

TBL5016-3 50 μ H AC-LISN

The TBL5016-3 is a Line Impedance Stabilization Network for the measurement of line-conducted interference within the range of 9 kHz to 30MHz, according to the CISPR 16-1-2 standard. The device is designed for testing 3-phase and single phase, AC-powered equipment with supply voltages up to maximum 450V/260V and 16A. Conducted noise can be measured on each phase and on the neutral conductor. The TBL5016-3 has separate RF outputs for each phase and neutral and consequently can be coupled with the TBLM1 to split the emissions in its common mode and differential mode components.

The single phase DUT socket is available in country-specific variants.



TBL5016-3 , variant with Schuko connector (CEE 7/3)

Features

- Frequency range: 9 kHz to 30 MHz
- Impedance: 50 Ω || (50 μ H + 5 Ω)
- Artificial hand: 220 pF + 511 Ω
- Switchable PE: 50 Ω || 50 μ H
- 250 μ H pre-filter
- Separate RF outputs for each line and neutral
- Air core inductors
- Line voltage: max. 540V/260V / 50 – 60 Hz, CAT II
- Max. current per line and neutral: 16A @ 23°C each
- 3-phase DUT socket: CEE / IEC60309, 3L+N+PE, 16A, female
- Single phase DUT socket: country specific

- Power connector: CEE / IEC60309, 3L+N+PE, 16A, male
- Measurement connectors: 50 Ω BNC
- Operating Temperature Range: +5°C ... + 40°C; 5% to 80% RH
- Safety: Safety Class I, IEC 1010-01

Application

- EMC conducted noise measurements

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SAFETY

Operating an AC LISN involves dealing with potentially lethal voltages and high ground leakage currents. The LISN shall only be operated by qualified staff.



Read this manual carefully and be sure to understand the operation of an AC LISN. Make sure that the conducted noise pre – compliance test equipment is set up correctly and that the necessary earth connections are reliably bonded to avoid the risk of lethal electric shocks.

Always supply the LISN only through an isolation transformer.

Take precautions, such as validating the signal amplitude at the RF output prior to connecting a spectrum analyzer or using attenuators and/or limiters to prevent damage to your test receiver or spectrum analyzer.

Do not carry out any modifications or manipulations of the TBL5016-3.

Avoid touching the housing, when operating the LISN at maximum current over extended time. The housing temperature may rise up to 50°C. Turn off the DUT after measurements to avoid unnecessary dissipation.

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1 Introduction

1.1 Pre-compliance testing of conducted emissions

Full compliance measurement of AC mains supplied products requires a high end set up consisting of an anechoic or screened chamber, a measurement receiver that complies with the requirements of CISPR 16, a 50 μ H LISN and a suitable table for the measurement setup. Great effort and cost ensures optimum accuracy and repeatability.

Pre-compliance measurements target to give a very close approximation of the EMC performance of the Device Under Test at a fraction of the cost of full compliance testing. The measurement receiver can be replaced by a spectrum analyzer with suitable sensitivity, bandwidth and detectors. The advent of affordable spectrum analyzers with EMI IF filters and Quasi-Peak detectors made EMC pre-compliance testing affordable for any company which develops electronic products. Together with test accessories from Tekbox, EMC pre-compliance set-ups cost hardly more than a standard oscilloscope a few years ago.

Eliminate uncertainty before going to the test house for compliance testing. There is hardly anything that can give you a return on invest as quickly as EMC pre compliance test equipment.

1.2 Line Impedance Stabilization Networks

A LISN is a device inserted between a power source and the supply terminals of a DUT (Device Under Test). It presents a defined impedance for the emissions produced by the DUT and emitted via the supply cables of the Device Under Test. The impedance seen by the RF emissions is 50 Ohm $\parallel$ 50 μ H + 5 Ohm which results in 50 Ohms for the most part of the specified frequency range. Only at the lower edge of its bandwidth, the impedance decreases. This impedance curve is specified in the corresponding test standards such as CISPR 16-1-2. Having a defined impedance for the emissions at the DUT terminals eliminates any influence of the power source impedance. Consequently, the measured amplitudes of the noise spectrum become independent of the power source characteristics:

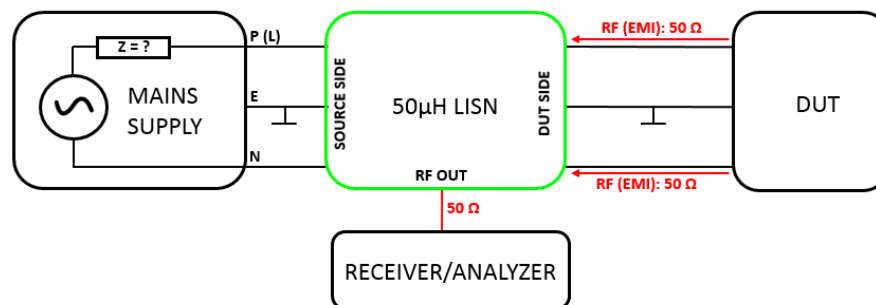


Figure 1 – Basic AC LISN set up: impedance levels

Furthermore, the AC LISN attenuates noise originating from the incoming mains supply towards the Receiver/Analyzer and DUT. For detailed information, refer to the LISN overview document, which can be downloaded from the Tekbox website

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1.3 RF output

The TBL5016-3 provides separate RF outputs for L1, L2, L3 and Neutral. Consequently, a complete conducted emission measurement consists of four separate measurements in case of a DUT supplied in Y-configuration, three separate measurements in case of DUTs supplied in Delta-configuration, or two separate measurements in case of single phase supplied DUTs. L1 is connected both to the 3-phase DUT socket, as well as to a country specific single phase socket to simplify connectivity of single phase supplied products. When measuring conducted emissions on any of the four paths, the three unused RF outputs have to be terminated with 50 Ohm.

As the TBL5016-3 provides separate outputs for each path, it can be connected to a TBLM1 LISN mate in order to split the output signal into its common mode and differential mode components.

The TBL5016-3 RF paths do not provide any built in attenuators / limiters. Take precautions, such as validating the signal amplitude at the RF output prior to connecting a spectrum analyzer or using attenuators and/or limiters such as the Tekbox TBFL1 to prevent damage to your test receiver or spectrum analyzer.

WARNING: Ensure that the spectrum analyzer RF input is disconnected when powering on or powering off the DUT. Use an attenuator/limiter, if the DUT switches inductive loads during operation or in case of any uncertainty concerning the DUT characteristics. After ensuring that the spectrum analyzer is not over-driven, you may remove or reduce external attenuation.

1.4 Informative schematic

The simplified schematic below shows the basic topology and the values of the main components of the TBL5016-3 AC LISN. It consists of four identical LISN paths.

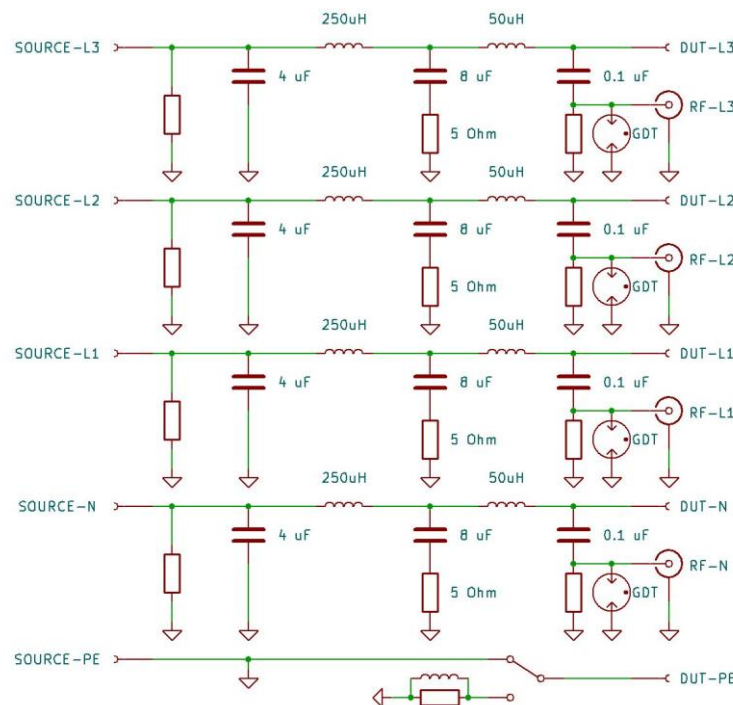


Figure 2 – 3-phase LISN, simplified schematic

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NOTE the high capacitor values, which cause considerable blind current at 50Hz/60Hz line voltages. Direct connection to the mains outlet would cause tripping of the ground fault switch. Refer to the next chapter on how to set up the AC LISN in a standard laboratory environment.

1.5 Laboratory set up

The DUT shall be isolated and elevated from the ground plane. The spectrum analyzer shall measure the conducted emissions on both line and neutral.

The value of the parallel combination of the capacitors is $12\mu\text{F}$ from each line and neutral to ground. This causes around 0.75A flowing into the earth connection and would trip the ground fault switch. Hence, an **insulation transformer** is required for any mains supply which is protected by a residual current device or ground fault (earth leakage) circuit breaker and good grounding is essential for safety.

The set up below is just informative. For the exact details of the set up and for the limits of conducted emissions refer to the relevant applicable standard or the examples in the LISN overview document, which can be downloaded from our website.

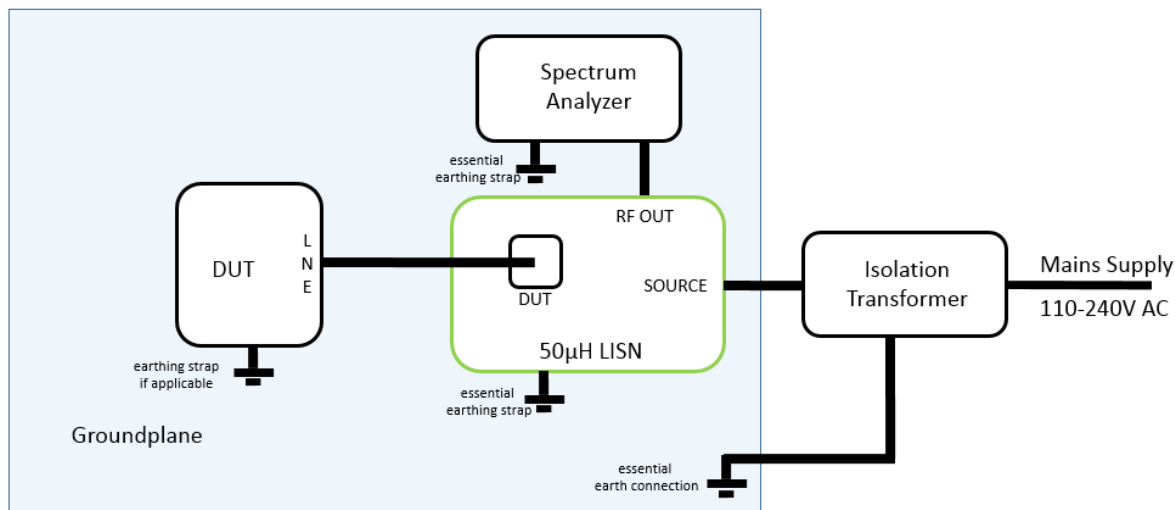


Figure 3 – Conducted noise pre-compliance measurement setup

SAFETY: Ensure that all required earth connections are reliably bonded and that the isolation transformer can supply the required load current.

1.6 Ground plane

Any voltage measurement must be made against a common circuit node which can be referred to as the “zero volt” reference. In order to provide a low impedance zero volt reference for RF measurements, a metal sheet must be provided as ground plane. All ground straps between equipment and ground plane shall be as short as possible and fastened with screws. Exact details on the size of the ground plane and the arrangement of the equipment and interconnecting cables are described in the applicable standards.

In a pre-compliance test set up, as a rule of thumb, the size of the ground plane shall be large enough to accommodate all involved equipment and exceed at least 10cm each side.

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2 TBL5016-3 specifications

2.1 Conformity

The TBL5016-3 is compliant with Safety Class I according IEC 1010-1.

(EN 61010-1: 1993 / IEC (CEI) 1010-1: 1990 A 1: 1992, EN 61010-1/A2: 1995 / IEC 1010-1/A2: 1995 /)

Rated Pollution degree: 2

Overvoltage category: II

EMC: EN61326-1/A1

2.2 Safety

In order to ensure safe operations, the user must follow all safety relevant information of this manual. All housing parts are connected with the earth conductor of the power cable, DUT socket, yellow banana receptacle and with the ground straps of the housing. It is not allowed to carry out any modifications or manipulations of the TBL5016-3. The TBL5016-3 shall be operated by qualified laboratory staff only.

2.3 Specifications

- Frequency range: 9 kHz to 30 MHz
- Impedance: 50 Ω || (50 μ H + 5 Ω)
- Artificial hand: 220 pF + 511 Ω
- Switchable PE: 50 Ω || 50 μ H
- 250 μ H pre-filter
- Air core inductors
- Line voltage: max. 540V/260V, 50 – 60 Hz, CAT II
- Max. current: 16A @ 23°C for each phase and neutral
- 3-phase DUT socket: CEE / IEC60309, 3L+N+PE, 16A, female
- Single phase DUT socket: country specific, note country specific DUT socket limits (see chapter 4)
- Power connector: CEE / IEC60309, 3L+N+PE, 16A, male
- Measurement connector: 50 Ω BNC, separate outputs for each line and phase
- Operating Temperature Range: +5°C ... + 40°C; 5% to 80% RH
- Safety: Safety Class I, IEC 1010-01
- Weight: 18 kg, length: 440mm, width: 442 mm, height: 180 mm

2.4 Supply voltage

The TBL5016-3 does not require any particular voltage settings. It can be operated with any supply voltage which does not exceed 540V/260V, 50Hz/60Hz.

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2.5 Front Panel

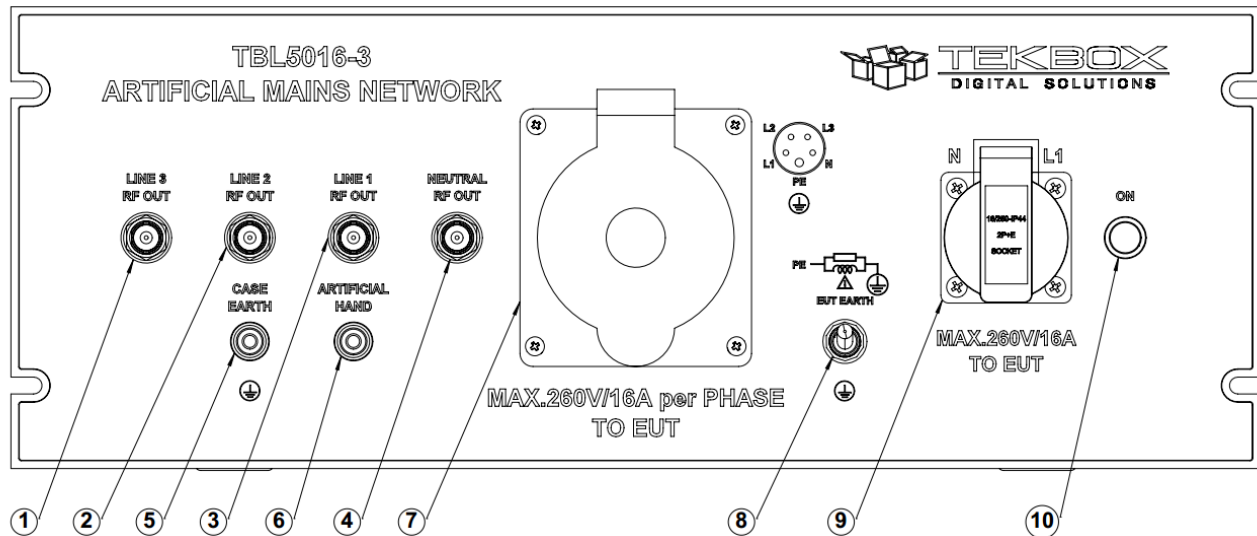


Figure 4 – Front panel layout

- 1) Line 3 BNC RF output
- 2) Line 2 BNC RF output
- 3) Line 1 BNC RF output
- 4) Neutral BNC RF output
- 5) Auxiliary case earth connector, safety banana jack
- 6) Artificial hand connector, safety banana jack
- 7) Three phase DUT socket, IEC60309, 3L+N+PE, 16A, female
- 8) Protective Earth switch to connect DUT earth either directly to case earth, or via 50 μ H || 50 Ohm
- 9) Single phase DUT socket, country specific
- 10) Power On indicator

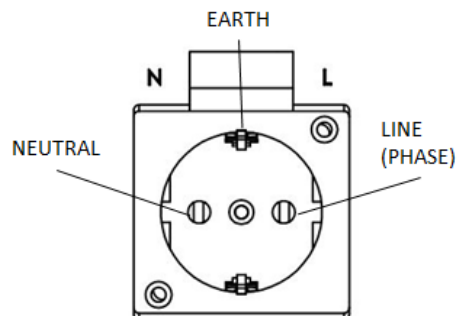


Figure 5 – DUT socket, pin assignment with reference to the rear power connector
For the pin-assignment of the three phase socket, refer to the graphics on the front panel

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2.6 Rear Panel

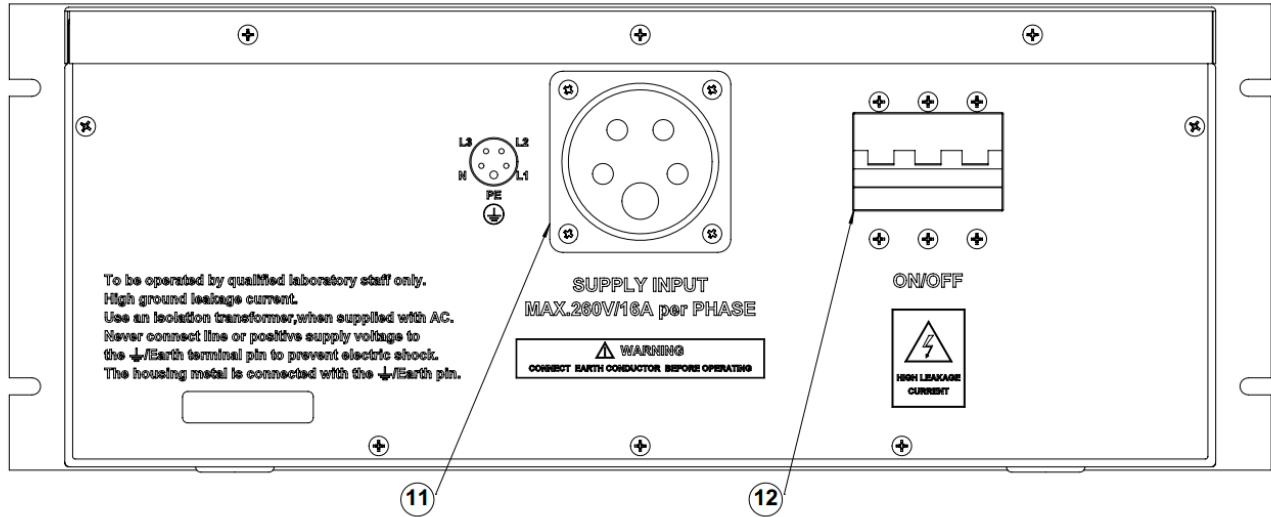


Figure 6 – Rear panel layout

- 11) Three phase power (source) socket, IEC60309, 3L+N+PE, 16A, male
- 12) Power switch

For the pin assignment of the power socket, refer to the graphics on the rear panel.

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2.7 Impedance

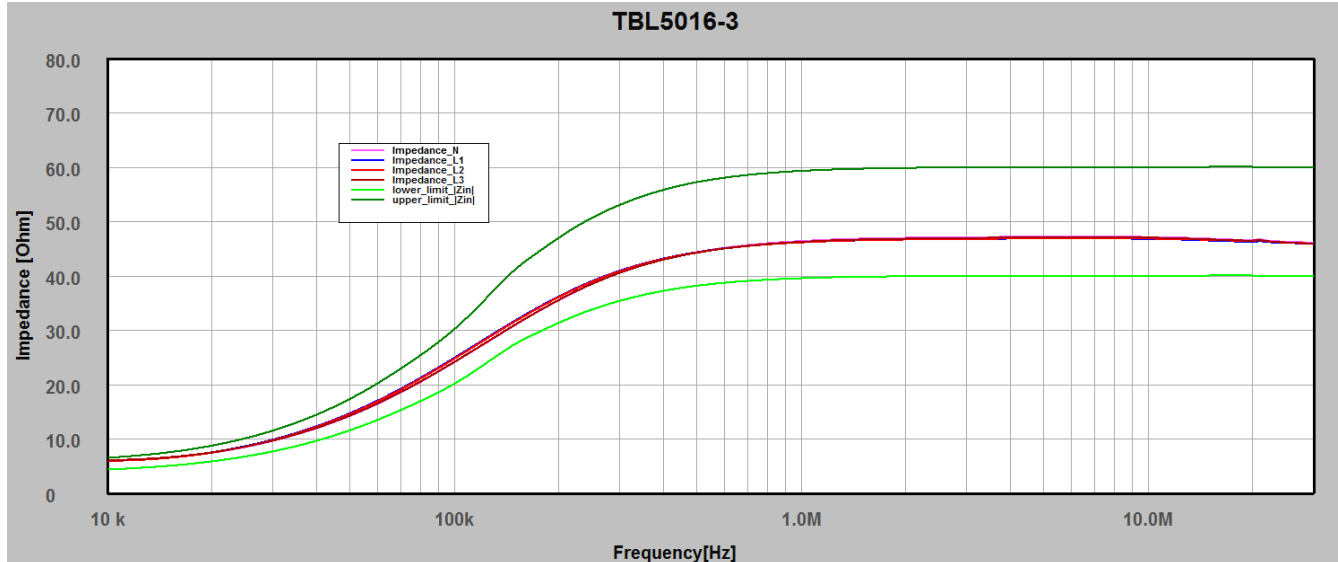


Figure 7 – Impedance vs. frequency at DUT terminals, limit lines according CISPR 16-1-2*

*) BNC connectors terminated with 50 Ohm. Impedance measured at the DUT terminals on the PCB. The wiring from DUT connector to the PCB can be considered as an additional 20 cm of DUT supply cable length.

2.8 Phase

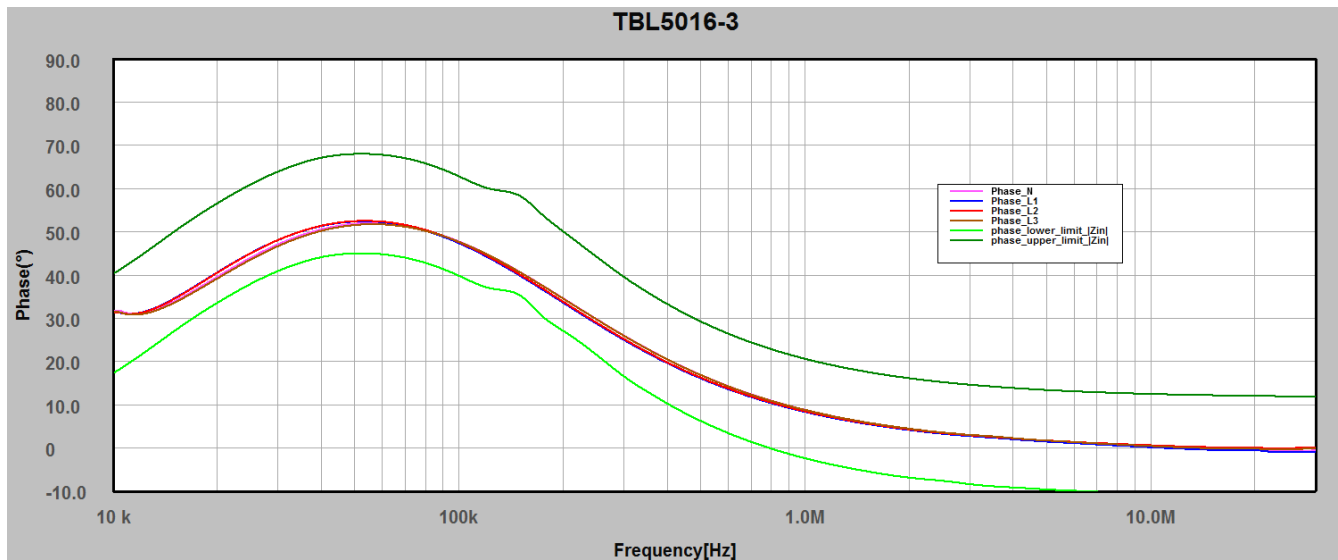


Figure 8 – Phase angle vs. frequency at DUT terminals, limit lines according CISPR 16-1-2*

*) BNC connectors terminated with 50 Ohm. Phase angle measured at the DUT terminals on the PCB. The wiring from DUT connector to the PCB can be considered as an additional 20 cm of DUT supply cable length

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2.9 Frequency response, S21 from DUT port to RF port

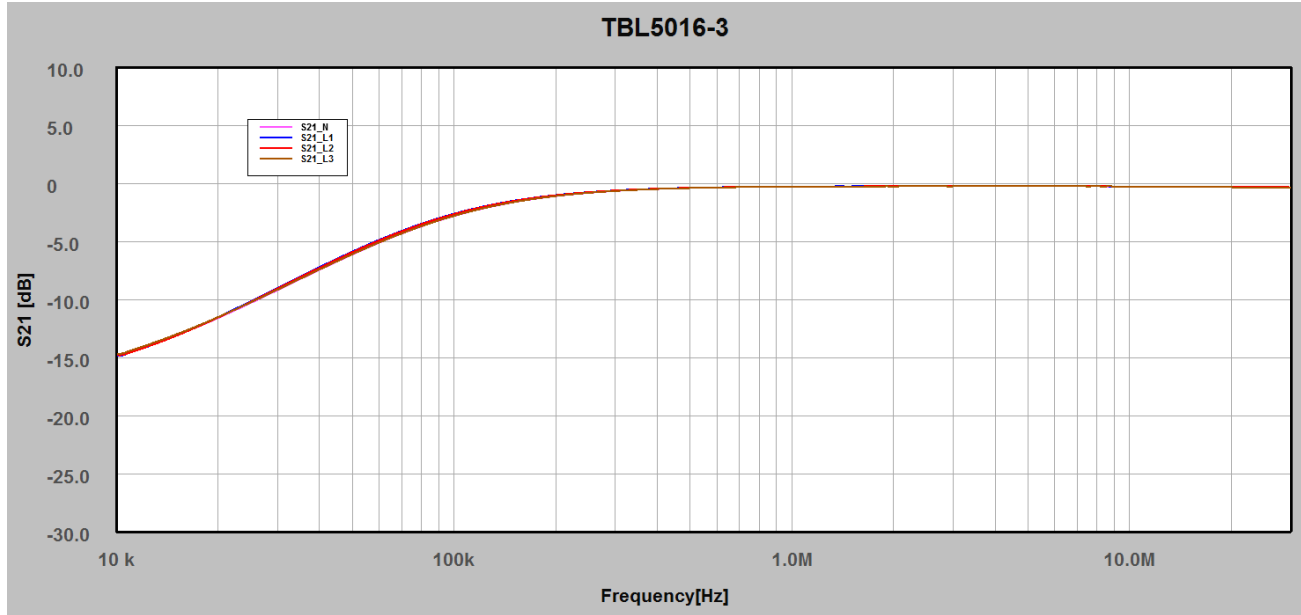


Figure 9 – Frequency response, S21, DUT terminals to BNC connector

Frequency [MHz]	Transmission Neutral / ATT_OFF [dB]
0.009	-15,76
0.015	-13.17
0.02	-11.57
0.03	-9.07
0.05	-5.93
0.07	-4.14
0.1	-2.67
0.15	-1.55
0.2	-1.11
0.3	-0.66
0.5	-0.42
0.75	-0.35
1	-0.32
1.25	-0.31
2.5	-0.30
5	-0.29
7.5	-0.30
10	-0.31
20	-0.36
30	-0.38

Table 1 – Frequency response, PCB DUT terminals to BNC, typical data

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2.10 Calibration data according to CISPR 16 -1-2 Annex A8

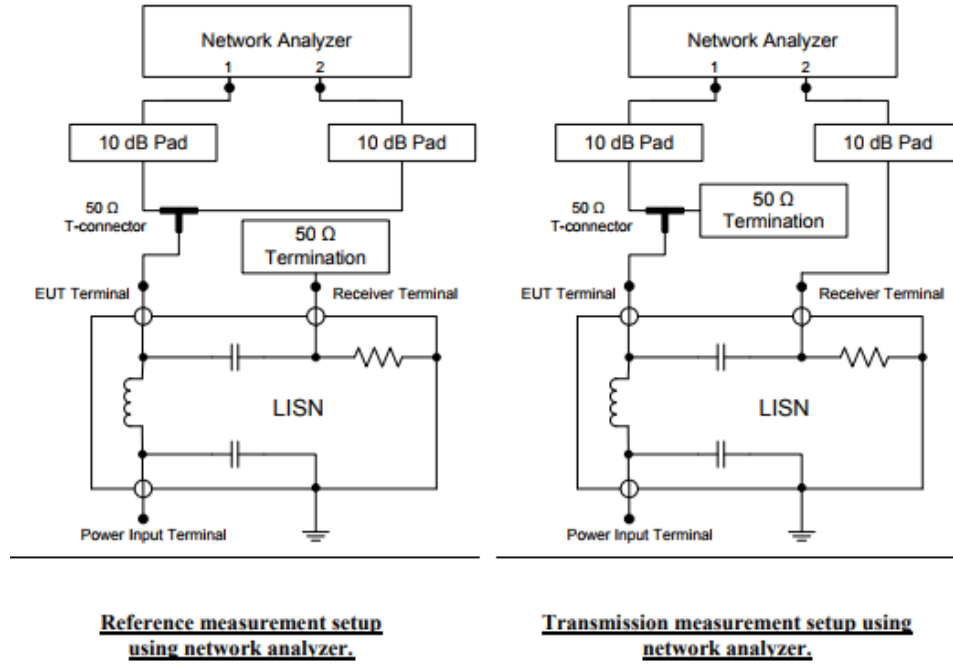


Figure 70 – Calibration set up according to CISPR 16-1-2 Annex A.8.

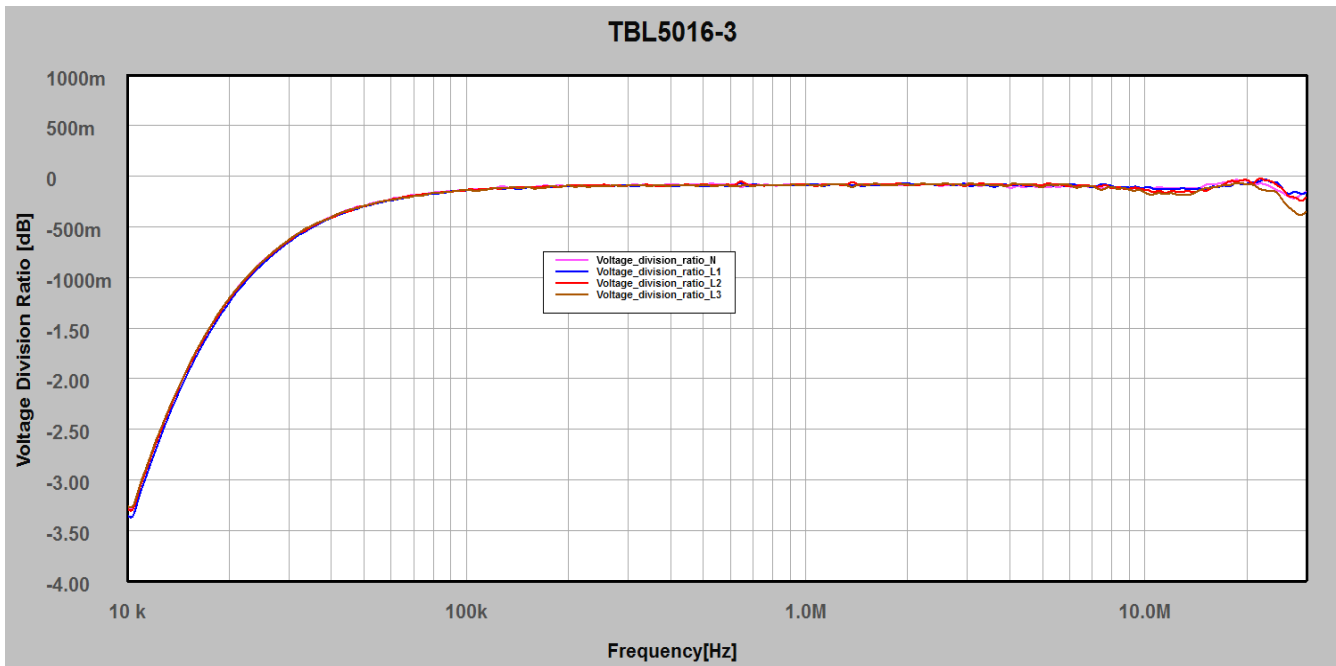


Figure 81 – Voltage Division Ratio versus frequency

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Frequency[MHz]	Typical Voltage Division Ratio [dB], L1, L2, L3, N
0.009	-3.48
0.015	-1.92
0.02	-1.21
0.03	-0.64
0.05	-0.31
0.1	-0.14
0.15	-0.11
0.2	-0.097
0.3	-0.096
0.5	-0.085
0.75	-0.091
1	-0.083
2.5	-0.095
5	-0.091
7.5	-0.11
10	-0.13
20	-0.22
30	-0.21

Table 2, TBL5016-3 LISN voltage division ratio, typical calibration data*

*) measured from DUT terminals on the PCB to BNC

2.11 Isolation

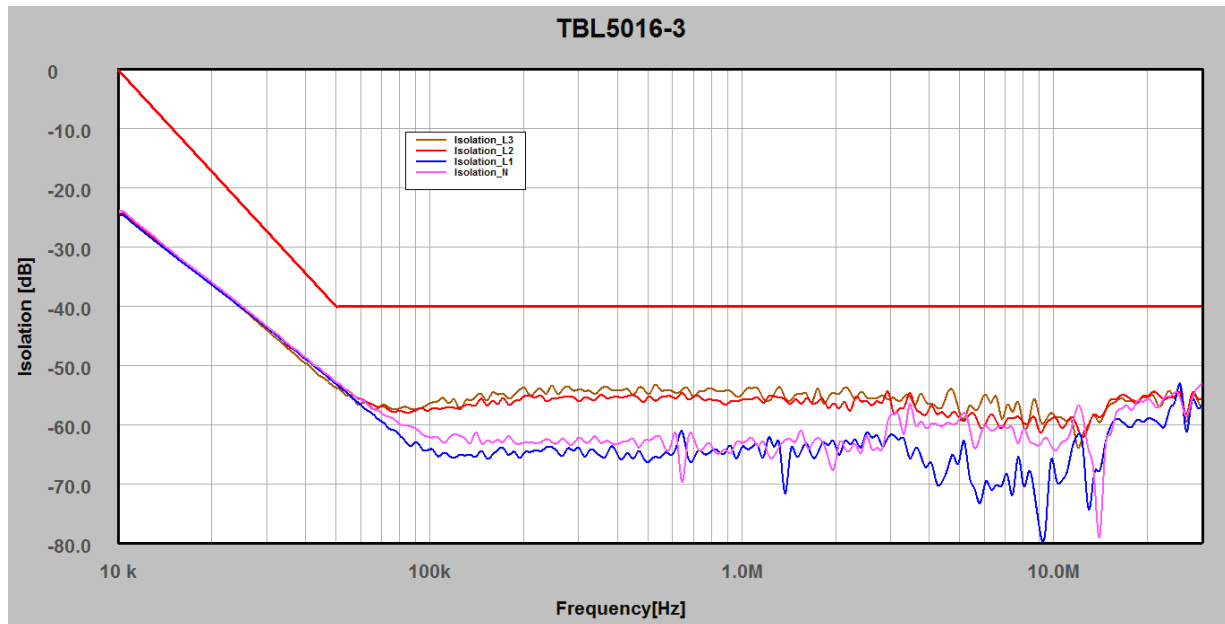


Figure 92: LISN Isolation, Source to RF out, limit line according CISPR 16-1-2

The isolation is measured between the mains (source) connector and RF port, with the DUT port terminated with 50 Ohm.

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2.12 Thermal characteristics

Avoid touching the housing, when operating the LISN at maximum current over extended time. Typical conducted noise measurements take less than 10 minutes per line. Turn off the DUT after measurements to avoid unnecessary dissipation.

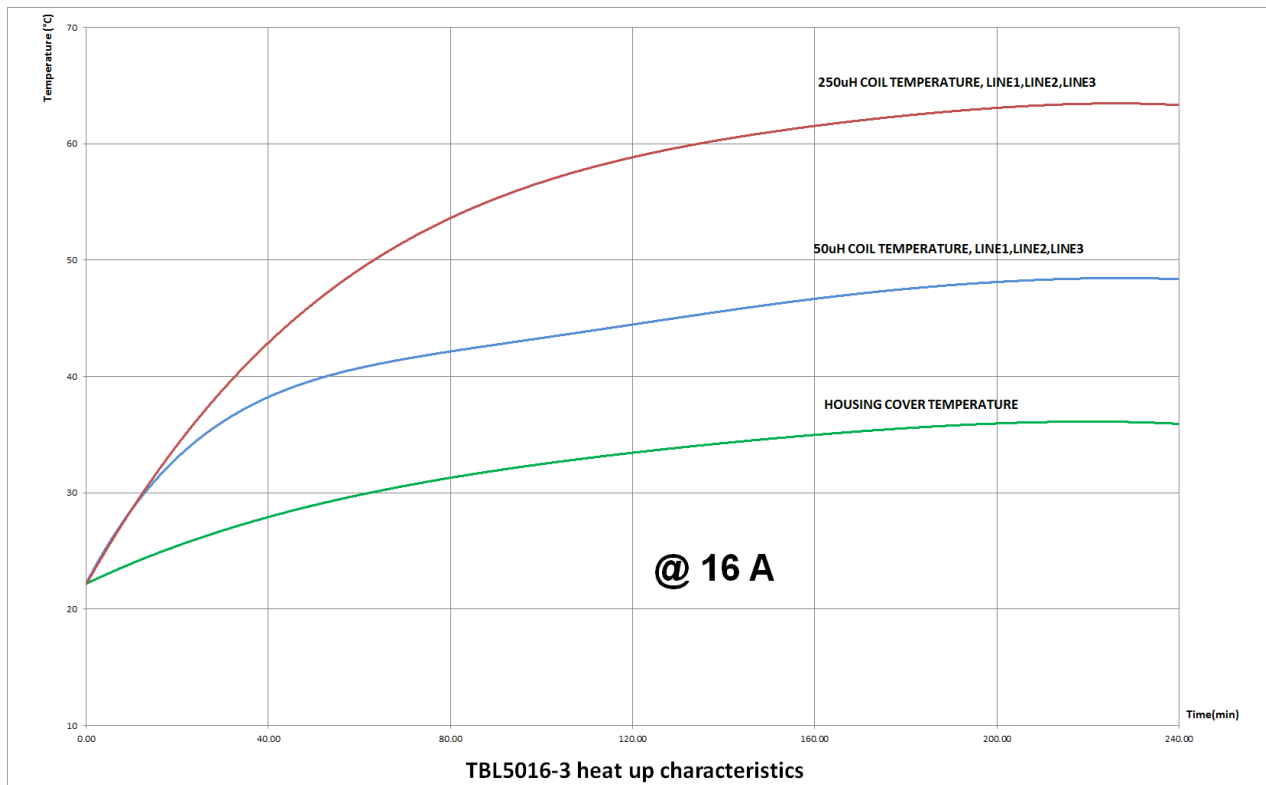


Figure 103: Coil and housing temperature at 16 A DUT current @ 22 °C ambient temperature

2.13 Protection

The TBL5016-3 offers only limited protection to prevent surges appearing at the input of the measurement receiver or analyzer.

All lines and neutral are equipped with a 275V varistor to ground. All four RF paths are protected by a 50V gas discharge tube.

Additional protection using a combined attenuator/ highpass filter / limiter at the spectrum analyzer RF input is recommended.

2.14 Artificial hand

When performing conducted noise measurements with devices which are held in hand, the artificial hand network mimics the influence of the human hand. Examples for such devices are power tools, hair driers, kitchen tools and similar equipment.

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Insulated housing sections that are touched by the hand when operating the equipment are covered with metal foil and connected to the artificial hand jack.

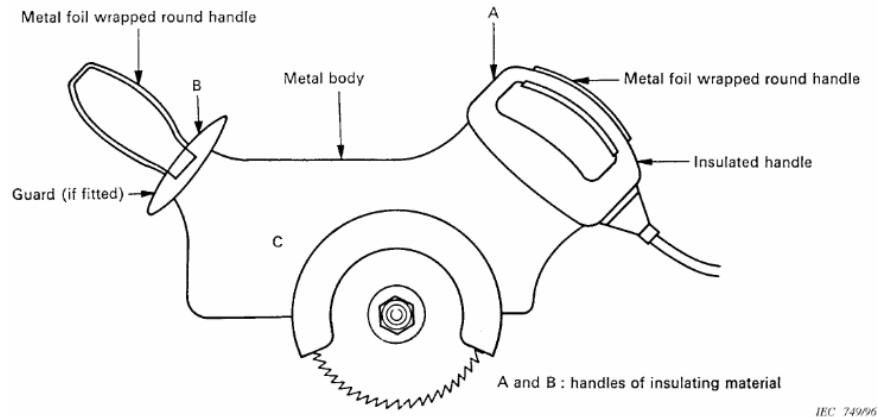


Figure 114 – Example from CISPR 16, portable electric saw with artificial hand

3 Operation checklist

- Setup the isolation transformer, TBL5016-3, DUT and spectrum analyzer according to Figure 3.
- Before powering the isolation transformer, measure the connectivity between each equipment chassis and ground plane.
- Ensure that the supply cable of the isolation transformer, the supply cable of the LISN, the supply cable of the spectrum analyzer and if applicable the supply cable of the DUT contain a ground conductor.
- Ensure, that the RF cable is not yet connected
- Ensure that the Protective Earth switch is set to direct ground position
- Ensure that a Limiter/Attenuator is attached to the RF input of the analyzer.
- Ensure that the power switch of the TBL5016-3 is in “OFF” position.
- Ensure that the DUT power switch is in “OFF” position.
- Power on the isolation transformer
- Power on the spectrum analyzer, set frequency, bandwidth, amplitude etc.
- Power on the TBL5016-3
- Power on the DUT
- Connect the RF cable to carry out the conducted noise measurements. If the conducted noise is not exceeding the analyzer input limits, remove the Limiter/Attenuator for better sensitivity and in order to avoid potential intermodulation.
- After finishing the measurement, proceed in reverse order. Take special care to disconnect the RF cable before powering off the DUT.

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4 Ordering Information

Part Number	Description
TBL5016-3 -EU	50μH LISN with Schuko socket (CE7/3, 16A), 100 cm coaxial cable BNC-male / N-male/RG223, 3 pieces BNC 50 Ohm termination
TBL5016-3 -US	50μH LISN with US socket (NEMA 5-15, grounded, type B, 15A), 100 cm coaxial cable BNC-male / N-male/RG223, 3 pieces BNC 50 Ohm termination
TBL5016-3 -AU	50μH LISN with Australian socket (AS/NZS 3112:201, 15A), 100 cm coaxial cable BNC-male / N-male/RG223, 3 pieces BNC 50 Ohm termination
TBL5016-3 -UK	50μH LISN with English socket (BS1363, 13A), 100 cm coaxial cable BNC-male / N-male/RG223, 3 pieces BNC 50 Ohm termination
TBL5016-3 -xx	Any other socket requirements upon customer request will have 2-3 weeks lead time
TBPC- IEC60309-3m TBPC- IEC60309-5m TBPC- IEC60309-10m	3-phase mains power cable, 16A, 3m, 5m or 10m length, CEE / IEC60309, 3L+N+PE, 16A, male, CEE / IEC60309, 3L+N+PE, 16A, female
TBCON-CEE-M	CEE / IEC60309, 3L+N+PE, 16A, male cable connector
TBCON-CEE-F	CEE / IEC60309, 3L+N+PE, 16A, female cable connector

Table 3– Ordering Information

Note the maximum current limitations of country specific DUT sockets. If you want to make full use of the 16A maximum current rating at the single phase output, order a TBL5016-3-EU plus a re-wirable Schuko plug which can be used to make a 16A extension cable for the DUT. Alternatively we can supply Schuko to C13 or C19 cables.

5 History

Version	Date	Author	Changes
V1.0	3.2.2022	Mayerhofer	Creation of the document
V1.1	3.2.2022	Mayerhofer	Ordering Information updated

Table 4– History