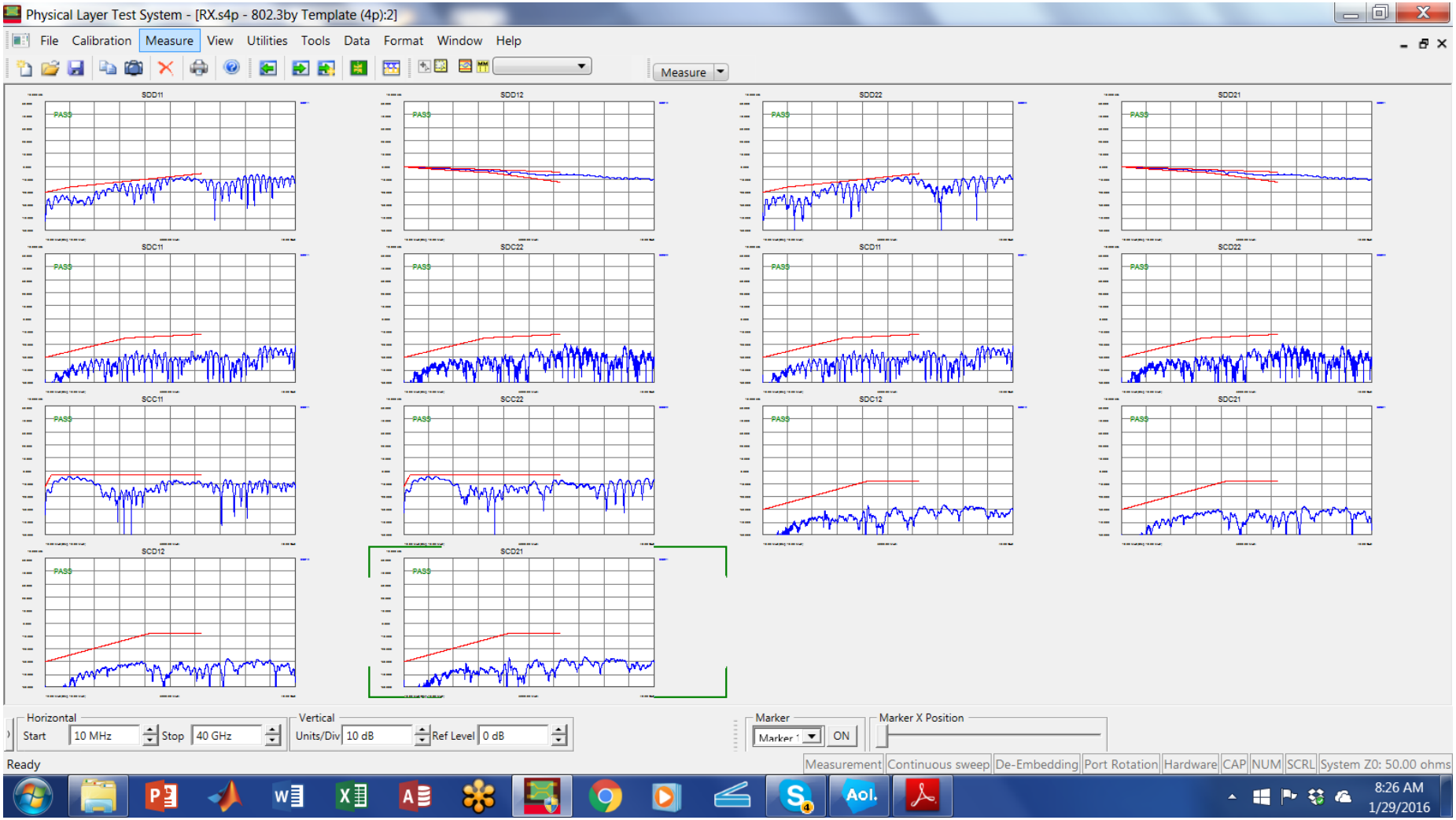
# QSFP28-Mated Test Fixture – 802.3bj/802.3by Specification

- Measurements 10 MHz-40 GHz



# SFP28-Mated Test Fixture – 802.3bj/802.3by Specification

- Measurements 10 MHz-40 GHz



# QSFP28 MTF – Figure of merit – ILD

$FOM_{ILD}$ is calculated according to 93A.4 with $f_b$=25.78125 GHz, $T_t$=9.6 ps, and $f_r$=0.75 × $f_b$. The fitted insertion loss and insertion loss deviation are computed over the range $f_{min}$=0.01 GHz to $f_{max}$=25 GHz. $FOM_{ILD}$ shall be less than 0.13 dB.

| Lane | $FOM_{ILD}$ (dB) |
|---|---|
| TX1 | 0.075 |
| TX2 | 0.045 |
| TX3 | 0.039 |
| TX4 | 0.044 |
| RX1 | 0.067 |
| RX2 | 0.046 |
| RX3 | 0.042 |
| RX4 | 0.053 |

http://www.ieee802.org/3/bm/public/jul14/plenary/diminico_01_0714_optx.pdf

# SFP28 - Mated test fixture specifications - ICN

**Table 110B–2—Mated test fixture integrated near-end crosstalk noise parameters**

| Description | Symbol | Value | Units |
|---|---|---|---|
| Symbol rate | $f_b$ | 25.78125 | GBd |
| Near-end disturber peak differential output amplitude | $A_{nt}$ | 600 | mV |
| Near-end disturber 20% to 80% rise and fall times | $T_{nt}$ | 9.6 | ps |

**Table 110B–1—Mated test fixtures integrated near-end crosstalk noise**

| Parameter | Value | Units |
|---|---|---|
| Integrated near-end crosstalk noise voltage | Less than 1.8 | mV |

| | | |
|---|---|---|
| 25.78125 GBd | MCB-TD-MCB-RD | HCB-TD-HCB-RD |
| NEXT ICN (mV) | 0.945 | 0.926 |
| | | |
| 26.5625 GBd | MCB-TD-MCB-RD | HCB-TD-HCB-RD |
| NEXT ICN (mV) | 0.976 | 0.962 |

http://www.ieee802.org/3/bm/public/jul14/plenary/diminico_01_0714_optx.pdf

# QSFP28 - Mated test fixture specifications - ICN

**Table 92–14—Mated test fixture integrated crosstalk noise parameters**

| Description | Symbol | Value | Units |
|---|---|---|---|
| Symbol rate | $f_b$ | 25.78125 | GBd |
| Near-end disturber peak differential output amplitude | $A_{nt}$ | 600 | mV |
| Far-end disturber peak differential output amplitude | $A_{ft}$ | 600 | mV |
| Near-end disturber 20% to 80% rise and fall times | $T_{nt}$ | 9.6 | ps |
| Far-end disturber 20% to 80% rise and fall times | $T_{ft}$ | 9.6 | ps |

**Table 92–13—Mated test fixtures integrated crosstalk noise**

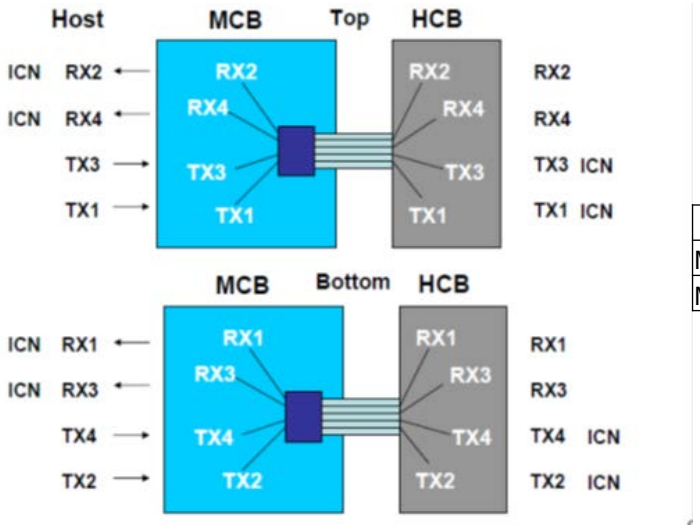
| Parameter | 100GBASE-CR4 | Units |
|---|---|---|
| MDNEXT integrated crosstalk noise voltage | less than 1.8 | mV |
| MDFEXT integrated crosstalk noise voltage | less than 4.8 | mV |

25.78125 GBd /26.5625 GBd

| | RX1 | RX2 | RX3 | RX4 |
|---|---|---|---|---|
| MDNEXT ICN (mV) | 1.08 | 0.95 | 1.00 | 0.95 |
| MDFEXT ICN (mV) | 3.72 | 4.09 | 2.77 | 3.01 |
| | TX1 | TX2 | TX3 | TX4 |
| MDNEXT ICN (mV) | 1.39/1.47 | 1.13 | 1.11 | 0.81 |
| MDFEXT ICN (mV) | 4.17/4.27 | 3.19 | 3.74 | 3.00 |

http://www.ieee802.org/3/bm/public/jul14/plenary/diminico_01_0714_optx.pdf

# QSFP28 - Mated test fixture specifications - ICN




| | RX1 | RX2 | TX1 | TX2 |
|---|---|---|---|---|
| MDNEXT ICN | 0.81 | 0.79 | 1.19 | 1.00 |
| MDFEXT ICN | 2.12 | 2.57 | 2.66 | 2.29 |

**MCB-ICN-RX1**
HCB RX1-MDFEXT-RX2,RX3,RX4
MCB RX1-MDNEXT-TX1,TX2,TX3,TX4

**HCB-ICN-TX1**
TX1-MDFEXT-TX2,TX3,TX4 MCB
TX1-MDNEXT-RX1,RX2,RX3,RX4 HCB

**MCB-ICN-RX2**
HCB RX2-MDFEXT-RX1,RX3,RX4
MCB RX2-MDNEXT-TX1,TX2,TX3,TX4

**HCB-ICN-TX2**
TX2-MDFEXT-TX1,TX3,TX4 MCB
TX2-MDNEXT-RX1,RX2,RX3,RX4 HCB

**MCB-ICN-RX3**
HCB RX3-MDFEXT-RX1,RX2,RX4
MCB RX3-MDNEXT-TX1,TX2,TX3,TX4

**HCB-ICN-TX3**
TX3-MDFEXT-TX1,TX2,TX4 MCB
TX3-MDNEXT-RX1,RX2,RX3,RX4 HCB

**MCB-ICN-RX4**
HCB RX4-MDFEXT-RX1,RX2,RX3
MCB RX4-MDNEXT-TX1,TX2,TX3,TX4

**HCB-ICN-TX4**
TX4-MDFEXT-TX1,TX2,TX3 MCB
TX4-MDNEXT-RX1,RX2,RX3,RX4 HCB

# CAUI/CDAUI chip-to-module interfaces

- CAUI-4 signaling rate for each lane is 25.78125 GBd[1].

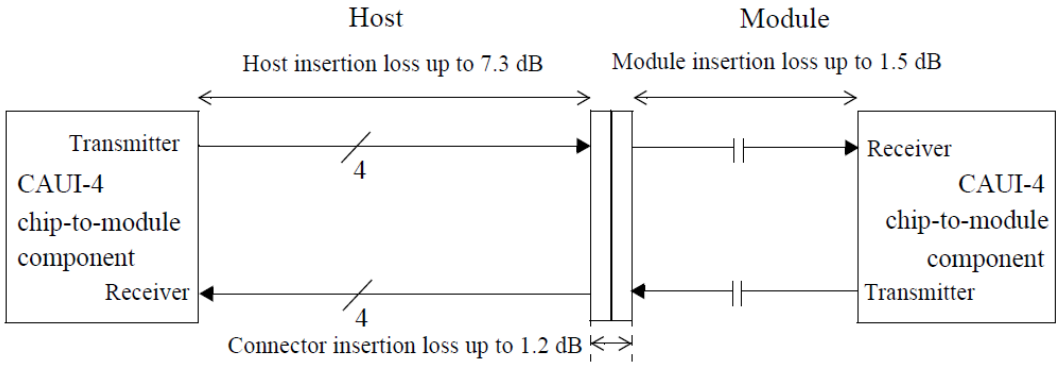



**Figure 83E–2—Chip-to-module insertion loss budget at 12.89 GHz**

- CDAUI-8 signaling rate for each lane is 26.5625 GBd[2]

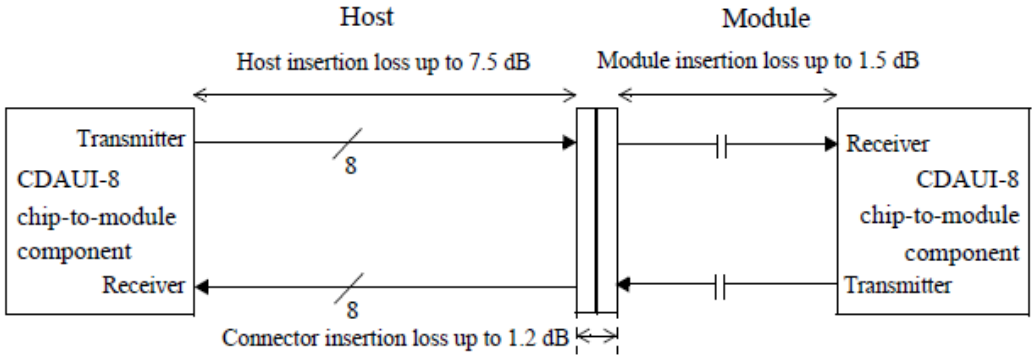



**Figure 120E–2—Chip-to-module insertion loss budget at 13.28 GHz**