IEEE 802.3bj Twinaxial Cu cable assembly objective

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Purpose

- **Provide information to consider minimum reach objective for passive cable assembly**
  - **Define a 4-lane 100 Gb/s PHY for operation over links consistent with copper twin-axial cables with lengths up to at least 5m.**

Supporters

- **Mark Bugg – Molex**
- **Mark Gustlin, Marco Mazzini – 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**

Suggested PHY Proposals - hatab_01_0911.pdf

"System Requirements for 100GbE 4x25G Backplane Channels"-hatab_01_0911.pdf

Suggested PHY Proposals

Proposal 1:

- PAM-4 PHY: Support for "Nelco" channels up to 40" (1m):
  - IL = -50 dB at 12.5 GHz
  - PAM-4 coding
  - FEC with NCG of at least 7 dB for 10^{-12} BER
  - Investigate Tx amplitude > 1Vpp
- NRZ PHY: Support for "Megtron" channels up to 40" (1m):
  - IL = -30 dB at 12.5 GHz
  - NRZ Coding
  - Tx amplitude 1Vpp
  - FEC with NCG of at least 2 dB for 10^{-12} BER

Proposal 2:

- NRZ PHY: Support for "Nelco" channels up to 30" (0.75m) and "Megtron" channels up to 40" (1m) :
  - IL = -35 dB at 12.5 GHz
  - NRZ Coding
  - Tx amplitude 1Vpp
  - FEC with NCG of at least 5 dB for 10^{-12} BER

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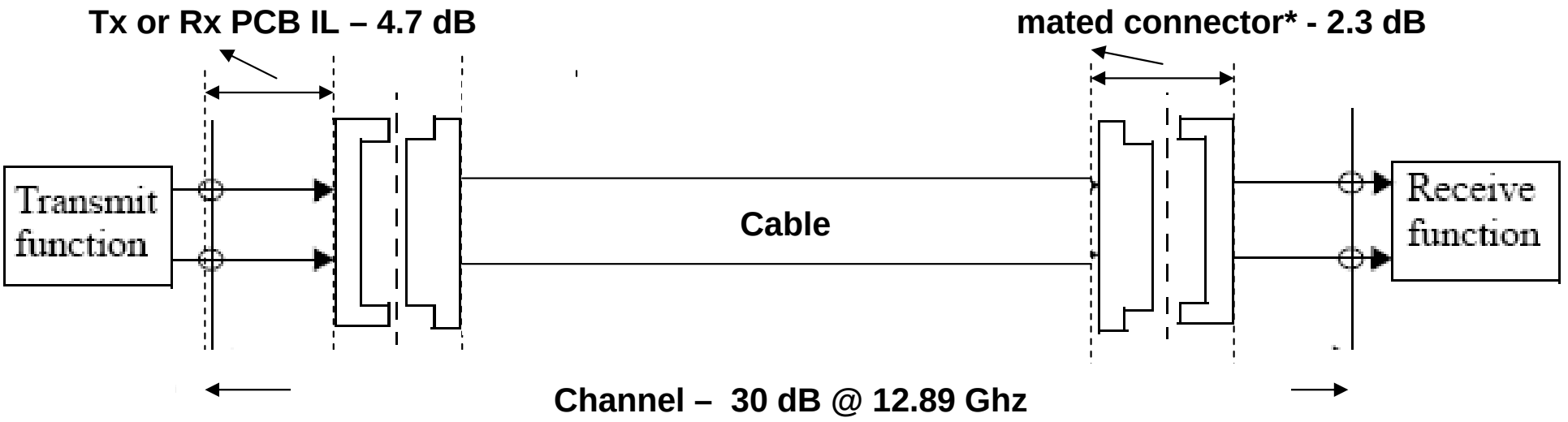
Channel insertion loss - 12.89 GHz – 5 m assembly



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

Channel IL= 2 x 4.70 dB (PCB) + 2 x 2.3 dB mated connector + 16.00 dB cable = 30 dB

Channel components	Total 30 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	0.641*sqrt(fGHz) = 2.3 dB
Cable 5 m 24 AWG	3.2 dB/m = 16 dB
Connector loss including paddle card termination	0.641*sqrt(fGHz) = 2.3 dB
Rx PCB-4” from Megtron4 measurements (1.175 dB/in)	OIF2010.132.01.pdf =4*(0.0838*fGHz+0.0944)= 4.7 dB

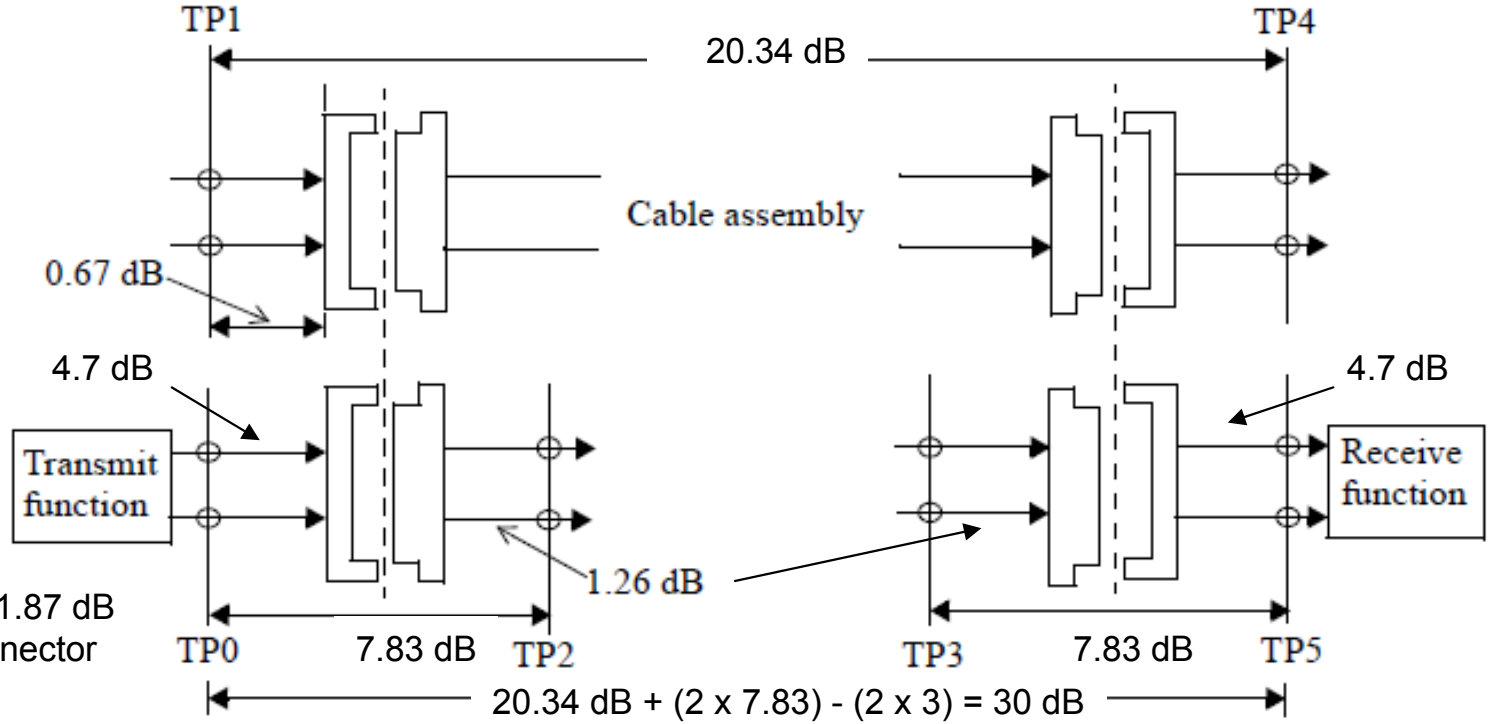
Loss budget examples

	Next generation signal integrity	
Uncoded rate, Gb/s	25.0	25.0
Line code	NRZ	4-PAM
Signaling rate, GBd	25.7813	12.8913
SNR for BER ≤ 10^{-12} , dB [1]	17.0	26.6
Cable length, m	5	7
Host TX PCB (4”) [2], dB	4.70 [3]	2.54 [3]
TX Connector, dB	2.30	1.63 [5]
Bulk cable, dB	16.00 [4]	14.5 [6]
RX Connector, dB	2.30	1.63 [5]
Host RX PCB (4”), dB	4.70 [3]	2.54 [3]
Total insertion loss, dB	30.00	22.84

[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] Measured cable pair 24 AWG 3.2 dB/m (+13% from measurement)
[5] Derived as 2.3 x sqrt(6.4453/12.8913)
[6] Measured cable pair 24 AWG 2.07 dB/m (+13% from measurement)

Channel insertion loss – 5 m cable length – 24 AWG

Illustration of channel insertion loss budget at 12.89 GHz

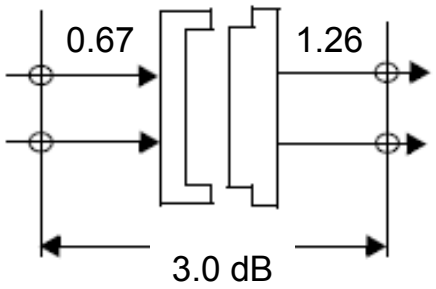


7.83-(4.7+1.26) = 1.87 dB
1.87 assumed connector loss

(30 dB - (16 + 2 x 4.7))/2 = 2.3 dB channel connector loss
= 1.87 host + 0.43 paddle card termination

1.87-1.07 = 0.8 host margin loss

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



Mated cable assembly and test point test fixture

Cable	3.2 dB/m	16 dB
Connector*	1.5 dB	3 dB
CA-TF loss	.67 dB	1.34 dB
cable assembly		20.34 dB

*assumes 1.07 dB connector and 0.43 dB termination paddle card

Channel Floor - goergen_01_0911

Defining a Minimum Channel Floor from Material Constraints -goergen_01_0911.pdf

Validation: Comparing Algebra to Calculus

30in 8mil track 17mil spacing, 1/2oz cu				
Impr FR-4	Algebraic		ADS / HFSS	
Freq	Zc in Ohms	Loss in dB	Zc in Ohms	Loss in dB
6GHz	50.8	15.6	51.2	14.6
14GHz	52	33.7	52.2	32.2
Meg6	Algebraic		ADS / HFSS	
Freq	Zc in Ohms	Loss in dB	Zc in Ohms	Loss in dB
6GHz	50.6	10.5	50.9	9.4
14GHz	52.6	20.3	52.9	18.6
40in 8mil track 17mil spacing, 1/2oz cu				
Impr FR-4	Algebraic		ADS / HFSS	
Freq	Zc in Ohms	Loss in dB	Zc in Ohms	Loss in dB
6GHz	50.8	20.9	51.2	19.5
14GHz	52	45	52.2	42.9
Meg6	Algebraic		ADS / HFSS	
Freq	Zc in Ohms	Loss in dB	Zc in Ohms	Loss in dB
6GHz	50.6	13.9	50.9	12.5
14GHz	52.6	26.9	52.9	24.8

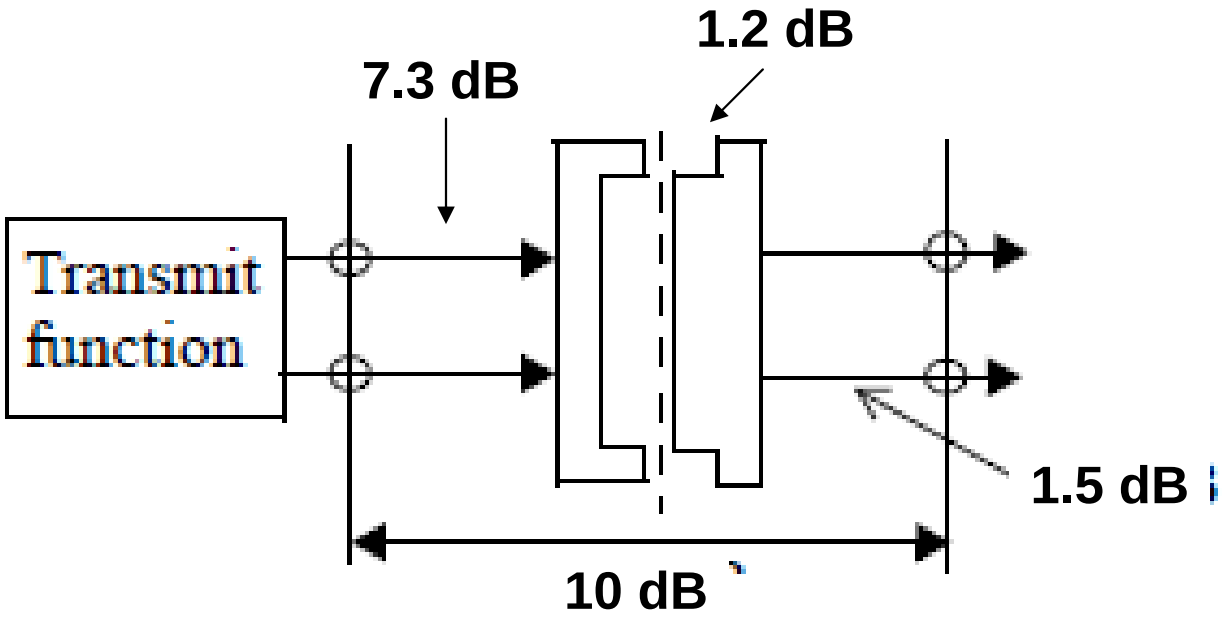
IEEE802.3 100Gb/s Ethernet Electrical Backplane and Twinaxial Copper Cable Assemblies Study Group

Summary

- **Channel loss budget provided consistent with copper twin-axial cables with lengths up to at least 5m, 4 inch host channel length, and channel loss of 30 dB @12.89 GHz.**

OIF CEI-28G-VSR description - dudek_01_1111

- **Loss budget host chip to module chip = 10 dB**
  - 7.3 dB for host
  - 1.2 dB for connector
  - 1.5 dB for module traces and capacitors.



Loss budget comparisons – 1.5 dB difference

- **Loss budget host + connector 802.3bj loss budget – diminico_01_1111.pdf= 7 dB**
  - 4.7 dB for host
  - 2.3 dB for mated connector

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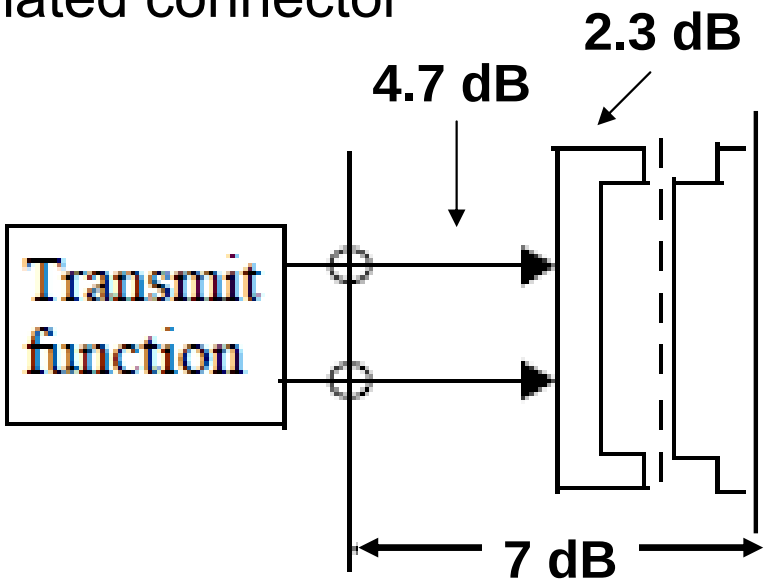

- **Loss budget host + connector OIF CEI-28G-VSR description - dudek_01_1111 = 8.5 dB**
  - 7.3 dB for host
  - 1.2 dB for matted connector

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