Effect of Interface Geometry on Transverse Conversion Loss For 40GbE connectivity Test Data and Information

Yakov Belopolsky, Bel Stewart
Rich Marowsky, Bel Stewart

IEEE P802.3bq 40GBASE-T Task force
San Antonio TX , USA, November 2014

Effect of Interface Geometry on Transverse Conversion Loss for 40GbE connectivity. Test Data and Information

Abstract

This technical contribution in support of IEEE 802.3bq 40GbE standard development provides information and test data for copper cable channels utilizing the standard connectors per IEC 61076-3-110 (Augmented RJ45 and IEC 60603-7 (RJ45) It discusses the differences between connectors and effects of interface geometry on the Transverse Conversion Loss (TCL). The TCL can be reduced by utilizing a higher level category 8.2 interface. The Ethernet systems from 1 to 40 GbE shall benefit from the reduction of the TCL and corresponding common mode noise

Transverse Conversion Loss TCL

$$TCL\ (dB) = 20\ LOG \frac{\text{Common Mode Voltage}}{\text{Differential Mode Voltage}} \text{ (measured on the same end)}$$

TCL - measure of the quality of transmission line feature as a source of common mode

Measure of the balance and Differential to Common Mode conversion applicable to the interface

Scd11 as an S-parameter.

TCL LIMITS , dB

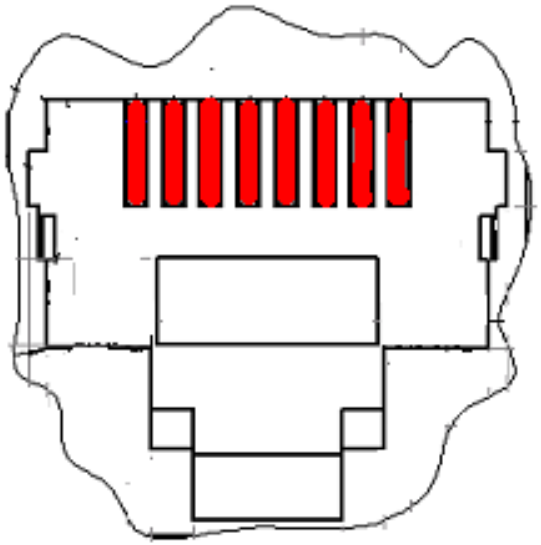
Frequency, MHz	Connector	Channel
	34-20LOG(f/100)	26-17LOG(f/100)
100	34.0	26.0
200	28.0	20.9
300	24.5	17.9
500	20.0	14.1
600	18.4	12.8
1000	14.0	9.0
1500	10.5	6.0
2000	8.0	3.9
2500	n/a	n/a
3000	n/a	n/a
Ref	PN-568-C-2-1-Draft 2.0c	

Negative Effects of High TCL

- **The high TCL causes greater common mode noise.**
- **The common mode noise reduces the signal energy.**
- **The common noise causes EMI and jitter**
- **The common mode signal has a different propagation velocity from the differential signal and an arbitrary phase.**
- **Two common noise signals can form an effectively parasitic differential signal superimposed on the original useful transmission resulting in data distortion**

STANDARD CONNECTOR INTERFACES

reviewed in this presentation

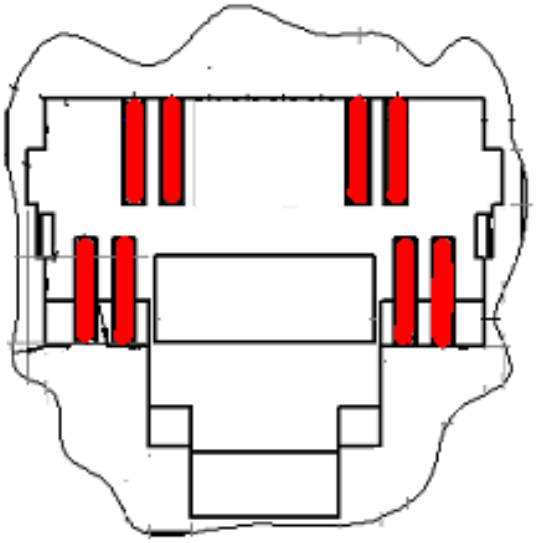


IEC 60603-7

8-CONTACTS

Category 3 to 6_A,

Proposed category 8.1



IEC 61076-3-110

8-CONTACTS

Category 7_A

Proposed category 8.2

IEC 60603-7 and *IEC 61076-3-110*

Connector is a disturbance in otherwise well-balanced cable

The connector interface :

- **subject to mechanical stresses and abuses**
- **subject to electrical discharges, in PoE in particular**
- **to be inexpensive and therefore not complex**
- **must be robust and easy to be used by millions**

BOTH ***IEC 60603-7*** **and** ***IEC 61076-3-110***

are used in the COPPER CABLING

IEC 60603-7 and *IEC 61076-3-110*

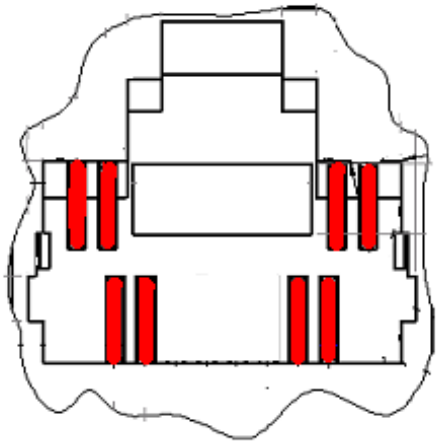
IEC 60603-7 **and** ***IEC 61076-3-110*** **are standard 4-pair connectors**

IEC 61076-3-110 **Augmented RJ45 was derived from RJ45 (Registered Jack)**

Augmented RJ45 **and RJ45 have the same form factor**

IEC 61076-3-110 **Augmented RJ45 was adopted by IEC to address applications over 1000 MHz**

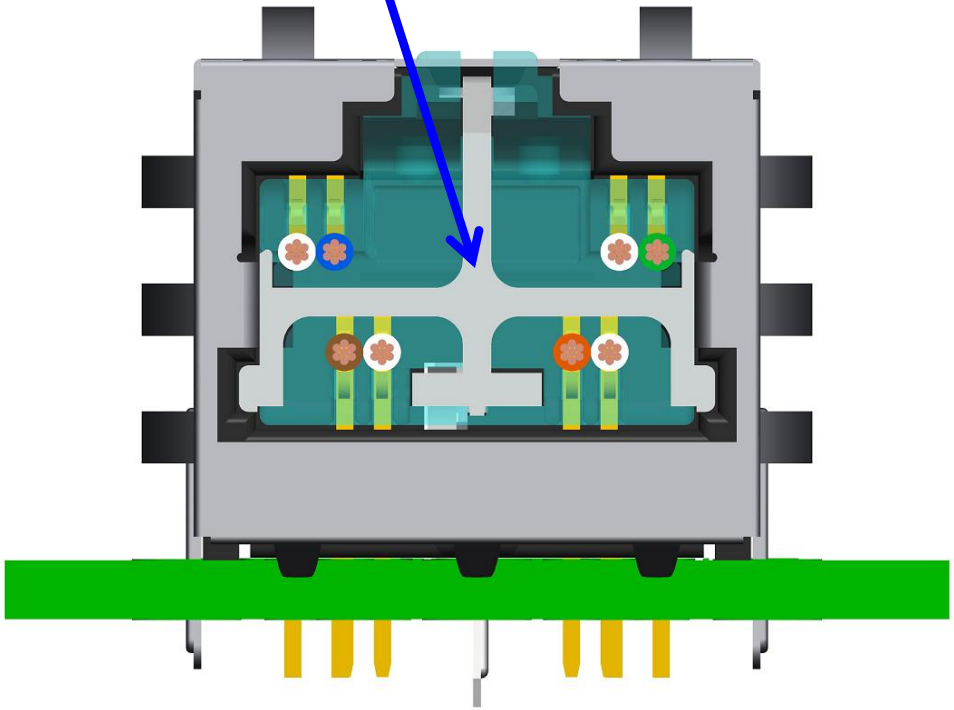
RJ45 ***evolved*** **from earlier connectors as a result it has the "split" pair**



IEC 61076-3-110

Augmented RJ45

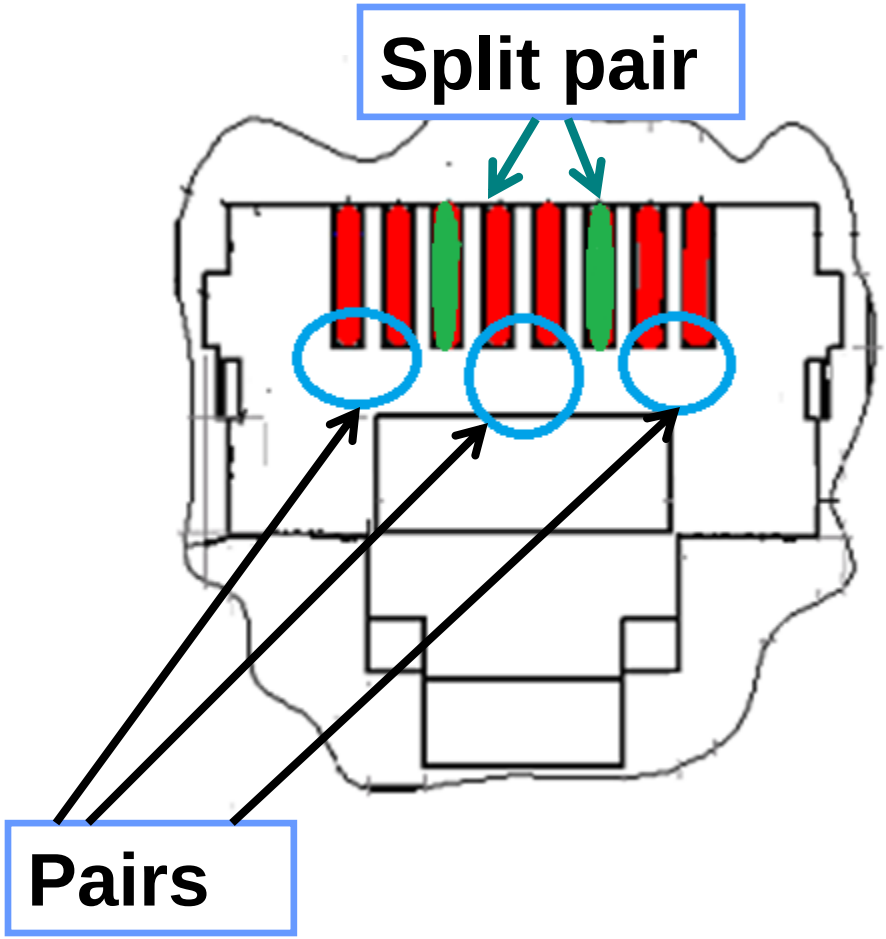
Conductive Faraday cage



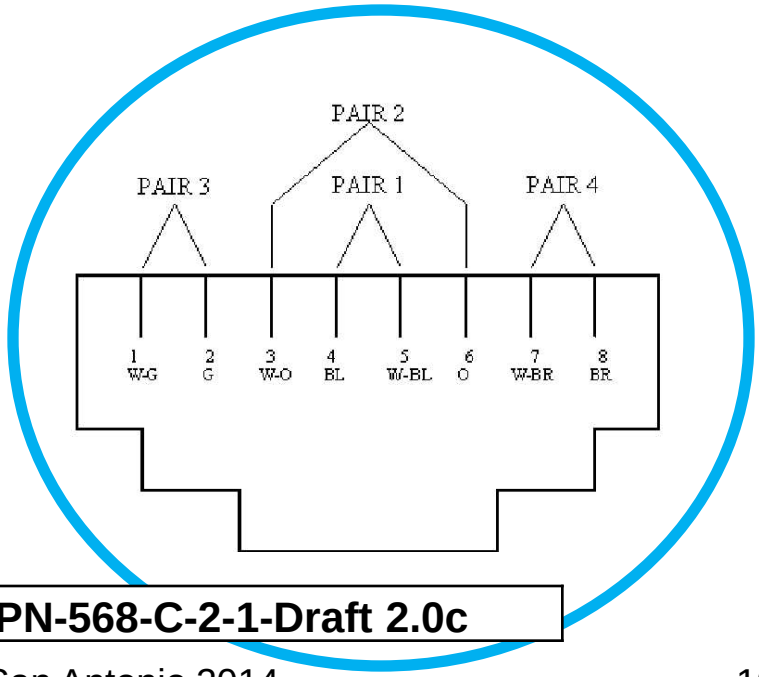
Pairs are balanced within connector

RJ45

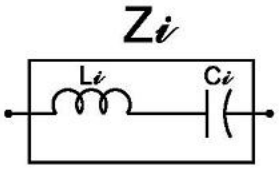
Split pair legacy problem

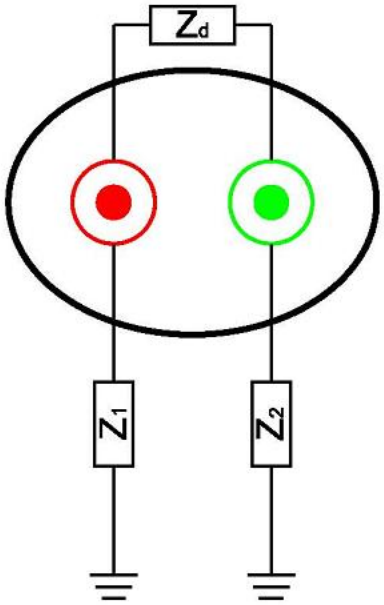


RJ45 Traditional pair assignment



PN-568-C-2-1-Draft 2.0c

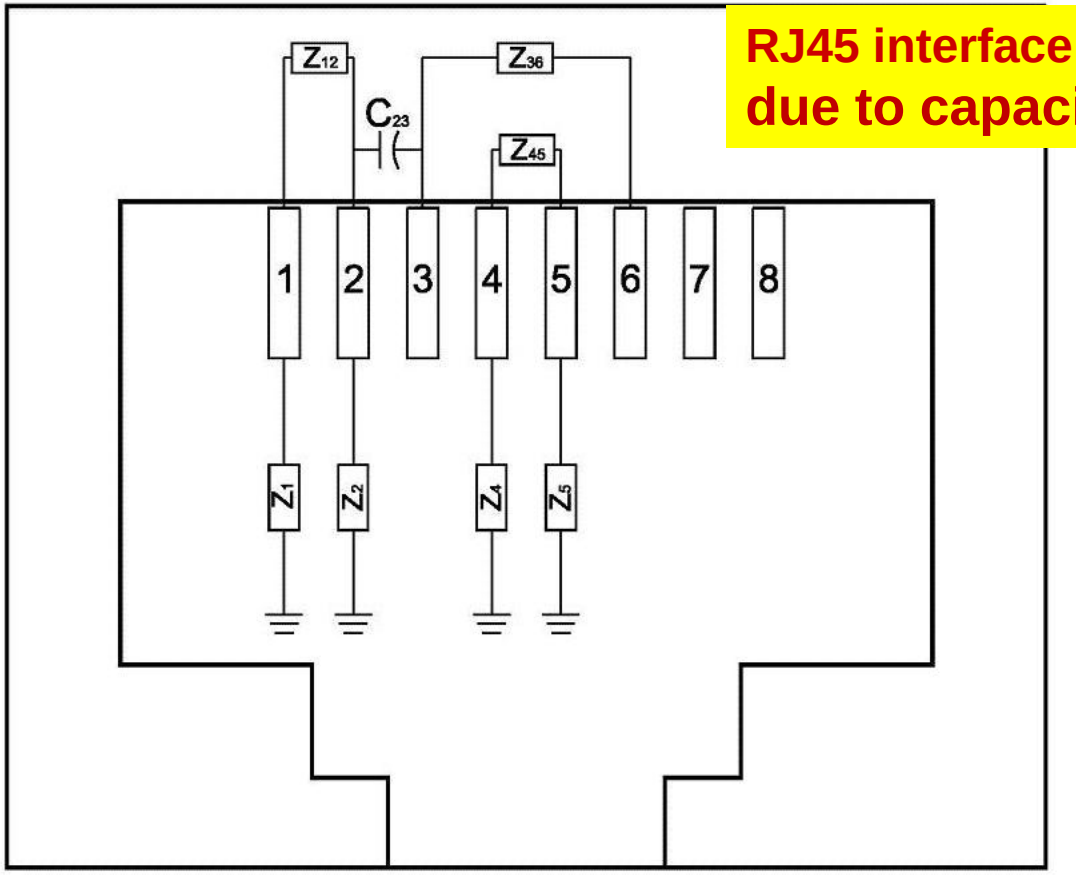




Ideally balanced differential pair

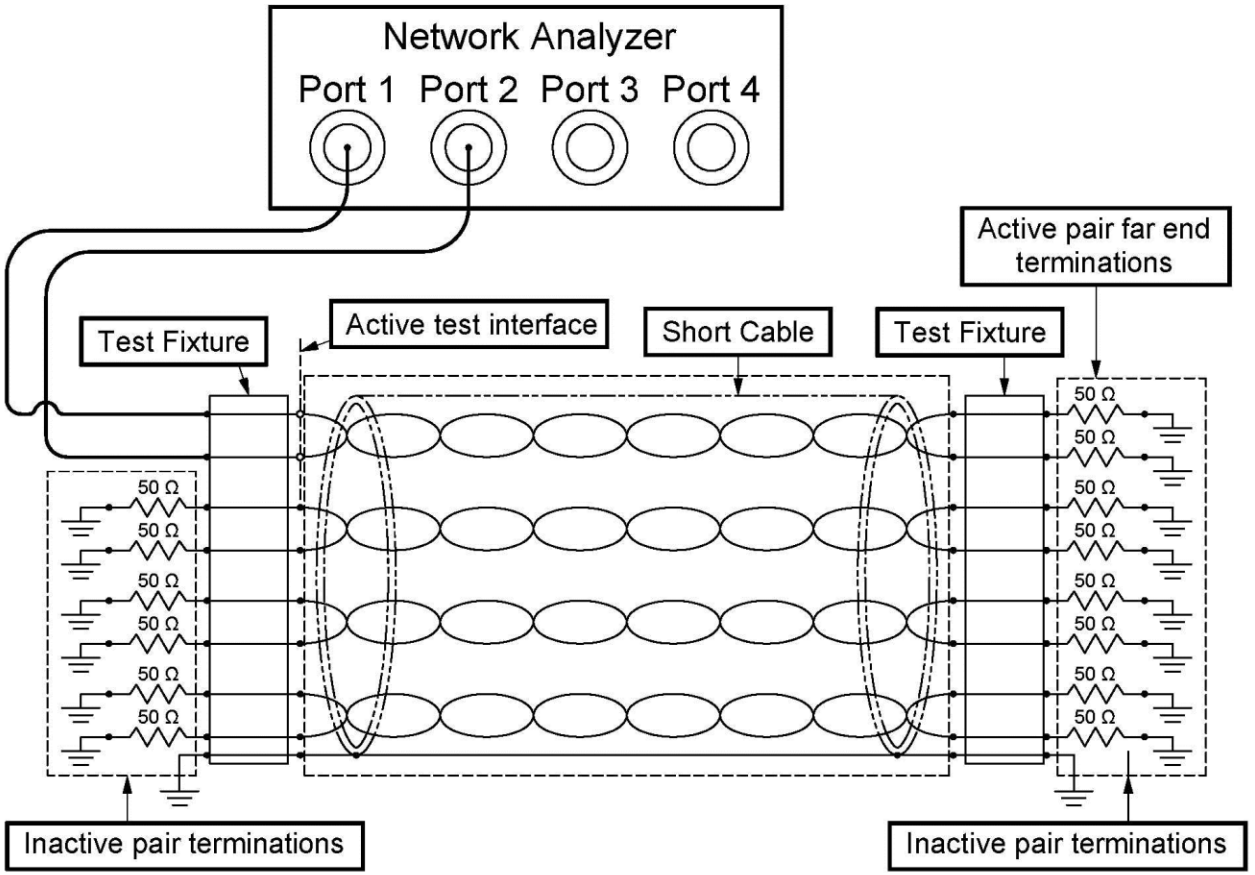
$Z_1 = Z_2$ and $Z_d = Z_1 + Z_2$

RJ45 Split pair legacy problem



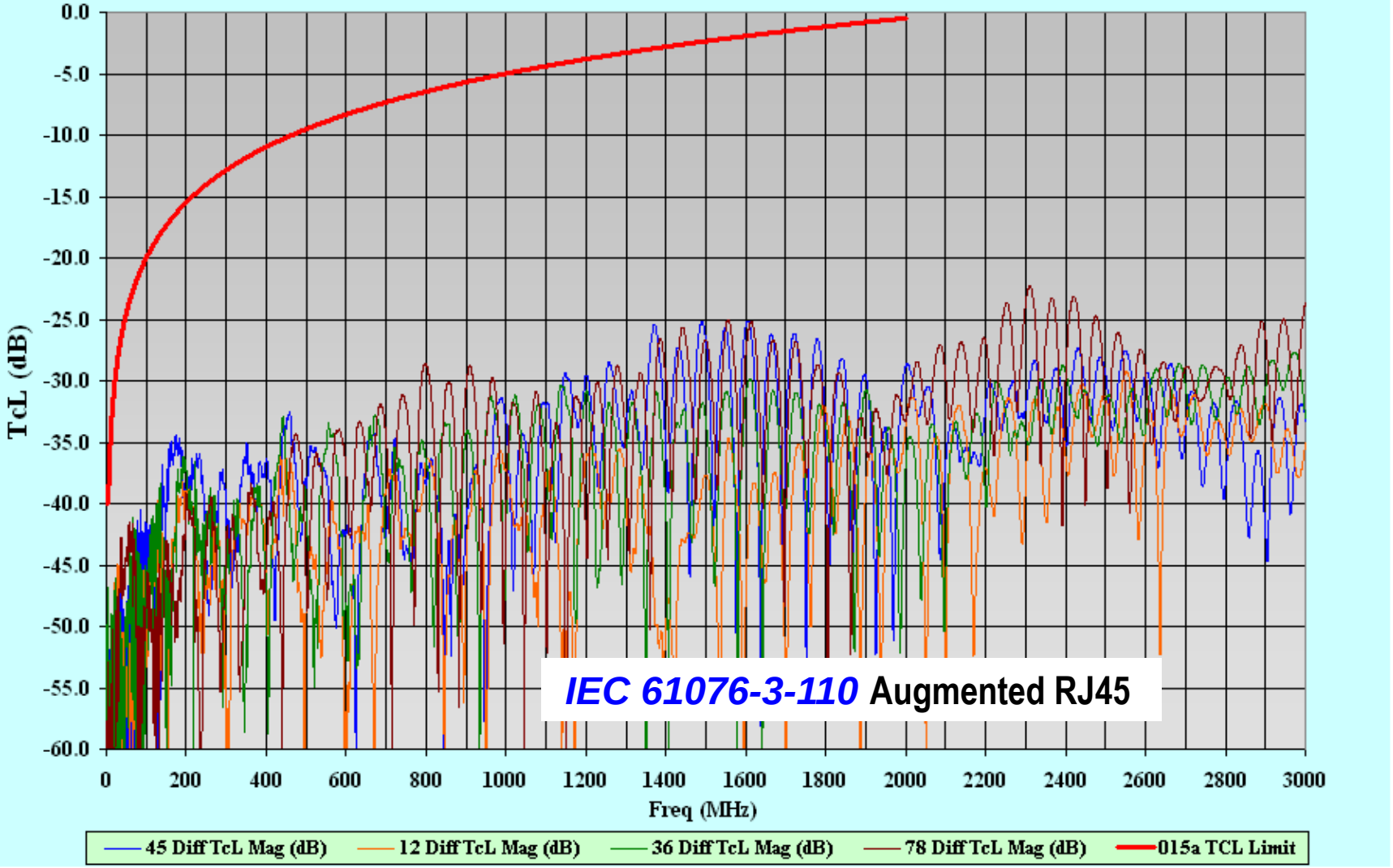
RJ45 interface:
due to capacitive coupling $Z_1 \neq Z_2$

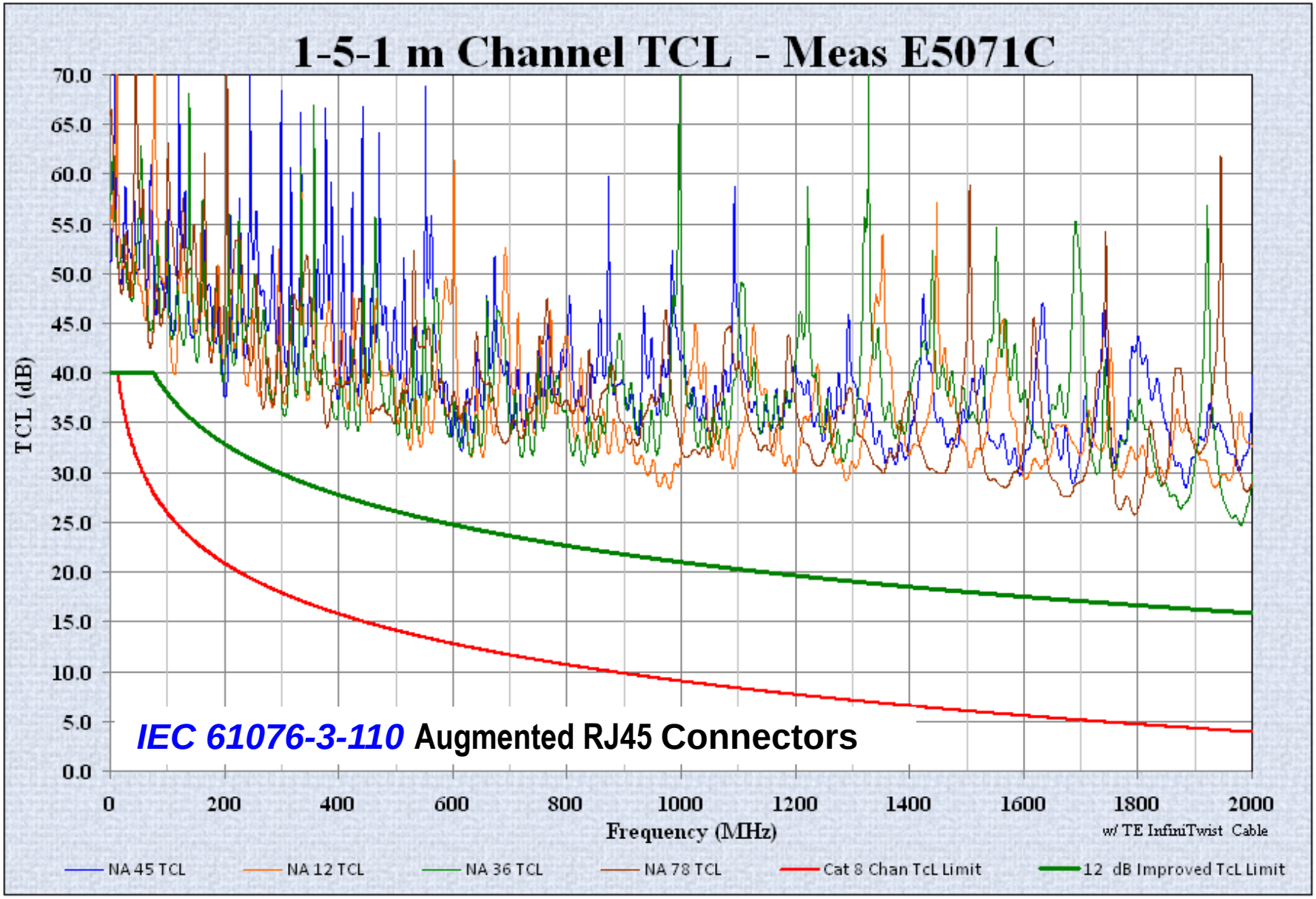
TCL MEASUREMENT



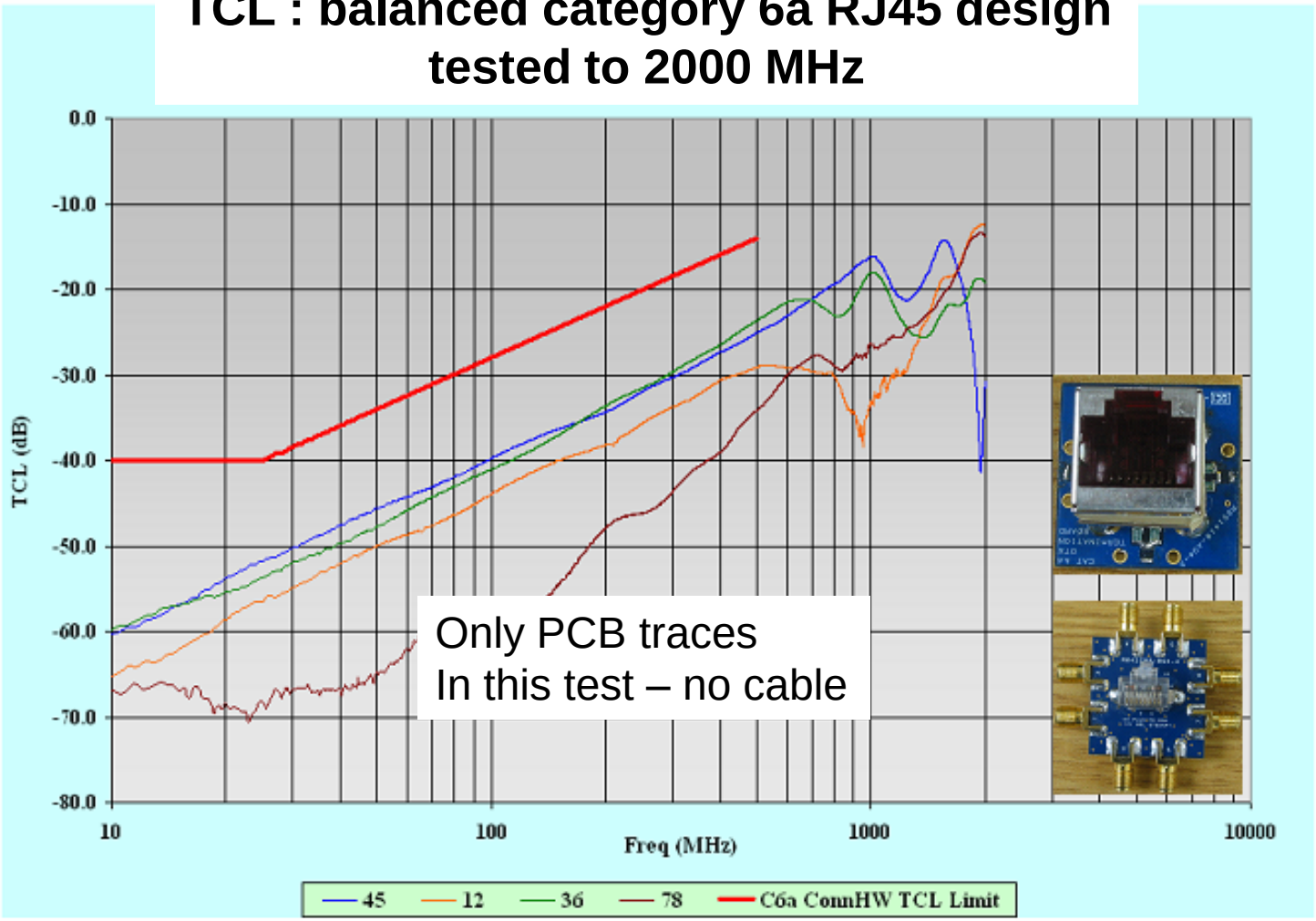
Note: a short cable to measure connectors
Longer length to represent channels

50 m *IEC 61076-3-110* **Augmented RJ45** CHANNEL TCL




1-5-1 m Channel TCL - Meas E5071C
TCL (dB)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Frequency (MHz)
w/ TE InfiniTwist Cable
IEC 61076-3-110 Augmented RJ45 Connectors
NA 45 TCL
NA 12 TCL
NA 36 TCL
NA 78 TCL
Cat 8 Chan TcL Limit
12 dB Improved TcL Limit

TCL : balanced category 6a RJ45 design tested to 2000 MHz



TEST SUMMARY – 1

CONNECTING HARDWARE

TCL TEST SUMMARY, dB

Frequency, MHz	Limit**	RJ45 *	Augmented RJ45 proposed cat 8.2
100	34.0	39.8	53.0
250	26.0	32.1	56.1
500	20.0	26.1	42.2
1000	14.0	16.5	29.2
2000	8.0	14.0	19.1
2500	n/a	n/a	17
3000	n/a	n/a	15

* category 8.1 RJ45 were not available
improved cat 6a RJ45 were used for testing

** test limit per PN-568-C-2-1-Draft 2.0c

TEST SUMMARY – 2

CHANNEL TEST			
TCL TEST SUMMARY , dB			
Frequency, MHz	RJ45 limit Category 8.1	Augmented RJ45 proposed cat 8.2	
		7 m	50 m
100	26.0	42	42
250	19.2	36	36
500	14.1	34	35
1000	9.0	28	30
2000	3.9	25	27
2500	n/a	22	23
3000	n/a	20	26

SUMMARY and CONCLUSIONS

- ***Tests demonstrated that the use of IEC 61076-3-110 (Augmented RJ45) Connectivity results in improved Transverse Transmission Loss in short and longer channels***

- ***The use of IEC 61-76-3-110 connectivity in data canters will enable better copper channels to support 40GBASE-T applications***

- ***Future work***

  Conduct additional testing in reference to Technical Report TR ISO/IEC 11801-99-1 channel class II