Twinaxial Ethernet Compliance Test Points, Test Fixtures, and Cable Assemblies

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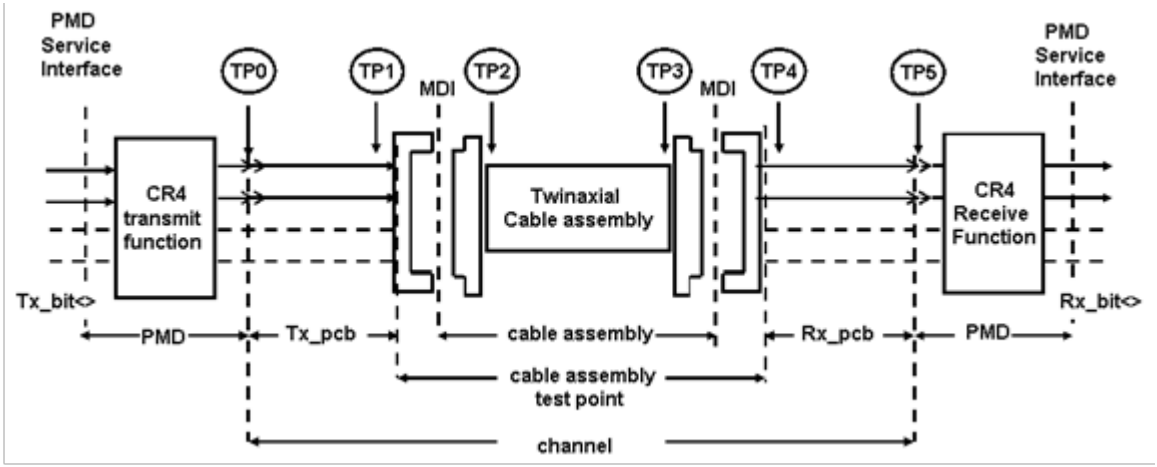
Channel and link Definitions

- The channel is defined between the transmitter and receiver blocks to include the transmitter and receiver differential controlled impedance printed circuit board and the cable assembly.
- The Media dependent interfaces (MDIs) refer to the connector interfaces. 100GBASE-CR4 specifies the quad small form factor pluggable (QSFP28) plug and receptacle.



Test Points and Descriptions

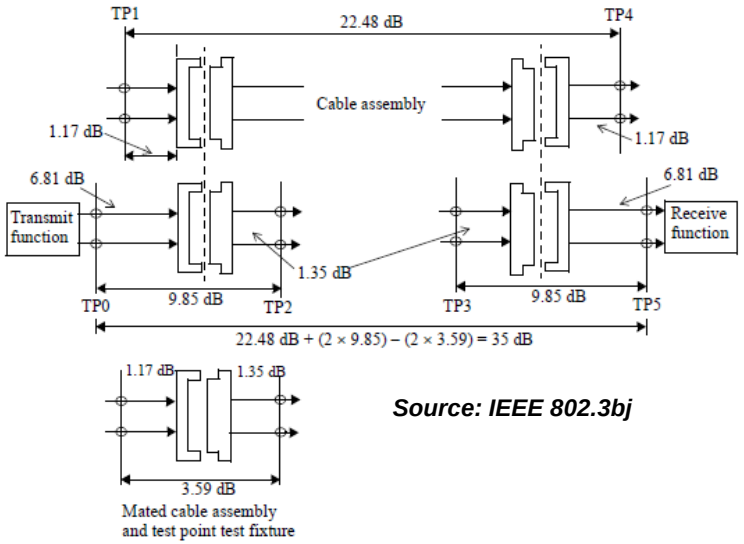
- For conformance testing five test points are standardized.

Test Points	Description
TP0 to TP5	The channel is defined between the transmitter and receiver blocks to include the transmitter and receiver differential controlled impedance printed circuit board and the cable assembly.
TP1 to TP4	All cable assembly measurements between TP1 and TP4. are performed with the test fixtures specified in 100GBASE-CR4.
TP0 to TP2 TP3 to TP5	A mated connector pair is included in both the transmitter and receiver specifications.
TP2	Transmitter parameters are measured at TP2 utilizing the test fixture specified in 100GBASE-CR4.
TP3	Receiver parameters are measured at TP3 utilizing the test fixture specified in 100GBASE-CR4.

Channel Parameters and Insertion Loss Budgets

- TP0 and TP5 may not be accessible in an implemented system
- Information (not required for conformance) of channel transmission characteristics and insertion loss budgets provided in Annex's.

Parameter description	f(GHz)	Unit
Transmitter and receiver differential printed circuit board trace loss (host PCB insertion loss 6.81 dB @12.89 GHz)	0.05≤f≤19	**dB**
Channel Insertion Loss (6.81 dB @12.89 GHz)	0.05≤f≤19	**dB**
Maximum channel insertion Loss (35 dB @12.89 GHz)	0.05≤f≤19	**dB**
Minimum channel insertion loss (x dB @12.89 GHz)	0.05≤f≤19	**dB**
Channel operating margin (3 dB)		**dB**

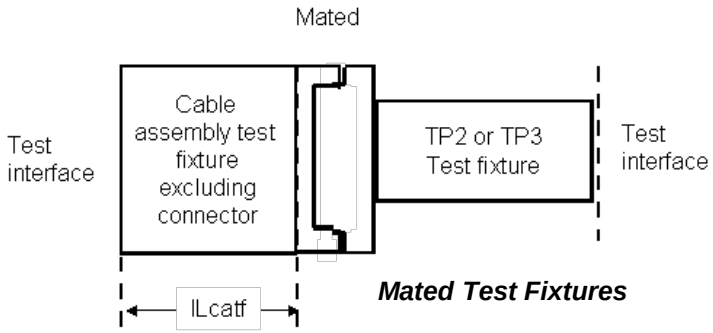


Source: IEEE 802.3bj

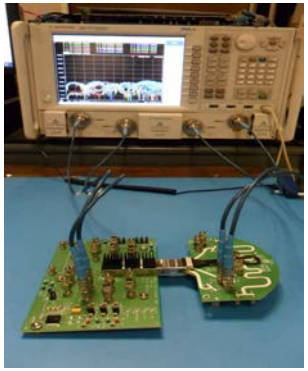
Insertion loss budget @ 12.89 GHz

Test Fixture Specifications

- 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.



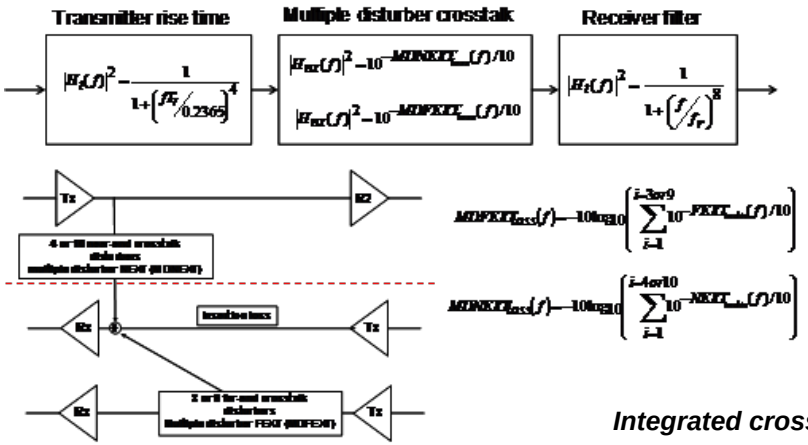
Mated Test Fixtures



Mated Test Fixtures Parameters

Parameter description	f(GHz)	Unit
Maximum insertion Loss	0.01≤f≤25	dB
Minimum Insertion Loss	0.01≤f≤25	dB
Minimum Return Loss	0.01≤f≤25	dB
Common-mode conversion insertion loss	0.01≤f≤25	dB
Common-mode return loss	0.01≤f≤25	dB
Common-mode to differential –mode return loss	0.01≤f≤25	dB
Integrated crosstalk noise		

Mated test fixtures parameters



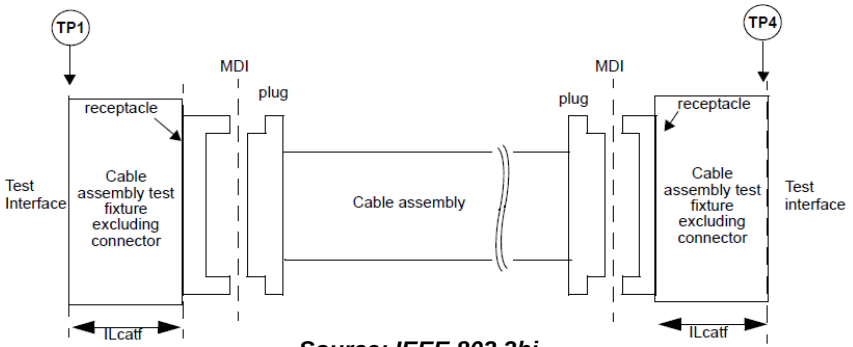
Description	Symbol	Value	Units
Symbol rate	f_b	25.78125	GBd
Near-end disturber peak differential output amplitude	A_{nt}	600	mV
Far-end disturber peak differential output amplitude	A_{ft}	600	mV
Near-end disturber 20% to 80% rise and fall times	T_{nt}	9.6	ps
Far-end disturber 20% to 80% rise and fall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

Source: IEEE 802.3bj

Integrated crosstalk noise (ICN)

Cable Assembly Characteristics TP1/TP4

- The twinaxial copper cable assembly consists of shielded signal pairs utilized for differential signaling at 25 Gb/s per differential signal pair.



Source: IEEE 802.3bj

Parameter description	f(GHz)	Unit
Maximum Insertion Loss (22.48 dB)	@12.89 GHz	**dB**
Minimum Insertion Loss (8 dB @ 12.89 GHz	0.05≤f≤19	**dB**
Minimum Return Loss	0.05≤f≤19	**dB**
Differential to common-mode return loss	0.05≤f≤19	**dB**
Differential to common-mode conversion loss	0.05≤f≤19	**dB**
Common-mode to common –mode return loss	0.05≤f≤19	**dB**
Common-mode to common –mode return loss	0.05≤f≤19	**dB**
Cable assembly Channel Operating Margin (3 dB)		**dB**

802.3bj/by/cd - Tx/Rx receiver PCB IL

- The recommended maximum and minimum printed circuit board trace insertion losses are specified in
- Equation (92A–1) and Equation (92A–2), respectively. Specified in 92A.4 EQ(92A-1 (max) and 92A-2 (min))– referenced 110A.4

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

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

where

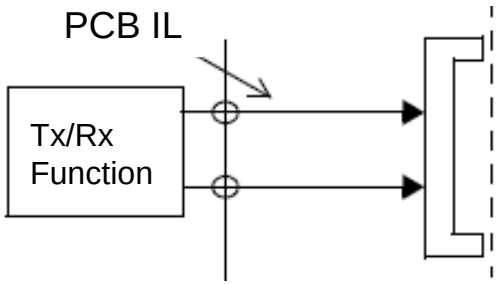
f	is the frequency in GHz
$IL_{PCB}(f)$	is the insertion loss for the transmitter and receiver PCB
$IL_{PCBmax}(f)$	is the recommended maximum insertion loss for the transmitter and receiver PCB

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

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



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 26-Jan 12	Elizabeth Kochuparambil Joel Goergen	Cisco

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

12

802.3bj Cu specifications

Transmitter and receiver differential PCB IL

- IL @ 26.56 GHz

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

for $0.01\ \text{GHz} \le f \le 19\ \text{GHz}$.

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 @ 26.56 GHz = 13.51 dB

PCB IL @ 12.89 GHz 1.5924 dB/in

GHz	ILpcb(max)	ILpcb(min)	inches (Max)	inches (Min)
12.89	6.81	1.17	4.27	0.74

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

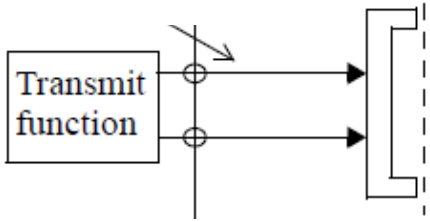
for $0.01\ \text{GHz} \le f \le 19\ \text{GHz}$.

where

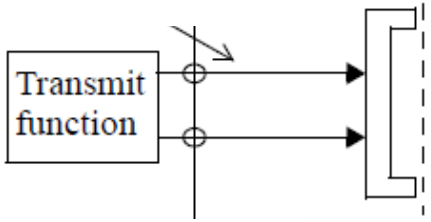
f is the frequency in GHz
$IL_{PCB}(f)$ is the insertion loss for the transmitter and receiver PCB
$IL_{PCBmin}(f)$ is the minimum insertion loss for the transmitter and receiver PCB

IL @ 12.89 GHz = 1.17 dB
IL @ 13.28 GHz = 1.20 dB
IL @ 26.56 GHz = 2.32 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



Host Channel

- Use transmitter and receiver differential printed circuit board trace loss max (with IL @ 26.56 GHz) slide 7.
- Note: The connector insertion loss is 1.5 dB for the mated test fixture. The host connector is allocated 0.5 dB for implementation allowance.

IL host connector @ 26.56 GHz = 11.5-7-2.5 = 2 dB

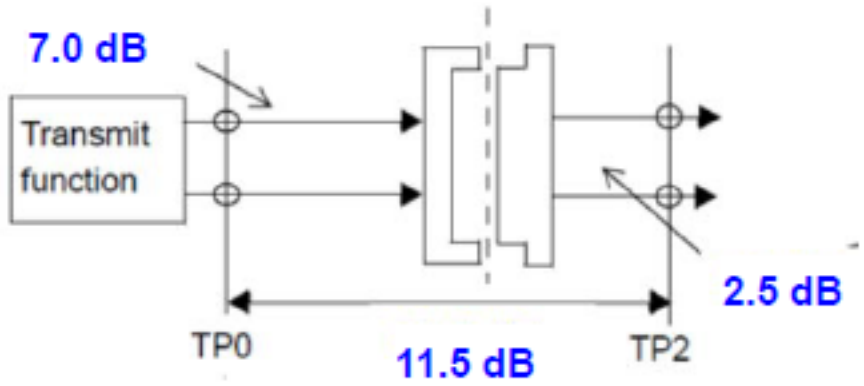
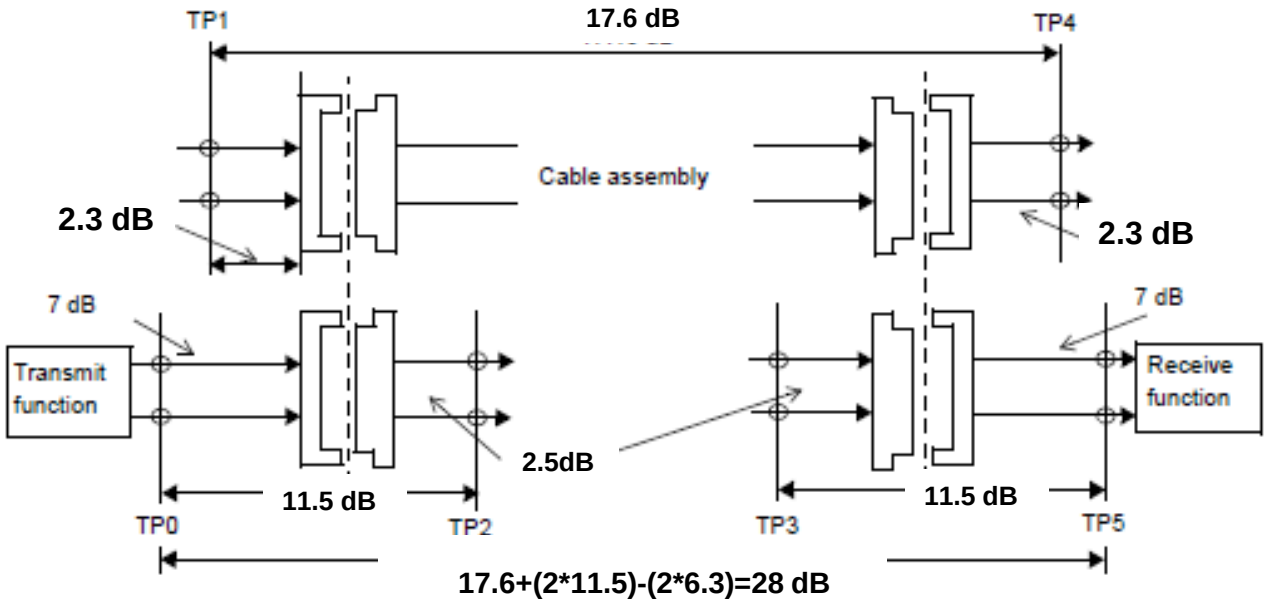
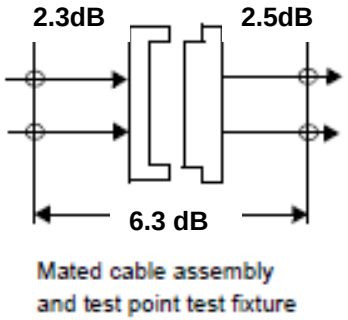


Figure 2: 100GEL CR **TP0-TP2** insertion loss budget at 26.56 GHz

Cable assembly and Channel IL - Baseline

- Cable assembly Max IL dB @ 26.56 GHz= 10 (bulk cable) + (2*2.3) (TF) +(2*1.5) (connector) = 17.6 dB
- Cable assembly Min IL dB @ 26.56 GHz= 2.5 (bulk cable) + (2*2.3) (TF) +(2*1.5) (connector) = 10.1 dB
- Channel Max IL dB @ 26.56 GHz= 17.6 (Cable assembly) +2*11.5 (TP0-TP2)- (2*6.3) MTF = 28 dB
- Channel Min IL dB @ 26.56 GHz= 10.1 (Cable assembly) +2*11.5 (TP0-TP2)- (2*6.3) MTF = 20.5 dB
- Channel Max IL dB @26.56 GHz =10 (bulk cable)+(2*7) Host IL +(2*2) Host connector IL = 28 dB
- 10 (bulk cable) =17.6 (CA) - (2*2.3) (TF) +(2*1.5) (connector)





Note: The connector insertion loss is 1.5 dB for the mated test fixture. The host connector is allocated 0.5 dB for implementation allowance.

802.3bj/by/cd - Test Fixture PCB IL

- 92.11.1.2 Test fixture insertion loss equation (92-34)

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

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

- 92.11.1.2 Test fixture insertion loss equation (92-34)

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

for $0.01 \text{ GHz} \le f \le 25$ GHz

where

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

TP0-TP3 test fixture IL - HCB

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

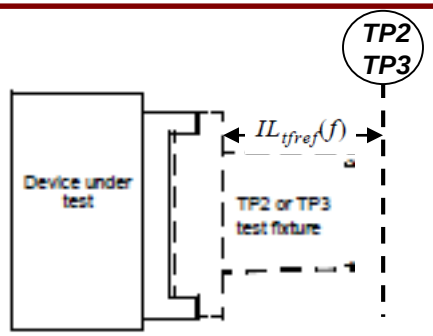
for $0.01 \le f \le 25$ GHz

where

f is the frequency in GHz

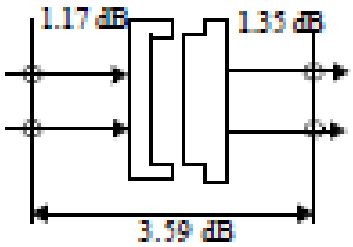
$IL_{tfref}(f)$ is the reference test fixture PCB insertion loss at frequency f

IL @ 12.89 GHz = 1.35 dB
IL @ 13.28 GHz = 1.38 dB
IL @ 26.56 GHz = 2.47 dB

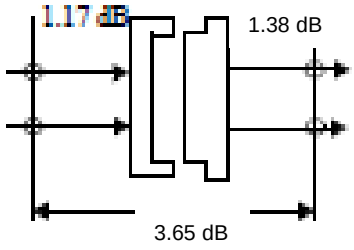


*ILtref(f)=1.013(-0.00144+0.13824*SQRT(26.56)+0.06624*26.56)=2.50 dB*

IL @ 12.89 GHz

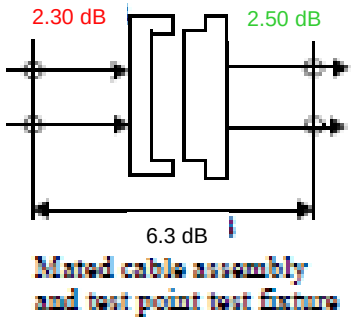


IL @ 13.28 GHz



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 @ 26.56 GHz



- Note: The connector insertion loss is 1.5 dB for the mated test fixture. The host connector is allocated 0.5 dB for implementation allowance.

Cable assembly test fixture IL - MCB

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

TBD

for 0.01 GHz ≤ f ≤ 25 GHz

where

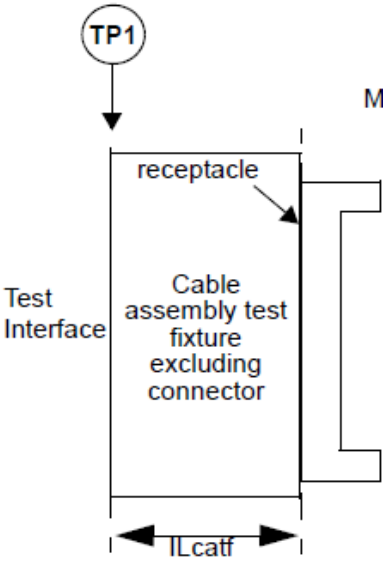
f is the frequency in GHz

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

IL @ 12.89 GHz = 1.17 dB

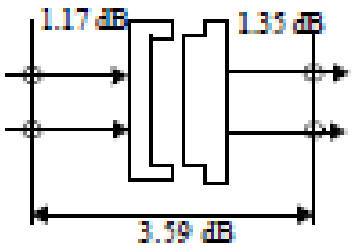
IL @ 13.28 GHz = 1.20 dB

IL @ 26.56 GHz = 2.14 dB



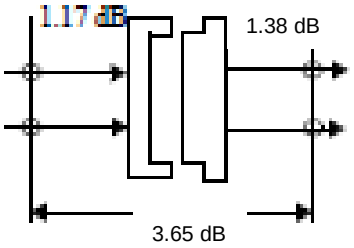
ILcatf(f) =1.073(-0.00125+0.12*SQRT(26.56)+0.0575*26.56)=2.30 dB*

IL @ 12.89 GHz



Mated cable assembly and test point test fixture

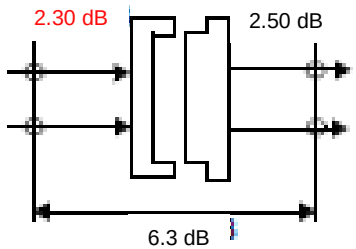
IL @ 13.28 GHz



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.

IL @ 26.56 GHz



Mated cable assembly and test point test fixture

Note: The connector insertion loss is 1.5 dB for the mated test fixture. The host connector is allocated 0.5 dB for implementation allowance.

Cable assembly test fixture reference IL

The reference insertion loss of the mated test fixture is determined using Equation (136B–1).

$$IL_{\text{MatedTF}}(f) = 0.471\sqrt{f} + 0.1194f + 0.002f^2 \text{ (dB)} \quad \text{(136B–1)}$$

for $0.01 \text{ GHz} \le f \le 25 \text{ GHz}$

where

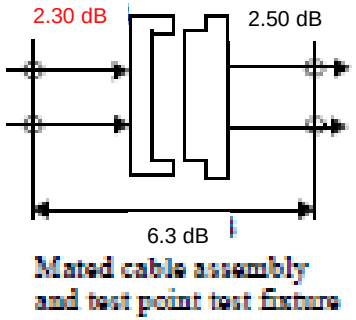
f is the frequency in GHz

GHz	dB
13.28	3.65
26.56	7.01

ILmatedTF(f)=0.899(0.471*SQRT(f)+0.1194*f+0.002*f^2)*

GHz	dB
26.56	6.3

IL @ 26.56 GHz



Note: The connector insertion loss is 1.5 dB for the mated test fixture. The host connector is allocated 0.5 dB for implementation allowance

Test Fixtures

- Test Fixture specifications – Adopt– referenced parameters 26.56 GHz f=0.01≤f≤40 (signaling rate 53.125 GBd).

Mated test fixtures parameters

Parameter description	Value	Unit
Maximum differential insertion Loss	Equation(TBD)	dB
Minimum differential Insertion Loss	Equation(TBD)	dB
Reference differential insertion loss	Equation (slide 22) TBD	dB
Figure of Merit(FOM) ILD	Equation(TBD)	dB
Minimum Differential Return Loss	Equation(TBD)	dB
Common-mode conversion insertion loss	Equation(TBD)	dB
Common-mode return loss	Equation(TBD)	dB
Common-mode to differential –mode return loss	Equation(TBD)	dB
Integrated crosstalk noise	(TBD)	mV