

R&S[®]ESH3-Z6

V-Network 5 μ H / 50 Ω

Manual



1178993202

This document describes the R&S®ESH3-Z6.

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1178.9932.02 | Version 01 | R&S®ESH3-Z6

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol , e.g. R&S®ESH3-Z6 is indicated as R&S ESH3-Z6.

1 Safety Instructions for LISNs

Products from the Rohde & Schwarz group of companies are manufactured according to the highest technical standards. To use the products safely, follow the instructions provided here and in the product documentation. Keep the product documentation nearby and offer it to other users.

Use the LISN only for its intended use and within its performance limits. Intended use and limits are described in the product documentation such as the data sheet, manuals and the safety instructions brochure. If you are unsure about the appropriate use, contact Rohde & Schwarz customer service.

Line impedance stabilization networks (LISNs) are designed according to CISPR 16-1-2 (EN 55016-1-2) and do not meet the permissible limit for the leakage current as defined in EN 61010-1. In addition, LISNs do not provide basic insulation, rated as measurement category II (protection class 1). Therefore, only electrically skilled people may connect, set up and use LISNs.

LISNs can thus pose hazardous and even life-threatening risks.

- Electrical shock because of a high leakage current and live parts if the LISN is not grounded.
- Electrical shock because the LISN does not have a fuse in the measuring circuit.
- Burns and fire hazard caused by overheating of the housing. Overheating can occur if the ventilation is insufficient or if the cables' cross-section is too small.

These users also need sound knowledge of at least one of the languages in which the user interfaces and the product documentation are available.

If any part of the LISN is damaged or broken, stop using the LISN. Never open the casing of the LISN. Only service personnel authorized by Rohde & Schwarz are allowed to repair the LISN. Contact Rohde & Schwarz customer service at <http://www.customer-support.rohde-schwarz.com>.

Lifting and carrying the product

If the product is heavy, you cannot move or carry it on your own. A single person can only carry a maximum of 18 kg safely, depending on age, gender and physical condition. Look up the weight in the data sheet. To move the product safely, you can also use lifting or transporting equipment such as lift trucks or forklifts. Follow the instructions provided by the lifting or transporting equipment manufacturer.

Choosing the operating site

Only use the LISN indoors in rooms equipped with a protective earth connection (for example EMC test rooms).

The product casing is not waterproof and water that enters the casing can electrically connect the casing with live parts. This can lead to electric shock, serious personal injury or death if you touch the casing.

You can operate the product up to an altitude of 2000 m above sea level. The product is suitable for pollution degree 2 environments where nonconductive contamination can occur.

For more information on environmental conditions such as ambient temperature and humidity, see the data sheet.

Setting up the instrument

Always place the LISN on a stable, flat and level surface with the bottom of the LISN facing down. Make sure that the air supply is not obstructed from any side.

Place the LISN on a nonflammable base, for example a metal plate, to prevent a fire if the ventilation system fails or if it gets too hot.

If the instrument has foldable feet, always fold the feet completely in or out to ensure stability. The feet can collapse if they are not folded out completely or if the LISN is moved without lifting it. The foldable feet are designed to carry the weight of the instrument, but not an extra load.

Observe the applicable national regulations and standards as part of the installation process.

Protective ground connection

Always establish a protective ground connection before connecting the LISN to a power source.

A protective ground protects you from electrically live parts on the casing caused by high leakage currents. High leakage currents can cause electric shock, serious personal injury or death if you touch the casing.

Ground cables must have a sufficient cross-section that complies with VDE 0100-540 part 5-54 (IEC 60364-5-54).

Validate that the ground connection is safe.

The ground connection must remain until the LISN has been disconnected from the power source.

If the LISN has an auxiliary voltage: Secure the test setup with a second protective ground. The second ground connection protects you from live parts if the ground connection of the auxiliary cable fails.

Connecting to power

The product is an overvoltage category II product and must be connected to a fixed installation used to supply energy-consuming equipment such as household appliances and similar loads. Be aware that electrically powered products have risks, such as electric shock, fire, personal injury or even death.

Keep to the protective measures given by VDE 0100-410 (IEC60634-4-41) while working with the LISN.

Take the following measures for your safety:

- Use double-insulated connecting cables with characteristics suitable for the application:
 - Appropriate minimum cross-section.
 - Appropriate minimum voltage rating.

Select the cable based on the maximum power consumption of the device under test, the fuse rating of the building installation and the cable length. When installing the supplied cable sockets, observe the assembly instructions and the requirements of the manufacturer.

- By design, LISNs do not have a fuse in the measuring circuit. Therefore, you have to make sure that the operating circuit between the power supply and the LISN's power connector is fused correctly.
- Only use the power cable delivered with the product. It complies with country-specific safety requirements.
- Only use intact cables and route them carefully so that they cannot be damaged. Check the power cables regularly to ensure that they are undamaged. Also ensure that nobody can trip over loose cables.
- Only connect the product to a power source with a maximum fuse protection according to the datasheet.
- Ensure that you can disconnect the product from the power source at any time. Pull the power plug to disconnect the product. The power plug must be easily accessible. If the product is integrated into a system that does not meet these requirements, provide an easily accessible circuit breaker at the system level.
- If the LISN has an auxiliary voltage: Before taking the LISN auxiliary voltage into operation, ensure that the voltage and frequency indicated on the product match the available power source. If the values do not match, contact Rohde & Schwarz customer service.

If the ventilation system is powered by an auxiliary voltage, always connect the auxiliary voltage before taking the LISN into operation. Operation without the ventilation system leads to overheating and can cause a fire.

Using accessories

Select accessories that are suitable for the instrument and the measurement task, especially if they are not manufactured by Rohde & Schwarz.






Measurement accessories such as current clamps or artificial hands must comply with the measurement category of your test setup.

Cleaning the product

Use a dry, lint-free cloth to clean the product. When cleaning, keep in mind that the casing is not waterproof. Do not use liquid cleaning agents.

Meaning of safety labels

Safety labels on the product warn against potential hazards.

	<p>Potential hazard</p> <p>Read the product documentation to avoid personal injury or product damage.</p>
	<p>Heavy product</p> <p>Be careful when lifting, moving or carrying the product. Carrying the product requires at least two people or transport equipment.</p>
	<p>Electrical hazard</p> <p>Indicates live parts. Risk of electric shock, fire, personal injury or even death.</p>
	<p>Hot surface</p> <p>Do not touch. Risk of skin burns. Risk of fire.</p>
	<p>Protective conductor terminal</p> <p>Connect this terminal to a grounded external conductor or to protective ground. This protects you against electric shock should an electric problem occur.</p>

2 Introduction

V-networks are devices that are used to measure disturbance voltages on mains-dependent loads. For measurements, they are usually inserted between the power supply and the equipment under test (EUT). The RF port provides the means to connect them to a test receiver and analyze the EUT characteristics.

The main features of a V-network are to:

- Supply the EUT with AC supply voltage or DC supply voltage.
- Provide a standardized load impedance.
- Isolate the test circuit from power supply disturbances.
- Deliver unsymmetric disturbance voltage generated by the EUT to the test receiver in a defined manner.

The R&S ESH3-Z6 in particular is a single phase V-network that corresponds to a 5 μH inductor. It complies to the requirements specified in CISPR 25.

Unpacking the R&S ESH3-Z6

1. Carefully remove the R&S ESH3-Z6 from the box it was delivered in.
2. Check the R&S ESH3-Z6 for any damage.
Retain the original packing material. If the instrument needs to be transported or shipped later, you can use the material to protect the control elements and connectors.

3 Instrument Tour

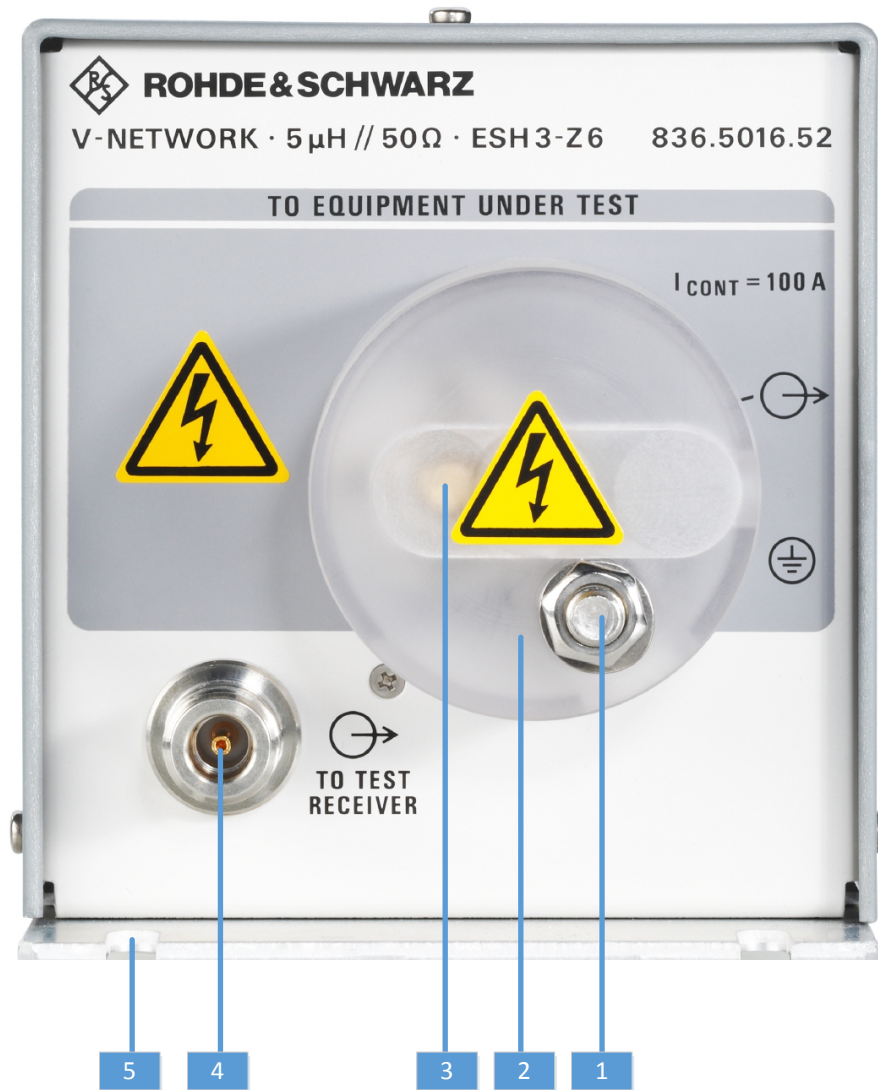


Figure 3-1: Front view (labeled To Equipment Under Test)

- 1 = Ground terminal X2.2
- 2 = Safety cap
- 3 = Power connector X2.1 (for EUT)
- 4 = RF output (to test receiver)
- 5 = Ground plate (contains 2 notches for ground cable connection)

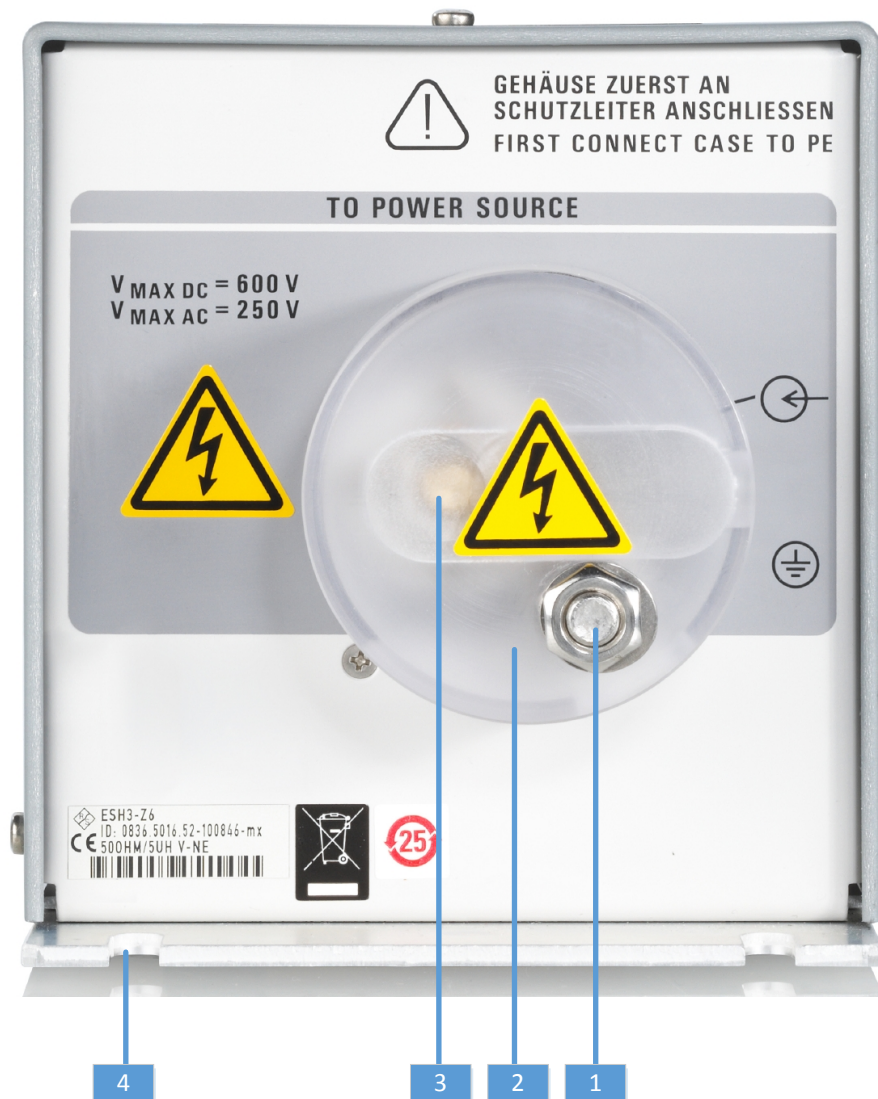


Figure 3-2: Rear view (labeled To Power Source)

- 1 = Ground terminal X1.2
- 2 = Safety cap
- 3 = Power connector X1.1 (to power source)
- 4 = Ground plate (contains 2 notches for ground cable connection)

4 Test Setup

Putting the R&S ESH3-Z6 into operation

1. Remove the nut that secures the safety cap (both front and back).
2. Remove the safety cap.
3. **DANGER!** Risk of electric shock. Before you connect the V-network to the power source, you have to connect the R&S ESH3-Z6 to a protective ground terminal. An unearthed R&S ESH3-Z6 is live. Touching a live electrical device causes serious personal injury, or even death.
The protective ground connection must remain until you have disconnected the V-network from the power supply.





Connect the R&S ESH3-Z6 to a reference ground.

- a) Connect the ground terminals X1.2 and X2.2 to a protective ground terminal.
- b) Screw on the safety nuts to secure the ground cables.
- c) If required by the test setup: Connect the ground plate to a protective ground terminal via the notches in the ground plate.

The R&S ESH3-Z6 has a single current path from X1.1 to X2.1. Therefore, the ground terminals may only be used as a return line if the EUT and its generator use reference ground as a return line (for example in case of low-voltage networks).

If the supply lines are isolated from the reference ground, you have to feed each line into a separate R&S ESH3-Z6 as shown in [Figure 4-1](#). In that case, you have to connect both V-networks to a protective ground terminal.

4. Make sure that the R&S ESH3-Z6 gets enough ventilation.
-  5. Connect the EUT to the power connector on the front side.
-  6. Connect the power connector on the back side of the R&S ESH3-Z6 to the power source.

Route the cables as specified by CISPR or as if no V-network were there.

7. Put the safety caps back on.
8. Secure the safety caps with the nut.
9. **NOTICE!** Risk of instrument damage. We recommend to keep the test receiver disconnected when you turn the power on or off. High power pulses that occur while turning the power on and off can damage the test receiver.

Connect the RF output to the RF input of a test receiver with a 50 Ω coaxial cable.

The test receiver shows the disturbance voltages in dB μ V.

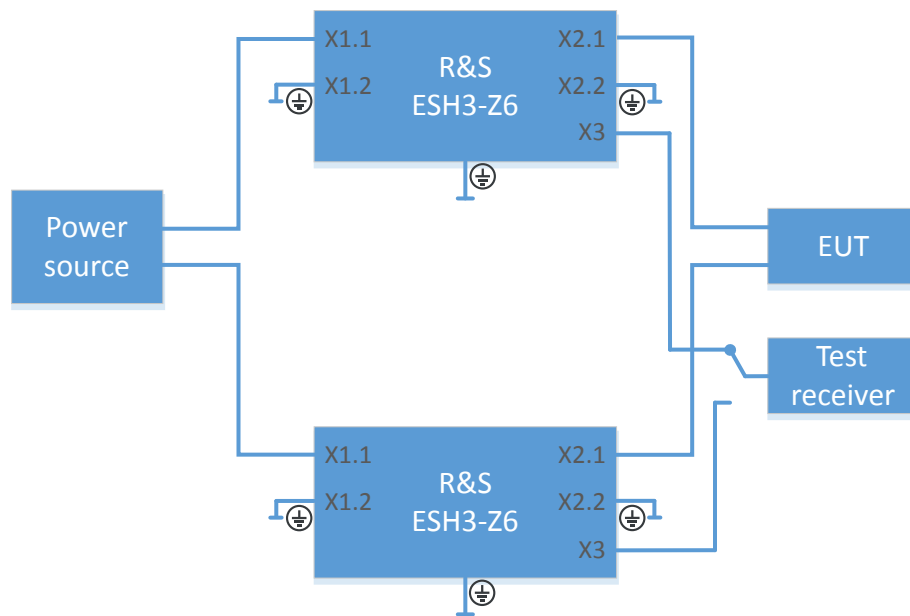


Figure 4-1: Test setup with two V-networks

Taking the R&S ESH3-Z6 out of operation

1. **DANGER!** Risk of electric shock. Always disconnect the R&S ESH3-Z6 from the power source before disconnecting it from anything else, especially the protective ground. An unearthed R&S ESH3-Z6 is live. Touching a live electrical device causes serious personal injury, or even death.
The protective ground connection must remain until you have disconnected the V-network from the power supply.
Disconnect the R&S ESH3-Z6 from the power source.
2. Disconnect all other cables.

5 Service

The V-network R&S ESH3-Z6 supplies the EUT with power during measurements and terminates the RFI voltage source of the EUT with a defined equivalent circuit $|Z| = 5 \mu\text{H} // 50 \Omega$. Refer to [Table 5-1](#) for the limit values of $|Z|_{X2}$.

The EUT can be fed with a 100 A continuous current via X1.1, L1, X2.1. C1 and L1 form a lowpass filter that isolates the EUT and test receiver from interference coming from the supply network.

The RFI voltage (0.1 MHz to 200 MHz) generated by the EUT is routed via the high-pass filter C2 and X3 to the test receiver with an input impedance of 50Ω .

Attenuation between X2 and X3 is high in the lower frequency range, which is due to the impedance $|Z|$ of the V-network and the highpass filter action of C2. The source impedance at X2 is 50Ω for this measurement. Attenuation measurements according to [Chapter 5.2.4, "Voltage Division Factor \(VDF\) X2 – X3"](#), on page 17 therefore only serve to check for proper operation of the R&S ESH3-Z6. Under real measurement conditions, the source impedance of the EUT is undefined and unknown.

Resistors R2, R6 and R7 discharge capacitors C1 and C2. Resistors R3, R4 and R5 dampen the resonance caused by winding capacitances of the coil.

Block diagram

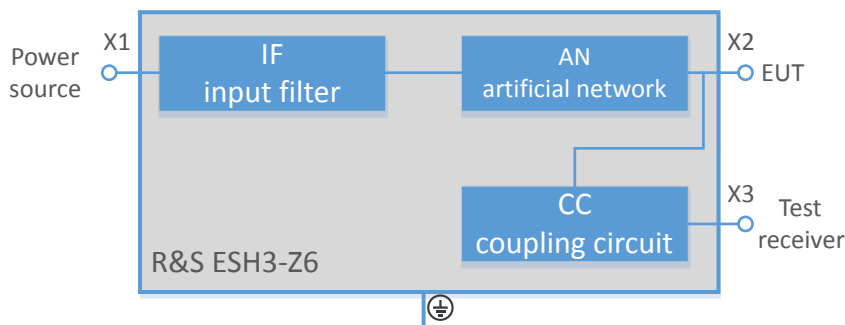


Figure 5-1: Block diagram for R&S ESH3-Z6

5.1 Test Equipment

Type of equipment	Recommended characteristics or features	Recommended model	R&S Order No.	Application
Power supply	Channel 1: +10 V / 10 A	HMP 4040	3629.6776.04	DC resistance
Digital multimeter	600 V, 20 A, AC/DC	Agilent 34401A R&S UDS 5		
Vector network analyzer	5 kHz ... 3 GHz	R&S ZNB4 R&S ZVR	1311.6010.22	
Connector reduction	Xn – BNC (Remark: Xn – bolt termination)		5719.6119.00	2 pcs
Attenuator	10 dB / BNC-M / BNC-F	Type normally used in industry		2 pcs
Termination 50 Ω	50 Ω / 1 W / BNC-M		3631.0771.00	2 pcs
T-branch	50 Ω / BNC-F	Type normally used in industry		
Short termination BNC	Short termination BNC-M	Type normally used in industry		
Power supply cable	Power supply cable with M8 lug and reference voltage conductor.	Current conductor $S \geq 2.5 \text{ mm}^2$ Voltage reference conductor $S \geq 0.75 \text{ mm}^2$		2 pcs

5.2 Performance Test

- [GND \(PE\) Resistance Check](#)..... 13
- [Power Conductor Resistance Check](#)..... 14
- [Impedance measurement X2 \(CISPR 25 - Ed 4: 2016\)](#)..... 15
- [Voltage Division Factor \(VDF\) X2 – X3](#)..... 17
- [Reflection VSWR of X3](#)..... 19

5.2.1 GND (PE) Resistance Check

Test equipment

- DC power supply
- Digital multimeter
- 2x power supply cable

Preparing the EUT

1. Set channel 1 of the DC power supply to 3 V, current limit 10 A.
2. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test setup for X1.2 - X2.2 bolts as shown in [Fig. 2](#).

The current conductors connect to output slots of power supply. The voltage reference conductors connect to the reference slots (signed SENSE) of power supply.

3. Tighten the torque of M8 nuts: 8 Nm to 10 Nm.
4. Turn on the DC power supply.

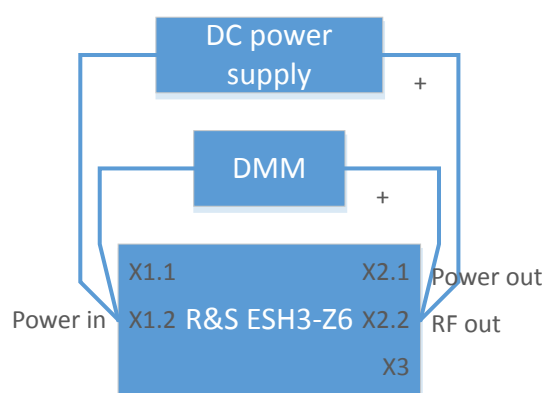


Figure 5-2: Test setup for GND resistance check

Performing the test

- Read out the voltage of the PE conductor on the digital multimeter.

The GND (PE) resistance must be $\leq 6 \text{ m}\Omega$.

Note: Calculate the GND (PE) resistance from the voltage drop at the test current.

5.2.2 Power Conductor Resistance Check

Test equipment

- DC power supply
- Digital multimeter
- 2x power supply cable

Preparing the EUT

1. Set the DC power supply to 3 V, current limit 10 A.
2. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test setup for X1.1 - X2.1 bolts as shown in Fig. 3.

The current conductors connect to output slots of power supply. The voltage reference conductors connect to the reference slots (signed SENSE) of power supply.

3. Tighten the torque of M8 nuts: 8 Nm to 10 Nm.
4. Turn on the DC power supply.

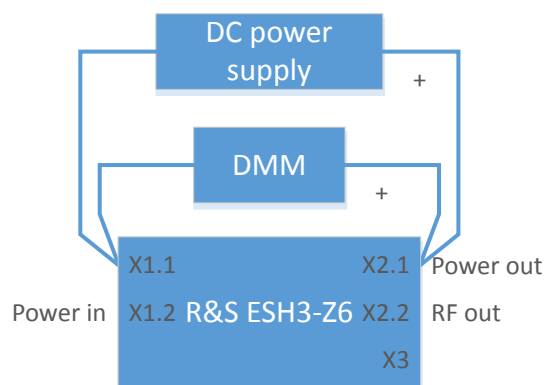


Figure 5-3: Test setup for conductor resistance test

Performing the test

- Read out the voltage of the AN conductor on the digital multimeter.

The power conductor resistance must be $\leq 6 \text{ m}\Omega$.

Note: Calculate the power conductor resistance from the voltage drop at the test current.

5.2.3 Impedance measurement X2 (CISPR 25 - Ed 4: 2016)

Test equipment

- Vector network analyzer
- BNC 50 Ω terminator
- 2x adapter Xn - BNC-F

Preparing the EUT

1. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test setup as shown in Fig. 4.

2. Install the Xn - BNC-F adapter on X1 and X2 connectors.
3. Tighten the torque of M8 nuts: 8 Nm to 10 Nm.
4. Connect the BNC 50 Ω termination to the BNC adapter installed on X3.

5. Connect the BNC short termination to the BNC adapter installed on X1.
6. Connect Port 1 to the X2 connector.

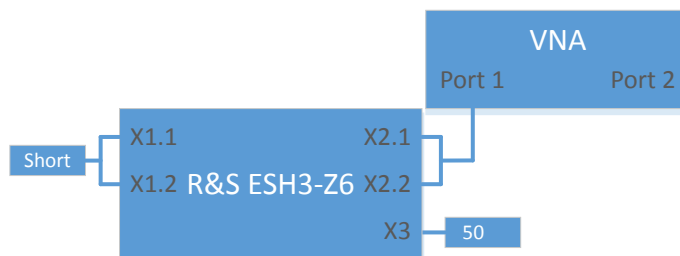


Figure 5-4: Test setup for impedance measurement

Performing the test

The test is a S11 measurement on the vector network analyzer.

1. Standardize Port 1 by OSM method.
2. Test the impedance of the artificial network conductor in the frequency range from 100 kHz to 200 MHz.

According to CISPR 25, edition 4: 2016, the deviation from the impedance shown in [Table 5-1](#) must be $\leq \pm 20\%$ in frequency range 100 kHz to 100 MHz.

Table 5-1: Impedance limits

Frequency	Impedance	Low limit	Upper limit
0.10 MHz	3.20 Ω	2.56 Ω	3.84 Ω
0.15 MHz	4.79 Ω	3.83 Ω	5.75 Ω
0.20 MHz	6.37 Ω	5.09 Ω	7.64 Ω
0.30 MHz	9.45 Ω	7.56 Ω	11.34 Ω
0.40 MHz	12.41 Ω	9.93 Ω	14.89 Ω
0.50 MHz	15.23 Ω	12.18 Ω	18.27 Ω
0.70 MHz	20.34 Ω	16.27 Ω	24.41 Ω
1.00 MHz	26.64 Ω	21.31 Ω	31.97 Ω
1.50 MHz	33.88 Ω	27.10 Ω	40.65 Ω
2.00 MHz	38.26 Ω	30.61 Ω	45.92 Ω
2.50 MHz	40.97 Ω	32.77 Ω	49.16 Ω
3.00 MHz	42.70 Ω	34.16 Ω	51.24 Ω
4.00 MHz	44.65 Ω	35.72 Ω	53.59 Ω
5.00 MHz	45.66 Ω	36.53 Ω	54.79 Ω
7.00 MHz	46.59 Ω	37.27 Ω	55.90 Ω

Frequency	Impedance	Low limit	Upper limit
10.00 MHz	47.10 Ω	37.68 Ω	56.53 Ω
15.00 MHz	47.39 Ω	37.91 Ω	56.87 Ω
20.00 MHz	47.49 Ω	37.99 Ω	56.99 Ω
30.00 MHz	47.56 Ω	38.05 Ω	57.07 Ω
50.00 MHz	47.60 Ω	38.08 Ω	57.12 Ω
70.00 MHz ¹	47.61 Ω	38.09 Ω	57.13 Ω
100.00 MHz	47.61 Ω	38.09 Ω	57.14 Ω
108.00 MHz ¹	47.61 Ω	38.09 Ω	57.14 Ω
120.00 MHz ¹	47.62 Ω	38.09 Ω	57.14 Ω
150.00 MHz ¹	47.62 Ω	38.09 Ω	57.14 Ω
170.00 MHz ¹	47.62 Ω	38.09 Ω	57.14 Ω
200.00 MHz ¹	47.62 Ω	38.09 Ω	57.14 Ω
¹ not in CISPR 24-Ed 4:2016			

5.2.4 Voltage Division Factor (VDF) X2 – X3

Test equipment

- Vector network analyzer
- 2x BNC 10 dB attenuator
- BNC T - Branch
- BNC 50 Ω terminator
- 2x adapter Xn - BNC-F

Preparing the EUT, part 1

1. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test setup as shown in [Figure 5-5](#).

2. Install the Xn - BNC-F adapter on X1 and X2 connectors.
3. Tighten the torque of M8 nuts: 8 Nm to 10 Nm.
4. Connect the BNC 50 Ω termination to the BNC adapter installed on X3.
5. Connect the Port 1 and Port 2 through two BNC 10 dB attenuator and BNC T-branch.
6. Connect the BNC T-branch output to the X2 connector.

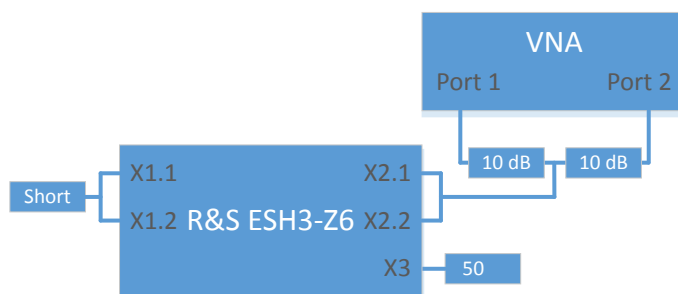


Figure 5-5: Test setup 1 for voltage division factor X2 - X3

Performing the test, part 1

The test is a S21 measurement on the vector network analyzer.

- ▶ Normalize Port 1 - Port 2 of the vector network analyzer.

Preparing the EUT, part 2

1. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test set-up as shown in [Figure 5-6](#).

2. Connect the Port 2 through the BNC 10 dB attenuator to the X3 connector.
3. Connect the BNC 50 Ω termination to the BNC T – Branch input.

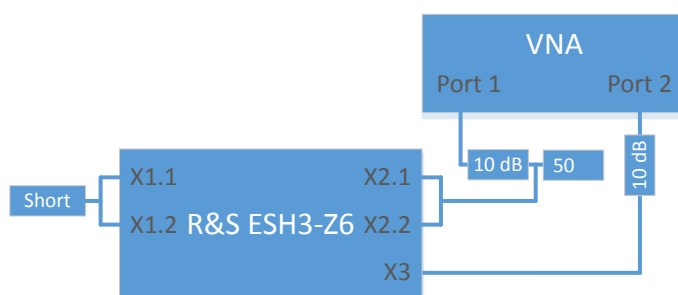


Figure 5-6: Test setup 1 for voltage division factor X2 - X3

Performing the test, part 2

- ▶ Read out the voltage division factor of conductor in frequency range 100 kHz to 200 MHz.

Target values:

- 100 kHz to 150 kHz: $S_{21} \leq 1.5$ dB to ≤ 1 dB (linearly decreasing with logarithm of frequency)
- 150 kHz to 100 MHz: $S_{21} \leq 1$ dB
- 100 MHz to 200 MHz: $S_{21} \leq 1$ dB to ≤ 2 dB (linearly increasing with logarithm of frequency)

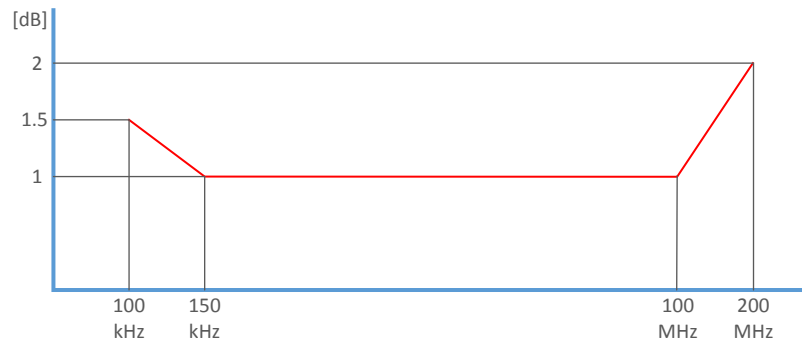


Figure 5-7: Limits for voltage division factor X2 - X3

5.2.5 Reflection VSWR of X3

Test equipment

- Vector network analyzer
- BNC 50 Ω terminator
- 2x adapter Xn - BNC-F

Preparing the EUT

1. **DANGER!** Do not connect the R&S ESH3-Z6 to mains voltage for the test. Connecting the R&S ESH3-Z6 to the mains voltage poses hazardous or even life-threatening risks to the operator.

Arrange the test setup as shown in [Fig. 5](#).

2. Install the Xn - BNC-F adapter on X1 and X2 connectors.
3. Tighten the torque of M8 nuts: 8 Nm to 10 Nm.
4. Connect the BNC 50 Ω termination to the BNC adapter installed on X2.
5. Connect the Port 1 to the X3 connector.

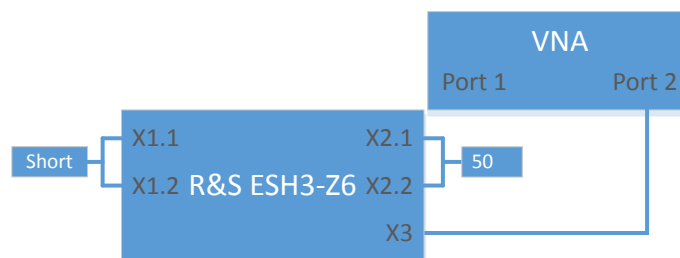


Figure 5-8: Test setup for VSWR of X3

Performing the test

The test is a S11 measurement on the vector network analyzer.

1. Standardize Port 1 by OSM method.
2. Select VSWR format in dB.
3. Read out the VSWR in the frequency range from 1 MHz to 200 MHz.

Target values:

- 1 MHz to 10 MHz: < -2 dB to < -18 dB (linearly decreasing with logarithm of frequency)
- 10 MHz to 100 MHz: < -18 dB
- 100 MHz to 200 MHz: < -18 dB to < -15 dB (linearly increasing with logarithm of frequency)

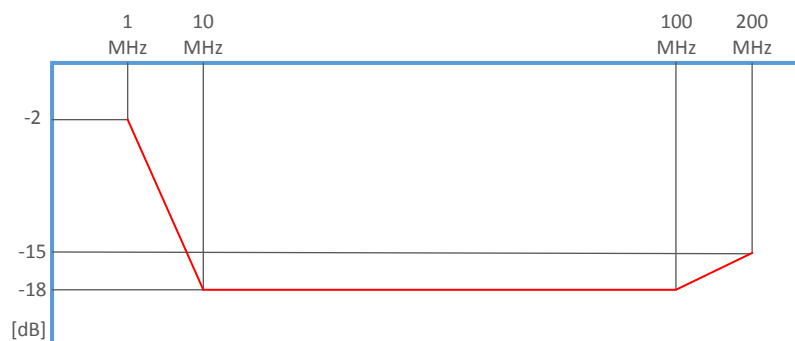


Figure 5-9: Limits for VSWR of X3

5.3 Repair

Although the V-network R&S ESH3-Z6 has no active components, the DC resistances of current path X1.1-X2.1 can deteriorate due to overloading, corrosion or mechanical deformation.

Faults can be localized and remedied in accordance with [Chapter 5.2, "Performance Test"](#), on page 13.

6 Circuit Diagram

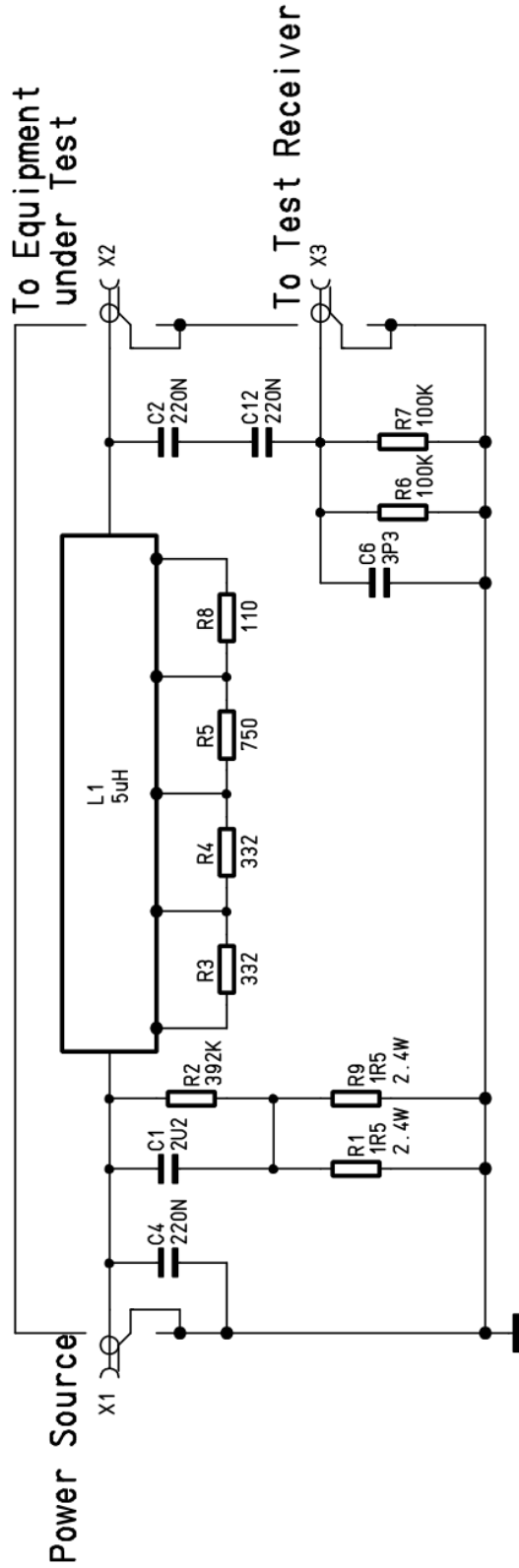


Figure 6-1: Circuit diagram for the R&S ESH3-Z6

7 Contacting Customer Support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz equipment, contact one of our Customer Support Centers. A team of highly qualified engineers provides telephone support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz equipment.

Up-to-date information and upgrades

To keep your instrument up-to-date and to be informed about new application notes related to your instrument, please send an e-mail to the Customer Support Center stating your instrument and your wish. We will make sure that you get the right information.

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8 Disposal

Rohde & Schwarz is committed to making careful, ecologically sound use of natural resources and minimizing the environmental footprint of our products. Help us by disposing of waste in a way that causes minimum environmental impact.

Electrical and electronic equipment

A product that is labeled as follows cannot be disposed of in normal household waste after it has come to the end of its service life. Even disposal via the municipal collection points for waste electrical and electronic equipment is not permitted.



Figure 8-1: Labeling in line with EN 50419

Rohde & Schwarz has developed a disposal concept for the ecofriendly disposal or recycling of waste material. As a manufacturer, Rohde & Schwarz completely fulfills its obligation to take back and dispose of electrical and electronic waste. Contact your local service representative to dispose of the product.