# IEEE 802.3 Electrical Backplane/ Twinax Cu Cable SG Objectives

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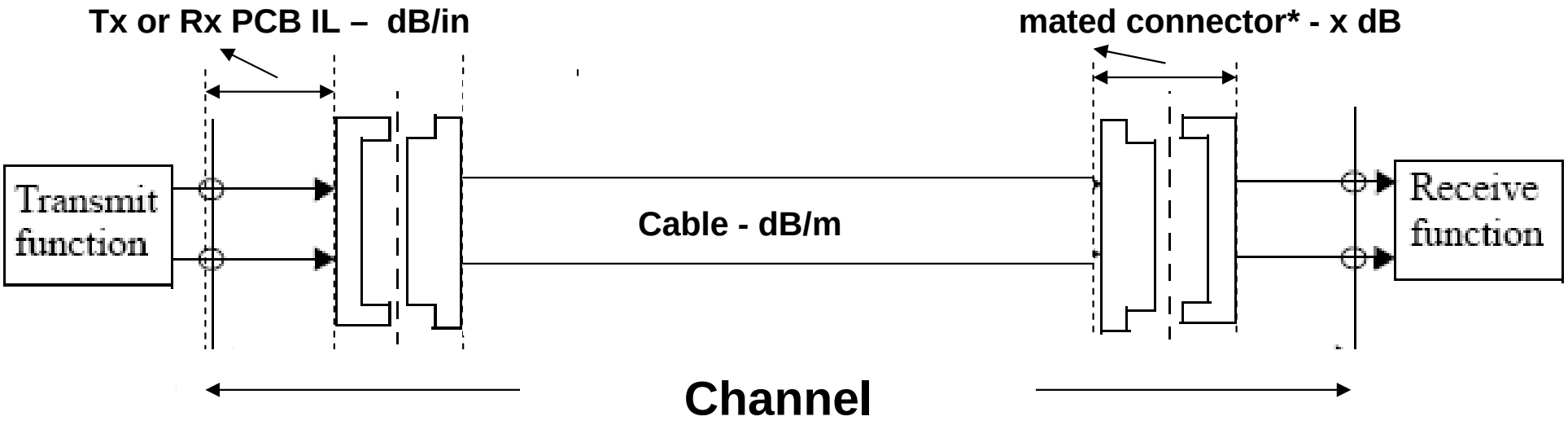
# Summary

•**Cable assembly and transmit/receive PCB lengths and *loss basis* critical to establishing channel insertion loss budget and implementation options e.g., signaling rate, line code...etc..**




- **Tx or Rx PCB IL and cable scale ~with length**
- **Loss basis dB/length**

***mated connector loss including paddle card and wire termination**

# Purpose

- **Goals**
  - **Provide information to consider minimum reach recommendations for passive cable assembly and host channel presented in "System Vendors View on 100 Gb/s Backplane and Copper Study Group Issues" -Gustlin_01_0311.pdf.**
    - **-5 m minimum target length for a passive cable specifications**
    - **-4 inch host channel (per side) of improved FR4 PCB material**
- **Non-goals**
  - **Provide noise (crosstalk) recommendations for channel or components e.g., host receptacle, test fixtures, etc….**

# Supporters

- Dan Dove – HP
- Galen Fromm, Jay Neer, Mark Bugg – Molex
- Vittal Balasubramanian – FCI
- Tom Palkert – Luxtera
- Mark Gustlin, Marco Mazzini, Lin Shen – Cisco
- Megha Shanbhag, Marc Dupuis, Nathan Tracy – TE Connectivity
- Bernd Jansen, Cattalen Pelard – LEONI Cables & Systems
- Rick Rabinovich – Alcatel-Lucent

# Cable assembly and transmit/receive PCB lengths

**"System Vendors View on 100 Gb/s Backplane and Copper Study Group Issues" - Gustlin_01_0311.pdf**

## Twinax Interface Desired Properties

- We believe that 5m should be used as our initial minimum target length for a passive cable specification
- Possible objective (from dambrosia_01_0311):

  Define a 4-lane 100 Gb/s PHY for operation over copper twin-axial cables for links consistent with lengths up to at least 5m
- Improved FR4 PCB material + 4" per side is a good starting point for the host channel
- A cable with a reasonable diameter and bend radius should be considered for the channel, for example, a twinax cable gauge of AWG24 might fulfill this requirement

- **Loss basis dB/length required for Channel IL budget**

# 40GBASE-CR4 and 100GBASE-CR10 channel insertion loss budget

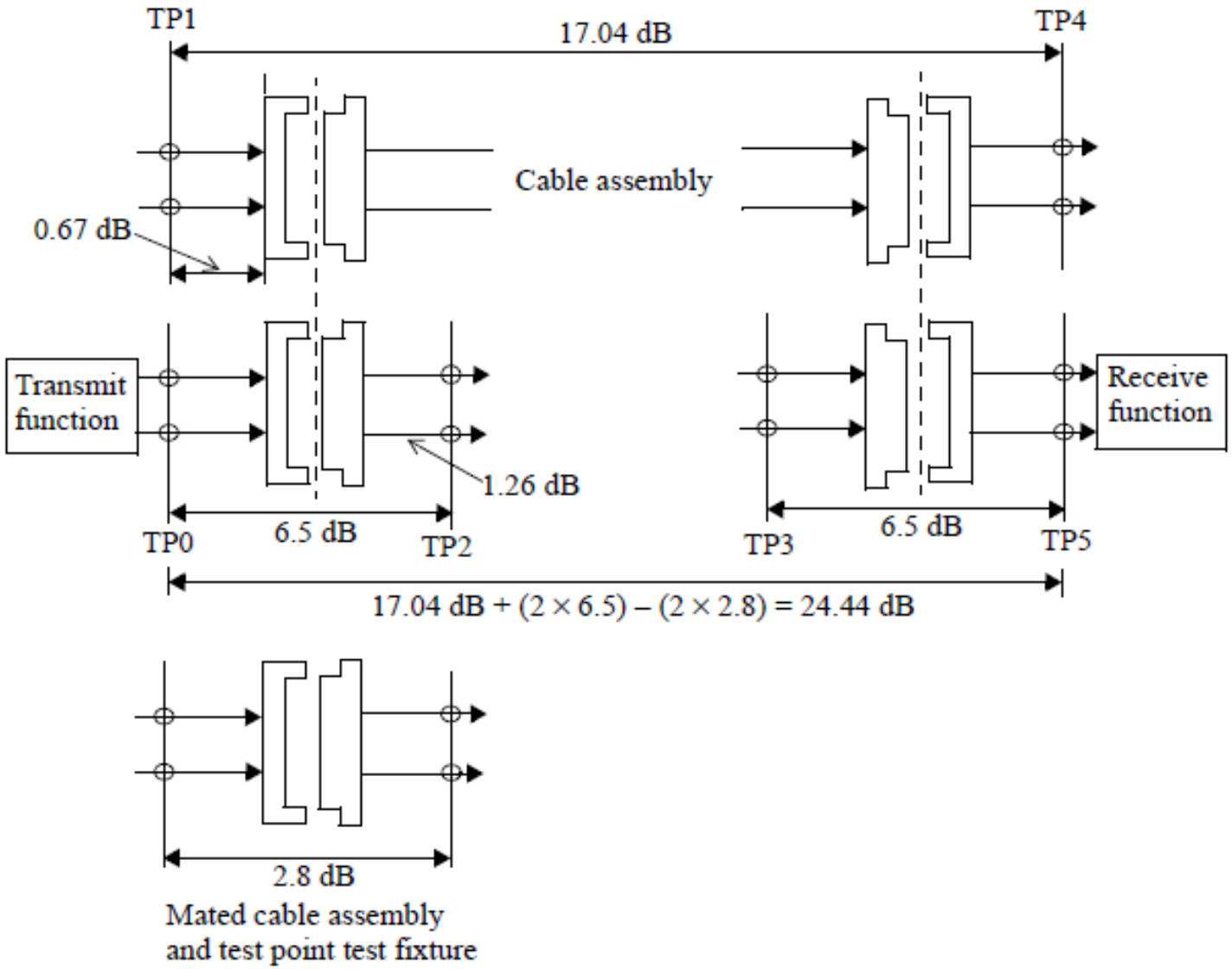
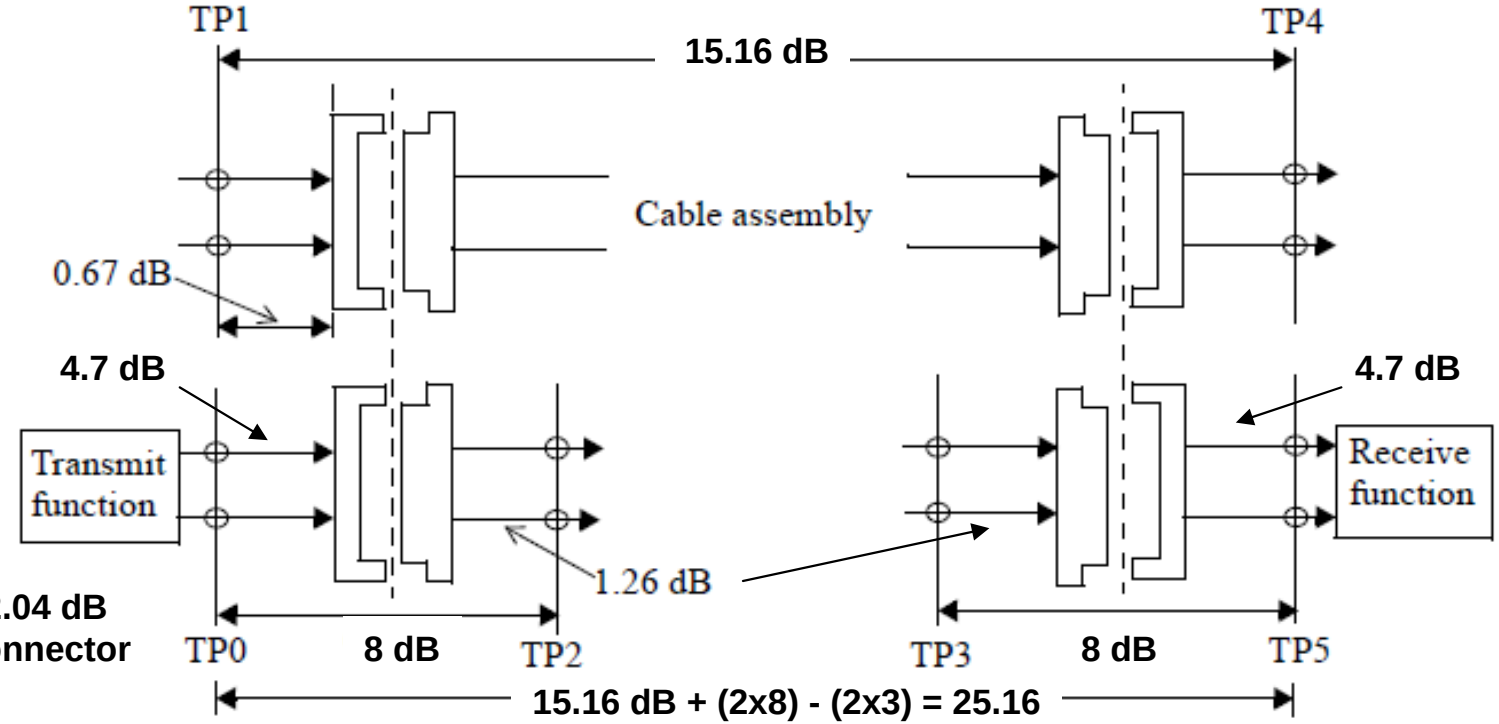



**Figure 85A–1—Illustration of channel insertion loss budget at 5.15625 GHz**

# Channel insertion loss – 3 m cable length – 26 AWG

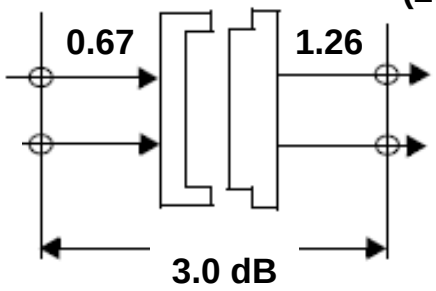
## Illustration of channel insertion loss budget at 12.89 GHz




8.0-(4.7+1.26) = 2.04 dB
2.04 assumed connector loss

2.04-1.07 = 0.97 host margin loss

3.0-(0.67+1.26) = 1.07 dB
1.07 assumed connector loss

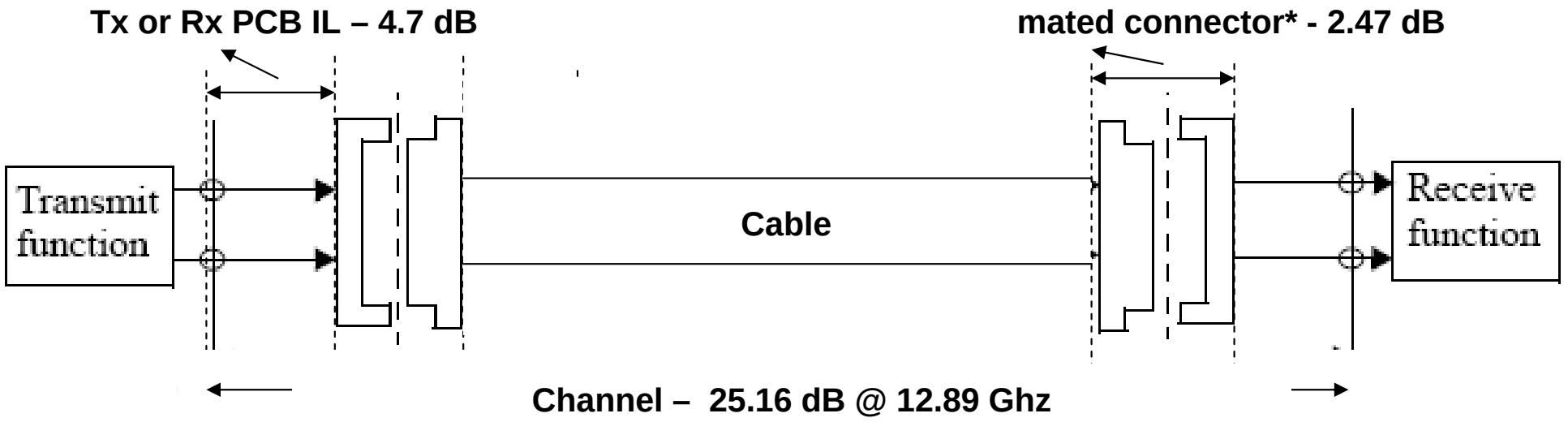



(25.16 dB - (10.82 + 2 x 4.7))/2 = 2.47 dB channel connector loss
= 2.04 host + 0.43 paddle card termination

| | | |
|---|---|---|
| Cable | 3.6 dB/m | 10.82 dB |
| connector* | 1.5 dB | 3 dB |
| CA-TF loss | .67 dB | 1.34 dB |
| cable assembly | | 15.16 dB |

*assumes 1.07 dB connector and 0.43 dB termination paddle card

# Channel insertion loss - 12.89 GHz – 3 m assembly



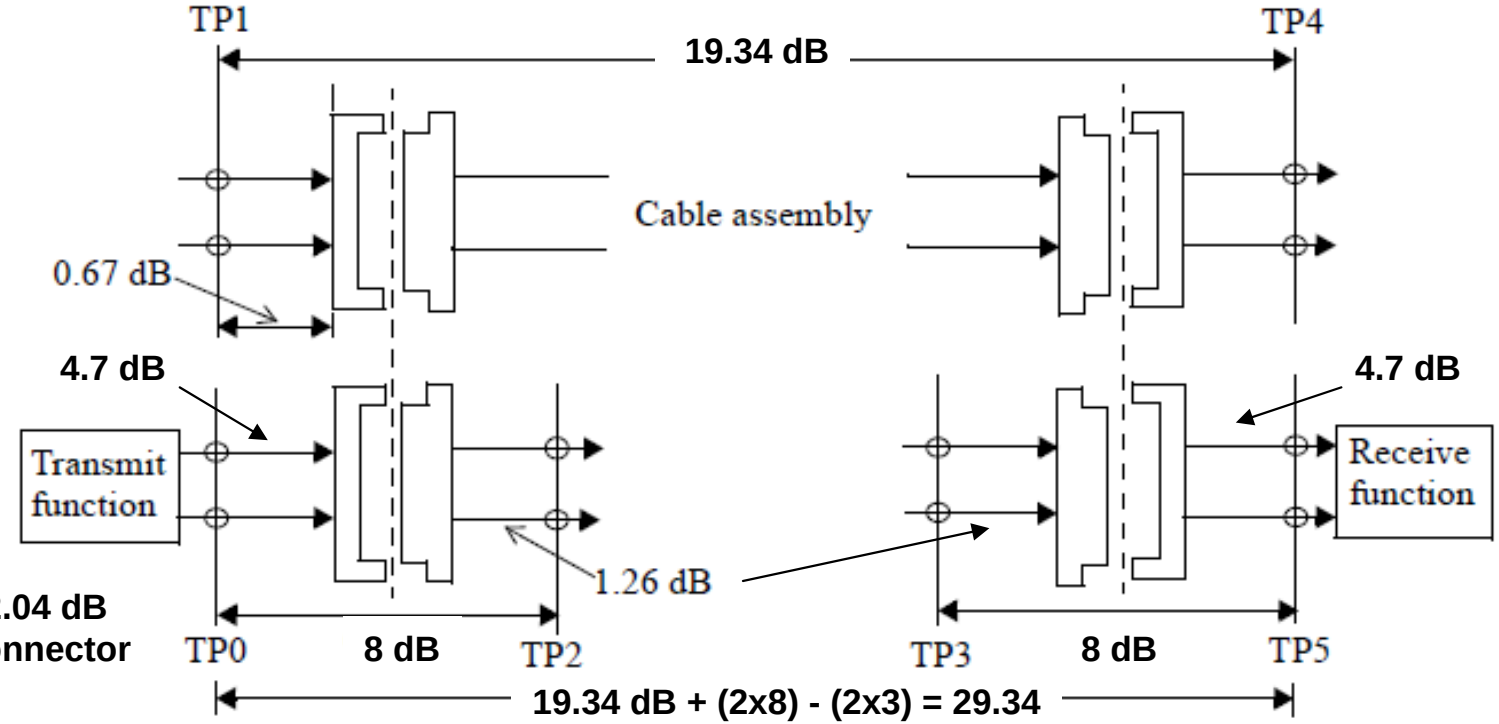

*mated connector loss including paddle card and wire termination

**Channel IL= 2 x 4.70 dB (PCB) + 2 x 2.47 dB mated connector + 10.82 dB cable = 25.16 dB**

| Channel components | Total 25.16 dB @ 12.89 |
|---|---|
| Tx PCB-4” from Megtron4 measurements (1.175 dB/in) | OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)= 4.7 dB |
| Host connector loss including paddle card termination | 0.688*sqrt(fGHz) = 2 47 dB |
| Cable 3 m 26 AWG measured (~3.6 dB/m) | 10.82 dB |
| Host connector loss including paddle card termination | 0.688*sqrt(fGHz) = 2.47 dB |
| Rx PCB-4” from Megtron4 measurements (1.175 dB/in) | OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)= 4.7 dB |

# Channel insertion loss – 5 m cable length – 24 AWG

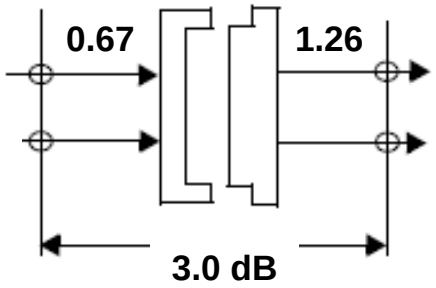
## Illustration of channel insertion loss budget at 12.89 GHz




8.0-(4.7+1.26) = 2.04 dB
2.04 assumed connector loss

2.04-1.07 = 0.97 host margin loss

3.0-(0.67+1.26) = 1.07 dB
1.07 assumed connector loss

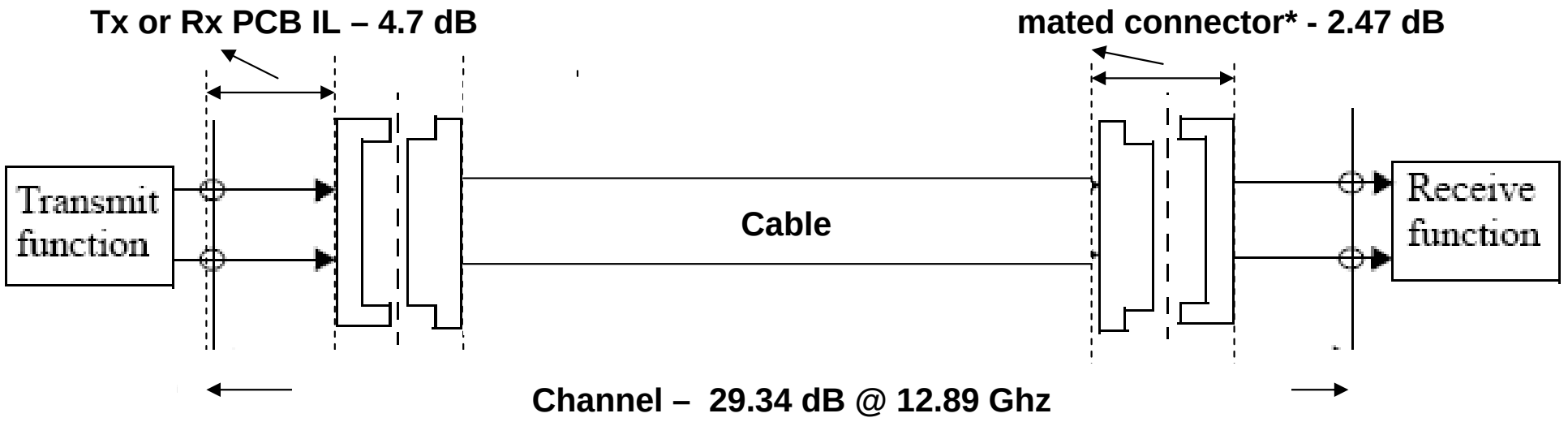



(29.34 dB - (15 + 2 x 4.7))/2 = 2.47 dB channel connector loss
= 2.04 host + 0.43 paddle card termination

| | | |
|---|---|---|
| Cable | 3 dB/m | 15 dB |
| Connector* | 1.5 dB | 3 dB |
| CA-TF loss | .67 dB | 1.34 dB |
| cable assembly | | 19.34 dB |

*assumes 1.07 dB connector and 0.43 dB termination paddle card

# Channel insertion loss - 12.89 GHz – 5 m assembly




*mated connector loss including paddle card and wire termination

**Channel IL= 2 x 4.70 dB (PCB) + 2 x 2.47 dB mated connector + 15.00 dB cable = 29.34 dB**

| Channel components | Total 29.34 dB @ 12.89 |
|---|---|
| Tx PCB-4” from Megtron4 measurements (1.175 dB/in) | OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)= 4.7 dB |
| Connector loss including paddle card termination | 0.688*sqrt(fGHz) = 2.47 dB |
| Cable 5 m 24 AWG scaled from 26 AWG + 10% | 9.82x.83*5/3*1.1 = ~15 dB |
| Connector loss including paddle card termination | 0.688*sqrt(fGHz) = 2.47 dB |
| Rx PCB-4” from Megtron4 measurements (1.175 dB/in) | OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)= 4.7 dB |

# 100GbE Electrical Backplane / Cu Cabling Call-For-Interest

## Loss budget examples

| | 40GBASE-CR4 signal integrity | | "Next generation" signal integrity | |
|---|---|---|---|---|
| **Uncoded rate, Gb/s** | 10.0 | 25.0 | 25.0 | 25.0 |
| **Line code** | NRZ | 4-PAM | 4-PAM | NRZ |
| **Signaling rate, GBd** | 10.3125 | 12.8913 | 12.8913 | 25.7813 |
| **SNR for BER ≤ $10^{-12}$, dB [1]** | 17.0 | 26.6 | 26.6 | 17.0 |
| **Cable length, m** | 7 | 7 | 7 | 3 |
| **Host TX PCB (4") [2], dB** | 3.50 | 4.33 | 2.54 | 4.70 |
| **TX Connector, dB** | 2.07 | 2.31 [3] | 1.41 [4] | 2.00 |
| **Bulk cable, dB** | 13.30 | 16.42 | 13.68 [5] | 10.82 |
| **RX Connector, dB** | 2.07 | 2.31 [3] | 1.41 [4] | 2.00 |
| **Host RX PCB (4"), dB** | 3.50 | 4.33 | 2.54 | 4.70 |
| **Total insertion loss, dB** | **24.44** | **29.70** | **21.58** | **24.22** |

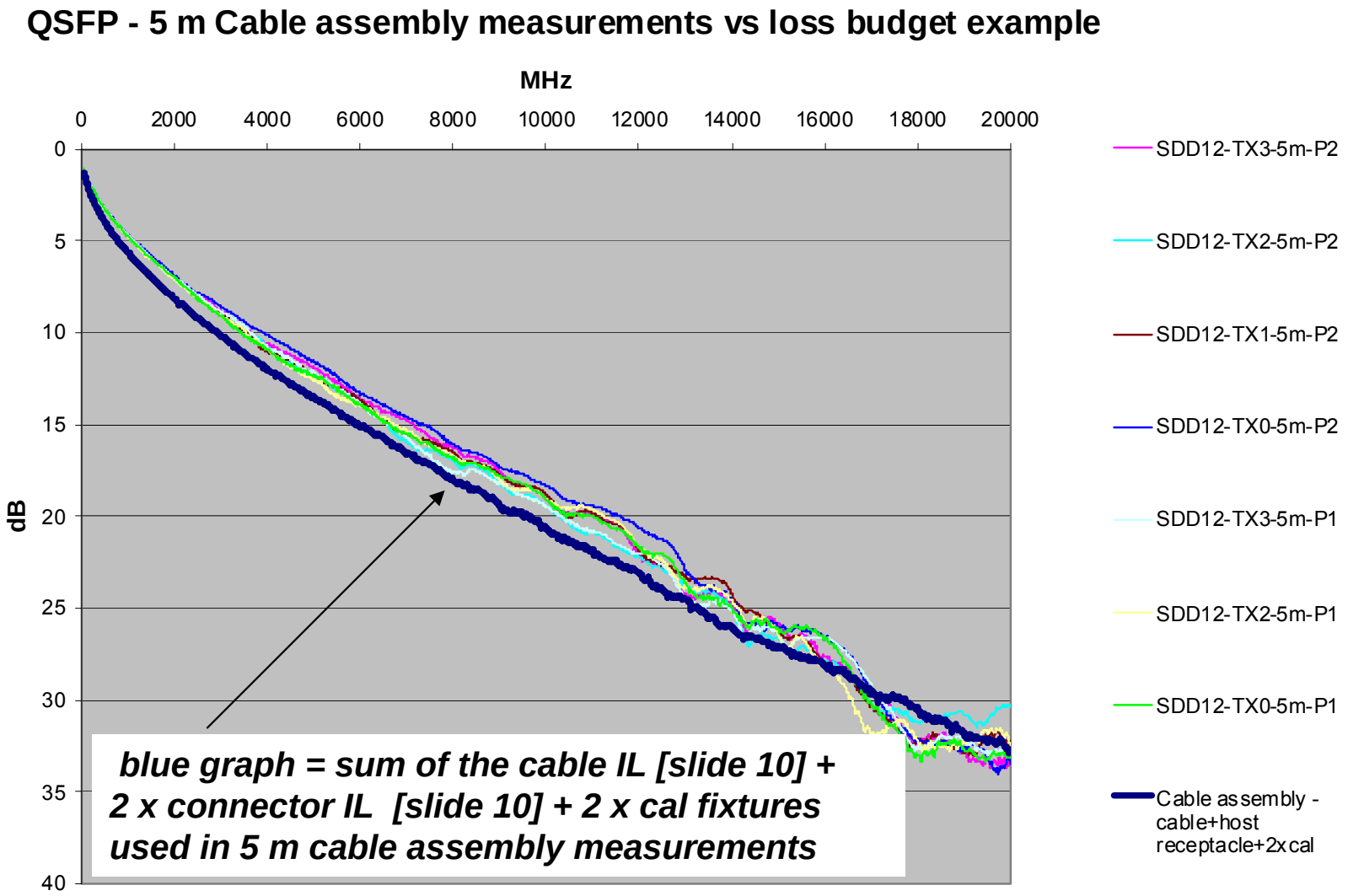
[1] Assumes fixed transmitter peak-to-peak differential output voltage.
[2] Losses are defined at the fundamental frequency for the cited signaling rate.
[3] Derived as 2.07 × sqrt( 6.4453/5.1563 )
[4] Derived as 2.00 × sqrt( 6.4453/12.8913 )
[5] Derived as (7/3) × 7.06 × 0.83 where 0.83 is the reduction in loss for 24AWG cabling relative to 26AWG

# Loss budget examples

| | *Next generation signal integrity* | | |
|---|---|---|---|
| Uncoded rate, Gb/s | 25.0 | 25.0 | 25.0 |
| Line code | NRZ | NRZ | 4-PAM |
| Signaling rate, GBd | 25.7813 | 25.7813 | 12.8913 |
| SNR for BER ≤ $10^{-12}$ , dB [1] | 17.0 | 17.0 | 26.6 |
| Cable length, m | 3 | 5 | 7 |
| Host TX PCB (4") [2], dB | 4.70 [3] | 4.70 [3] | 2.54 [3] |
| TX Connector, dB | 2.47 | 2.47 | 1.75 [6] |
| Bulk cable, dB | 10.82 [4] | 15.00 [5] | 13.68 [7] |
| RX Connector, dB | 2.47 | 2.47 | 1.75 [6] |
| Host RX PCB (4"), dB | 4.70 [3] | 4.70 [3] | 2.54 [3] |
| Total insertion loss, dB | 25.16 | 29.34 | 22.26 |

[1] Assumes fixed transmitter peak-to-peak differential output voltage.
[2] Losses are defined at the fundamental frequency for the cited signaling rate.
[3] Tx PCB-4" from Megtron4 measurements-OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)
[4] Cable 3 m 26 AWG measured includes ~1 dB fixture insertion loss
[5] Cable 5 m 24 AWG scaled from 3 m 26 AWG measurements
[6] Derived as 2.47 x sqrt(6.4453/12.8913)
[7] Derived as (7/3) x 0.83 where 0.83 is the reduction in loss for 24 AWG cabling relative to 26 AWG

# Measurements vs loss budget - 5 m cable assembly




**5 m cable assembly measurements from "bugg_01_0111.pdf"**

# Conclusions

• **Information provided to consider minimum reach recommendations for passive cable assembly and host channel presented in “System Vendors View on 100 Gb/s Backplane and Copper Study Group Issues” -Gustlin_01_0311.pdf.**

**-5 m minimum target length for a passive cable specifications**

**-4 inch host channel (per side) of improved FR4 PCB material**