



Advanced Test Equipment Corp.

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Page 1 of 24
INSTRUCTION MANUAL
ISN T8 IMPEDANCE STABILIZATION NETWORK (ISN)

INSTRUCTION MANUAL
for
**IMPEDANCE STABILIZATION
NETWORK (ISN)**

Model: ISN T8
150 kHz to 30 MHz



Table of Contents

1.0 Introduction.....	4
2.0 Product Information	5
2.1 Overview	5
2.2 Standard ISN T8 Items (included).....	5
2.3 Additional ISN T8 Test Accessories (optional).....	5
2.4 ISN Calibration Kit.....	6
2.5 Other equipment available from Com-Power	7
3.0 Product Specifications	8
4.0 Product Implementation	9
4.1 Product Application.....	9
4.1.1 When can the ISN T8 be used?.....	9
4.1.2 How do I choose which LCL Adapter to use?.....	9
4.1.3 What is LCL?	10
4.2 Product Connection Details	11
<i>Figure 1 – Equipment setup for standard pin arrangements</i>	<i>11</i>
<i>Figure 2 – Equipment setup for non-standard pin arrangements.....</i>	<i>11</i>
4.2.1 Connector Pin-outs.....	11
<i>Figure 3 – ISN T8 Connector Pin Arrangements/Pair Designations</i>	<i>11</i>
<i>Figure 4 – RJ45 LCL Adapter Pin Arrangements</i>	<i>12</i>
<i>Figure 5 – RJ45 Connecting Adapter Pin Arrangements.....</i>	<i>12</i>
<i>Figure 6 – RJ11 LCL Adapter Pin Arrangements</i>	<i>12</i>
<i>Figure 7 – RJ11 Connecting Adapter Pin Arrangements.....</i>	<i>12</i>
<i>Figure 8 – (8) 1mm banana jack LCL Adapter Pin Arrangements.....</i>	<i>12</i>
<i>Figure 9 – (8) 1mm banana jack Connecting Adapter Pin Arrangements</i>	<i>12</i>
4.2.2 RJ45 Connector Wiring – Common ethernet cables	13
<i>Figure 10 – Standard Patch Cable – Connector Wiring Diagram</i>	<i>13</i>
<i>Figure 11 – 10/100 Mb/s Cross-over Cable – Connector Wiring Diagram.....</i>	<i>13</i>
<i>Figure 12 – 1 Gb/s Cross-over Cable – Connector Wiring Diagram.....</i>	<i>13</i>
4.3 Test Setup Details.....	14
<i>Figure 13 – Acceptable Equipment Arrangements for Test Setup</i>	<i>14</i>
4.4 Measurement	15
4.4.1 What Type of Coaxial Cabling Should Be Used with the ISN T8?.....	15
4.4.2 Use of Attenuator or Transient Limiter for Input Protection	15
4.4.3 Correction Factors	17

5.0	Important Safety Precautions	18
5.1	Maintenance	18
5.2	Environmental Conditions.....	18
6.0	Warranty	19
7.0	ISN Theory	20
	Figure 14 – Circuit Concept of ISN T8 (CISPR 22, Figure D.3)	20
8.0	Typical Performance Data	21
	Figure 15 – Typical Asymmetric Impedance Characteristics	21
	Figure 16 – Typical Asymmetric Phase Characteristics	21
	Figure 17 – Typical Longitudinal Conversion Loss (LCL) Characteristics (Cat.3)	22
	Figure 18 – Typical Longitudinal Conversion Loss (LCL) Characteristics (Cat.5)	22
	Figure 19 – Typical Voltage Division Factor (VDF) Characteristics.....	23
	Figure 20 – Typical Isolation Characteristics.....	23
	Figure 21 – Typical Symmetric Insertion Loss Characteristics.....	24

1.0 Introduction

This manual includes product specifications, safety precautions, product maintenance and warranty information. It also includes instructions for connection of the ISN and associated accessories to the Equipment Under Test (EUT) and Ancillary Equipment (AE) and testing guidelines.

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2.0 Product Information

2.1 Overview

The ISN T8 Impedance Stabilization Network (ISN) is designed based on the circuit illustrated in Figure D.3 of CISPR 22. It is used for common mode conducted disturbance measurements on telecommunication ports intended for connection to Cat. 3 or Cat. 5 networks utilizing one, two, three or four unshielded, balanced, twisted pairs.

2.2 Standard ISN T8 Items (included)

- ✓ **RJ45 Adapter Set** (wiring arrangement per ANSI/TIA/EIA-568-B)

Adapter Type	Interface Connector(s)	Wiring Diagram	Part Number
Cat. 3 LCL Adapter	RJ45	Figure 4	ISN-LCL-CAT3-T8-RJ45
Cat. 5 LCL Adapter	RJ45	Figure 4	ISN-LCL-CAT5-T8-RJ45
Connecting Adapter	RJ45	Figure 5	ISN-ADA-T8-RJ45

- ✓ **Instruction Manual**
- ✓ **Calibration data and Certificate traceable to NIST**
(ISO 17025 accredited calibration also available)

2.3 Additional ISN T8 Test Accessories (optional)

- ✓ **RJ11 Adapter Set** (wiring arrangement per ANSI/TIA/EIA-568-B)

Adapter Type	Interface Connector(s)	Wiring Diagram	Part Number
Cat. 3 LCL Adapter	RJ11	Figure 6	ISN-LCL-CAT3-T8-RJ11
Cat. 5 LCL Adapter	RJ11	Figure 6	ISN-LCL-CAT5-T8-RJ11
Connecting Adapter	RJ11	Figure 7	ISN-ADA-T8-RJ11

- ✓ **(8x) 1mm Banana Jack Adapter Set** (for non-standard pin arrangements)

Adapter Type	Interface Connector(s)	Wiring Diagram	Part Number
Cat. 3 LCL Adapter	(8x) 1mm banana	Figure 8	ISN-LCL-CAT3-T8-1mm
Cat. 5 LCL Adapter	(8x) 1mm banana	Figure 8	ISN-LCL-CAT5-T8-1mm
Connecting Adapter	(8x) 1mm banana	Figure 9	ISN-ADA-T8-1mm
(4) UTP Adapter Cable	RJ45		ISN-T8-CBL-1mm-RJ45
(2) Pair Adapter Cable	RJ11		ISN-T8-CBL-1mm-RJ11

2.4 ISN Calibration Kit

Com-Power's ISN Calibration Kit provides all of the needed calibration adapters/accessories. Also provided are detailed, step-by-step instructions to intuitively guide you through the calibration of the following electrical parameters:

- ✓ Impedance - [asymmetric - common-mode]
- ✓ Phase [asymmetric - common-mode]
- ✓ Voltage Division Factor (VDF)
- ✓ Decoupling Attenuation (Isolation)
- ✓ Longitudinal Conversion Loss (LCL)

Generally, any of the following combinations of test & measurement equipment may be employed for the calibration:

- ❖ Network Analyzer with [2-port] S-parameter capabilities
- ❖ Spectrum Analyzer or EMI Receiver with Tracking Generator, and Impedance Analyzer (or equivalent)
- ❖ Spectrum Analyzer or EMI Receiver, Synthesized Signal Generator, and Impedance Analyzer (or equivalent)
- ❖ Gain-Phase Analyzer with Impedance measurement capabilities

The ISN calibration kit is available with the following items:

Part Description	Part Number
Balance Transformer (LCL Probe)	ISN-BT-T248
Balance Transformer Calibration Load Block	ISN-CLB-BT
(2x) 10 dB Attenuators	ATTN-10-T248
(2x) 150Ω to 50Ω Adapters	ADA-515-T248
BNC Short Adapter	ADA-0-BNC
BNC 50 Ω Terminator	BNC-50-BNC
8 cm Twisted Pair with 1mm banana plugs	ISN-CBL-1mm
(2x) RJ45 (or RJ11) Common Mode Adapter	ISN-ADA-T248-RJxx
(4x) 1x100Ω Pair Termination for LCL Adapter w/1mm	ISN-100x1-T248-1mm
4x100Ω Termination Block for Conn. Adapter w/1mm	ISN-100x4-T8-1mm

Adapters/Terminations for LCL measurement of individual pairs

Part Number for Pair Adapter or 100Ω AE Terminator	Single Pair RJ11 or RJ45		Two Pairs RJ11 or RJ45			Three or Four Pairs RJ45				
	P1	100Ω	P1	P2	100Ω	P1	P2	P3	P4	100Ω
ISN-T2-xxx-RJyy	X	X								
ISN-T4-xxx-RJyy			X	X	X					
ISN-T8-xxx-RJyy						X	X	X	X	X

2.5 Other equipment available from Com-Power



Antennas



Antenna Kits



Absorbing Clamps



Coupling/Decoupling Networks (CDN)



Comb Generators



Current Probes



Emissions Test Systems



Conducted Immunity Test Systems



Impedance Stabilization Networks (ISN)



Line Impedance Stabilization Networks (LISN)



Antenna Masts



Near-Field Probe Sets



Preamplifiers



Power Amplifiers



Spectrum Analyzers



Product Safety Test Equipment



Transient Limiters



Turntables



Antenna Tripods



Telecom Test Systems

www.com-power.com

3.0 Product Specifications

Technical

Frequency Range:	150 kHz to 30 MHz		
Compliant Standards:	CISPR 16-1-2, CISPR 22, EN 55022		
ISN Type:	Figure D.3 of CISPR 22 / EN 55022		
Impedance/Phase (EUT Port):	150Ω ±20Ω / 0° ±20°		
Longitudinal Conversion Loss			
ISN T8 w/Cat. 3 LCL Adapter:	55-10*log[1+(f/5) ²] dB	±3 dB	150 kHz to 30 MHz
ISN T8 w/Cat. 5 LCL Adapter:	65-10*log[1+(f/5) ²] dB	±3 dB	150 kHz to 2 MHz
	where:	-3 dB	2 MHz to 30 MHz
	f = frequency in MHz	+4.5 dB	
Voltage Division Factor			
(EUT Port to RF Port):	10.5 dB ±1 dB		
Isolation (decoupling)			
(AE Port to EUT Port):	>35 dB @ 150 kHz	(increasing linearly with logarithm of frequency from 150 kHz to 1.5 MHz)	
	>55 dB @ 1.5 MHz		
	>55 dB, 1.5 MHz to 30 MHz		
Symmetric Insertion Loss			
(AE Port to EUT Port):	Max: 3 dB ±0.25 dB		
Symmetric Load Impedance:	100Ω		
Transmission Bandwidth:	>100 MHz		

Electrical

Max. Current Rating:	800 mA (per line), 1.6 A (per pair)
Max. Voltage Ratings:	50 V _{DC} / 32 V _{AC} (line to ground @ 50/60 Hz)

Mechanical

Total Conductors / (Pairs)	8 conductors / (4 unshielded twisted pairs)		
RF & I/O Connectors			
ISN T8	EUT/AE Port:	DB-25 (female - non-metallic D-shell)	
	RF Port:	Coaxial BNC (female - 50Ω)	
LCL Adapters	ISN Port:	DB-25 (male - metallic D-shell)	
	EUT Port:	RJ45 Jack (also available with RJ11 or (8) 1mm banana jacks)	
Connecting Adapters	ISN Port:	DB-25 (male - metallic D-shell)	
	EUT Port:	RJ45 Jack (also available with RJ11 or (8) 1mm banana jacks)	
Dimensions (L x W x H)			
ISN T8:	6.5" x 4.125" x 3" (16.5 cm x 10.5 cm x 7.6 cm)		
LCL & Connecting Adapters:	2.2" x 2.4" x 1.6" (5.6 cm x 6.1 cm x 4.1 cm)		
Weight			
ISN T8:	1 lb., 1.7 oz. (502 grams)		
Cat. 3 LCL Adapters:	2.1 oz. (60 grams)		
Cat. 5 LCL Adapters:	2.2 oz. (62 grams)		
Connecting Adapters:	2 oz. (57 grams)		

Environmental

Operating Temperature:	40°F to 104°F (5°C to 40°C)	- INDOOR USE ONLY -
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4.0 Product Implementation

The following sections contain useful information about your ISN T8. Guidance is provided for; determining when use of an ISN is appropriate; how to use the ISN, including application of correction factors. Also, detailed connection and wiring diagrams are provided for proper connection of the Equipment Under Test (EUT) and Accessory (or ancillary) Equipment (AE) to the ISN.

Notwithstanding the information provided herein, the user is encouraged to refer to the appropriate test specification and/or applicable test procedures for test requirements, which hold precedence over any conflicting information provided here. This information is provided for guidance purposes only, and may or may not be appropriate for your specific test requirements, and may become outdated or obsolete. The following information is based on a current understanding of general test requirements, and may not be complete.

4.1 Product Application

4.1.1 When can the ISN T8 be used?

The ISN T8 is appropriate for measurements on unshielded lines containing one, two, three or four balanced pairs, intended for connection to Cat. 3 or Cat. 5 networks.

The user should ensure that the maximum ratings (voltage, current), declared in Section 3 of this document, are not exceeded.

4.1.2 How do I choose which LCL Adapter to use?

The Cat. 3 LCL adapter simulates a network employing Cat. 3 compliant cabling, and the Cat. 5 LCL adapter simulates a network employing Cat. 5 compliant cabling.

If the EUT is intended to be connected to Cat. 3 networks, then the Cat. 3 LCL adapter should be used. If the EUT is intended to be connected to Cat. 5 networks, then the Cat. 5 LCL adapter should be used. If the EUT is intended to be connected to either network category, then the test should be performed with the Cat. 3 LCL adapter and again with the Cat. 5 adapter. The emission levels measured using the Cat. 3 LCL adapter are likely to be slightly higher than the emission levels measured using the Cat. 5 LCL adapter.

The pin arrangements of the LCL/Connecting adapters equipped with RJ45 and RJ11 jacks [ISN-LCL-CATx-T8-RJxx] are consistent with the respective arrangements specified in ANSI/TIA/EIA-568-B, and are illustrated in Section 4.2.1 of the present document.

For non-standard pin arrangements, use of the following accessories is recommended:

LCL Adapter:	P/N: ISN-LCL-CATx-T8-1mm
Connecting Adapter:	P/N: ISN-LCL-CATx-T8-1mm
RJ45 Wiring Adapter:	P/N: ISN-T8-CBL-1mm-RJ45
RJ11 Wiring Adapter:	P/N: ISN-T4-CBL-1mm-RJ11

The LCL adapter connects to the EUT port of the ISN. The network cable to be tested connects directly to the LCL adapter.

The connecting adapter connects to the AE port of the ISN. The network cable which is connected to the accessory equipment connects directly to the connecting adapter. See Figures 1 and 2 in Section 4.2.

4.1.3 What is LCL?

Longitudinal Conversion Loss (LCL) is an electrical parameter by which the state of electrical balance is gauged, as it relates to the physical geometry and the dielectric properties of a twisted pair of conductors. A balanced transmission line (with respect to its surroundings) is one whose two insulated conductors are perfectly symmetrical, in that they are physically identical to one another in diameter, concentricity, dielectric material, and are uniformly twisted with equal length conductors

Specifically, LCL is the ratio between the [wanted] differential voltage magnitude and the [unwanted] common-mode voltage magnitude. The latter refers to the voltage quantity that has been converted from differential mode to common-mode, occurring due to [and in direct proportion to] the quantity or state of imbalance which exists between the twisted pair conductors in the cable.

The LCL of an ideally balanced transmission line is infinite; and, conversely, the LCL of an ideal unbalanced transmission line (i.e.: coaxial) is zero. The LCL for a Cat. 6 cable is 10 dB greater (more balanced) than that of a Cat. 5 cable, which is 10 dB greater than that of a Cat. 3 cable.

4.2 Product Connection Details

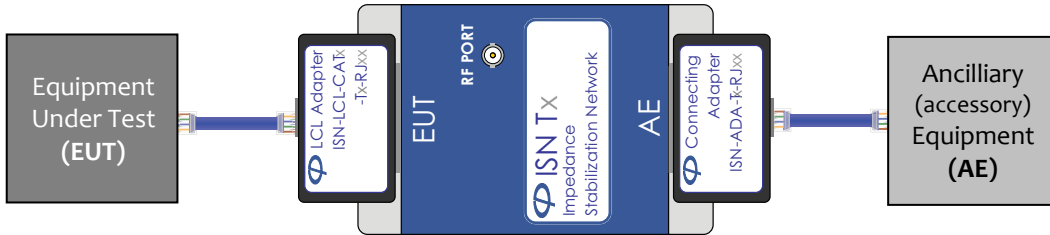


Figure 1 – Equipment setup for standard pin arrangements

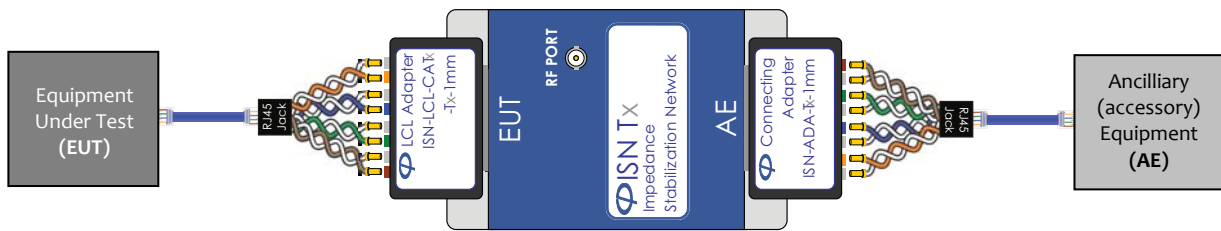


Figure 2 – Equipment setup for non-standard pin arrangements

4.2.1 Connector Pin-outs

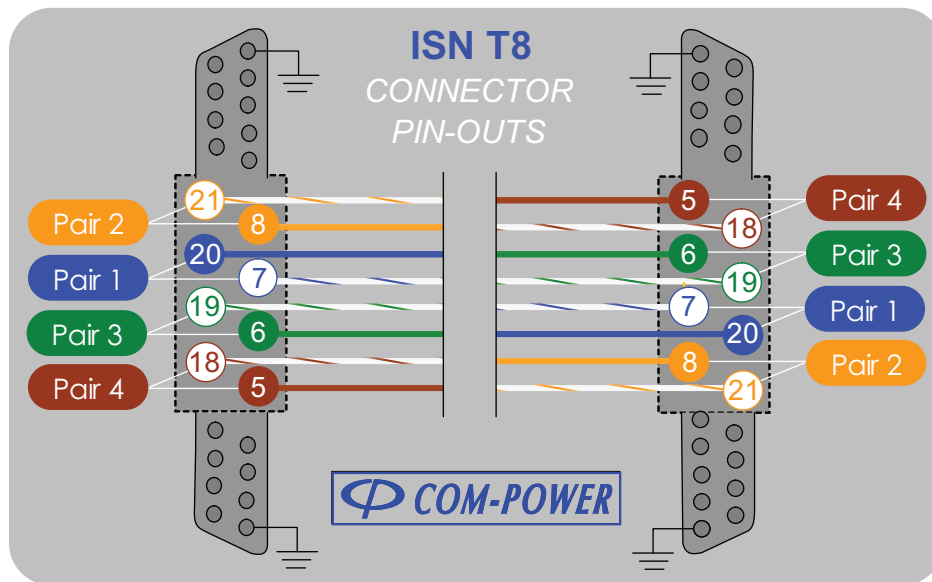


Figure 3 – ISN T8 Connector Pin Arrangements/Pair Designations

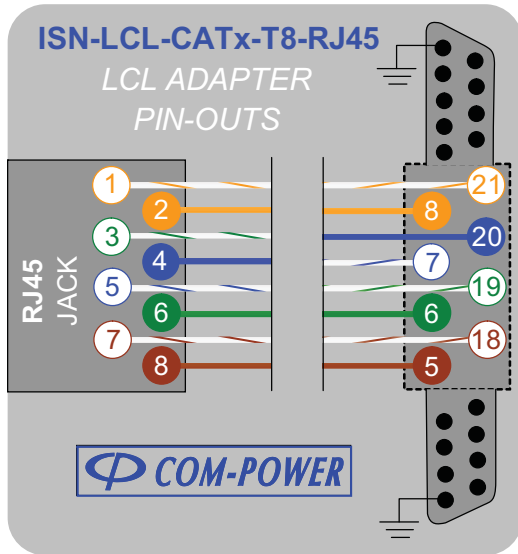


Figure 4 – RJ45 LCL Adapter Pin Arrangements

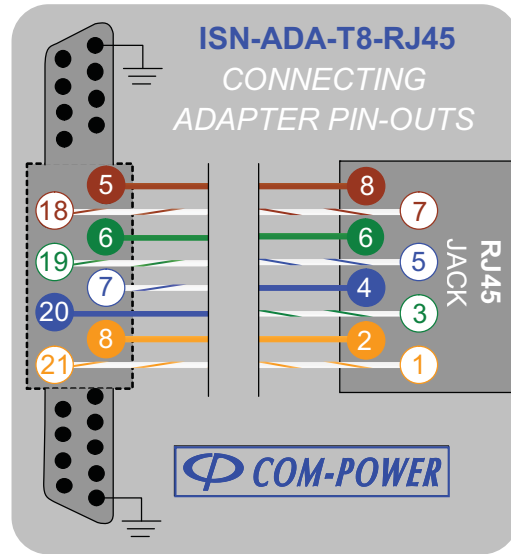


Figure 5 – RJ45 Connecting Adapter Pin Arrangements

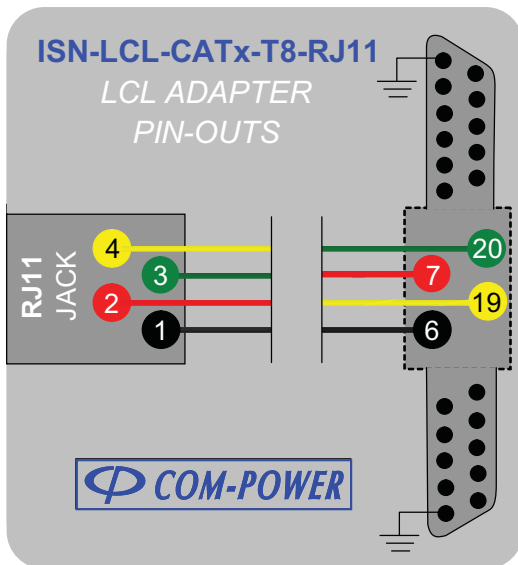


Figure 6 – RJ11 LCL Adapter Pin Arrangements

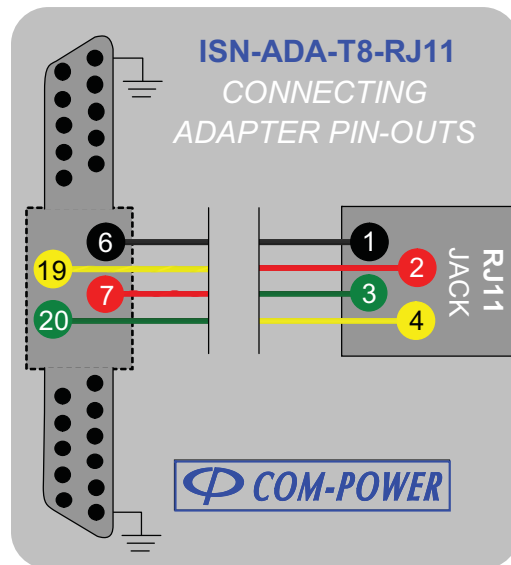


Figure 7 – RJ11 Connecting Adapter Pin Arrangements

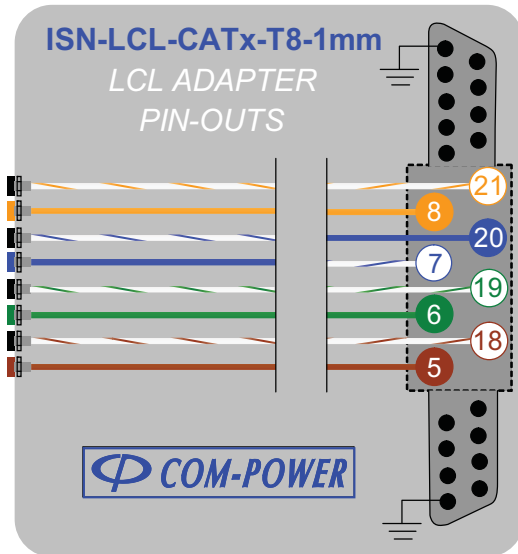


Figure 8 – (8) 1mm banana jack LCL Adapter Pin Arrangements

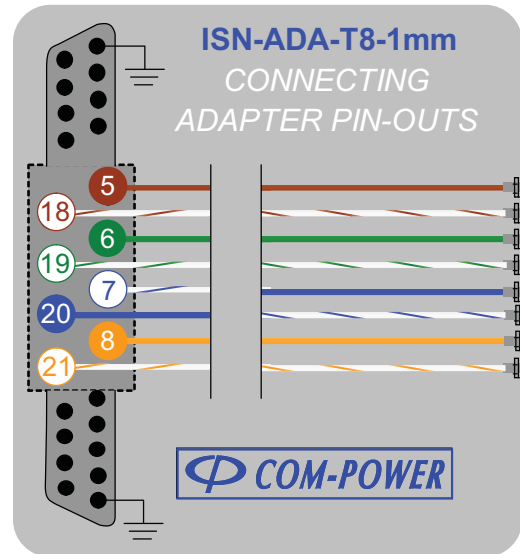


Figure 9 – (8) 1mm banana jack Connecting Adapter Pin Arrangements

4.2.2 RJ45 Connector Wiring – Common ethernet cables



Figure 10 – Standard Patch Cable – Connector Wiring Diagram



Figure 11 – 10/100 Mb/s Cross-over Cable – Connector Wiring Diagram



Figure 12 – 1 Gb/s Cross-over Cable – Connector Wiring Diagram

4.3 Test Setup Details

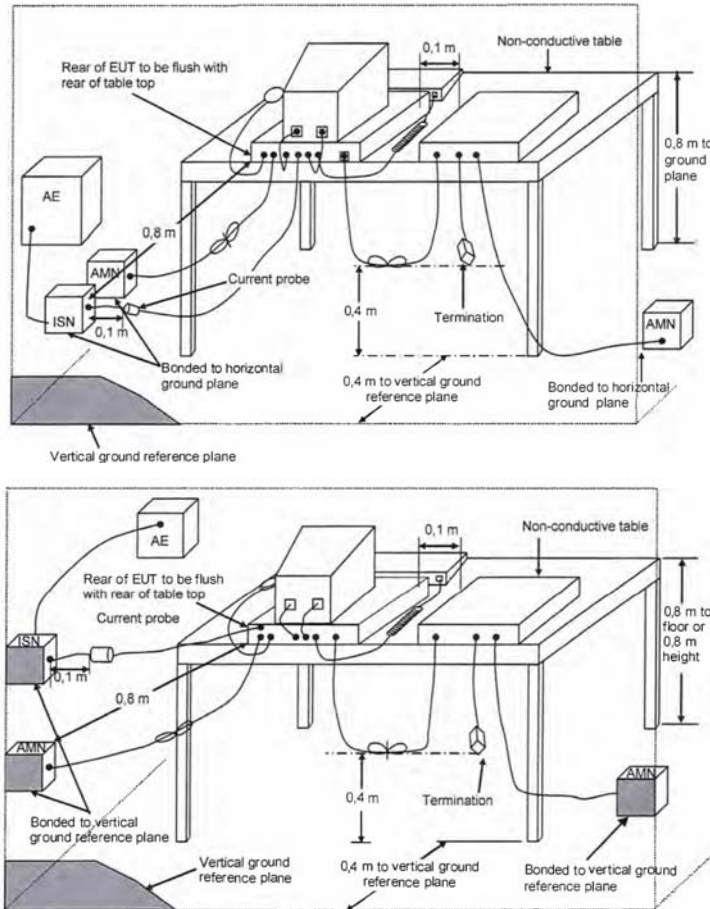


Figure 13 – Acceptable Equipment Arrangements for Test Setup

4.4 Measurement

This section provides essential information for using your ISN for accurate measurements of common mode disturbance voltages from the EUT which are present on the lines to which it is connected.

4.4.1 What Type of Coaxial Cabling Should Be Used with the ISN T8?

For EMI measurements, connections should always be made with a high quality, coaxial cable having a nominal impedance of fifty ohms.

Double-shielded coax, such as RG-223 (approx. Ø1/4") or RG-214 (approx. Ø 1/2") is recommended. These types of coax cable feature two silver-plated copper braid shields. The silver plating increases the life of the cable, among other advantages.

Lower quality cables have shields comprised of unplated copper or even foil, which tend to break easily, and degrade or corrode over time. Once the shield has been compromised, the impedance and insertion loss can be affected, leading to measurement inaccuracies, as well as increasing the likelihood of picking up ambient radio signals that can interfere with your measurements.

Good to high quality connectors should be used on the coax cables. Lower quality connectors tend to break easily, and may not terminate the shield properly.

If you are installing, or if you have installed, your own connectors, make sure that the connectors are designed to fit your specific cable dimensions. The individual diameters of the center conductor, dielectric material, and outer conductor can vary from cable to cable (even when the overall diameter of the cables are the same or similar).

4.4.2 Use of Attenuator or Transient Limiter for Input Protection

It is highly recommend that an external attenuator or transient limiter be used between the RF port of the ISN T8 and the input of the measuring instrument for all conducted measurements.

The attenuator or transient limiter should have at least 10 dB attenuation, and be capable of withstanding no more than about four times the maximum input power of your measuring instrument. Typically, measuring instruments have a maximum input of one watt, so a four watt attenuator or transient limiter is ideal.

Using an external attenuator or transient limiter accomplishes the following:

- ✓ Adds a barrier of protection for the highly sensitive RF input of your spectrum analyzer or EMI receiver, as described below. The following assumes a 10 dB/4W attenuator or limiter.

If a high amplitude signal is present [1W to 4W], its amplitude will be reduced by 10 dB [0.1W to 0.4], which the instrument is capable of withstanding.

If a higher amplitude signal is present [$>4W$], then the attenuator or limiter will blow, and become an open circuit, protecting the analyzer input from exposure to the signal. The prevailing logic here is that it is cheaper to replace an attenuator than to replace/repair the RF input of your instrument.

- ✓ Provides impedance matching in order to reduce RF reflections.

In addition to the above, a transient limiter offers the following additional advantages when compared to the attenuator alone:

- ✓ Provides protection against incidental transients.
- ✓ Provides DC blocking protection.

Due to the nature of the ISN T8, transient or DC voltages are not likely to be present at the RF port, and is more likely to occur due to human error, or when performing measurements on power lines.

4.4.3 Correction Factors

As with all ISN's, the impedance of the ISN T8 is 150Ω. Since the input impedance of your measuring instrument is 50Ω, it will measure one-third of the voltage that is present at the RF port. This is what is referred to as the Voltage Division Factor (VDF).

$$VDF_{(linear)} = \frac{V_{(150\Omega)}}{V_{(50\Omega)}} = 3 \text{ -or- } VDF_{(dB)} = 20 \times \log\left(\frac{V_{(150\Omega)}}{V_{(50\Omega)}}\right) = 9.5 \text{ dB}$$

where:

$V_{(50\Omega)}$ = Voltage measured across 50Ω
 = Voltage measured with 50Ω input impedance
 = Measured Value

$V_{(150\Omega)}$ = Voltage present across 150Ω
 = Voltage present across an ISN/CDN network
 = Corrected Value

Additionally, other nominal losses occur within the ISN and LCL adapters, which must also be accounted for in order to accurately correct the measured voltage levels present at the RF port of the ISN. The voltage division factors supplied with your ISN T8 include all such losses, ranging from 9.5 to 11.5 dB over the frequency range.

There are two sets of factors included, corresponding to the calibration of the ISN T8 with the Cat. 3 LCL Adapter and the ISN T8 with the Cat. 5 LCL Adapter. Make sure that the appropriate set of factors are used, depending on which LCL adapter you are using.

These frequency-specific correction factors are added to the values measured on the spectrum analyzer or EMI receiver:

$$V_{(150\Omega)} = V_{(50\Omega)} \times VDF_{(linear)} \text{ -or- } V_{(150\Omega)} = V_{(50\Omega)} + VDF_{(dB)}$$

Keep in mind that if you are using an external attenuator or transient limiter, that must also be taken into account. And, if significant, you should also correct your data for the insertion loss of the cable you are using to connect the ISN T8 to your measuring instrument. These are all losses, so they must be added to your measured value.

$$V_{(150\Omega)} = V_{(50\Omega)} + VDF_{(dB)} + \text{External Atten. (dB)} + \text{Cable Loss (dB)}$$

NOTE: Some [attenuator/cable] manufacturers may report loss as a negative value. If this is the case, they should be entered into your software, or applied into your calculations, as absolute values for purposes of measurement correction.

5.0 Important Safety Precautions

The ISN must be securely fastened to the earth ground before making any connections to external power. Proper grounding of the ISN is essential for accurate measurements, as well as preventing potentially high leakage currents from presenting a hazard to test personnel. To help establish proper grounding the base of the ISN is an unpainted, conductive plate with mounting holes which can be utilized for securely bolting it to the ground plane.

5.1 Maintenance

There are no user serviceable parts inside the unit. User modifications to the ISN or its accessories will void the warranty and may also invalidate the calibration. If you feel the ISN is not functioning properly, discontinue use and contact us for assistance. If we ask that you return the ISN for service, you will be provided with a Return Merchandise Authorization (RMA) number. The RMA number should be displayed in a prominent location on the packaging and on the product.

5.2 Environmental Conditions

This equipment is designed for indoor use to be safe under the following environmental conditions:

- Temperature: 5° C to 40° C
- Maximum relative humidity: 80%

6.0 Warranty

Com-Power warrants to its Customers that the products it manufactures will be free from defects in materials and workmanship for a ***period of three (3) years***. This warranty shall not apply to:

- Transport damages during shipment from your plant.
- Damages due to poor packaging.
- Products operated outside their specifications.
- Products Improperly maintained or modified.
- Consumable items such as fuses, power cords, cables, etc.
- Normal wear
- Calibration
- Products shipped outside the United States without the prior knowledge of Com-Power.

In addition, Com-Power shall not be obliged to provide service under this warranty to repair damage resulting from attempts to install, repair, service or modify the instrument by personnel other than Com-Power service representatives.

Under no circumstances does Com-Power recognize or assume liability for any loss, damage or expense arising, either directly or indirectly, from the use or handling of this product, or any inability to use this product separately or in combination with any other equipment.

When requesting warranty services, it is recommended that the original packaging material be used for shipping. Damage due to improper packaging will void warranty.

If you feel that the product is not working as intended, or is malfunctioning, please contact Com-Power for assistance. If the product must be returned to Com-Power, a Return Merchandise Authorization (RMA) number will be supplied to you. The RMA number should be displayed in a prominent location on the packaging and on the product, along with a description of the problem, and your contact information.

7.0 ISN Theory

Impedance Stabilization Networks (ISN) provide a means by which to measure common-mode disturbance voltages (conducted emissions) on telecommunication ports. The ISN T8 is used for measurements on unshielded telecommunication ports intended for connection to Cat. 3 or Cat. 5 wired networks. It is suitable for cables with one, two, three or four balanced pairs. The design of the ISN T8 is based on Figure D.3 of CISPR 22 (EN 55022).

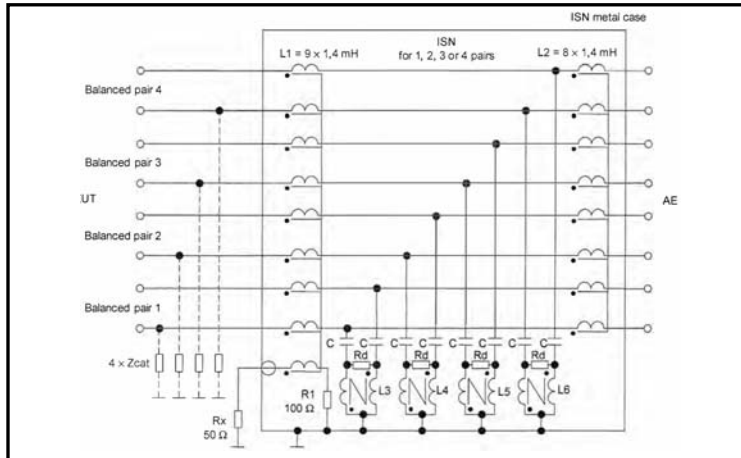


Figure 14 – Circuit Concept of ISN T8 (CISPR 22, Figure D.3)

The basic concept of the ISN is similar to that of an LISN (Line Impedance Stabilization Network) for disturbance voltage measurements on power lines, insofar as they both:

- connect in series with, and impose a defined impedance on, the lines under test; thereby providing a distinct advantage over current or voltage probe measurements, where the impedance of the lines is largely uncontrolled.
- provide isolation between the input and output ports, which:
 - ✓ minimizes influence of the input impedance on the impedance of the network.
 - ✓ reduces the contribution of unwanted signals to the measurement results.

The ISN is used for measurements on lines which host various types of high-speed, symmetric (differential-mode) communications, often operating within the same frequency band over which the measurements are performed. It is for this reason that, from a differential-mode perspective, the ISN should not impede the wanted signal path [thru-put], but should impede the path to the measurement port, as the intent of the test is not to limit the level of the wanted signals. In addition, the ISN measures all conductors of the line simultaneously with respect to ground, thereby measuring only the common-mode voltages, and not the differential.

In contrast, the LISN is used to measure each current carrying conductor individually, with reference to ground, making no distinction between, and therefore measuring, both differential and common mode voltages. In most cases, it need only pass the power frequencies (50 or 60 Hz), far below those frequencies over which measurements are performed.

8.0 Typical Performance Data

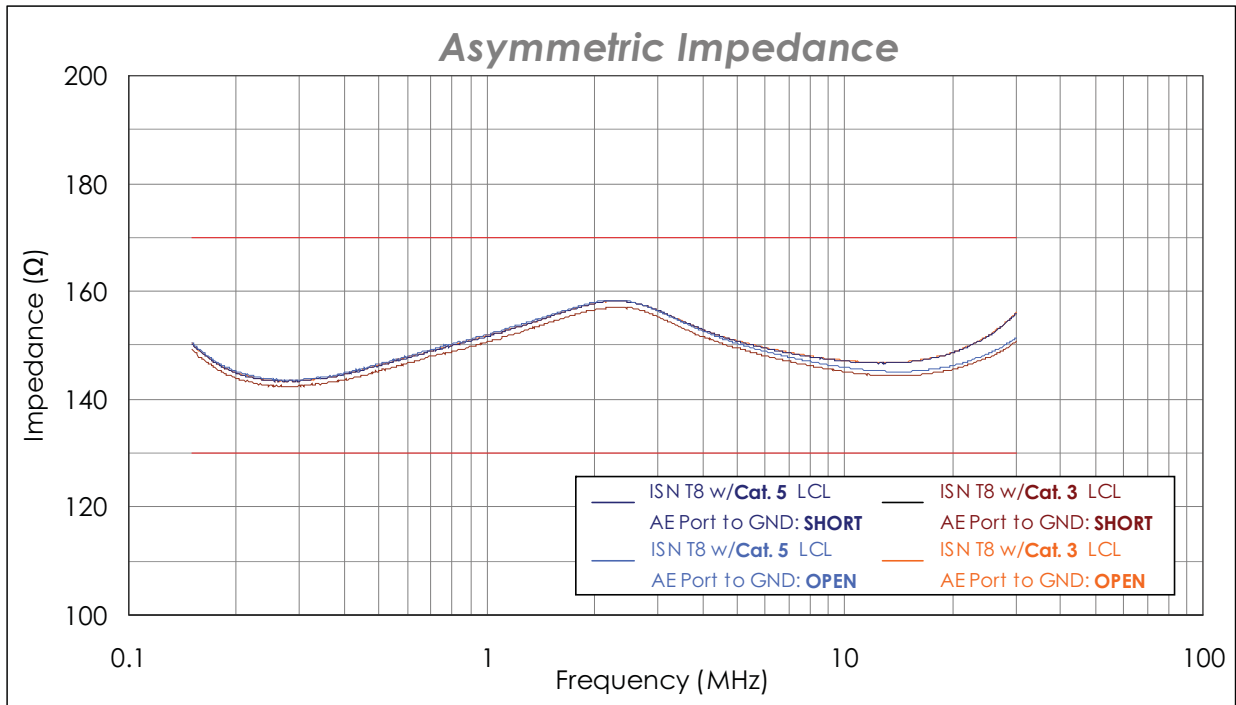


Figure 15 – Typical Asymmetric Impedance Characteristics

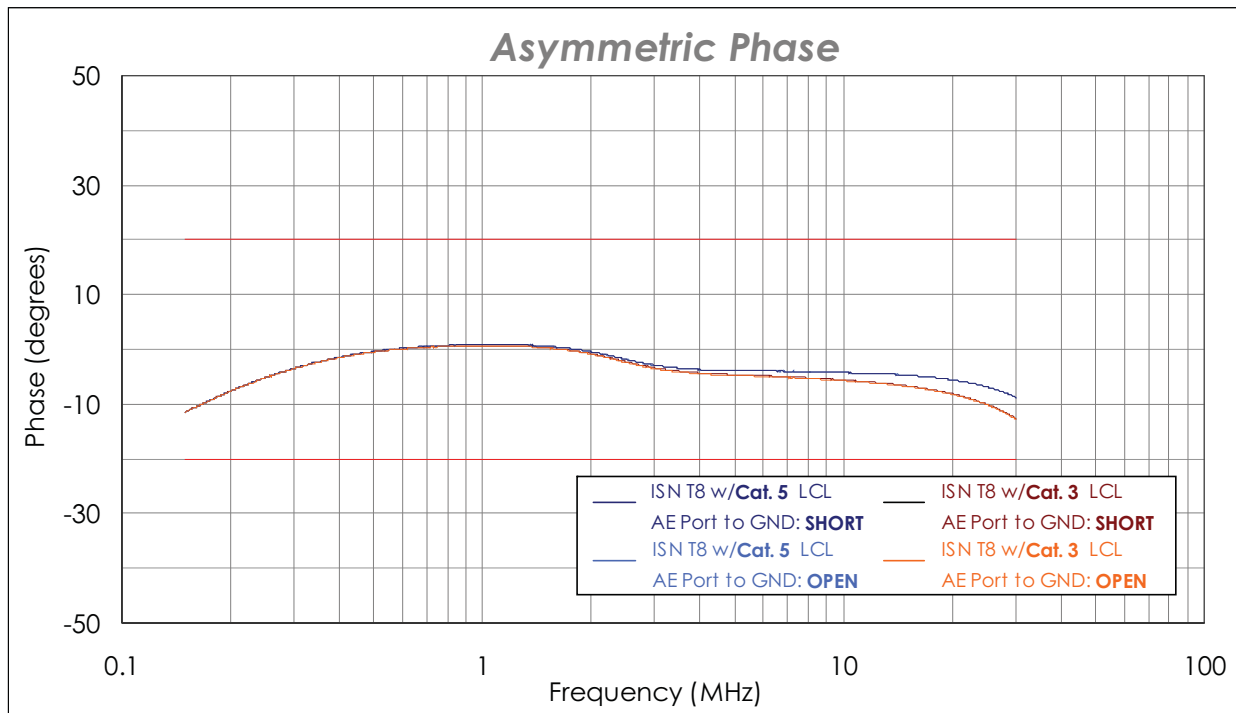


Figure 16 – Typical Asymmetric Phase Characteristics

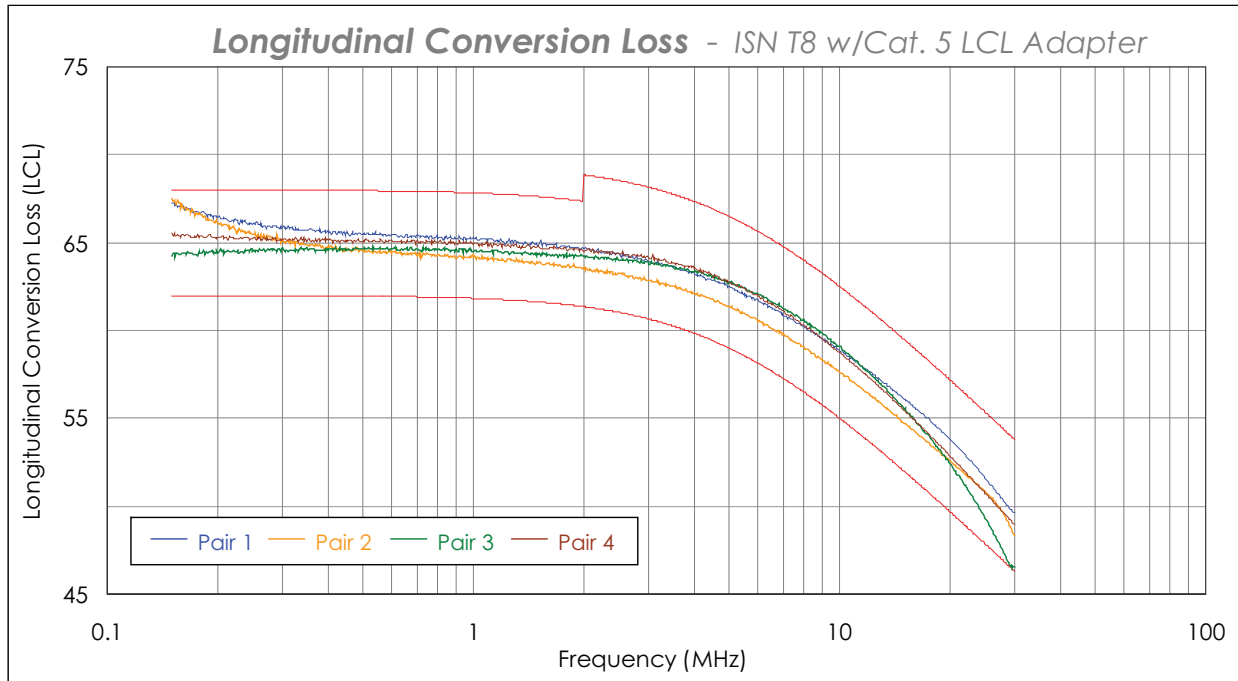


Figure 17 – Typical Longitudinal Conversion Loss (LCL) Characteristics (Cat.3)

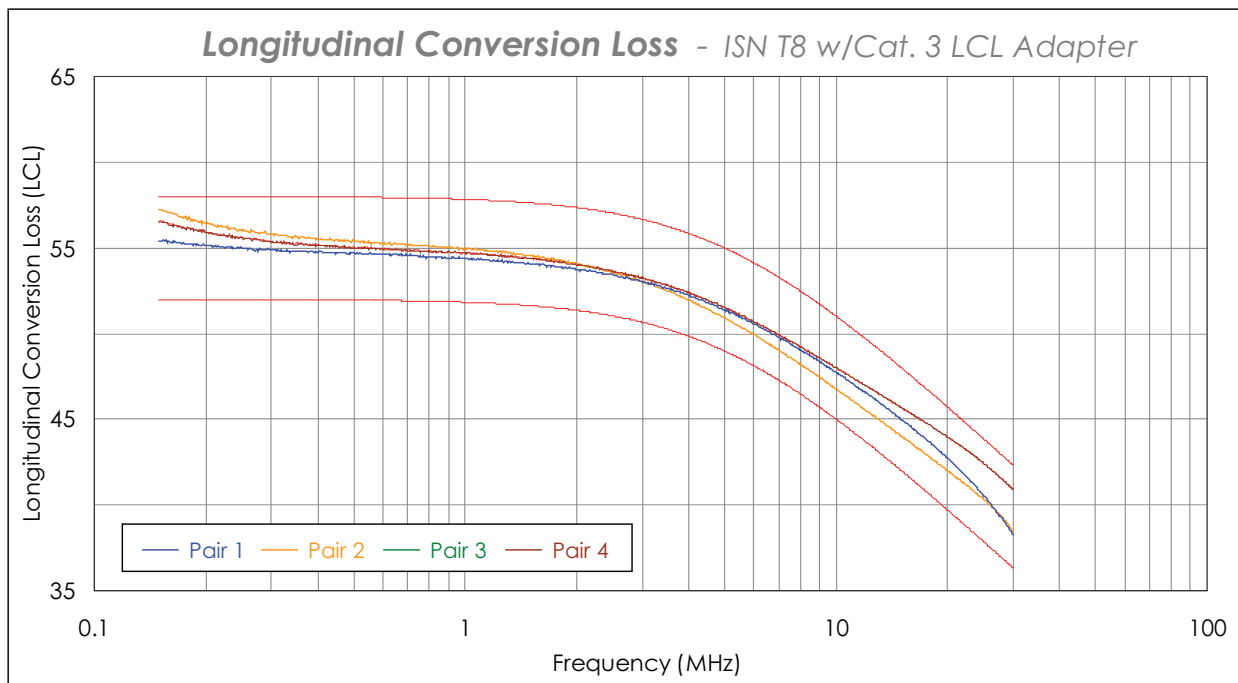


Figure 18 – Typical Longitudinal Conversion Loss (LCL) Characteristics (Cat.5)

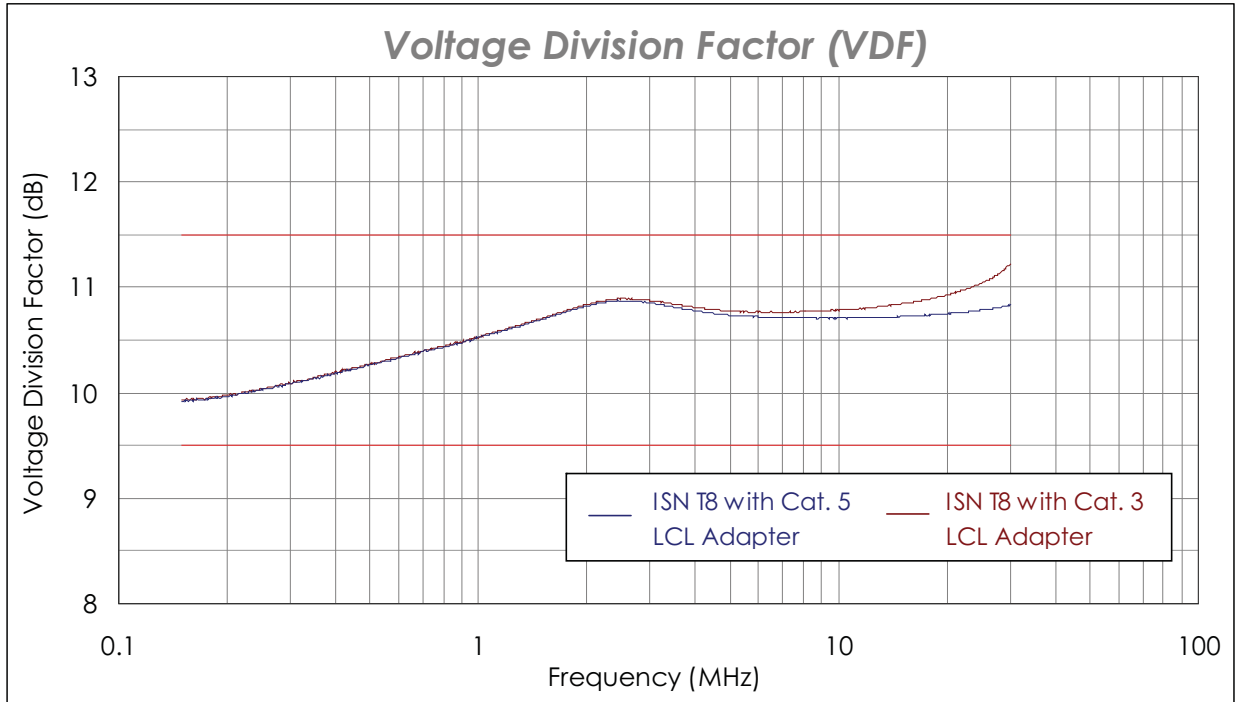


Figure 19 – Typical Voltage Division Factor (VDF) Characteristics

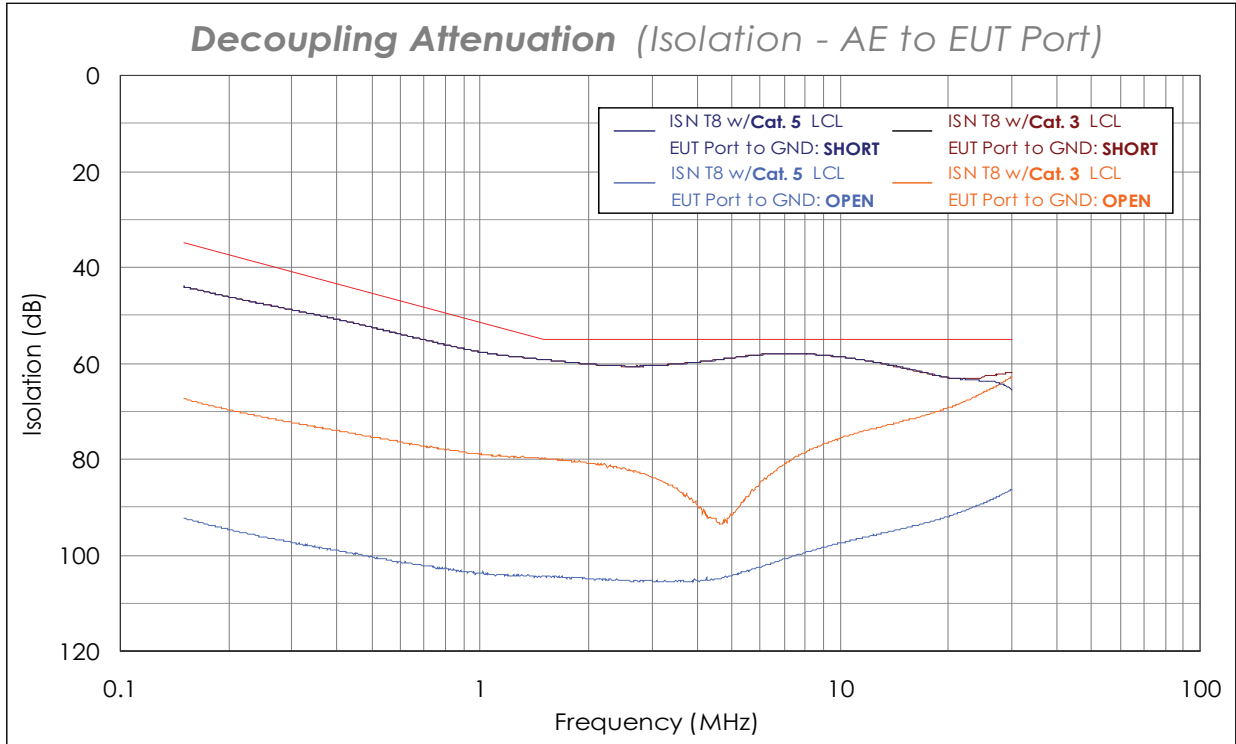


Figure 20 – Typical Isolation Characteristics

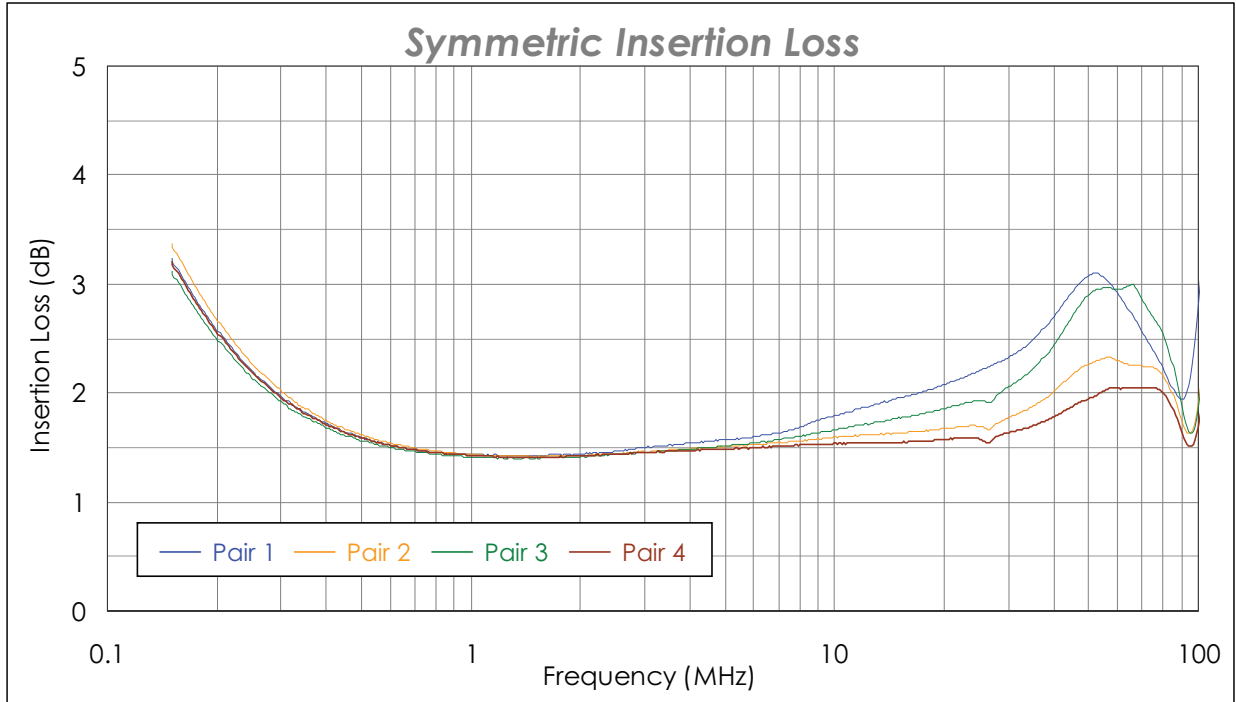


Figure 21 – Typical Symmetric Insertion Loss Characteristics