# TBL5016-2C 50µH LISN

The TBL5016-2C is a Line Impedance Stabilization Network designed to measure conducted emissions on power supply lines in the 9kHz to 30MHz frequency range, as specified by the CISPR 16-1-2 standard. The device is designed for testing single phase, AC-powered equipment with supply voltages up to maximum 250V and 16 A. Conducted noise can be measured on the phase and on the neutral conductor. The TBL5016-2C features a line selector switch, a switchable limiter / highpass filter / attenuator, a PE switch to mimic extension cables and an artificial hand connection.
The device is available with country-specific EUT connectors.




TBL5016-2C, variant with Schuko connector (CEE 7/3) socket

## Features

- Frequency range: 9 kHz to 30 MHz
- Impedance: 50 Ω ‖ (50 µH + 5 Ω)
- Artificial hand: 220 pF + 511 Ω
- Switchable PE: 50 Ω ‖ 50 µH
- Limiter / attenuator / highpass filter: +6dBm / 10 dB /150 kHz to 30 MHz
- Air core inductors
- Line voltage: max. 250V / 50/ 60 Hz or DC
- Max. current: 16 A @ 23°C
- EUT socket: country specific
- Measurement connector: 50 Ω BNC
- Power connector: IEC 60320 C19
- Operating Temperature Range: +5°C … + 40°C; 5% to 80% RH

## Application

- EMC conducted emission measurements

# TBL5016-2C 50µH AC-LISN

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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. The ground brackets must be securely connected to the protective earth conductor available on site, before making any other electrical connection. This connection must not be separated, until the mains supply is disconnected from the LISN setup.

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 TBL5016-2C.

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 EUT after measurements to avoid unnecessary dissipation.

# TBL5016-2C 50µH AC-LISN

## 1 Introduction

### 1.1 Pre-compliance testing of conducted emissions

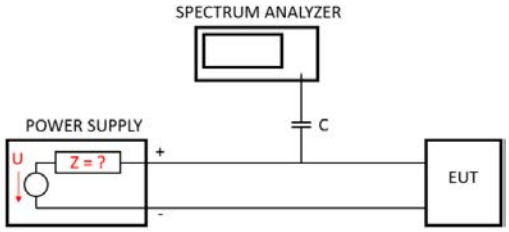
Full compliance measurement of AC mains supplied products requires a high end set up consisting of a screened chamber, a measurement receiver that complies with the requirements of CISPR 16, a 50µH LISN and a suitable table for the measurement setup. Great effort and cost ensure optimum accuracy and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

Pre-compliance measurements aim to characterize the Equipment Under Test's EMC performance for a fraction of the expense of full compliance testing. The availability of low-cost spectrum analyzers with EMI IF filters and Quasi-Peak detectors makes EMC pre-compliance testing feasible to any company that develops electronic products. Together with affordable test equipment 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.

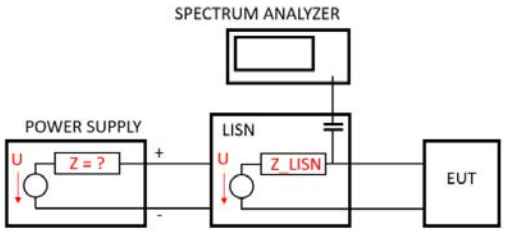
### 1.2 Line Impedance Stabilization Networks

**Principle of conducted emission measurements:**




Emissions are measured by capacitively coupling to supply lines. The EUT's supply port impedance and the power supply's source impedance interact as a voltage divider for RF emissions on the supply line. Power supply source impedances are rarely specified; therefore, the results of emission measurements vary amongst power supplies.

**What is the purpose of LISNs?**




- The LISN acts as a coupler for RF on supply lines
- The LISN establishes a defined source impedance, enabling repeatable measurements
- The LISN attenuates noise coming from the supply towards the receiver/analyzer and EUT

# TBL5016-2C 50µH AC-LISN

## 1.3 RF output

The RF output section is AC-coupled to either the phase or neutral line. The path is selected using a rotary switch on the front panel. The RF section also features a combined switchable attenuator, limiter and high pass filter.

The TBL5016-2C offers several levels of protection to prevent surges appearing at the input of the measurement receiver or analyzer.

Both the neutral line and phase line are equipped with a 275V varistor to ground. The RF path is always protected by a 50V gas discharge tube.

When the attenuator/limiter switch is in “ON” position, a 10dB attenuator and a Schottky diode limiter offer additional protection. Furthermore, the attenuator/limiter path contains a 150kHz high pass filter.

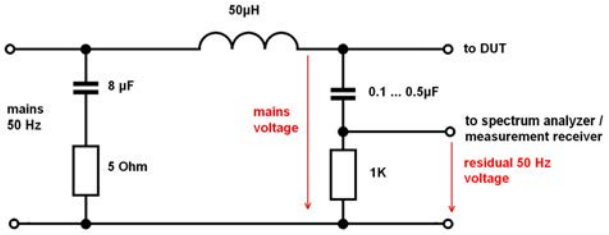
Be aware that the residual 50 Hz voltage in the “attenuator OFF” position depends on the value of the input impedance of the spectrum analyzer / measurement receiver at 50 Hz. If the measurement device has a high impedance at 50 Hz, the residual 50 Hz voltage may be relatively high. Use an external highpass filter to suppress high amplitude / low frequency emissions and the residual 50 Hz voltage in order to prevent damage of the RF input.

The objective of the unprotected output is using external protection, if you suspect that the internal limiter or high pass filter is creating nonlinear distortions.

If the internal attenuator is turned off, is strongly advised to always employ external protection, such as attenuators or combined attenuators/limiters as the TBFL1 and/or high pass filters. Remove external protection only if you need to extend the dynamic range of the measurement and are confident that the EUT emissions do not exceed your spectrum analyzer's maximum input ratings. Be cautious that such emissions may go unnoticed if you do not monitor the frequency band below 150 kHz or 9 kHz.

**Understanding residual 50 Hz voltage at the RF output of LISN:**

The image below depicts the basic circuit diagram of an AC LISN:




The full AC mains voltage is present at the DUT terminals of the LISN. The RF coupling capacitor and the 1K resistor form a voltage divider that determines the amplitude of the 50 Hz voltage at the RF connector.

Consider a 0.1 µF capacitor with an impedance of 32K at 50 Hz in series with a 1K resistor. In the absence of a load, the 50 Hz voltage at the LISN's RF terminal is roughly 6.6V. Assuming a 50 Ohm load in parallel with the 1K resistor, the remaining 50 Hz voltage would be negligible.

Most LISN implement a higher capacitance value in order to meet standards at lower frequencies. Assuming a 0.5µF capacitor, the residual 50 Hz voltage at the LISN's RF terminal might reach 31V. If a 50 Ohm load is connected in parallel to the 1K resistor, this value will be lowered to insignificant.

However, a low-cost analyzer is unlikely to have an input impedance of 50 ohms at 50 Hz. For frequencies lower than 9 kHz, the input impedance is rarely specified. Furthermore, low-cost analyzers incorporate GaAs switches at the RF input, which are inherently sensitive at low frequencies.

Consequently, if the internal protection is turned off, consider inserting external 9 kHz or 150 kHz high pass filters at the RF input of a spectrum analyzer / measurement receiver to provide protection against residual 50

Hz voltage. Low insertion loss in the pass band ensures that the measurement's dynamic range is not reduced. Tekbox supplies various high pass filters for this purpose.

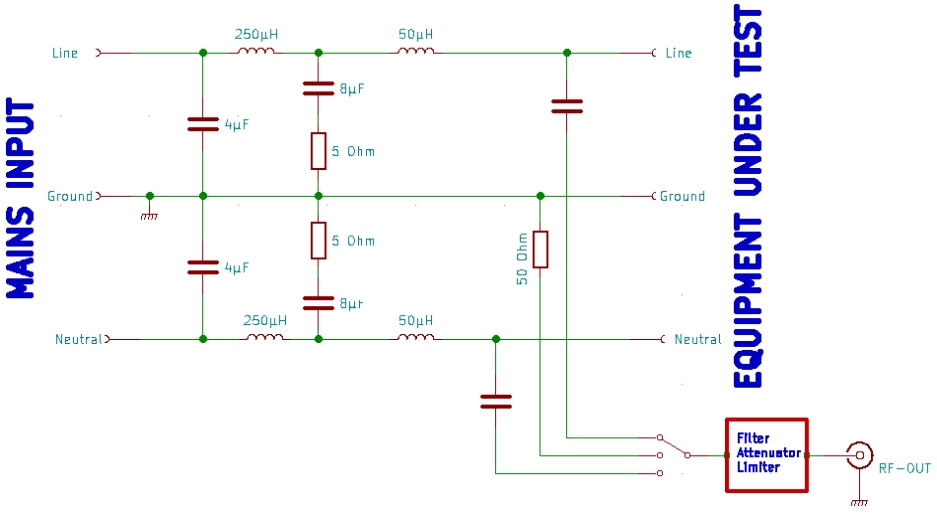
**Warning:**

Unlike oscilloscopes, spectrum analyzers' RF inputs commonly offer no protection against high amplitude spurious or transients. Maximum input ratings typically vary from +20 to +30 dBm.

To protect the spectrum analyzer RF input from transients, unplug the coaxial cable when turning on/off the EUT. Use external attenuators or an attenuator/limiter/ high pass filter device such as the TBFL1 to examine the lower frequency range for spurious signals with high amplitude until you are certain, that the spurious levels do not exceed the spectrum analyzer ´s maximum input ratings. As the limiter is a non-linear component, high amplitude spurious can create intermodulation and falsify the measurement result. Use external attenuators instead, if you suspect that the limiter is causing non-linear distortions.

## 1.4 Informative schematic

The picture below shows the basic topology and the values of the main components of the TBL5016-2C LISN. A rotary line selector switch connects the RF output to either Line, Ground or Neutral. A combined 10dB attenuator / 150 kHz highpass filter / limiter can be inserted into the RF path with another rotary switch.




*50 Ω // (50µH + 5 Ω) LISN, informative schematic*

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

## 1.5 PE Switch

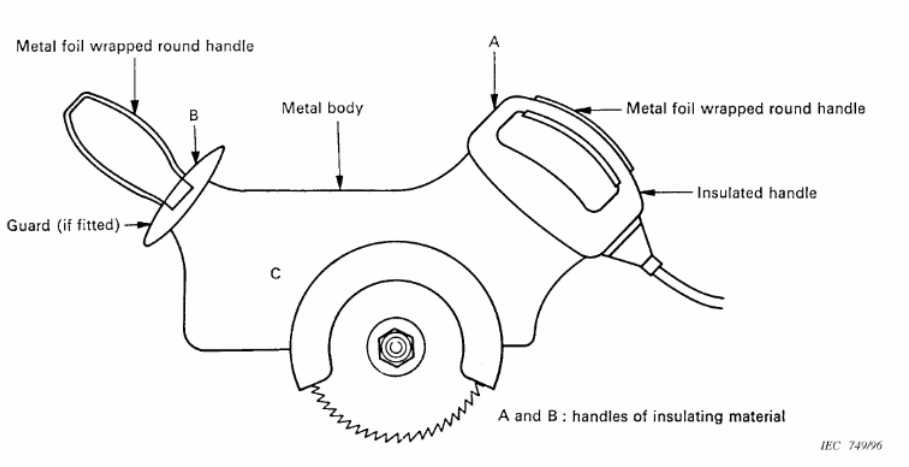
The protective earth switch connects the earth pin of the EUT socket either directly to LISN ground or in series with a parallel combination of a 50 µH choke and a 50 Ohm resistor.

Engaging the 50 µH choke // 50 Ohm resistor network decouples the protective earth of the EUT RF-wise from the protective earth of the LISN. This way, the effect of long extension cords on the EUT's EMC suppression circuitry can be tested.

## 1.6 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.

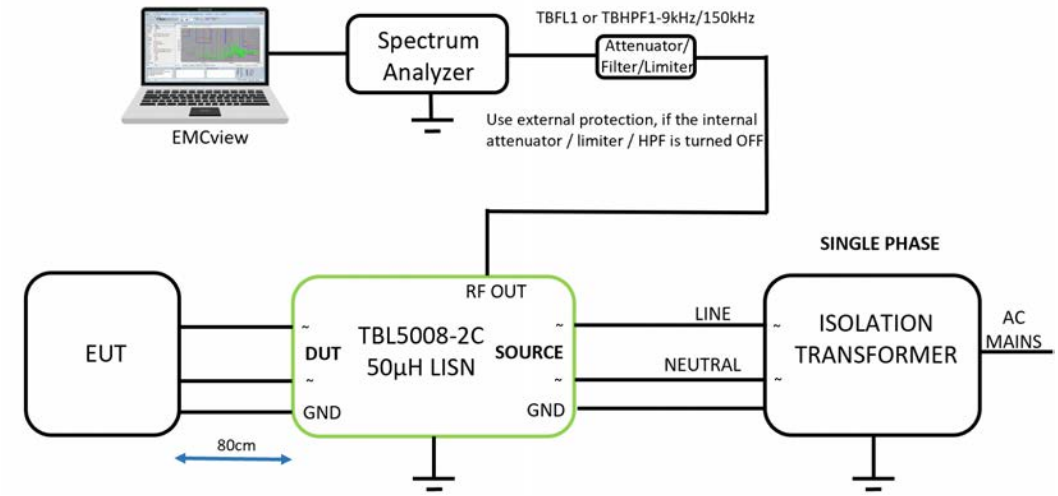
Insulated housing sections that are touched by the hand when operating the equipment are covered with metal foil and connected to the artificial hand jack.




*Example from CISPR 16, portable electric saw with artificial hand*

# 2 Laboratory set up

# TBL5016-2C 50µH AC-LISN




*Basic wiring diagram for conducted emission measurements*

A typical setup places the LISN on an 80 cm-high wooden table. The groundplane is positioned both on the wall and on the floor. The EUT is placed on the table, 40 cm in front of the groundplane on the wall. The LISN is placed on the groundplane on the floor.

For the detailed setup, follow the drawings and specifications in the applicable standard.

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

## 2.1 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 referring to the ground plane and the arrangement of the equipment and interconnecting cables are described in the applicable standards.

In a pre-compliance test setup, there may not always be enough space to install permanent ground planes.

Tekbox provides roll-up ground planes from conducted fabrics that can be setup temporarily and removed and stored easily.

## 2.2 Pre-compliance setup with roll-up ground plane

The TBGP-250/140-B roll-up ground plane consists of a conductive fabric bonded to a fleece. The ground plane is 250 cm long and 140 cm wide.

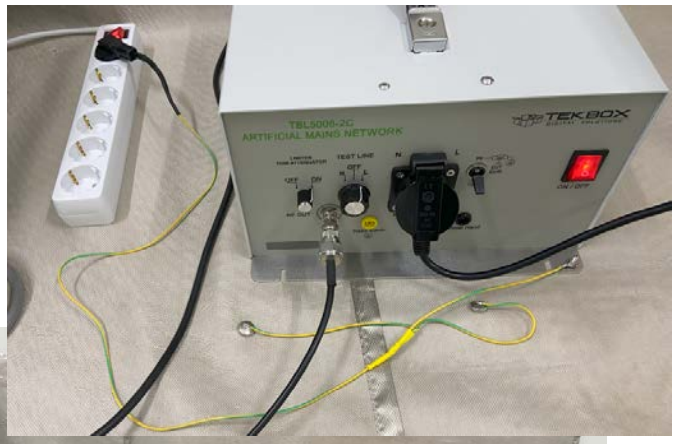


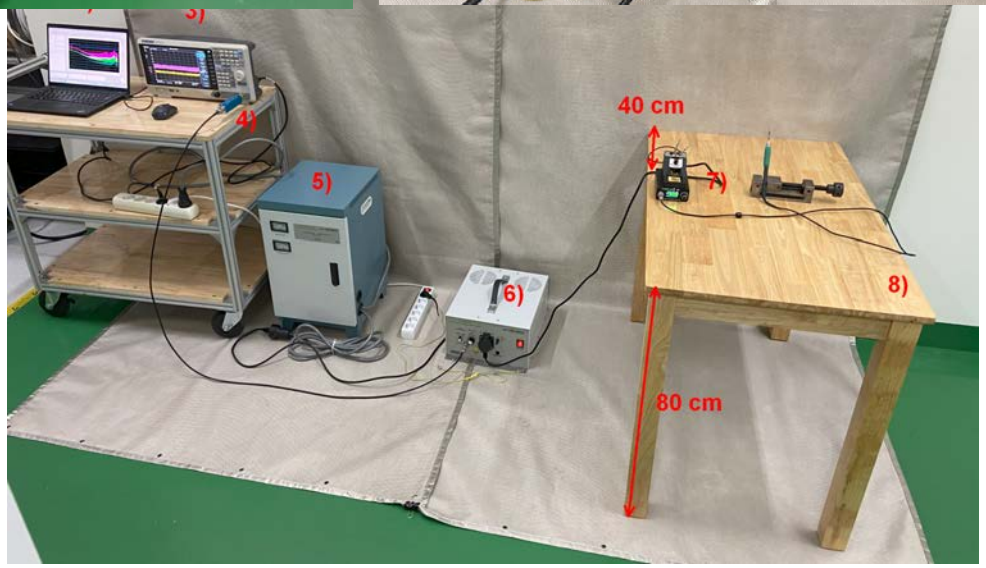


# TBL5016-2C 50µH AC-LISN

The ground plane has eyelets on both short sides for convenient storage and deployment. Metal spring clamps or fabric rivets can be used to connect Earth.






Example pre-compliance set up:

1) roll-up ground planes
2) PC, EMCview software
3) spectrum analyzer
4) TBFL1 transient limiter
5) isolation transformer
6) LISN
7) EUT
8) wooden table

## 3 Operation checklist

- Setup the isolation transformer, TBL5016-2C, EUT and spectrum analyzer according to chapter 1.5.
- 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 EUT contain a ground conductor.
- Ensure that the Protective Earth switch is set to direct ground position unless you want to simulate an extension cable.
- Ensure that the line selection switch is set to “0” and the internal attenuator to “ON”
- Ensure that the power switch of the TBL5016-2C is in “OFF” position.
- Ensure that the EUT power switch is in “OFF” position.
- Power on the isolation transformer
- Power on the spectrum analyzer, set frequency, bandwidth, amplitude etc.
- Power on the TBL5016-2C and then power on the EUT
- Set the line selection switch to phase or neutral and carry out the conducted noise measurements.

After finishing the measurement, proceed in reverse order. Take special care to set the line selection switch to “0” or to disconnect the RF cable before powering on/off the EUT.

# 4 TBL5016-2C specifications

## 4.1 Conformity

The TBL5016-2C is compliant with CISPR 16-1-2.

In line with the CISPR 16-1-2 standard compliant design and setup specification, the TBL5016-2C V-LISN exhibits high ground leakage currents and non-standard isolation and consequently cannot meet the safety requirements of EN 61010-1.

Furthermore CISPR 16-1-2 specifies high capacitance values for the capacitors from Line and from Neutral to Ground (PE). These capacitance values are not commercially available in Y2 rating and are implemented using AC rated capacitors with suitable voltage rating.

In order to prevent the danger of lethal electric shock, the operator is responsible for ensuring protective measures in line with IEC 60364-4-41 and IEC 60364-5-54 and to follow all safety related information of this manual.

## 4.2 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, EUT socket, yellow banana receptacle and with the ground strap of the housing. It is not allowed to carry out any modifications or manipulations of the TBL5016-2C. The TBL5016-2C shall be operated by qualified laboratory staff only.

## 4.3 Specifications

- Frequency range: 9 kHz to 30 MHz
- Impedance: 50 Ω ‖ (50 µH + 5 Ω)

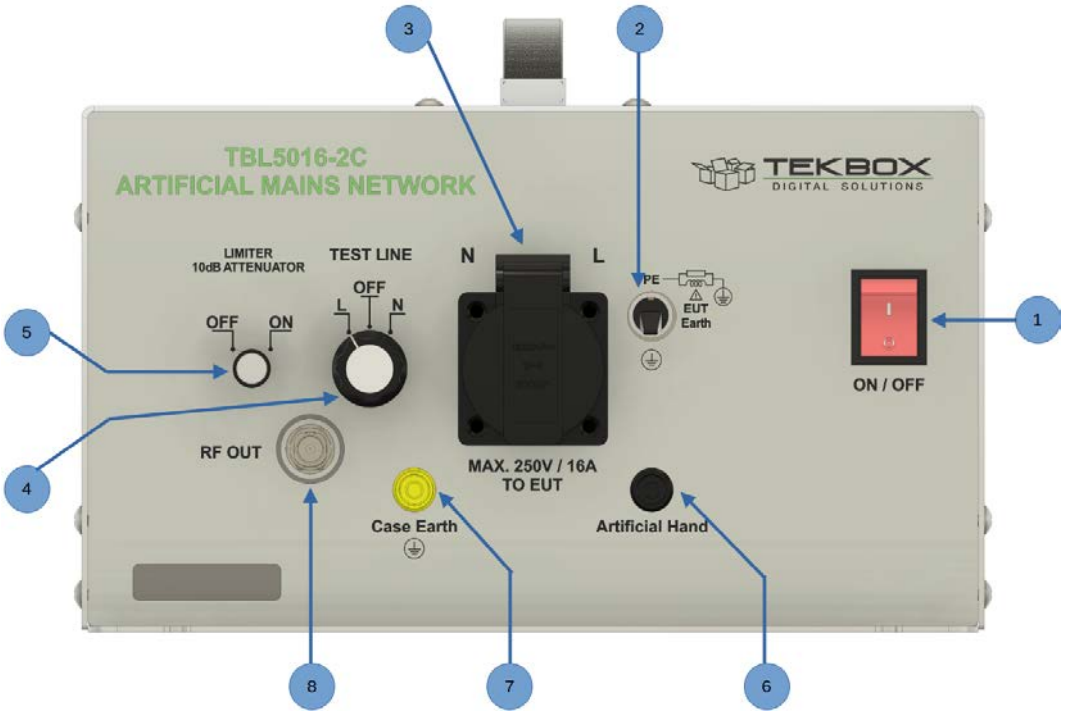
- Artificial hand: 220 pF + 511 Ω
- Switchable PE: 50 Ω ‖ 50 µH; simulates effects of extension cable drums for power tools
- Attenuator / Highpass Filter / Limiter: 10 dB / +6 dBm / 150 kHz to 30 MHz
- Maximum voltage: max. 250V / 50 – 60 Hz or DC
- Max. current: 16 A @ 23°C; Fuses: 16 A, slow
- EUT socket: country specific, note country specific EUT socket limits (see chapter 4)
- Measurement connector: 50 Ω BNC
- Power connector: IEC 60320 C19; Fuses: 16 A, slow
- Operating Temperature Range: +5°C … + 40°C; 5% to 80% RH
- Chassis grounding: protruding, stainless steel bottom panel, with 4mm mounting slots and holes
- Weight and dimensions: 10.2 kg; W x H x L – 35 cm x 18 cm x 41 cm

## 4.4 Supply voltage

The TBL5016-2C does not require any particular voltage settings. It can be operated with any supply voltage which does not exceed 250V, 50Hz/60Hz. It can also be used for DC powered EUTs

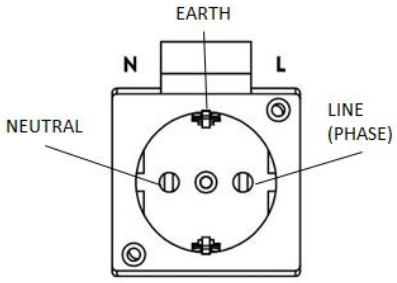
# TBL5016-2C 50µH AC-LISN

## 4.5 Front Panel




*Front panel layout*

1) Mains switch
2) Protective Earth switch to connect EUT earth either directly to case earth, or via 50µH ‖ 50 Ohm; simulates extension cable drums
3) EUT socket, country specific
4) RF path selection, N (neutral), OFF, L (phase)
5) Limiter + 10 dB attenuator + 150kHz high pass filter switch
6) Auxiliary case earth connector, safety banana jack
7) Artificial hand connector, safety banana jack
8) 50 Ω RF output, BNC jack

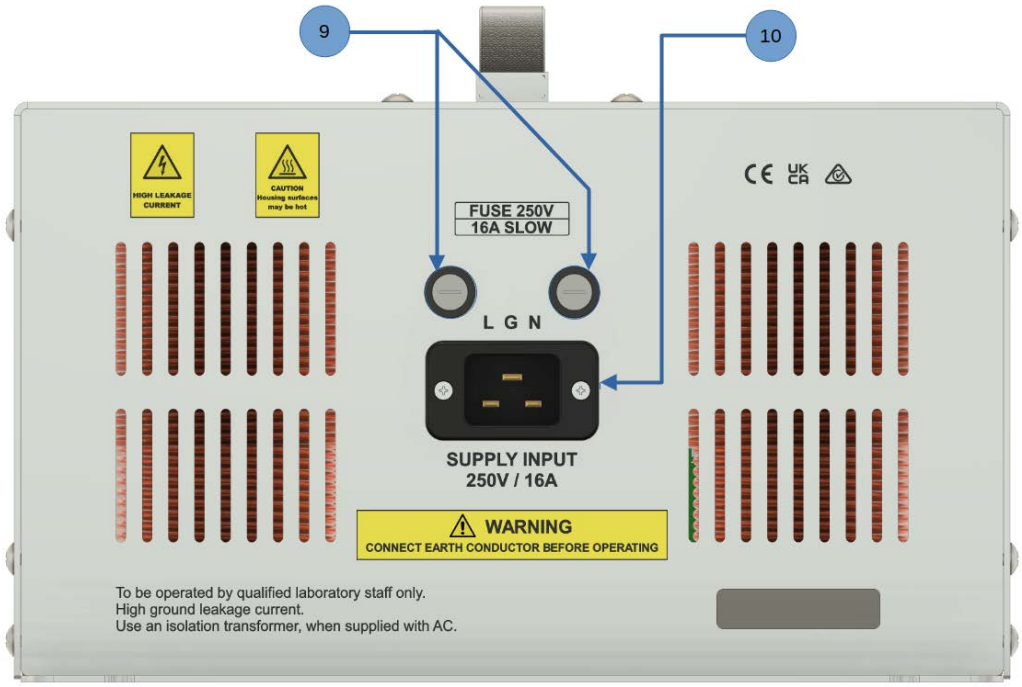



*EUT connector, pin assignment with reference to the rear power connector *)*

# TBL5016-2C 50µH AC-LISN

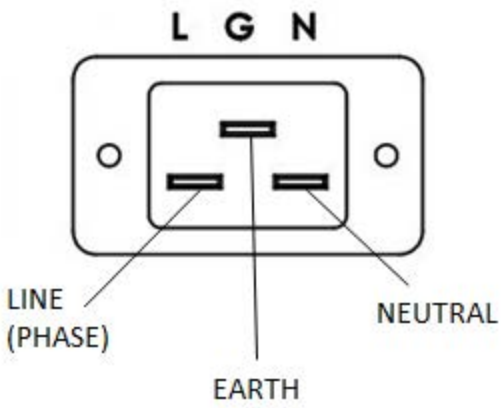
*) For Schuko sockets: depends on the orientation of the cable connected to the mains power outlet

## 4.6 Rear Panel




*Rear panel layout*

9) Fuses, 16 A, slow
10) Power socket: IEC 60320 C19

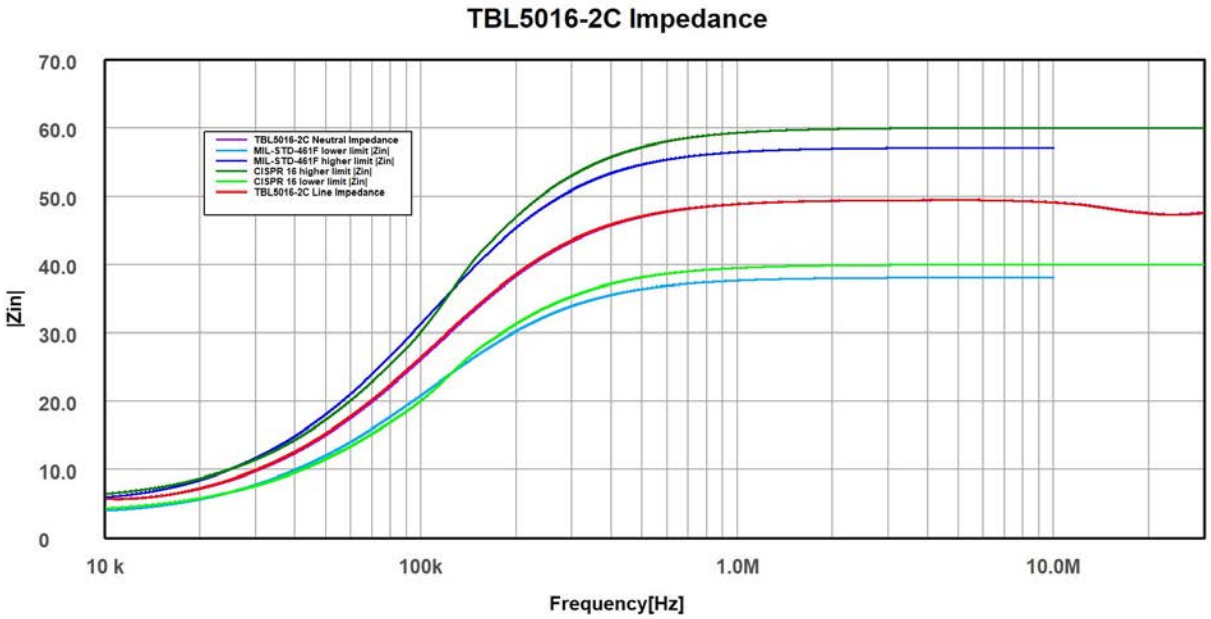



*Mains connector, pin assignment *)*

# TBL5016-2C 50µH AC-LISN

*) For Schuko connectors: Depends on the orientation of the plug with respect to the mains power outlet

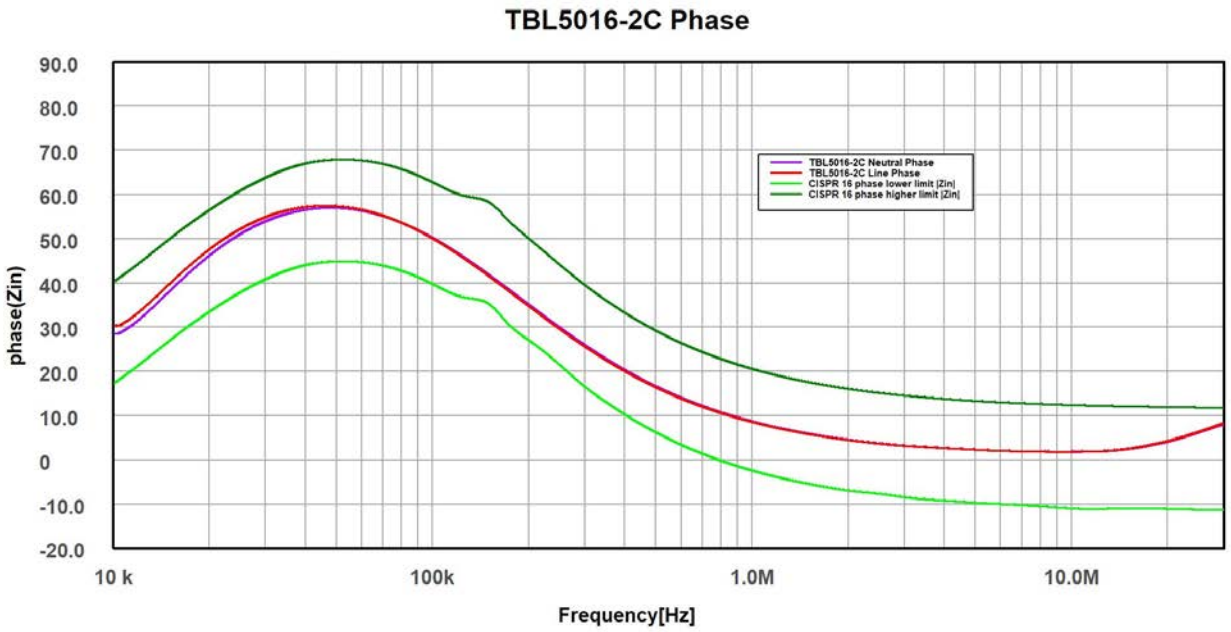
## 4.7 Impedance




*Impedance vs. frequency at EUT terminals*

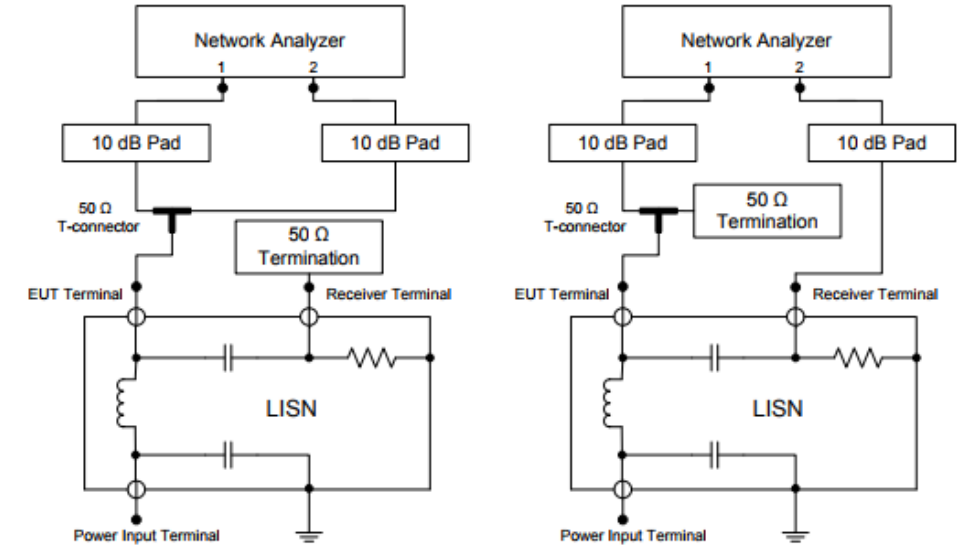
# TBL5016-2C 50µH AC-LISN

## 4.8 Phase




*Phase angle vs. frequency at EUT terminals*

## 4.9 Calibration data according to CISPR 16 -1-2 Annex A8

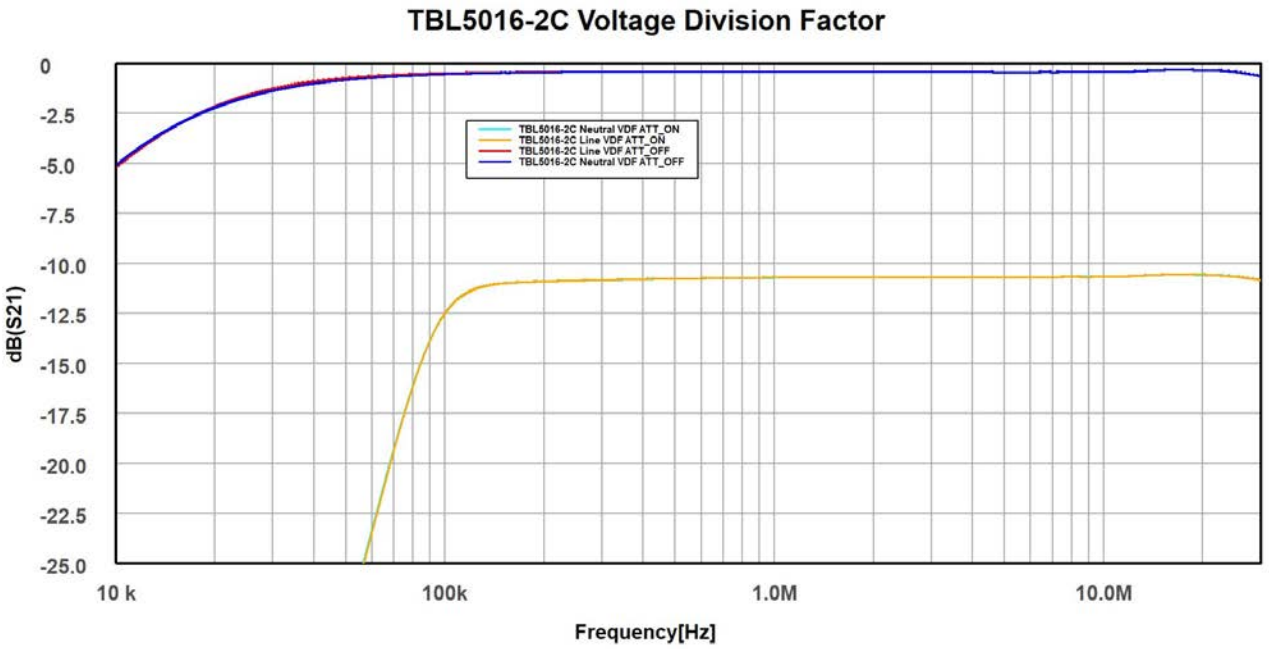



**Reference measurement setup using network analyzer.**

**Transmission measurement setup using network analyzer.**

# TBL5016-2C 50µH AC-LISN

*Calibration set up according to CISPR 16-1-2 Annex A.8.*



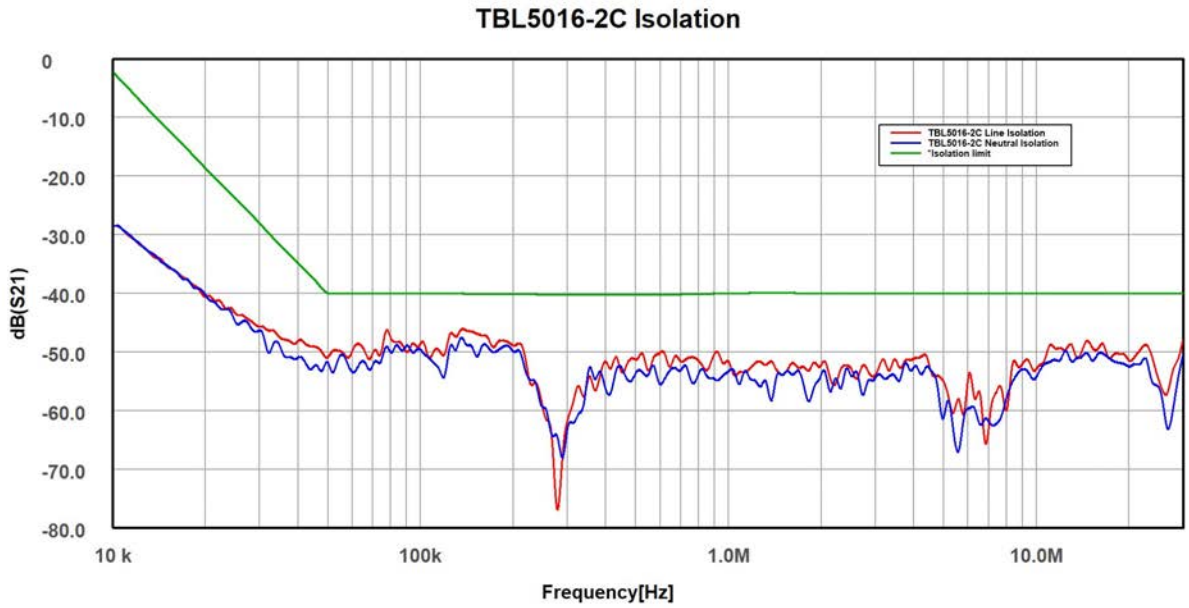

*Voltage Division Ratio versus frequency, for Attenuator / Limiter / HPF "ON" and "OFF"*

| | Attenuator / Limiter / High Pass Filter OFF | | Attenuator / Limiter / High Pass Filter ON | |
|---|---|---|---|---|
| **Frequency [MHz]** | **VDR Line [dB]** | **VDR Neutral [dB]** | **VDR Line [dB]** | **VDR Neutral [dB]** |
| 0.009 | -5,85 | -5,80 | -49,28 | -49,81 |
| 0.015 | -3,19 | -3,16 | -49,98 | -49,75 |
| 0.02 | -2,17 | -2,22 | -49,47 | -48,52 |
| 0.03 | -1,27 | -1,37 | -41,76 | -41,18 |
| 0.05 | -0,73 | -0,83 | -28,48 | -28,28 |
| 0.075 | -0,55 | -0,63 | -17,59 | -17,53 |
| 0.1 | -0,49 | -0,54 | -12,51 | -12,49 |
| 0.15 | -0,45 | -0,48 | -10,99 | -10,99 |
| 0.2 | -0,43 | -0,45 | -10,90 | -10,91 |
| 0.3 | -0,42 | -0,43 | -10,83 | -10,84 |
| 0.5 | -0,42 | -0,42 | -10,76 | -10,77 |
| 0.75 | -0,42 | -0,42 | -10,73 | -10,73 |
| 1 | -0,42 | -0,42 | -10,71 | -10,71 |
| 1.25 | -0,42 | -0,42 | -10,70 | -10,70 |
| 2.5 | -0,43 | -0,44 | -10,69 | -10,69 |
| 5 | -0,45 | -0,45 | -10,69 | -10,69 |
| 7.5 | -0,44 | -0,44 | -10,68 | -10,68 |
| 10 | -0,42 | -0,42 | -10,67 | -10,67 |
| 20 | -0,34 | -0,34 | -10,58 | -10,58 |
| 30 | -0,65 | -0,64 | -10,85 | -10,85 |

*Table 1, TBL5016-2C LISN voltage division ratio*

# TBL5016-2C 50µH AC-LISN

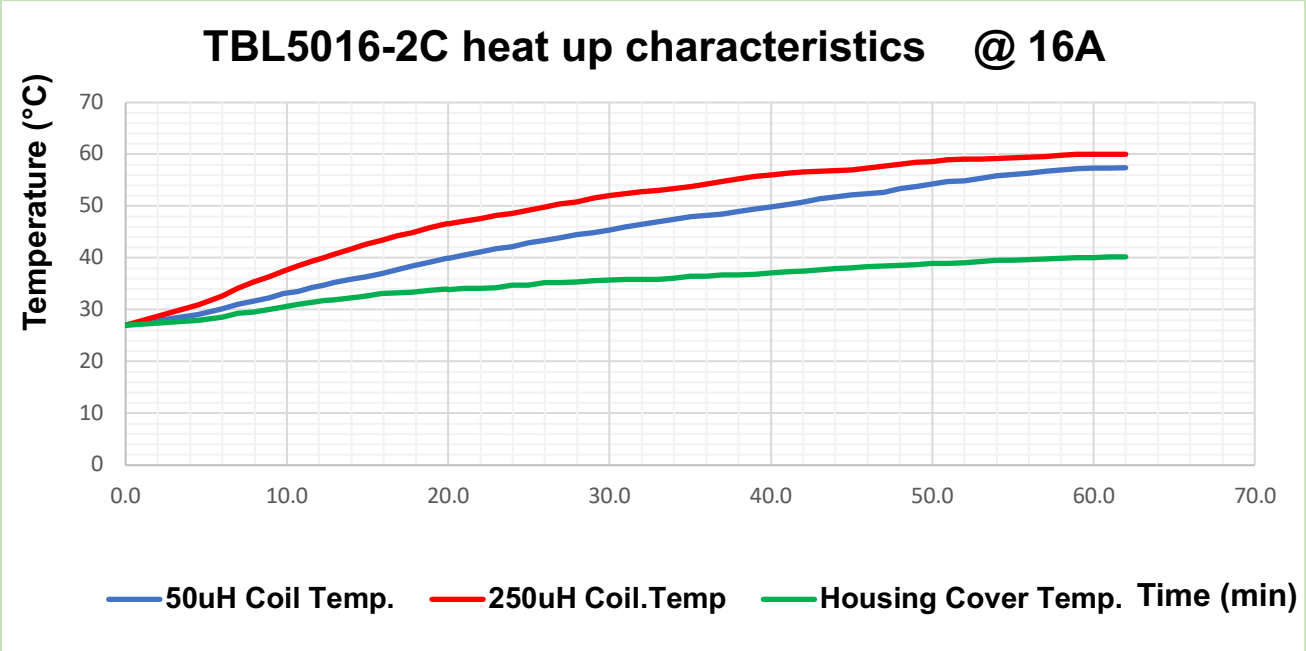
## 4.10 Isolation




*LISN Isolation, Source to RF out*

## 4.11 Thermal characteristics

Avoid touching the housing, when operating the LISN at maximum current over extended time. Turn off the EUT after measurements to avoid unnecessary dissipation.




*Coil and housing temperature at 16 A EUT current @ 27 °C ambient temperature*

## 5 Ordering Information

| Part Number | Description |
|---|---|
| TBL5016-2C-EU | 50µH LISN with Schuko socket (CE7/3, 16 A), 16 A cold appliance cable, 75 cm coaxial cable BNC-male / N-male/RG223 |
| TBL5016-2C-US | 50µH LISN with US socket (NEMA 5-15, grounded, type B, 15A), 15A cold appliance cable, 75 cm coaxial cable BNC-male / N-male/RG223 |
| TBL5016-2C-AU | 50µH LISN with Australian socket (AS/NZS 3112:201, 15A), 15A cold appliance cable, 75 cm coaxial cable BNC-male / N-male/RG223 |
| TBL5016-2C-UK | 50µH LISN with English socket (BS1363, 13A), 16 A cold appliance cable, 75 cm coaxial cable BNC-male / N-male/RG223 |
| TBL5016-2C-xx | Any other socket requirements upon customer request will have 3-4 weeks lead time |

*Table 2– LISN Ordering Information*

Note the maximum current limitations of country specific EUT sockets and cold appliance cables. If you want to make full use of the 16 A maximum current rating, order a TBL5016-2-EU plus a rewirable Schuko plug which can be used to make a 16 A extension cable for the EUT.

**LISN Accessories**

| Part Number | Description |
|---|---|

# TBL5016-2C 50µH AC-LISN

| | |
|---|---|
| TBSP-16-Schuko | Rewirable 16 A Schuko (CEE 7/4) plug for extension cables |
| TBLCAC-16-*EU* | Additional cold appliance cable, 16 A, 1.8m, C19 to country specific ( *-EU/US/UK/AU* ) |
| TBLCAL - EU | Calibration adapters SMA-F-CE7/3 Neutral + SMA-F-CE7/3 Line |
| TBLCAL - US | Calibration adapters SMA-F-NEMA 5-15 Neutral + SMA-F- NEMA 5-15 Line |
| TBLCAL - AU | Calibration adapters SMA-F-AS/NZS 3112:201 Neutral + SMA-F-AS/NZS 3112:201 Line |
| TBLCAL - UK | Calibration adapters SMA-F- BS1363 Neutral + SMA-F- BS1363 Line |

**Protection accessories**

| **Part Number** | **Description** |
|---|---|
| TBFL1 | External 10 dB attenuator / Limiter / High Pass Filter |
| TBAS1 | 3, 6, 10, 20dB attenuator set, N-Male / N-Female, 2 W, DC – 3 GHz |
| TBAS4 | 3, 6, 10, 20dB attenuator set, N-Male / N-Female, 2 W, DC – 6 GHz |
| TBHPF1-9kHz-B | External 9 kHz High Pass Filter |
| TBHPF1-150kHz-B | External 150 kHz High Pass Filter |
| TBHPF2-150kHz | External 150 kHz High Pass Filter |
| TBHPF3-150kHz | External 150 kHz High Pass Filter |

**Other Accessories**

| **Part Number** | **Description** |
|---|---|
| TBGP-250/140 | Roll Up Ground Plane, 250 cm x 140 cm |
| TBMR-110M | Measurement Receiver, DC – 110 MHz |

## 6 History

| Version | Date | Author | Changes |
|---|---|---|---|
| V1.0 | 3.2.2025 | Mayerhofer | Creation of the document |
| V1.1 | 10.3.2025 | Mayerhofer | Chapter 5 updated |

*Table 3– History*

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