

## TBOH01 5 $\mu$ H LISN MANUAL



The TBOH01 5 $\mu$ H LISN is a device required to setup conducted noise measurements of DC-powered devices. It is designed to be used for EMC pre-testing in the frequency range of 150kHz to 110 MHz according to the CISPR-25 standard, ISO 7637-2, ISO11452-2/4/5 and with limitations DO-160/ED-14G. The LISN is inserted into the supply line of the DUT (Device Under Test). Conducted noise which is present at the supply terminals of the DUT can be measured at the BNC connector using a spectrum analyzer or a measurement receiver. The source (supply) terminal and the DUT terminal are decoupled by a 5 $\mu$ H inductor.

## CONTENTS

<b>1 INTRODUCTION</b>	2	<b>3 CISPR 25 LIMITS FOR BROADBAND CONDUCTED EMISSIONS ON POWER INPUT TERMINALS</b>	9
1.1 PARAMETERS	2	<b>4 MEASUREMENT EXAMPLES</b>	9
1.2 SCHEMATIC	2	<b>5 HISTORY</b>	10
1.3 IMPEDANCE	3		
1.4 FREQUENCY RESPONSE	4		
1.5 IMPEDANCE	4		
<b>2 APPLICATION</b>	7		
2.1 STANDARD SETUP	7		
2.2 SETUP FOR MEASURING POWER SUPPLY NOISE SPECTRUM OF POWER SUPPLIES	8		
2.3 SETUP FOR RF IMMUNITY TESTING	8		

## TABLES

Table 1 – Insertion loss measured between DUT and BNC terminal; Source terminals open/shorted	6
Tables 2,3 – Tables 2,3 are just a simplified excerpt. Refer to the standard for further details	9
Table 4 – History	13

## PICTURES

Picture 1 – 300kHz...100MHz, measured impedance of the 5 $\mu$ H LISN	3
Picture 2 – 0,3...3MHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted	4
Picture 3 – 0,3...100MHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted	4
Picture 4 – 0,3...1GHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted	5
Picture 5 – 0,3...100MHz, isolation measured between DUT and source terminals; BNC connector terminated with 50 $\Omega$	5
Picture 6 – Basic functionality of a LISN	7
Picture 7 – Example setup for a conducted noise measurement of a DC powered device	7
Picture 8 – Setup for measuring power supply noise spectrum	8
Picture 9 – Setup for RF injection	8
Picture 10 – Simple laboratory set up	9
Picture 11 – conducted emissions, frequency range 150kHz to 108MHz	10
Picture 12 – Example: conducted emissions, pre-compliance measurement of an automotive LED driver using two LISNs	10

## 1. INTRODUCTION

The TBOH01 5 $\mu$ H LISN is a device required to setup conducted noise measurements of DC-powered devices. It is designed to be used for EMC pre-testing in the frequency range of 150kHz to 110 MHz according to the CISPR-25 standard, ISO 7637-2, ISO11452-2/4/5 and with limitations DO-160/ED-14G.

The LISN is inserted into the supply line of the DUT (Device Under Test). Conducted noise which is present at the supply terminals of the DUT can be measured at the BNC connector using a spectrum analyzer or a measurement receiver. The source (supply) terminal and the DUT terminal are decoupled by a 5 $\mu$ H inductor.



### 1.1. PARAMETERS

**Frequency range: 100kHz – 110MHz (1GHz, see figure 4)**

**DC Resistance: 40 m $\Omega$**

**Maximum current: 10A**

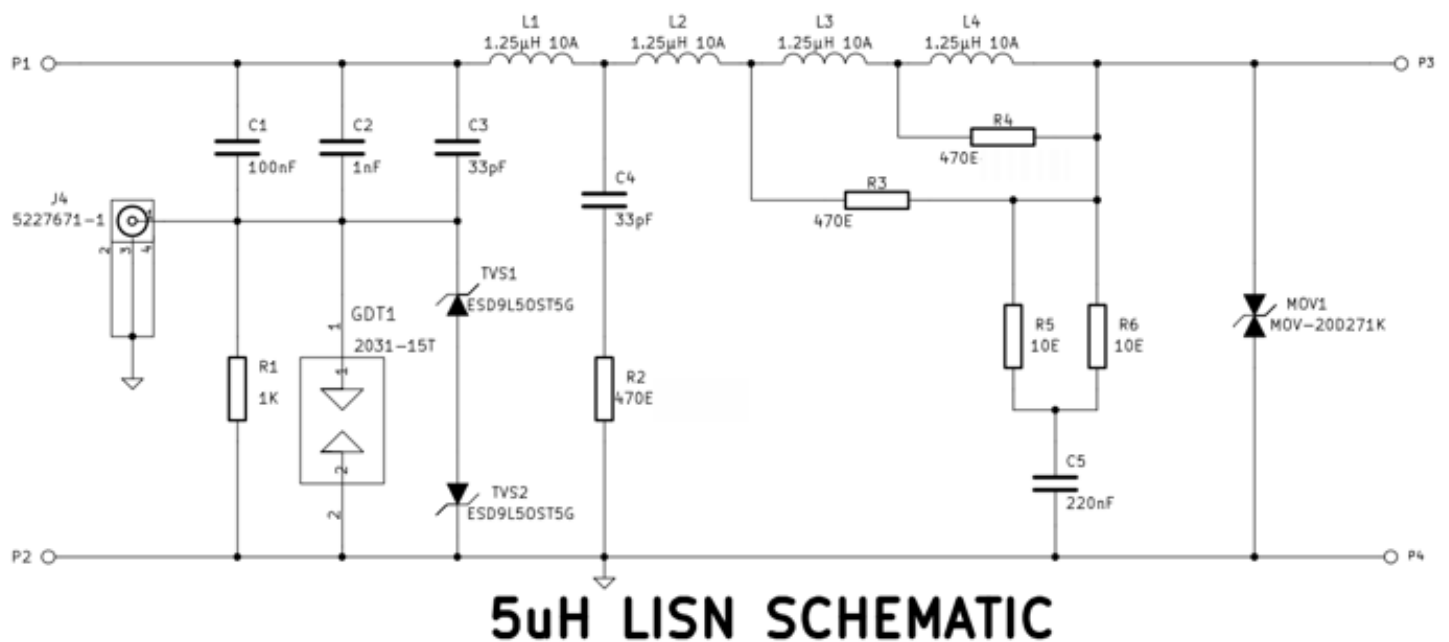
**Nominal operating voltage range: 0 – 75V DC;**

**Absolute maximum rating: 200V**

**Built in surge protection**

**Terminals suitable to clamp external source capacitors**

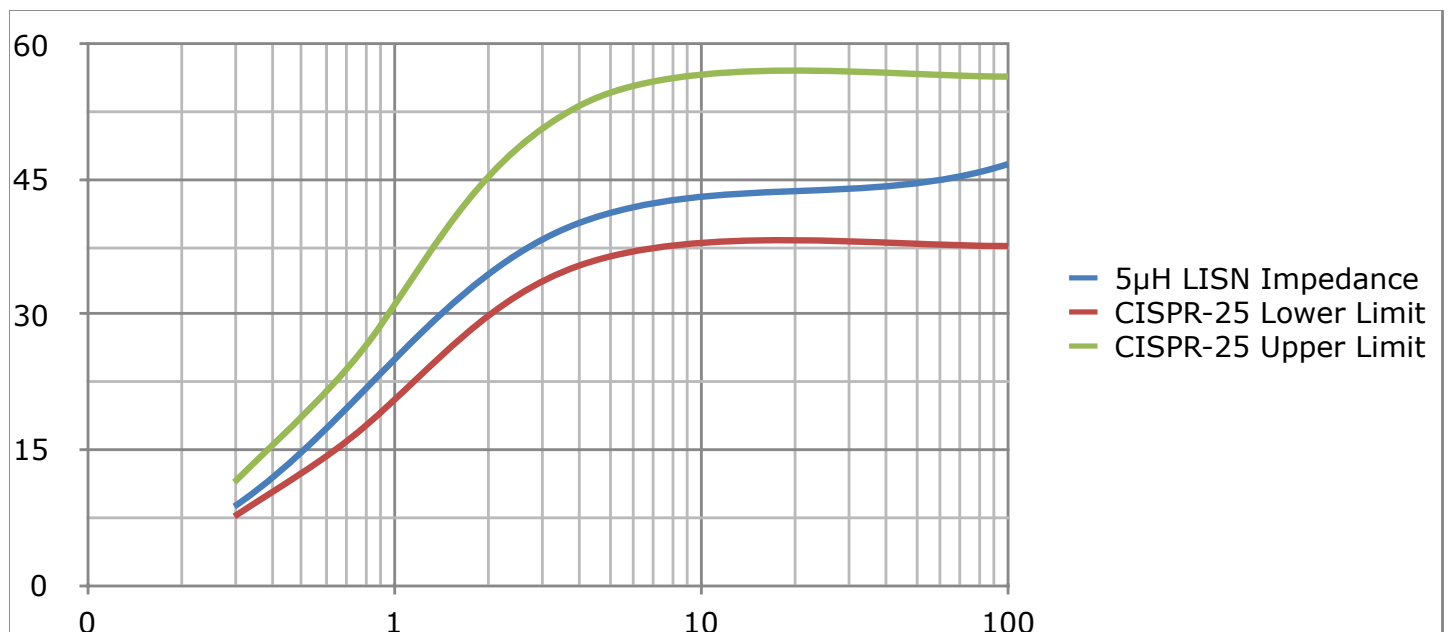
### 1.2 SCHEMATIC



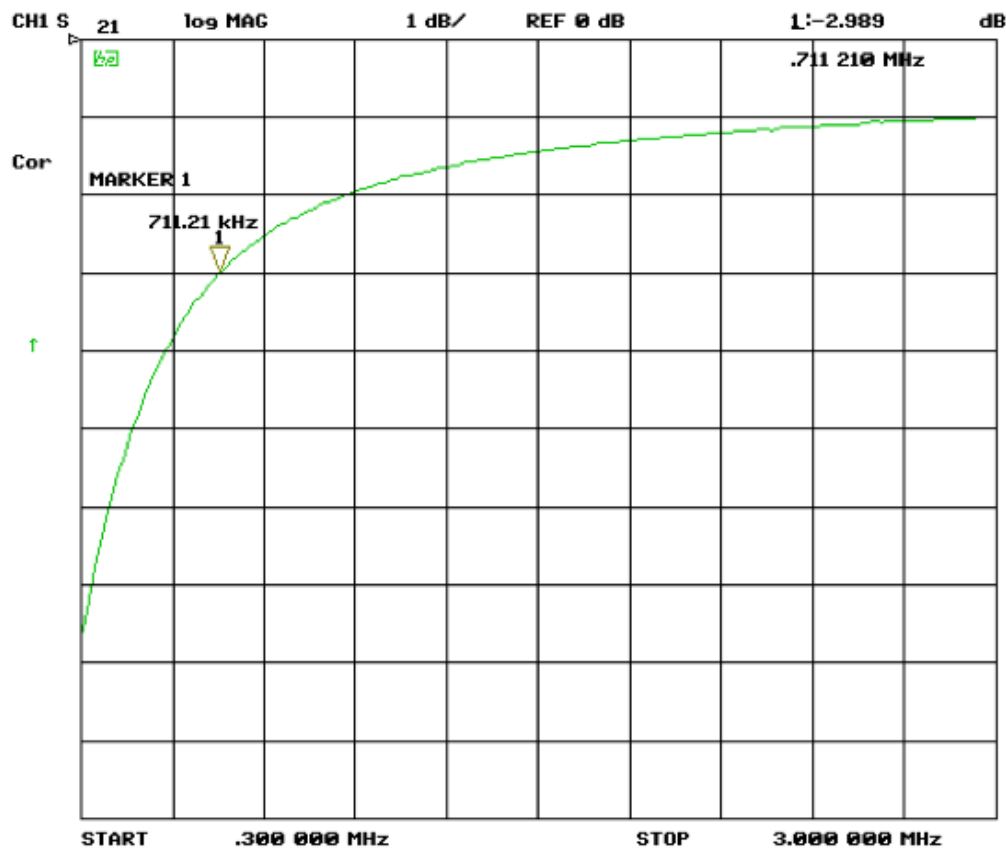
## P1: DUT+; P3: SOURCE+; CON1: SPECTRUM ANALYZER / MEASUREMENT RECEIVER

BOM:				
C1	C3216X7R2E104K	100nF 250V X7R 1206	TDK Corporation	Digikey
C2	1206PC102KAT1A	1nF 250V X7R 1206	AVX	Digikey
C3, C4	501R18N330JV4E	33pF 500V NP0 1206	Johanson	Digikey
C5	C3225X7R2E224M	220nF 250V X7R 1210	TDK Corporation	Digikey
CON1	DOSIN-801-0034	BNC 50 $\Omega$ 180° PCB mount	Dosin	Dosin
GDT1	2031-15T-SM-RPLF	GAS TUBE 60V 1KA	Bourns Inc.	Digikey
HOUSING	1550DBK or 1550D	BOX ALUM 4.51X2.52X2.17"	Hammond	Digikey
L1, L2, L3, L4	1.25 $\mu$ H; 8 turns, $\varnothing$ 17mm	$\varnothing$ 1,4mm enamelled copper wire		
MOV1	MOV-20D271K	VARISTOR 270V 20MM	Bourns Inc.	Digikey
P1, P2, P3, P4	Banana Jacks			
PCB	5 $\mu$ H LISN V1.0	double sided, 95x58x1.6mm	FZ-Electronics	FZ
R1	RC1206FR-071KL	RES 1K OHM 1/4W 1% 1206	Yageo	Digikey
R2	RC1206FR-07470RL	RES 470 OHM 1/4W 1% 1206	Yageo	Digikey
R3, R4	4-1622820-8	RES 470 OHM 1W 5% 2512	TE Connectivity	Digikey
R5, R6	1622820-4	RES 10 OHM 1W 5% 2512	TE Connectivity	Digikey
TVS1, TVS2	ESD9L5.0ST5G	TVS ULT LOW CAP SOD-923	ON-Semiconductor	Digikey

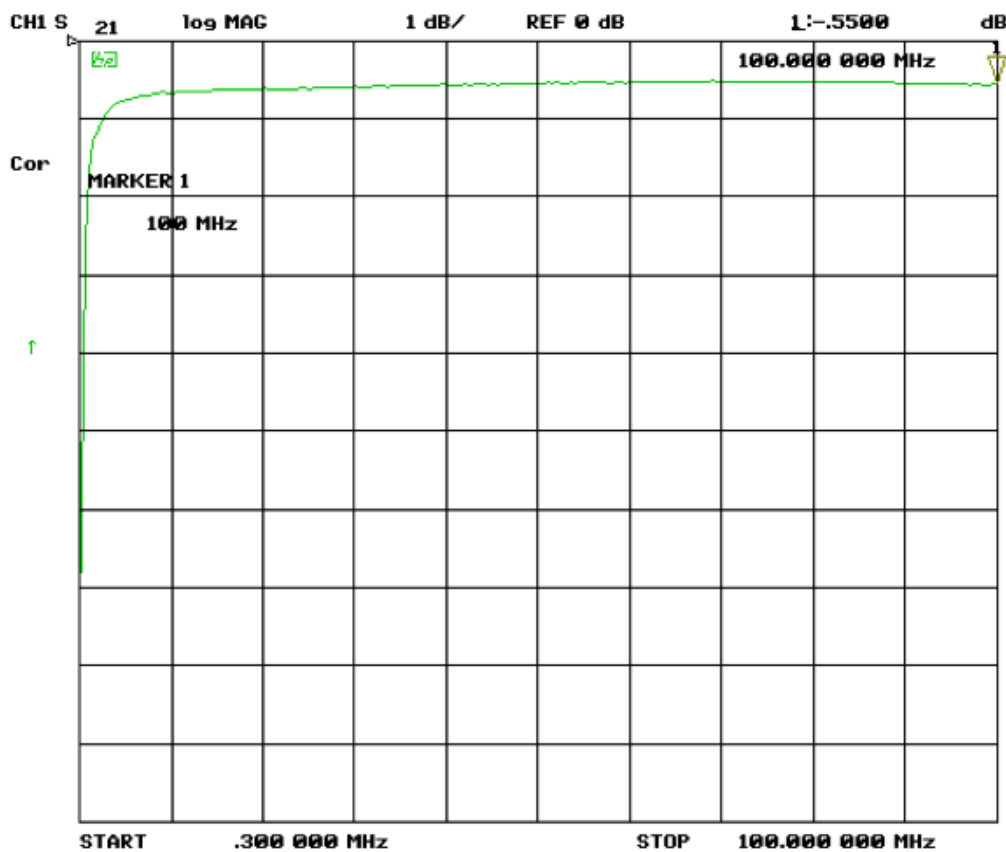
## 1.3. IMPEDANCE

Picture 1 – 300kHz...100MHz, measured impedance of the 5 $\mu$ H LISN

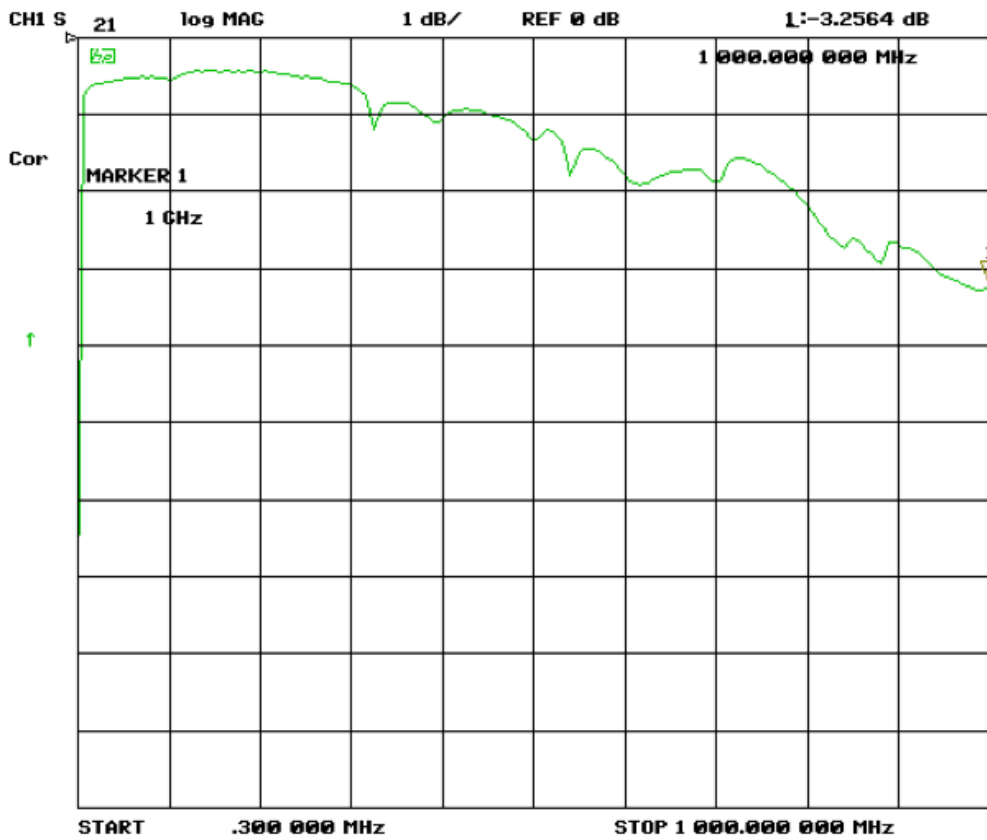
## 1.4. FREQUENCY RESPONSE



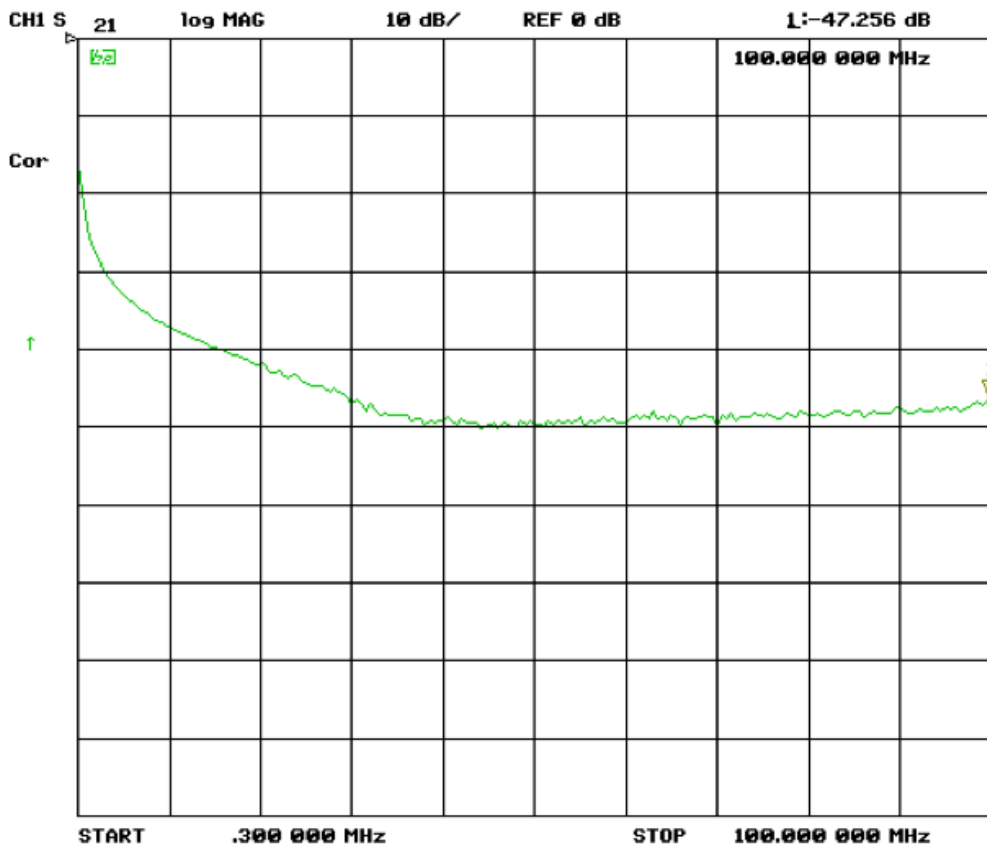
Picture 2 – 0,3...3MHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted



Picture 3 – 0,3...100MHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted



Picture 4 – 0,3...1GHz, insertion loss measured between DUT terminals and BNC connector; source terminals shorted



Picture 5 – 0,3...100MHz, isolation measured between DUT and source terminals; BNC connector terminated with 50 $\Omega$

Frequency	Max. insertion loss (DUT terminals to BNC; source terminals open)	Max. insertion loss (DUT terminals to BNC; source terminals shorted)
150 kHz	-16.3 dB	-12.7 dB
200 kHz	-13.5 dB	-10.3 dB
250 kHz	-11.1 dB	-8.5 dB
300 kHz	-9 dB	-7.2 dB
350 kHz	-7.8 dB	-6.1 dB
400 kHz	-6.7 dB	-5.3 dB
450 kHz	-5.9 dB	-4.7 dB
500 kHz	-5.1 dB	-3.9 dB
600 kHz	-4.2 dB	-3.4 dB
700 kHz	-3.5 dB	-3 dB
800 kHz	-3 dB	-2.5 dB
900 kHz	-2.7 dB	-2.3 dB
1 MHz	-2.5 dB	-2.1 dB
5 MHz	-1.2 dB	-1.2 dB
10 MHz	-0.7 dB	-0.7 dB
50 MHz	-0.8 dB	-0.8 dB
100 MHz	-1 dB	-1 dB
150 MHz	-1.2 dB	-1.2 dB
250 MHz	-1.9 dB	-1.9 dB

*Table 1, insertion loss measured between DUT and BNC terminal; Source terminals open/shorted*

## SOURCE CAPACITORS:

CISPR 25 and ISO 11452-2/4/5 specify a 1 $\mu$ F capacitor to be connected in parallel to the source terminals. The TBOH01 terminals have perpendicular holes to easily insert and clamp the pins of the external capacitor. DO-160 specifies a 10 $\mu$ F capacitor in parallel to the source terminals. However, consider that the TBOH01 is not specified for the full DO-160 frequency range. Use the correction table column "source terminals shorted" for these applications. ISO7637-2 does not specify an external capacitor. Use the correction table column "source terminal open" then.

## 2. APPLICATION

A Line Impedance Stabilisation Network basically is a coupling device to measure conducted noise present on supply lines with a measurement receiver or spectrum analyzer. It establishes a defined impedance setup for the measurement, independent of the impedance of the power source. Hence the name Line Impedance Stabilisation Network.

A LISN has three terminals – both ends of a feedthrough path for DC and a 50  $\Omega$  coaxial terminal to connect a measurement receiver or spectrum analyzer.

Conducted noise from the Device Under Test (DUT) is coupled from the supply line to a 50  $\Omega$  BNC terminal.

Coupling loss from the DUT connector to the BNC connector is less than 1 dB from 3 MHz to 100 MHz. On the other hand, the LISN isolates the DUT and BNC terminals from conducted noise coming from the source side (Figure 5).

The DUT can be any DC powered electronic device. The Source can be any DC power supply up to 200V max.

Though the LISN is normally used to measure conducted noise from a DC powered device, it could also be used to inject RF to the supply lines of the DUT. This setup requires an additional 50  $\Omega$  feedthrough terminal at the BNC connector. Furthermore the LISN could be used to measure the noise of a source, for example a switched mode power supply or a DC/DC converter output. In this case, the power supply has to be connected to the DUT terminals and a load has to be connected to the Source terminals.

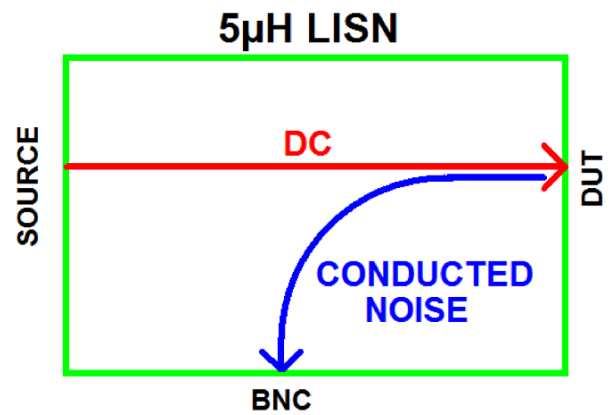
The test configurations shown in the following chapters are just examples and not strictly according to standards. They should rather serve as an easy means to carry out EMC pre-testing in the lab, before going to a certified test house.

Setup dimensions, Limits for spurious levels, bandwidth and detector settings for the measurement receiver or spectrum analyzer have to be derived from the applied standards.

### 2.1. STANDARD SETUP

Conducted noise measurements are typically conducted using a sheet metal as ground plane. The GND terminals of all involved devices are connected to the metal shield using short cables.

As the measurement will be conducted in lab, rather than in a shielded chamber, a background noise measurement should be carried out with the DUT switched off or disconnected in order to be able to differentiate between conducted noise spectrum and background electric smog.

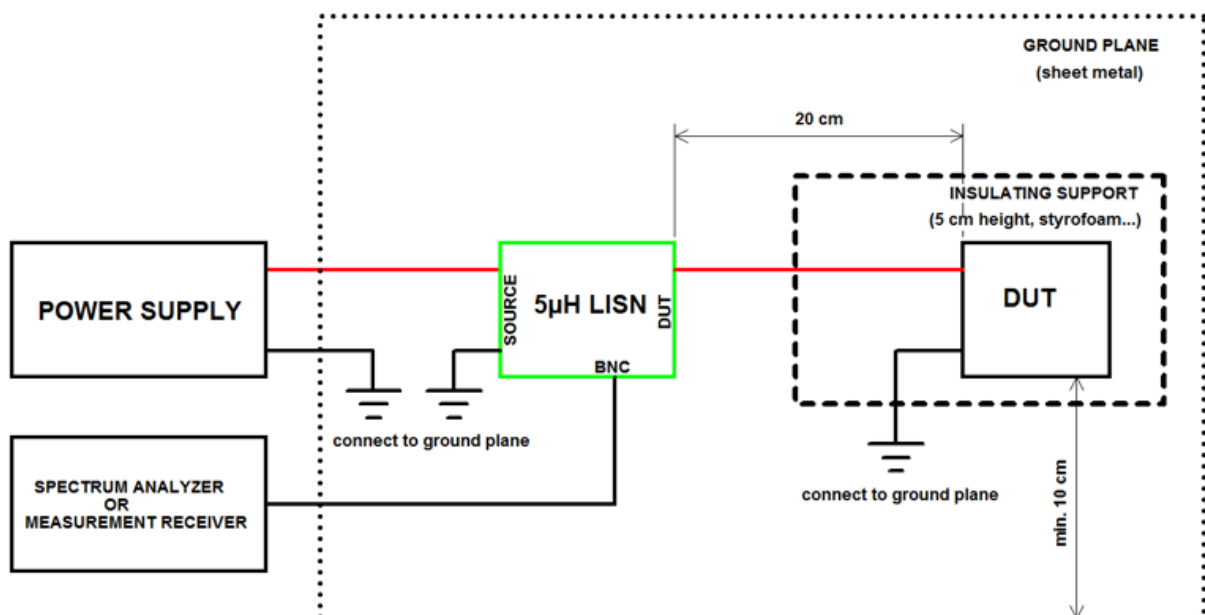


Picture 6 – basic functionality of a LISN

Standard conformant measurements would make use of two LISNs, if the vehicle power return line of the DUT is longer than 200 mm. One in the positive and another one in the negative supply line and then alternatively measure the noise. For a precompliance measurement, measuring the positive supply line gives a good indication on the performance of the device. The measurement can then be repeated with the LISN inserted into the negative supply line to check if the noise levels are any different.

Professional conducted noise measurements are done in shielded chambers, as any RF smog picked up by the wires from LISN to DUT or by the DUT itself, will be present at the BNC terminal. Consequently, a measurement with the DUT powered off should be done upfront in order to distinguish between real conducted noise generated by the DUT and RF smog from other sources (background noise).

The picture below shows a typical conducted emissions measurement setup, such as specified in CISPR-25 standard. Setup details will differ depending on the type of DUT and applicable standards. For example, if the DUT has a vehicle power return line shorter than 200 mm, one LISN is inserted into the positive supply line. If the vehicle return line of the DUT is longer than 200 mm, two LISNs are required. One for the positive supply line and one for the power return line.

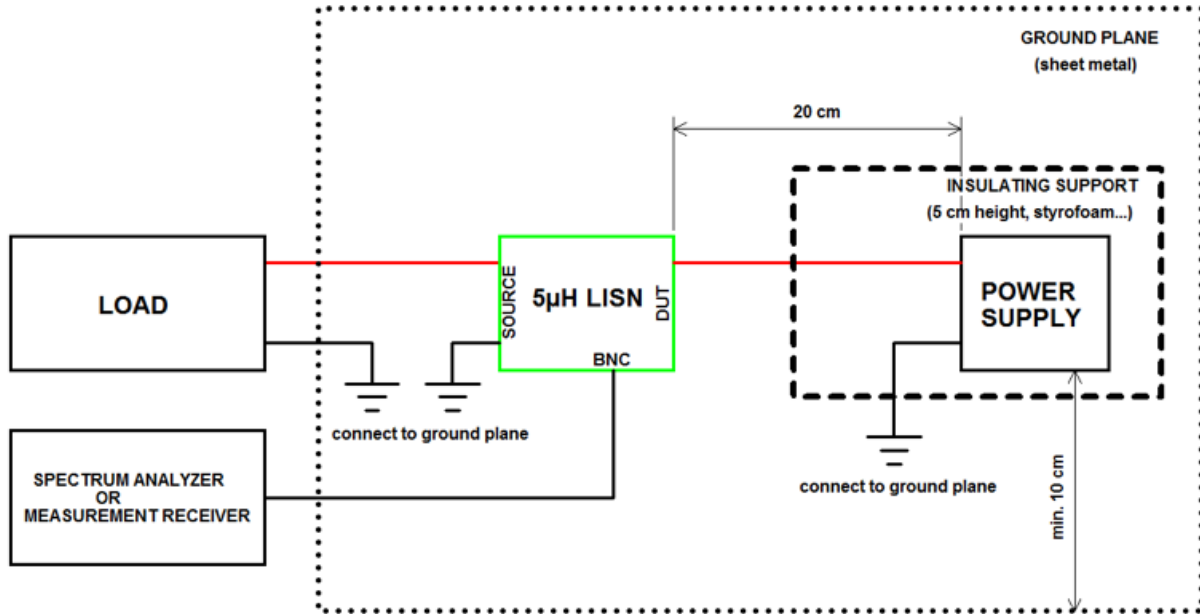


Picture 7 – example setup for a conducted noise measurement of a DC powered device



## 2.2. SETUP FOR MEASURING POWER SUPPLY NOISE SPECTRUM OF POWER SUPPLIES

The LISN can also be used to measure noise spectrum at the output terminals of a power supply or switched mode regulator.

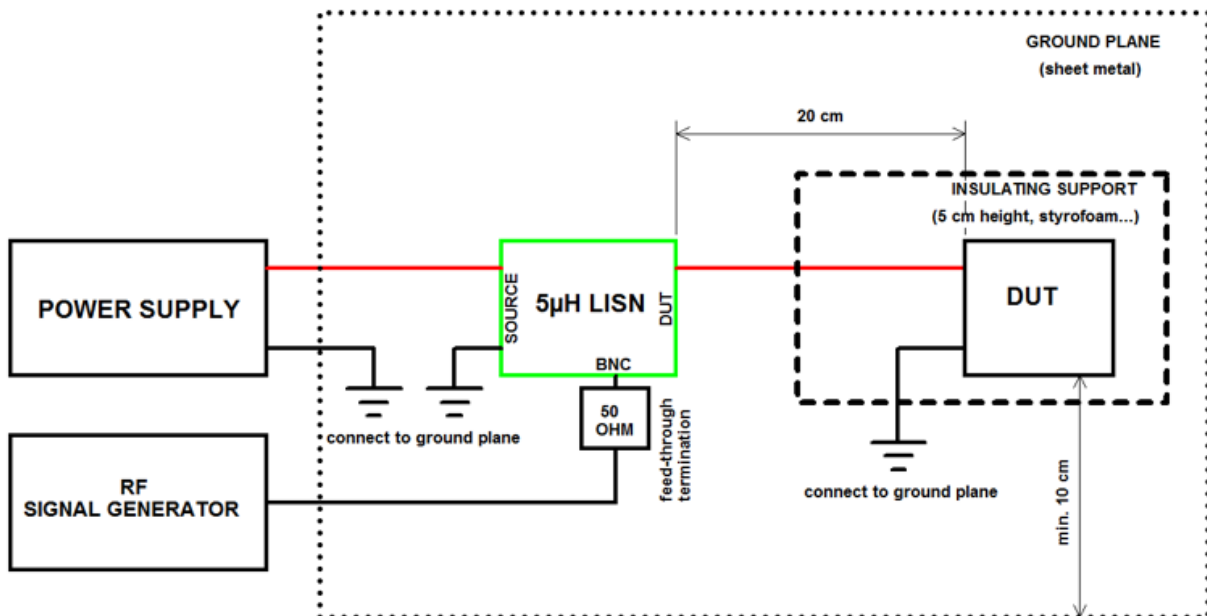


Picture 8 – setup for measuring power supply noise spectrum

Kindly notice again, that for exact set ups, you need to check the standards applicable to your DUT, especially CISPR 25, chapter 6.1.2 which defines if one or two LISNs have to be used for the setup.

## 2.3. SETUP FOR RF IMMUNITY TESTING

By adding a 50 Ohm feed through termination, the LISN can also be utilized to inject RF into the supply line of the DUT. The power rating of the feedthrough termination has to match the injected RF power level.



Picture 9 – setup for RF injection

### 3. CISPR 25 LIMITS FOR BROADBAND CONDUCTED EMISSIONS ON POWER INPUT TERMINALS

CLASS	Levels in dBµV									
	0,15 – 0,3 MHz		0,53 – 1,8 MHz		5,9 – 6,2 MHz		30 – 54 MHz		76 – 108 MHz	
	Peak	Quasi Peak	Peak	Quasi Peak	Peak	Quasi Peak	Peak	Quasi Peak	Peak	Quasi Peak
1	110	97	86	73	77	64	68	55	62	49
2	100	87	78	65	71	58	62	49	56	43
3	90	77	70	57	65	52	56	43	50	37
4	80	67	62	49	59	46	50	37	44	31
5	70	57	54	41	53	40	44	31	38	25

For short duration disturbances, add 6 dB to the level shown in the table

Measuring instrument bandwidth (6 dB)		
Frequency band [MHz]	Broadband peak or quasi-peak	Narrowband peak or average
0,15 - 30	9 kHz	9 kHz
30 – 1000 FM Broadcast Mobile Service	120 kHz 120 kHz	120 kHz 9 kHz

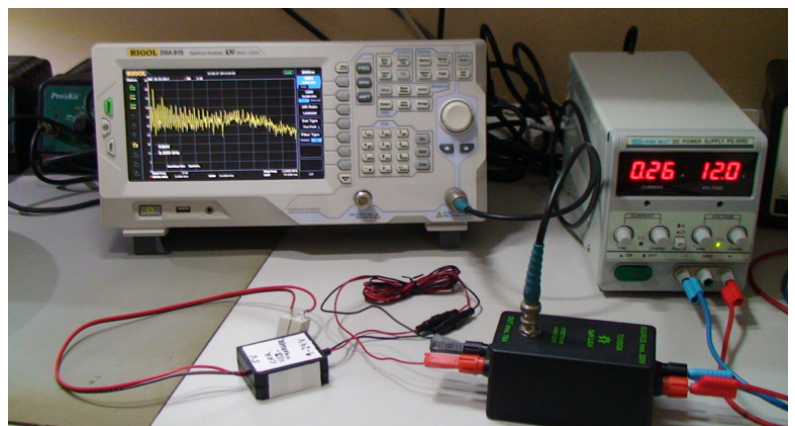
*The tables 2,3 above are just a simplified excerpt. Refer to the standard for further details*

### 4. MEASUREMENT EXAMPLES

The picture to the right shows a simple set up to do a quick test of a 9V to 24V USB car charger adapter. The charger adapter gets supplied with 12 V at the DUT terminals of the LISN. The power supply is connected to the Source terminals of the LISN. A spectrum analyzer is connected to the BNC connector of the LISN.

#### SPECTRUM ANALYZER SETTINGS:

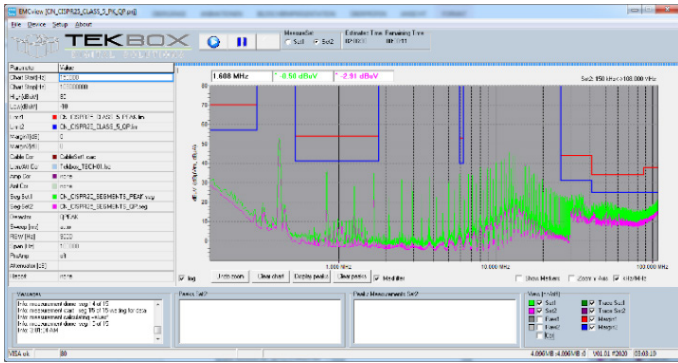
Frequency: 150kHz - 3MHz  
 Detector Type: Positive Peak (use Max. Hold or Quasi Peak, if available)  
 Filter Type: EMI  
 BW: 9kHz  
 Internal Attenuator: OFF  
 Units: dBµV



**Picture 10 – simple laboratory set up**

The setup is not CISPR25 conformant – no metal ground plane is involved. Nevertheless, the measurement permits a judgement of the conducted emission performance of the DUT and will be very useful to determine, if modifications of the circuit result in improved suppression of conducted emissions.

The screenshot below shows the result of a CISPR 25 conducted noise measurement of a DC/DC converter carried out with two TBOH01, a Rigol DSA815 and the Tekbox PC SW EMCview. With reference to the CISPR 25 limits, the measurement result shows compliance with Class 5 limits.



Picture 11 – conducted emissions, frequency range 150kHz to 108MHz



Picture 12 – Example: conducted emissions, pre-compliance measurement of an automotive LED driver using two LISNs

## 5. HISTORY

Version	Date	Author	Changes
V1.0	14.09.2010	L.D.HIEU	Creation of the document
V1.1	18.11.2013	L.D.HIEU	Chapter 2 updated
V1.2	17.03.2014	L.D.HIEU	Part number of R2 corrected
V1.3	25.11.2014	MAYERHOFER	Chapter 1.1 updated
V1.4	17.01.2016	MAYERHOFER	Insertion loss table added
V1.5	8.8.2016	MAYERHOFER	Picture 12 added
V1.6	24.4.2017	MAYERHOFER	Updated chapters 1, 1.4, 3, 4

Table 4 – History