R&S®RT-ZHD07/15/16/60
High Voltage Differential Probe
User Manual

1800258802
Version 02

ROHDE&SCHWARZ
Make ideas real

This user manual describes the following R&S®RT-ZHD models and options:

- R&S®RT-ZHD07 (1800.2307.02)
- R&S®RT-ZHD15 (1800.2107.02)
- R&S®RT-ZHD16 (1800.2207.02)
- R&S®RT-ZHD60 (1800.2007.02)

Muehldorfstr. 15, 81671 Muenchen, Germany
Phone: +49 89 41 29 - 0
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

1800.2588.02 | Version 02 | R&S®RT-ZHD07/15/16/60

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol and without product type numbers, e.g. R&S®RT-ZHD is indicated as R&S RT-ZHD, and the R&S®ProbeMeter is indicated as R&S ProbeMeter.

Contents

1 Safety and regulatory information

The product documentation helps you to use the product safely and efficiently. Follow the instructions provided here and throughout the manual.

Intended use

The product is intended for the development, production and verification of electronic components and devices in industrial, administrative, and laboratory environments. Use the product only for its designated purpose. Observe the operating conditions and performance limits stated in the data sheet.

The probe is designed for usage with oscilloscopes that have a Rohde & Schwarz probe interface. Supported Rohde & Schwarz oscilloscopes are listed in the probe's data sheet.

Where do I find safety information?

Safety information is part of the product documentation. It warns you of potential dangers and gives instructions on how to prevent personal injury or damage caused by dangerous situations. Safety information is provided as follows:

- In Chapter 1.1, "Safety instructions", on page 5. The same information is provided in many languages as printed "Safety Instructions". The printed "Safety Instructions" are delivered with the product.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

1.1 Safety instructions

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 product 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 printed "Safety Instructions for Oscilloscopes and Accessories" document. If you are unsure about the appropriate use, contact Rohde & Schwarz customer service.

Using the product requires specialists or specially trained personnel. These users also need sound knowledge of at least one of the languages in which the user interfaces and the product documentation are available.

Reconfigure or adjust the product only as described in the product documentation or the data sheet. Any other modifications can affect safety and are not permitted.

Never open the casing of the product. Only service personnel authorized by Rohde & Schwarz are allowed to repair the product. If any part of the product is dam-

aged or broken, stop using the product. Contact Rohde & Schwarz customer service at https://www.rohde-schwarz.com/support.

In these safety instructions, the term "product" covers instruments (oscilloscopes), probes and their accessories.

Choosing the operating site

Only use the product indoors. The product casing is not waterproof. Water that enters can electrically connect the casing with live parts, which can lead to electric shock, serious personal injury or death if you touch the casing. If Rohde & Schwarz provides accessories designed for outdoor use of your product, e.g. a protective cover, you can use the product outdoors.

Unless otherwise specified in the data sheet, 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.

Performing measurements

Take the following measures for your safety:

- To ascertain voltage-free state, use an appropriate voltage tester. Any measurement setup including an oscilloscope is not suitable for this purpose.
- The maximum input voltage on channel inputs and the external trigger input must not exceed the value specified in the data sheet.
- Observe all voltage and current ratings of the instrument, the probes, and the accessories. Exceeding the allowed voltages can lead to an electric shock. Limits and ratings are marked on the products and listed in the data sheets. Consider that the rated voltage depends on the frequency. The voltage limitation curves or values are provided in the data sheet.
- Never cause any short circuits when measuring sources with high output currents.
- Use only probes and accessories that comply with the measurement category (CAT) of your measurement task. If the product is rated for any measurement category, the permitted category is indicated on the product and in the data sheet. If you use other than Rohde & Schwarz accessories, make sure that they are suitable for the instrument and the measurement task.
- Set the correct attenuation factor on the instrument according to the probe being used. Otherwise, the measurement results do not reflect the actual voltage level, and you might misjudge the actual risk.
- When working with high voltages and current probes, observe the additional operating conditions specified in these safety instructions.
- Prevent the probe from receiving mechanical shock. Avoid putting excessive strain on the probe cable or exposing it to sharp bends. Touching a broken cable during measurements can cause injuries.
- Set up all probe connections to the instrument before applying power.

Working with hazardous voltages

Voltages higher than 30 V RMS, or 42 V peak, or 60 V DC are regarded as hazardous contact voltages. Direct contact with them can cause serious injuries.

Make sure that only electrically skilled persons use the products for measurements on hazardous contact voltages. These working conditions require special education and experience to perceive risks and to avoid hazards which electricity can create.

Make sure that the measurement instrument is properly connected to protective earth.

When working with hazardous contact voltages, use protective measures to preclude direct contact with the measurement setup:

- Do not touch exposed connections and components when power is applied.
- Switch off the test circuit while connecting and disconnecting probe leads.
- Use only insulated voltage probes, test leads and adapters.
- Make sure that the input leads fulfill the safety requirements for your measurement. The delivered input leads might have a jacket wear indicator that indicates a worn jacket by different jacket color. In this case, do not use the input lead. Replace it with a new one.
- When connecting to the DUT, keep your fingers behind finger guard. Remove jewelry, watches, and other metallic objects. Only use 4 mm safety banana plugs.

1.2 Labels on the product

Labels on the casing inform about:

- Personal safety
- Product and environment safety
- Identification of the product

Table 1-1: Meaning of safety labels

	Potential hazard Read the product documentation to avoid personal injury or product damage.
	Electrical hazard Indicates live parts. Risk of electric shock, fire, personal injury or even death.

1.3 Warning messages in the documentation

A warning message points out a risk or danger that you need to be aware of. The signal word indicates the severity of the safety hazard and how likely it will occur if you do not follow the safety precautions.

WARNING

Potentially hazardous situation. Could result in death or serious injury if not avoided.

CAUTION

Potentially hazardous situation. Could result in minor or moderate injury if not avoided.

NOTICE

Potential risks of damage. Could result in damage to the supported product or to other property.

2 Product description

The R&S RT-ZHD high-voltage differential probe is designed to safely measure high voltage floating circuits using a grounded oscilloscope. The probe extends the measurement capability of oscilloscopes in measuring electronic power converters, inverters, motor speed controls, switch mode power supplies and many other applications.

The probe is equipped with the Rohde & Schwarz probe interface. It can be connected to any Rohde & Schwarz instrument that is compatible with this interface. When connected to the front panel, the probe is controlled by the oscilloscope's software. Supported oscilloscopes are listed in the data sheet.

2.1 Key characteristics and key features

2.1.1 Key characteristics

Table 2-1: Key characteristics

Parameter		**R&S RT-ZHD07**	**R&S RT-ZHD15/16**	**R&S RT-ZHD60**
Bandwidth		DC - 200 MHz	DC - 100 MHz (RT-ZHD15) DC - 200 MHz (RT-ZHD16)	DC - 100 MHz
Dynamic range (differential input)	Attenuation high:	±750 V	±1500 V	±6000 V
	Attenuation low:	±75 V	±150 V	±600 V
Operating voltage window (each pin to GND)		±750 V	±1500 V	±6000 V
Differential Offset		±1000 V	±2000 V	±2000 V
Diff. input resistance		5 MΩ	10 MΩ	40 MΩ
Diff. input capacitance		2.5 pF	2 pF	2 pF
R&S ProbeMeter, measurement error		< 0.1 %	< 0.1 %	< 0.12 %
Maximum input voltage to earth (each terminal)		300 V CAT III 600 V CAT II 600 V (RMS) / 4500 V (peak)	1000 V CAT III 1000 V (RMS) / 6800 V (peak)	1000 V CAT III 1750 V (RMS) / 6800 V (peak)

Maximum voltage input

The R&S RT-ZHD high-voltage differential probe is rated for CAT III environments. Maximum working voltages between each input lead and earth ground apply for all attenuation settings. The limits are listed in Table 2-1.

The probe is designed to measure electrical devices or installations of categories 0 (I), II, or III if the effective value of the measured voltage against earth ground does not exceed the maximum working voltage. The maximum working voltage is derated for higher frequencies. Voltage derating over frequency is specified in the data sheet.

The rating ensures that the probe is protected against short transient overvoltages as long as the maximum working voltage limit is observed.

Do not use the probe to measure effective working voltages higher than the specified voltage between each input lead and earth ground even if the effective differential voltage is lower than the specified voltage.

2.1.2 Key features

Micro button

The micro button remotely controls important functions of the Rohde & Schwarz oscilloscope. The function is assigned at the oscilloscope.

For details, see Chapter 4.1, "Micro button", on page 25.

R&S ProbeMeter

The R&S ProbeMeter measures the DC voltage of the input signal directly at the probe tip. It provides a continuous high-precision DC voltage measurement that is independent of the settings of the oscilloscope and runs in parallel to the time domain measurement. If activated on the base unit, the measured value is displayed on the screen of the Rohde & Schwarz oscilloscope.

The R&S ProbeMeter simultaneously measures both differential and common mode DC voltages.

For details, see Chapter 4.2, "R&S ProbeMeter", on page 25.

Data memory

The probe has an integrated data memory, containing the individual probe correction parameters (e.g. gain, delay, offset). These parameters are read out and processed by the Rohde & Schwarz oscilloscope. As a result, the probe offers a high degree of accuracy, and additional calibration procedures are not required.

Overrange indication

There are two indications for overrange:

- Input overrange indicates an overrange of an input signal against earth, i.e. a violation of the operating voltage window.
- Output overrange lights up if the differential voltage is too high even if the voltage to earth is within the specification.

Each overrange condition is indicated by an individual red LED (3 LEDs in total) and a common buzzer signal. The buzzer can be switched off. For details, see "Overrange

indicator at the input terminals" and "Overrange indicator at the output terminal" on page 16.

Switchable bandwidth limit

The R&S RT-ZHD contains a switchable analog lowpass with a cutoff frequency of 5 MHz. For measurements with long leads, it is convenient to reduce overshot and noise by activating the bandwidth limit.

Switchable attenuation

The R&S RT-ZHD has three attenuation modes: "Auto", "Attenuation high" to reach the maximum measurable differential voltages, and "Attenuation low" to reduce noise.

The attenuation setting changes only the maximum measurable differential voltage between the two input voltages. The maximum working voltage between each input lead and earth ground applies for all attenuation settings.

For details, see "Range: attenuation setting" on page 15.

2.2 Unpacking and checking

1. Unpack the product carefully.
2. Retain the original packing material. Use it when transporting or shipping the product later.
3. Using the delivery notes, check the equipment for completeness.
4. Check the equipment for damage.

   If the delivery is incomplete or equipment is damaged, contact Rohde & Schwarz.

Delivery notes

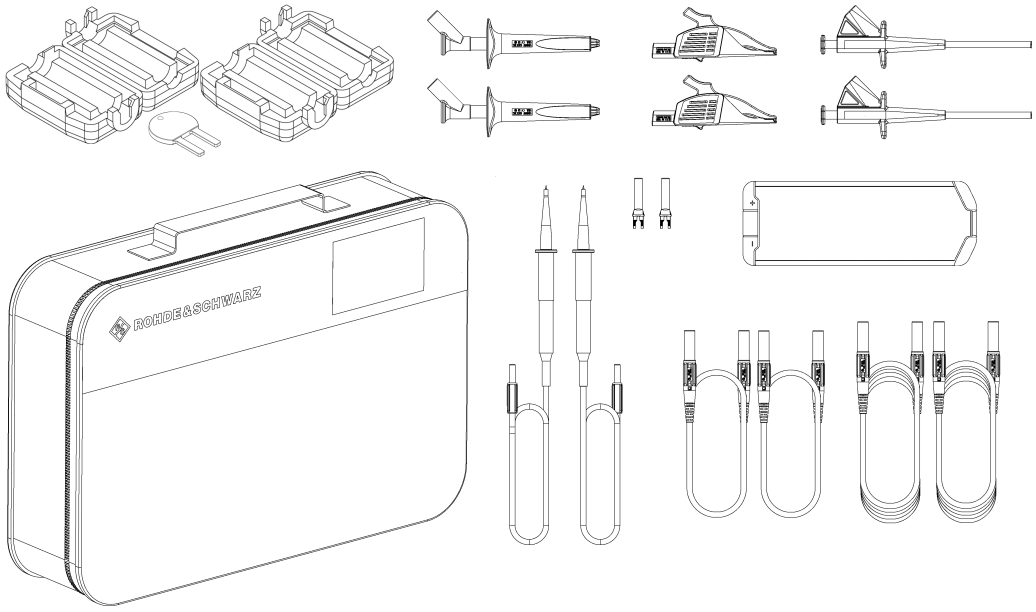


Figure 2-1: R&S RT-ZHD probe with accessories

The following items are included in the delivery:

- R&S RT-ZHD high-voltage differential probe
- Carrying case
- Pince clip (black and red)
- Safety Alligator clips (black and red)
- Test clips (black and red)
- Leads 17 cm (black and red)
- Leads 100 cm (black and red)
- Spade terminal (black and red)
- Test Leads (black and red)
- User manual
- R&S RT-ZHD data sheet
- Calibration certificate
- Safety instructions for oscilloscopes and accessories (multilingual)
- Documented calibration values (if ordered)
- Two hinged ferrite cores with opening key

Accessories supplied with the device are listed in Chapter 2.4, "Accessories and items", on page 17.

2.3 Description of the probe

The R&S RT-ZHD consists of the probe control box, two input leads, a probe cable and a probe box.

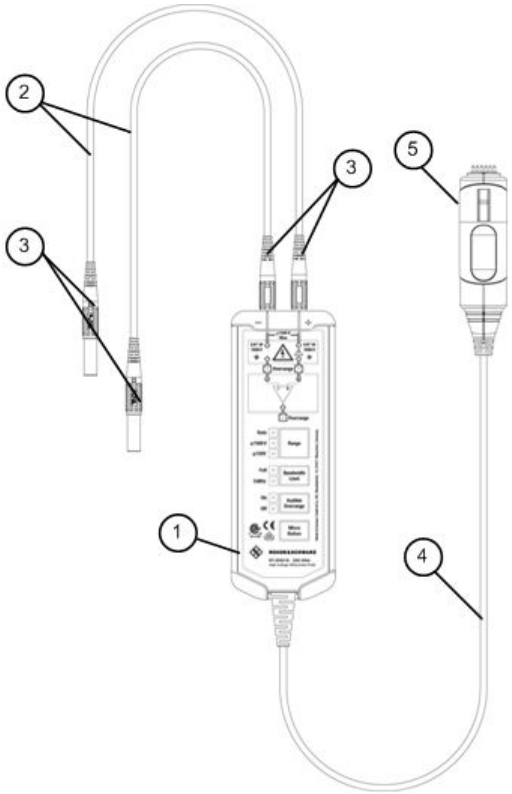


Figure 2-2: R&S RT-ZHD probe

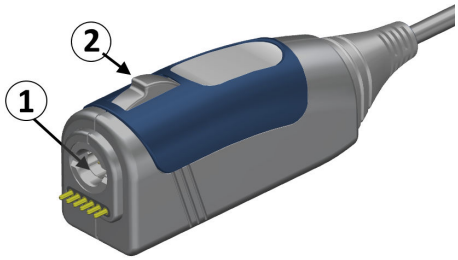
1 = Probe control box
2 = Input leads
3 = Safety banana plug (4 mm)
4 = Probe cable
5 = Probe box

2.3.1 Probe box

The probe box connects the probe and the oscilloscope via the Rohde & Schwarz probe interface. The Rohde & Schwarz probe interface contains a male precision 7 mm (276 mil) BNC connector and six pogo pin connectors. This interface provides the required supply voltage and is also used to transmit analog signals and digital data simultaneously. All the analog voltages required by the probe are generated in the probe box.

The BNC connector is a precision component designed to reach a much higher frequency limit when connected to an instrument with Rohde & Schwarz probe interface.

Connect the probe only to an instrument with Rohde & Schwarz probe interface. Never connect it to a usual BNC jack, because this can damage the probe interface.



(1) Rohde & Schwarz probe interface with 7 mm (276 mil) coaxial connector and 6 pogo pins

(2) Release knob

2.3.2 Probe control box

Contains the high-voltage divider, the active differential amplifier and other electronic components. All components are designed to ensure safe operation at hazardous contact voltages within the specified working voltage and measurement category. In particular, all air gaps and creeping distances comply with all current safety standards to protect the user, the measurement object, and the probe against any harm or damage.

The active differential amplifier takes the difference between the positive and negative signal input voltages. The probe transfers this difference signal to the oscilloscope. Common mode voltages are rejected.

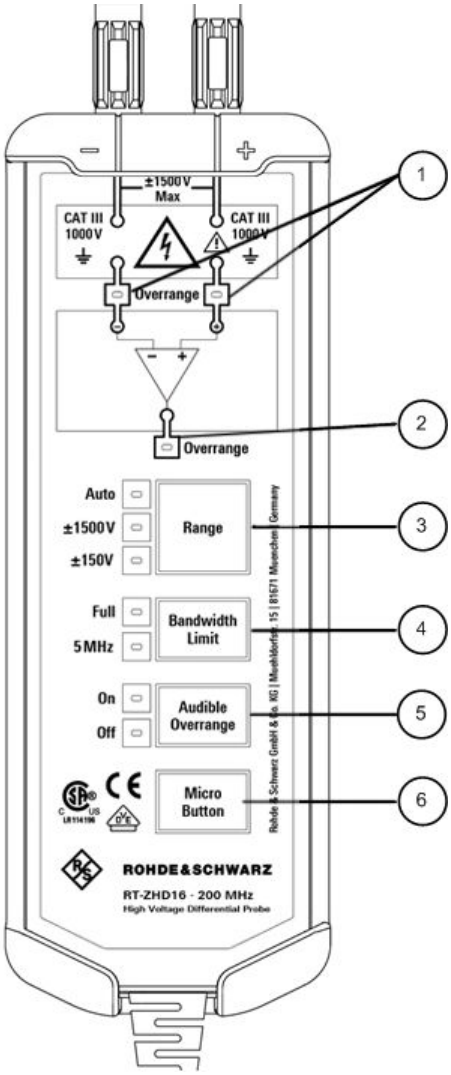


Figure 2-3: Probe control box

1 = Overrange indicators at each of the inputs
2 = Overrange indicator at the output
3 = Range: attenuation setting
4 = Bandwidth limit 5 MHz
5 = Audible overrange on/off
6 = Micro button (function programmable)

Range: attenuation setting

Pressing the [Range] button of the probe changes the attenuation mode.

- "Auto": (default on start-up and preset)
  The attenuation of the probe is automatically selected by the oscilloscope and depends on the vertical scaling of the scope.
- "Attenuation high"
  You can select the attenuation of the probe and it is not changed by the vertical scope settings. In this mode, you reach the maximum measurable differential voltages.

- "Attenuation low"
  You can select the attenuation of the probe and it is not changed by the vertical scope settings. This setting is characterized by less noise. If the attenuation is changed from "high" to "low", the sensitivity is changed by the factor of 10 and the measurable differential voltage is divided by a factor of 10.

The attenuation values depend on the probe:

Table 2-2: Attenuation and maximum peak voltages of R&S RT-ZHD

Probe type	Attenuation high		Attenuation low	
	Attenuation	Max. voltage	Attenuation	Max. voltage
RT-ZHD07	250 : 1	750 V_{pk}	25 : 1	75 V_{pk}
RT-ZHD15/16	500 : 1	1500 V_{pk}	50 : 1	150 V_{pk}
RT-ZHD60	1000 : 1	6000 V_{pk}	100 : 1	600 V_{pk}

The selected attenuation does not influence the allowed working voltage, measurement category, and the usable common mode range. Thus, setting the attenuation does not cause a hazardous situation or a measurement error due to inadmissible common mode voltages.

Audible overrange on/off

Whenever an overrange condition occurs, the buzzer generates a continuous audible alarm. The button toggles the buzzer on and off.

Overrange indicator at the input terminals

The overrange indicator lights red if the voltage of the single ended input signal to GND exceeds the dynamic input range limit of the probe. In this case, the signal on the probe output may not accurately represent the signal on the probe input.

The overvoltage indication works well on DC signals. AC signal (frequencies above some kHz) are not covered by the overvoltage indication.

Overrange indicator at the output terminal

The overrange indicator lights red if the voltage of the differential signal exceeds the dynamic range limit at the output of the probe. In this case, the signal on the probe output may not accurately represent the signal on the probe input.

Micro button

The micro button remotely controls important functions of the Rohde & Schwarz oscilloscope. The function is assigned at the oscilloscope.

For details, see Chapter 4.1, "Micro button", on page 25.

2.3.3 Probe cable

Connects the probe control box to the probe box. Its length of around 150 cm allows for a comfortable working distance to the base unit.

2.3.4 Input leads

The delivered input leads provide flexible contact to the DUT even in confined physical conditions. The input leads are plugged to the probe control box and can be substituted by other measurement leads with a 4 mm safety banana plug. However, the maximum performance can only be achieved with the delivered short leads (17 cm) in combination with the safety alligator clips. The 4 mm safety banana plugs can be used to contact the DUT directly, or to connect suitable contact accessories like the pincer clip delivered with the probe.

The delivered input leads have a jacket wear indicator. If the jacket is worn, a different jacket color becomes visible. If you see this color indicator, do not use the probe lead.

If other input leads are used, make sure that they fulfill the safety requirements for your measurement. Only use leads with 4 mm safety banana plugs.

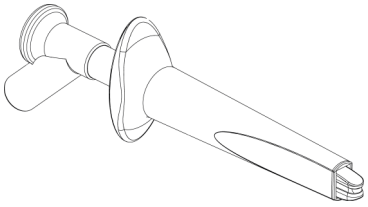
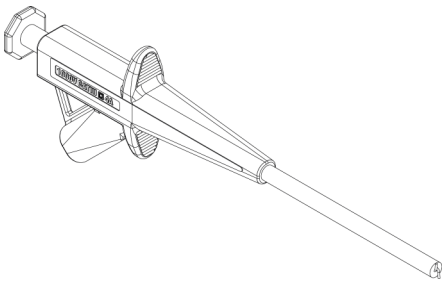
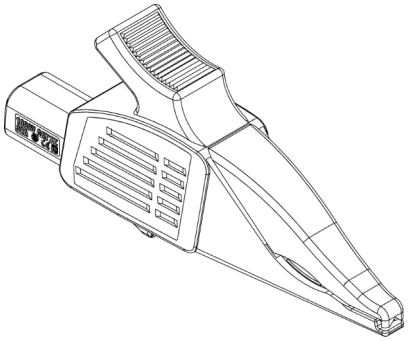
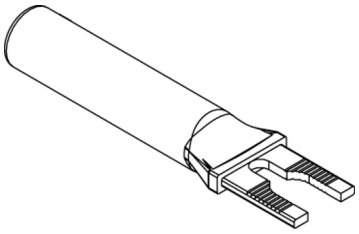
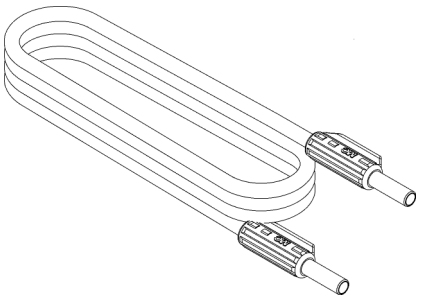
2.4 Accessories and items

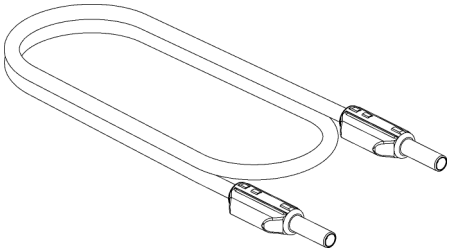
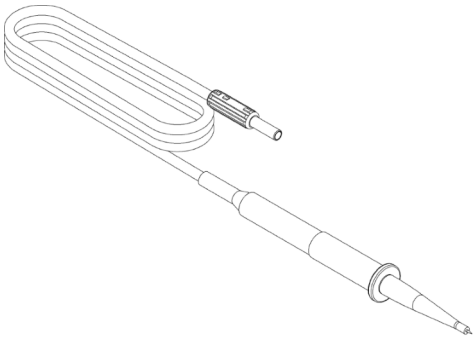
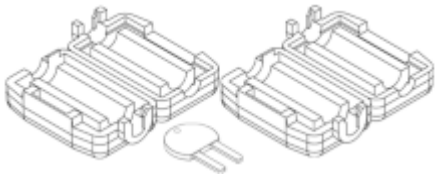
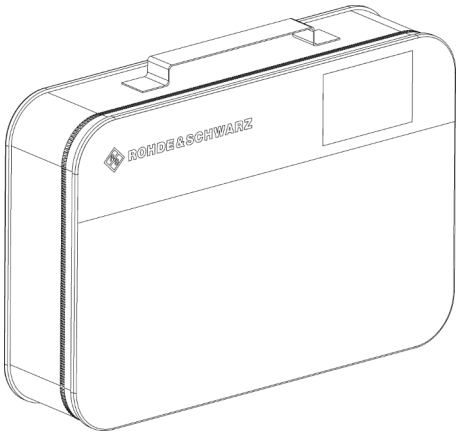
2.4.1 Accessories supplied

Table 2-3 shows the accessories that are supplied with the R&S RT-ZHD high-voltage differential probe.

Observe the measurement category (CAT) of the accessories. The accessory with the minor CAT value defines the CAT value of the whole measurement setup.

Table 2-3: Supplied accessories

Item	Quantity	Description
	2	Test clip Maximum rating: 1000 V (RMS) CAT IV
	2	Pincer clip Maximum rating: 1000 V (RMS) CAT III
	2	Safety Alligator clip Maximum rating: 1000 V (RMS) CAT III
	2	Spade terminal Maximum rating: 1000 V (RMS) CAT II Opening ∅ 2 mm and 4.1 mm **Reduces the CAT of the measurement setup to CAT II. No protective shroud: Do not plug if high voltage is on.**
	2	Long Leads (100cm) Maximum rating: 1000 V (RMS) CAT III

Item	Quantity	Description
	2	Short Leads (17cm) Maximum rating: 1000 V (RMS) CAT III
	2	Test leads Maximum rating: 1000 V (RMS) CAT III
	1	Two hinged ferrite cores With key for easier opening
	1	Soft case with foam inlay

For a list of spare parts, see Chapter 5.7, "Spare parts", on page 42.

2.4.2 Service accessories

To order accessories for servicing the probe, contact your Rohde & Schwarz service center. The following accessories are available:

Table 2-4: Service accessories

Item	Description
R&S RT-ZK2	The service kit is used to calibrate the probe, to do performance tests, and for servicing. The service kit includes all adapters and accessories to connect the probe to the required measuring instruments.
R&S RT-ZHD Service Manual	The service manual contains a detailed description of the performance test to verify the specifications, and other important service procedures.

2.5 Dimensions

With the accessory for specified operation conditions, the R&S RT-ZHD has the following dimensions:

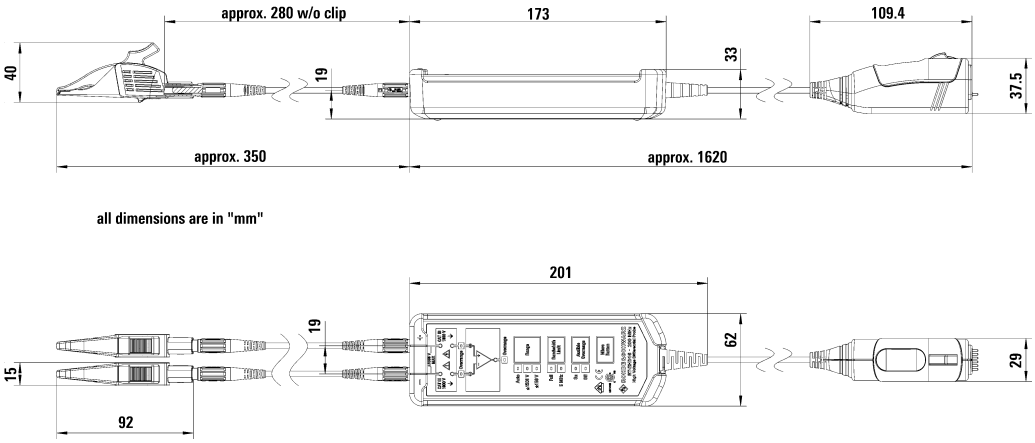


Figure 2-4: Dimensions of the R&S RT-ZHD probe with accessories

3 Connecting the probe

3.1 Handling the probe

The R&S RT-ZHD can withstand a moderate amount of physical and electrical stress. To avoid damage, treat the probe with care:

- Handle the probe by the probe box or probe control box.
- Avoid strain on the probe cable and route it carefully.
- Keep the probe dry.
- Prevent the probe from receiving mechanical shock.
- Store the probe in a shock-resistant case, e.g. in the shipping case.

Preventing electrostatic discharge (ESD)

Electrostatic discharge is most likely to occur when you connect or disconnect a DUT.

► **NOTICE!** Electrostatic discharge can damage the electronic components of the product and the device under test (DUT).

Ground yourself to prevent electrostatic discharge damage:

a) Use a wrist strap and cord to connect yourself to ground.
b) Use a conductive floor mat and heel strap combination.

Discharge cables and probe clips before you connect them.

3.2 Connecting the probe to the oscilloscope

The probe is designed for usage with oscilloscopes that have a Rohde & Schwarz probe interface. Supported Rohde & Schwarz oscilloscopes are listed in the probe's data sheet.

1. Make sure that the oscilloscope is properly grounded.

   The probe is grounded by the Rohde & Schwarz probe interface through the grounding of the oscilloscope.

2. **NOTICE!** Risk of damaging the probe.
   Connect the probe only to an instrument with Rohde & Schwarz probe interface. Never connect it to a usual BNC jack, because this can damage the probe interface.

   Connect the probe box (1) to the Rohde & Schwarz probe interface of the oscilloscope (2).

   The probe snaps in when connected properly to the port.

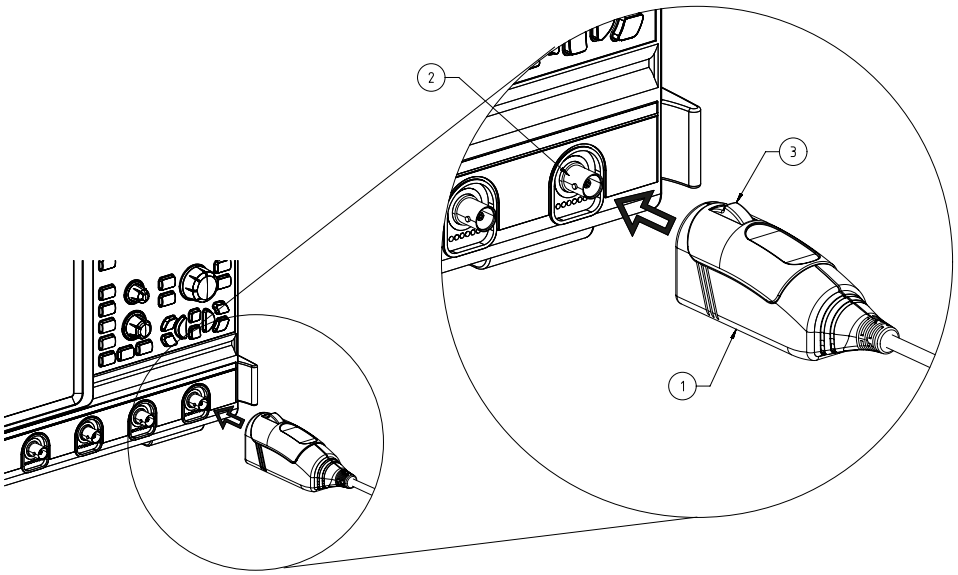


Figure 3-1: Connecting the probe to the Rohde & Schwarz oscilloscope

3. Do a functional check as described in Chapter 6, "Functional check", on page 43.

► To disconnect the probe:

a) Press and hold the release button (3).
b) Pull the probe box away from the oscilloscope.

During usage, the probe slightly heats up. Warming is normal behavior and not a sign of malfunction.

3.3 Identification of the probe

When the probe is connected to the oscilloscope, the oscilloscope recognizes the probe and reads out the probe-specific parameters.

The oscilloscope settings for attenuation and offset are automatically adjusted. After the probe is connected to the oscilloscope and the settings are adjusted, the waveform is shown for the channel to which the probe is connected.

The complete probe information is shown in the probe settings dialog. For more information, refer to the user manual of your oscilloscope.

3.4 Connecting the probe to the DUT

To ensure your personal safety, follow the procedure in the prescribed order. Never use the probe to measure effective working voltages higher than the specified voltage between each input lead and earth ground even if the effective differential voltage is

lower than the specified voltage. Read and observe Chapter 1.1, "Safety instructions", on page 5.

To connect the probe to the DUT

1. Switch off the test circuit.
2. Connect the probe to the oscilloscope as described in Chapter 3.2, "Connecting the probe to the oscilloscope", on page 21.
3. Connect the input leads to the probe control box (4 mm safety banana jack).
4. Connect the clips to the input leads (4 mm safety banana plugs).
5. **WARNING!**
   When working on hazardous voltages, take the following measures for your safety:
   - Do not touch exposed connections and components of the DUT.
   - Do not touch the unsafe area of probe accessories during a measurement. The finger guard provides protection. Keep your fingers behind the finger guard.
   - Keep the probe control box and the probe cable away from the circuit being measured.

   Connect the clips to the DUT. Ensure a stable connection between the DUT and the probe.

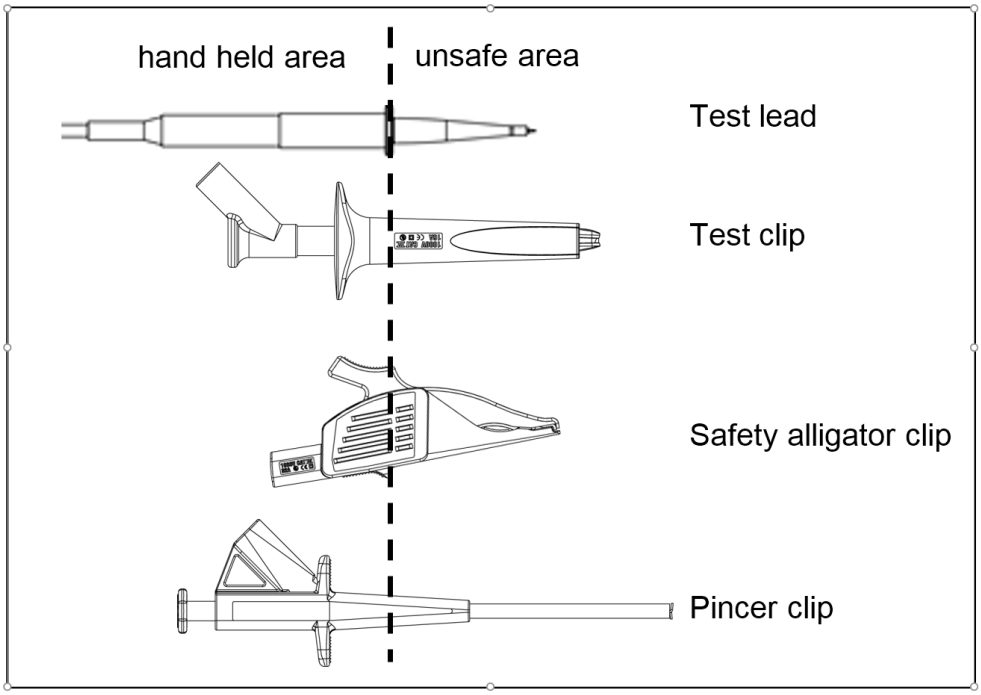


Figure 3-2: Hand held / unsafe areas

6. Switch on the test circuit.

To disconnect the probe

1. Switch off the test circuit.

2. Disconnect the clips from the DUT. Observe the safety measures described in step 5 of the connecting procedure.
3. Remove the input leads from the probe control box.
4. Disconnect the probe from the oscilloscope. Disconnection from the measuring instrument is always the last step to ensure proper grounding during the complete measurement process.

3.5 Reducing noise induction

Twist the input leads to cancel noise that is induced into the input leads.

If input leads shape a large loop area, they pick up any radiated electromagnetic field that passes through the loop. The fields induce noise in the input leads that appears as a differential mode signal. Twisting the leads minimizes the loop area.

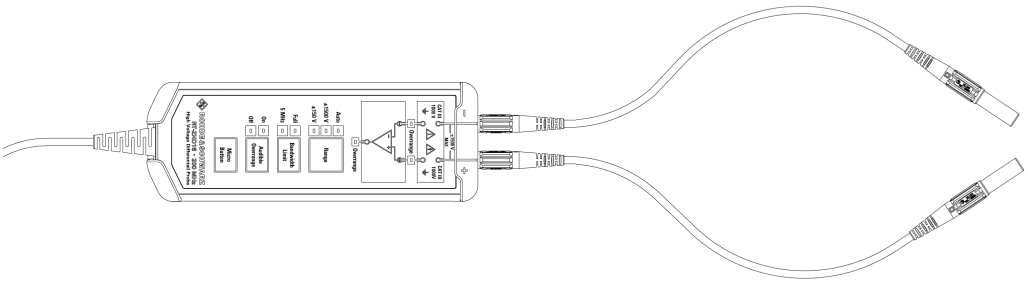


Figure 3-3: Leads, untwisted

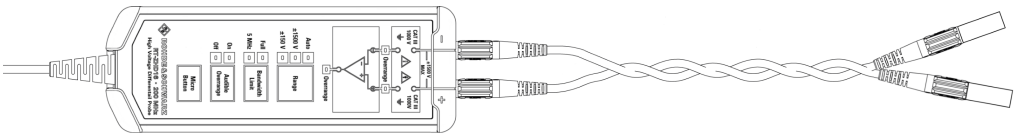


Figure 3-4: Leads, twisted

4 Features and characteristics of R&S RT-ZHD probes

4.1 Micro button

The micro button provides easy and quick access to important functions of the Rohde & Schwarz oscilloscope. After a function has been assigned, pressing the micro button remotely controls this specific function on the base unit. For example, "Run continuous" or "Run single" are often assigned to the micro button.

The configuration of the micro button is part of the probe settings of the channel to which the probe is connected. For more details, see the oscilloscope's user manual.

4.2 R&S ProbeMeter

The R&S ProbeMeter is an integrated voltmeter that measures DC voltages with higher precision compared to the oscilloscope's DC accuracy. The DC voltage is measured continuously and runs parallel to the time domain measurement of the oscilloscope.

High-precision measurements are achieved through immediate digitization of the measured DC voltage at the probe control box.

The R&S ProbeMeter measures the differential and common mode DC voltages simultaneously and without reconnecting the probe. For a definition of differential and common mode input voltages, see Chapter 4.4, "Characteristics of differential probes", on page 27.

When the R&S ProbeMeter is active, the measured values are displayed on the oscilloscope. The R&S ProbeMeter state is part of the probe settings of the channel to which the probe is connected. For details, refer to the user manual of the Rohde & Schwarz oscilloscope.

Advantages of the R&S ProbeMeter:

- Measures DC voltages of different levels, no need to adjust the measurement range of the oscilloscope.
- True DC measurement (integration time > 100 ms), not mathematical average of displayed waveform.
- High measurement accuracy and low temperature sensitivity.
- Simple means of setting the oscilloscope's trigger level and vertical scaling if a waveform is not visible.
- Independent of oscilloscope settings for position, vertical scale, horizontal scale, and trigger.
- Unique way to detect unexpected or inadmissible common mode voltages, e.g. bias points - measurement of common mode DC voltages without reconnecting the probe.

- Measurement range is ±maximum allowable voltage + offset compensation setting. Maximum measurement accuracy is achieved when offset compensation is switched off.

4.3 Offset compensation

The offset compensation can compensate a DC component of the input signal between the positive and negative input in front of the active amplifier in the probe control box. Offset compensation is particularly helpful if single-ended signals are measured with a differential probe, for example, with the negative input socket connected to ground. These signals often have a superimposed DC component, which can be compensated using the offset compensation on the probe.

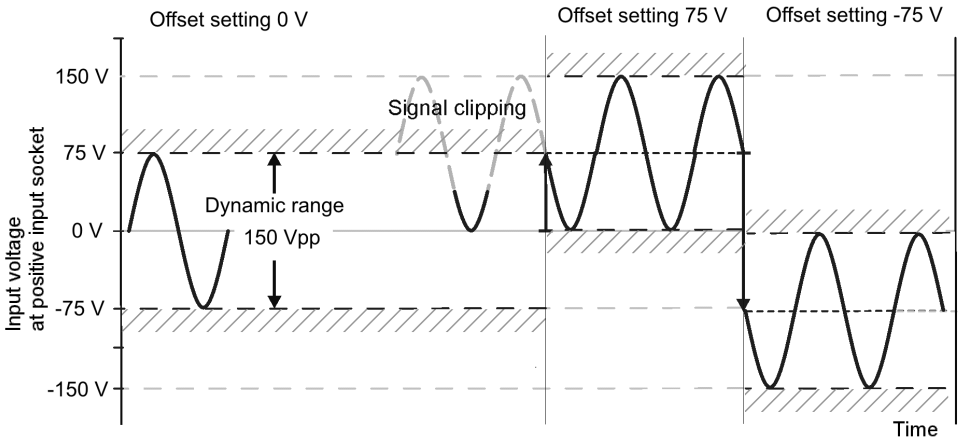


Figure 4-1: Differential offset compensation voltage for single-ended measurement (negative signal socket connected to ground e.g. RT-ZHD15 attenuation low)

Only differential DC offsets can be compensated. It is **not** possible to compensate for common mode DC offsets using the offset compensation function. For a definition of differential and common mode input voltages, see Chapter 4.4, "Characteristics of differential probes", on page 27.

There are several ways to set the offset compensation:

- Use the vertical knob at the oscilloscope if its function is set to offset.
- Enter the offset value in the channel settings or probe settings on the Rohde & Schwarz oscilloscope.
- Use the micro button to measure input signals with different DC offsets: assign "Offset to mean" to the micro button. See also Chapter 4.1, "Micro button", on page 25.

For more details, see the oscilloscope's user manual.

4.4 Characteristics of differential probes

A differential probe has three sockets: the positive signal socket (+), the negative signal socket (-), and the signal output which is connected to ground.

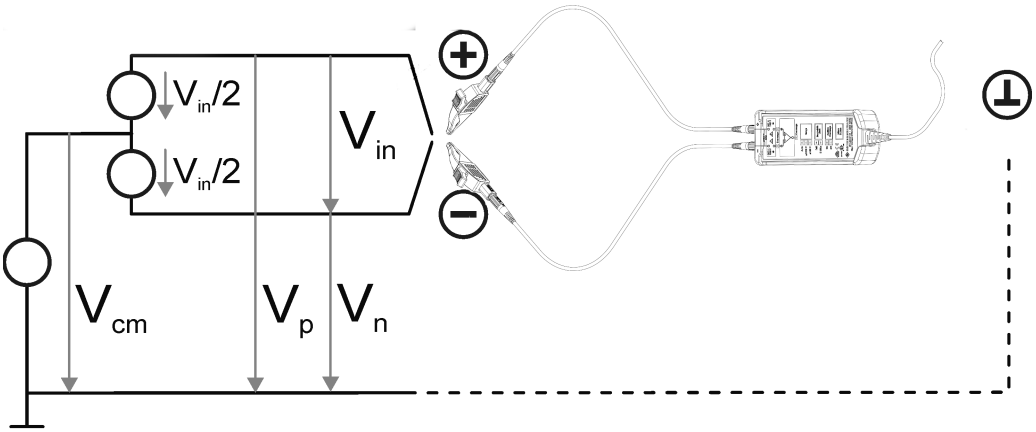


Figure 4-2: Input voltages on a differential probe

Multiple input voltages can be defined for a differential probe:

- Differential mode input voltage (V_{in}, V_{dm})
  Voltage between the positive and negative signal sockets
- Positive single-ended input voltage (V_p)
  Voltage between the positive signal socket and the ground socket
- Negative single-ended input voltage (V_n)
  Voltage between the negative signal socket and the ground socket
- Common mode input voltage (V_{cm})
  Mean voltage of positive and negative signal sockets referred to the ground socket, respectively

Two of these voltages are independent values, the other two can be calculated:

$$V_{in} = V_p - V_n$$

$$V_{cm} = \frac{V_p + V_n}{2}$$

Typically, the differential and the common mode input voltages are used to describe the behavior of a differential probe.

The output voltage V_{out}, which is displayed on the base unit, is obtained by superimposing the voltages generated from the differential mode input voltage and from the common mode input voltage:

$$V_{out} = A_{vdm}V_{in} + A_{vcm}V_{cm}$$

In this equation, A_{vdm} is the amplification of the differential mode input voltage and A_{vcm} is the amplification of the common mode input voltage.

An ideal differential probe is expressed as $A_{vdm} = 1$ and $A_{vcm} = 0$. In this case, the displayed voltage exactly equals to the differential input voltage V_{in} between the two signal sockets, and the common mode input voltage is suppressed.

4.4.1 Common mode rejection ratio (CMRR)

An *ideal* differential probe outputs a voltage that depends only on the differential input voltage V_{in} between positive and negative input, and suppresses the common mode voltages. This is equivalent to an infinite common mode rejection ratio (CMRR).

In contrast, real probes have a finite CMRR, resulting in a small part of the common mode voltage visible in the output signal. The CMRR is defined as the ratio of the amplifications of differential and common mode input signals:

$$CMRR = \frac{A_{vdm}}{A_{vcm}}$$

Example:

If a differential input voltage of 1 V yields an output voltage of 10 mV ($A_{vdm} = 0.01$) and a common mode input voltage of 1 V an output voltage of 0.1 mV ($A_{vcm} = 0.0001$), the CMRR is 100 (40 dB).

A high CMRR is important if significant common mode signals are encountered at the probe input, for example:

- DC voltages for setting the operating points of active DUTs
- Different ground levels of probe and DUT, e.g. floating DUTs
- An interference that couples equally to both conductors of a differential transmission line
- Probing on ground-referenced signals. In this case, the common mode component is always equal to half of the input voltage.

4.4.2 Dynamic range and operating voltage window

Two separate specifications are necessary to characterize the permissible input voltage range of a differential voltage probe:

- The dynamic range (or "differential mode range") designates the maximum differential voltage V_{in} that can occur between the positive and negative signal pin.
- At the same time, the two voltage values at each of the two signal pins V_p and V_n referenced to the common ground must not exceed a specific limit value. This limitation is referred to as the operating voltage window (some manufacturers also use the less precise term "common mode range" for the same parameter).

If one of these ranges is exceeded, an unwanted signal clipping can occur.

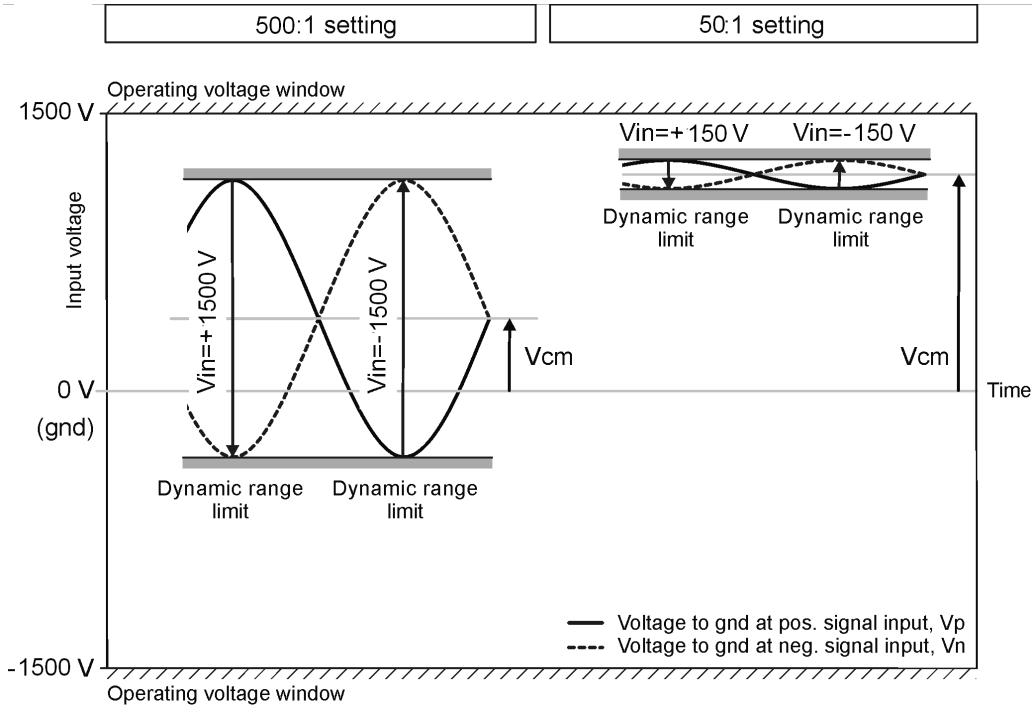


Figure 4-3: Dynamic range and operating voltage window for both attenuation ratios 50:1 and 500:1 (e.g. R&S RT-ZHD15)

The dependencies of dynamic range, operating voltage window and attenuation ratio are shown in Figure 4-3. The dynamic range between the positive and negative signal pins depends on the selected attenuation. The operating voltage window between each of the signal pins and common ground is not affected by the attenuation.

The Figure 4-4 shows several examples for permissible and impermissible inputs.

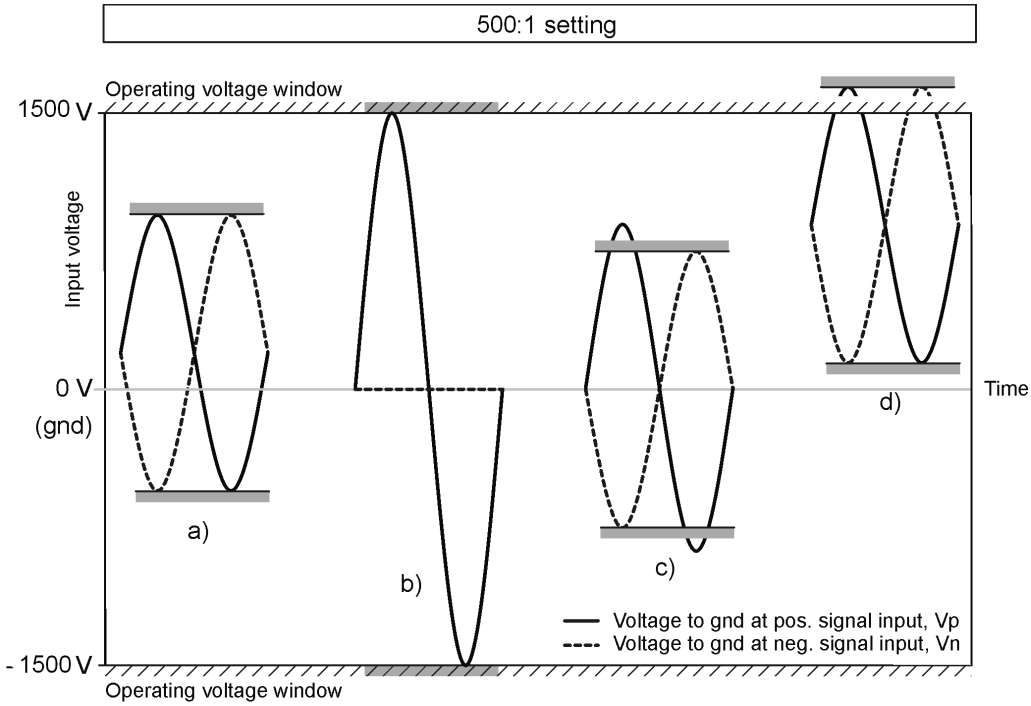


Figure 4-4: Signal curves (e.g. R&S RT-ZHD15)

a) = Two signals of ±750 V and opposing phase are applied to positive and negative inputs. At the peaks, the probe is driven with an input voltage of ±1500 V between the positive and negative signal pin. The dynamic range limit is reached.
b) = The negative signal pin is connected to ground, the positive pin is driven with an input voltage of ±1500 V. Dynamic range and operating voltage window are used completely. Note that the oscilloscope displays the same waveform as with example a).
c) = Dynamic range limit is exceeded. The oscilloscope displays a clipped signal.
d) = Operating voltage window is exceeded. The oscilloscope displays a clipped signal.

WARNING

Signal clipping of HF-signals

Only differential input signals are detected by the probe and displayed by the base unit. The probe suppresses common mode signals. Therefore, the R&S RT-ZHD has over-range indicators at the input terminals. The overvoltage indication works well on DC signals. AC signals (frequencies above some kHz) are not covered by the overvoltage indication.

4.5 Typical characteristics of the R&S RT-ZHD

The R&S RT-ZHD differential probe provides an electrical connection between the DUT and the oscilloscope. The probe transfers the voltage of the electrical signal tapped off the DUT to the oscilloscope, where it is displayed graphically. Although a probe has a wide variety of specifications, these specifications can be grouped into two classes of basic requirements:

- High signal integrity of the transferred signal:
  With an ideal probe, the output signal that is transferred to the base unit would be identical to the input signal between the probe tips, and signal integrity would be extremely high. Every real probe, however, transfers the input signal in altered form. A good probe causes only minimum alterations. How the probe can fulfill this requirement is mainly determined by its bandwidth and CMRR.
- Low loading of the input signal:
  Every probe is a load for the signal to be measured. This means that the signal to be measured changes when the probe is connected. A good probe causes only a minimum change to the signal, so that the function of the DUT is not adversely affected. How the probe can fulfill this requirement is mainly determined by its input impedance.

The parameters of a R&S RT-ZHD probe are specified for the short leads and the safety alligator clips between the probe and the DUT. With longer or shorter connections, the connection inductance has a significant effect on the measurement.

4.5.1 Improve the signal integrity

To improve the signal integrity, apply the two hinged ferrite cores. Snap in the ferrites to the probe cable near to the probe control box.

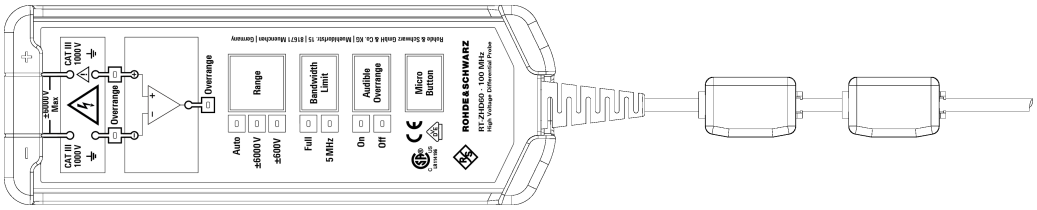


Figure 4-5: Probe cable with additional hinged ferrite cores

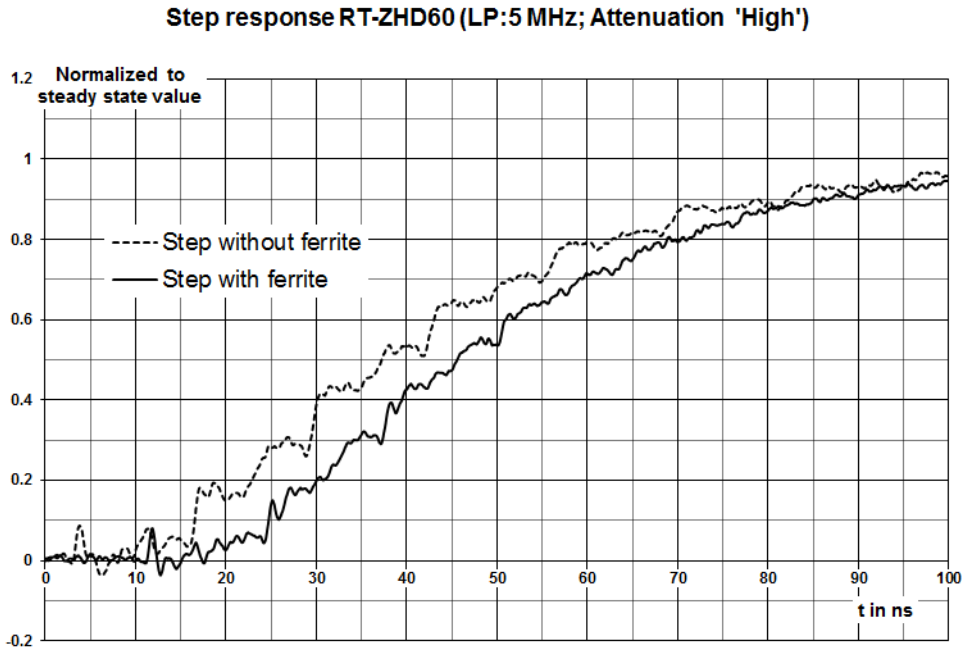


Figure 4-6: Improvement with additional hinged ferrite cores

In Figure 4-6, you can see the improvement in the signal integrity. The curve "Step with ferrite" is artificially delayed for 8 ns for a better view. The ferrite cores do not add any additional delay. The most significant improvement can be seen with the R&S RT-ZHD60 in the "Mode">"Attenuation High" and 5 MHz low pass (LP) on.

4.5.2 Bandwidth

The bandwidth (BW) of a probe is one of its specific parameters. The bandwidth of the probe and the bandwidth of the base unit together form the system bandwidth. The following explanations refer to the probe itself, but can also be applied to the entire system.

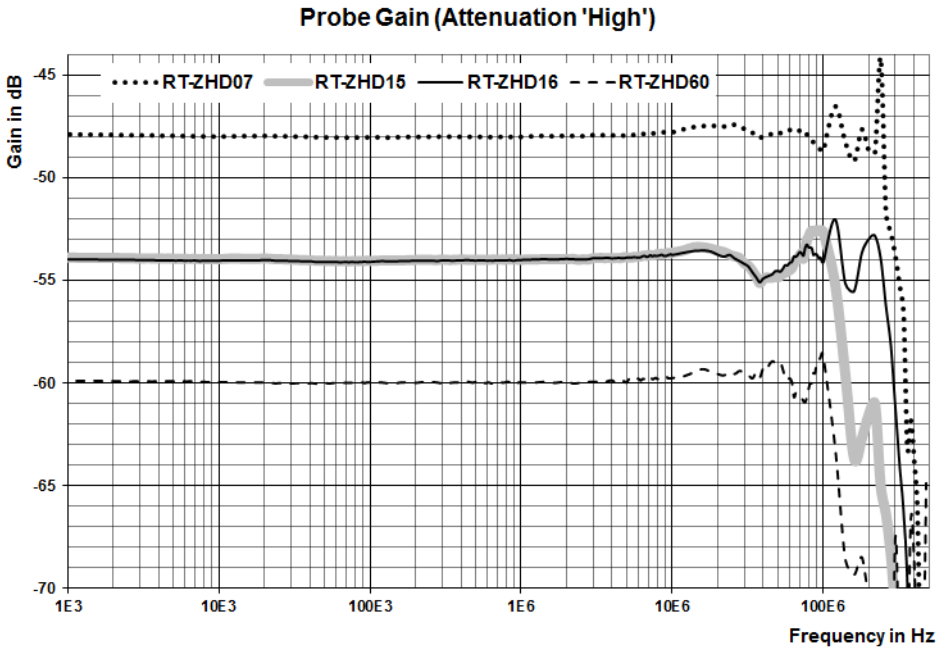


Figure 4-7: Amplitude frequency response of the R&S RT-ZHD (Attenuation 'High')

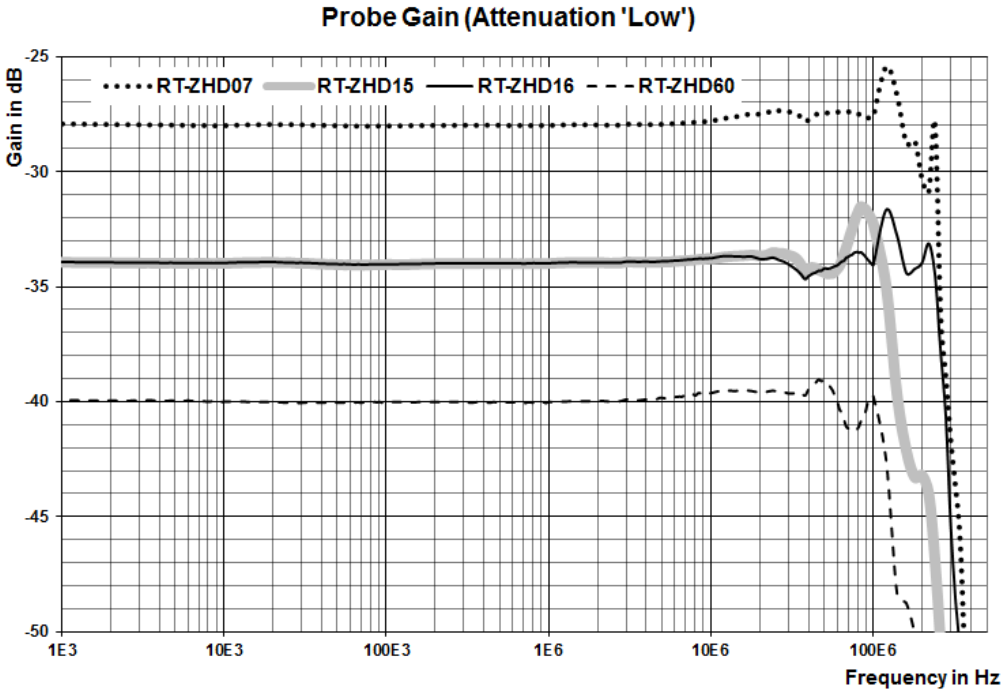


Figure 4-8: Amplitude frequency response of the R&S RT-ZHD (Attenuation 'Low')

The bandwidth:

- Specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 70 % (–3 dB) of its amplitude.

- Specifies the transferable spectrum for other waveforms. E.g., with square wave signals, the fifth harmonic should still be within the bandwidth for a high signal integrity.
- Determines the minimum measurable signal rise time. The rise time t_{rise} of the probe is inversely proportional to its bandwidth. The following approximation applies:

$$t_{rise} \approx \frac{0.4}{BW}$$

4.5.3 Step response

In addition to bandwidth, a constant amplitude frequency response of the probe is decisive for high signal integrity. All frequency components are transferred with the same gain so that the input signal is displayed without distortion.

Figure 4-9 and Figure 4-10 show a typical step response of all R&S RT-ZHD differential probes up to 30 ns. The propagation delay is normalized to the beginning of the step. The amplitude is normalized to the steady state value.

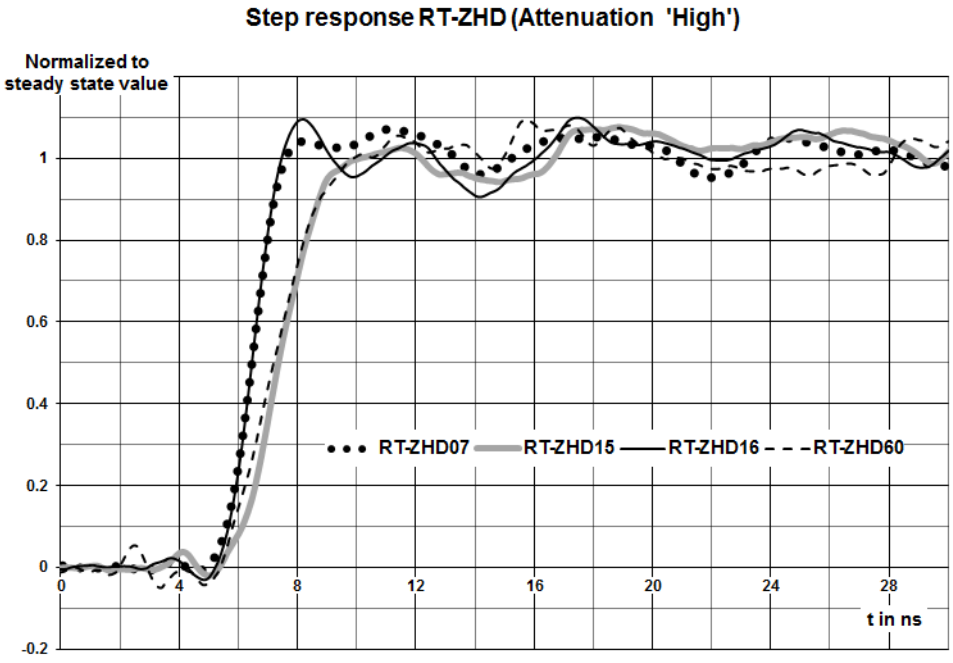


Figure 4-9: Step response of the R&S RT-ZHD (Attenuation 'High')

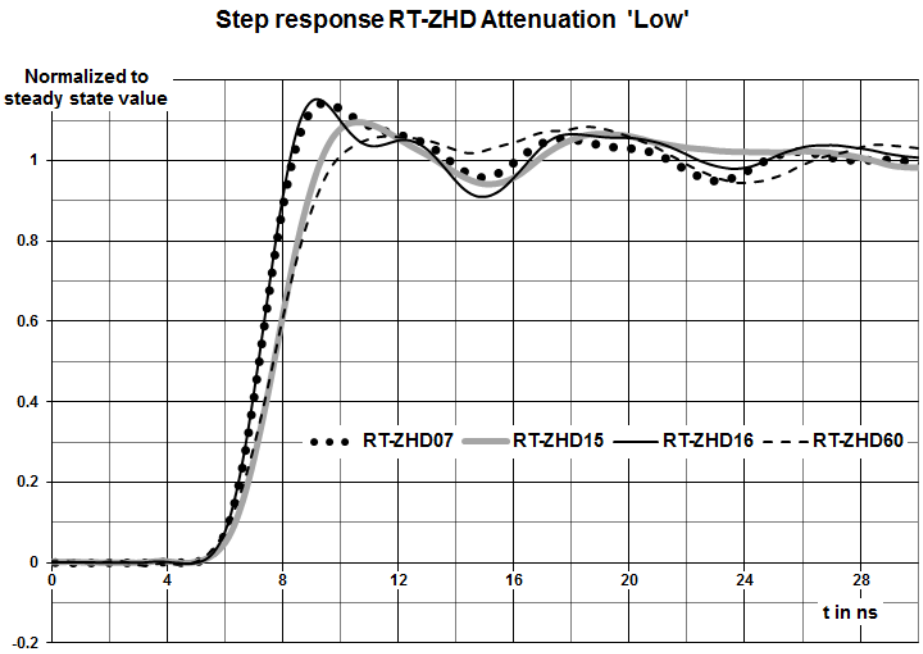


Figure 4-10: Step response of the R&S RT-ZHD (Attenuation 'Low')

The behavior of all R&S RT-ZHD is similar for more than 30 ns after a step. The curves in Figure 4-11 and Figure 4-12 show the step response of the R&S RT-ZHD16 probe, as a typical example.

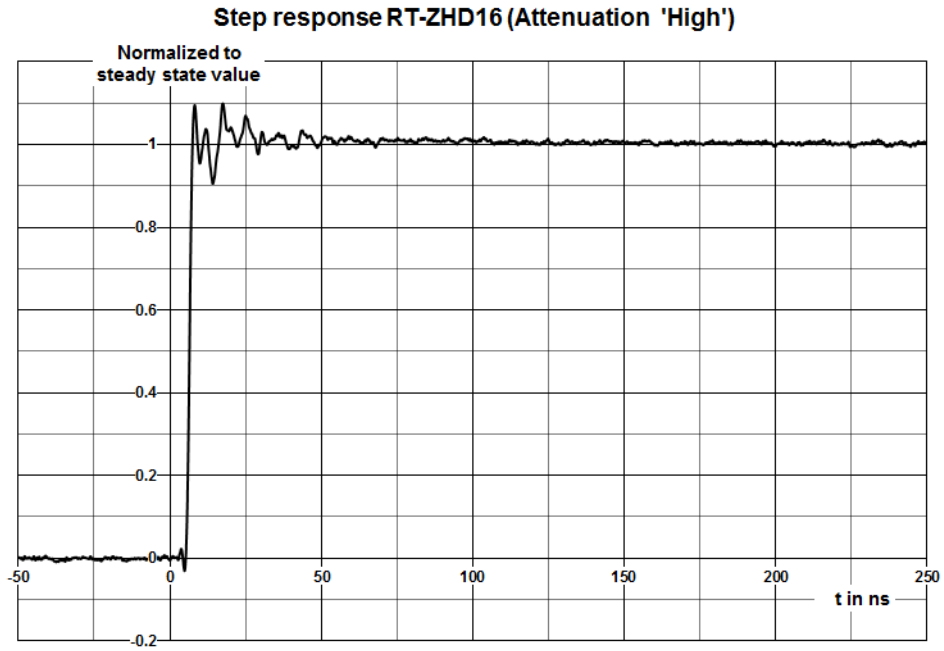


Figure 4-11: Typical step response e.g. of the R&S RT-ZHD16 (Attenuation 'High')

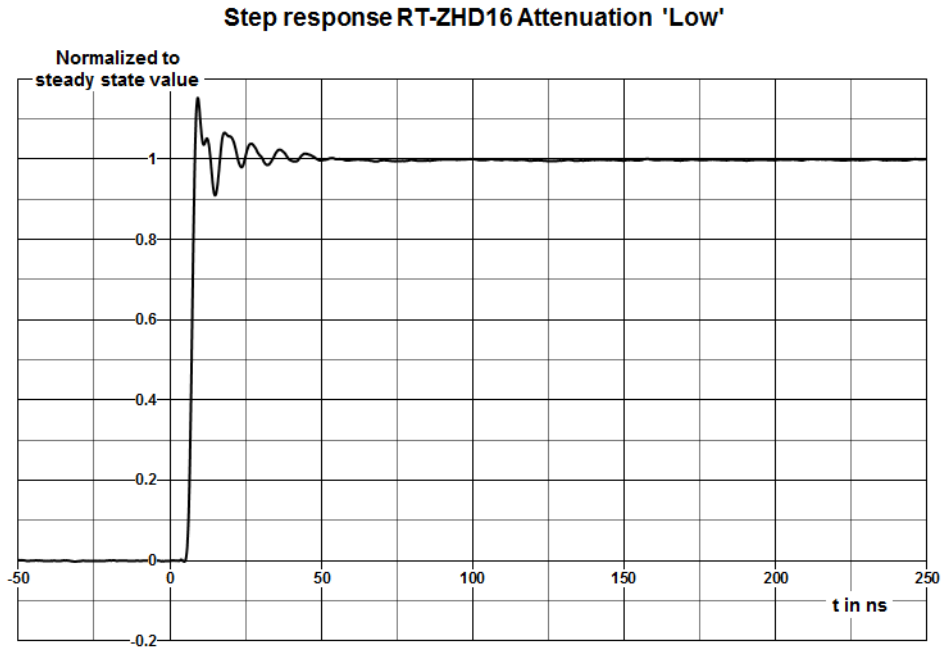


Figure 4-12: Typical step response e.g. of the R&S RT-ZHD16 (Attenuation 'Low')

4.5.4 CMRR

The CMRR is good for low-frequency signals, but it continuously decreases for higher frequencies. Therefore, the CMRR is usually specified as a function of frequency.

The figures below show typical CMRR with a symmetrical connection for an R&S RT-ZHD differential probe. An asymmetrical connection to the test point can decrease the CMRR. To achieve the best possible CMRR, the connection to the DUT should always be as symmetrical as possible.

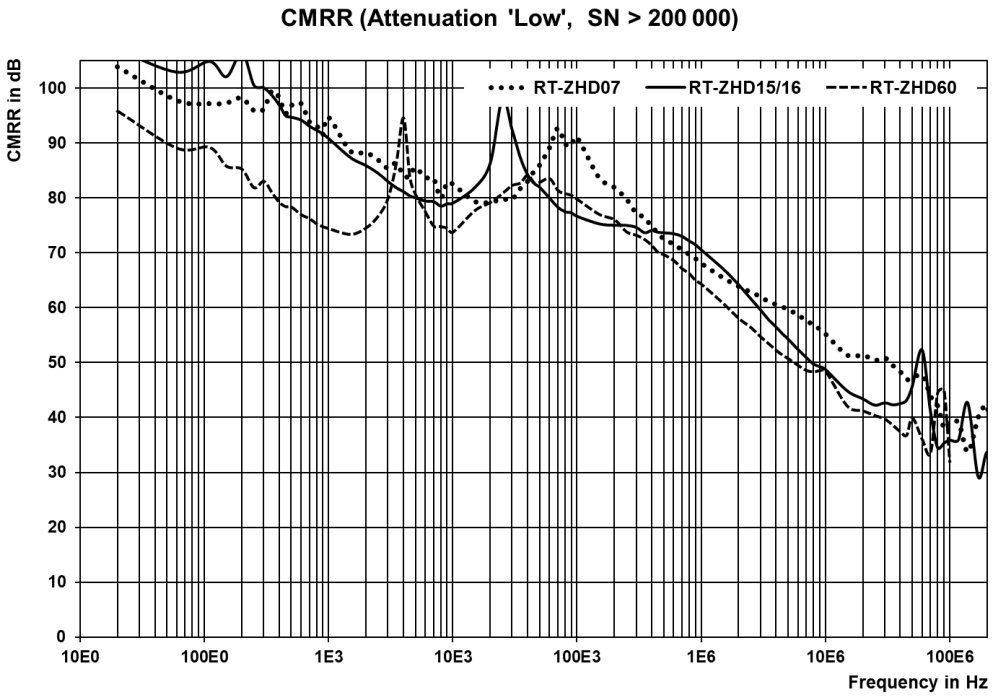


Figure 4-13: Typical CMRR of R&S RT-ZHD probes with serial numbers >200000 as a function of frequency with attenuation 'Low'

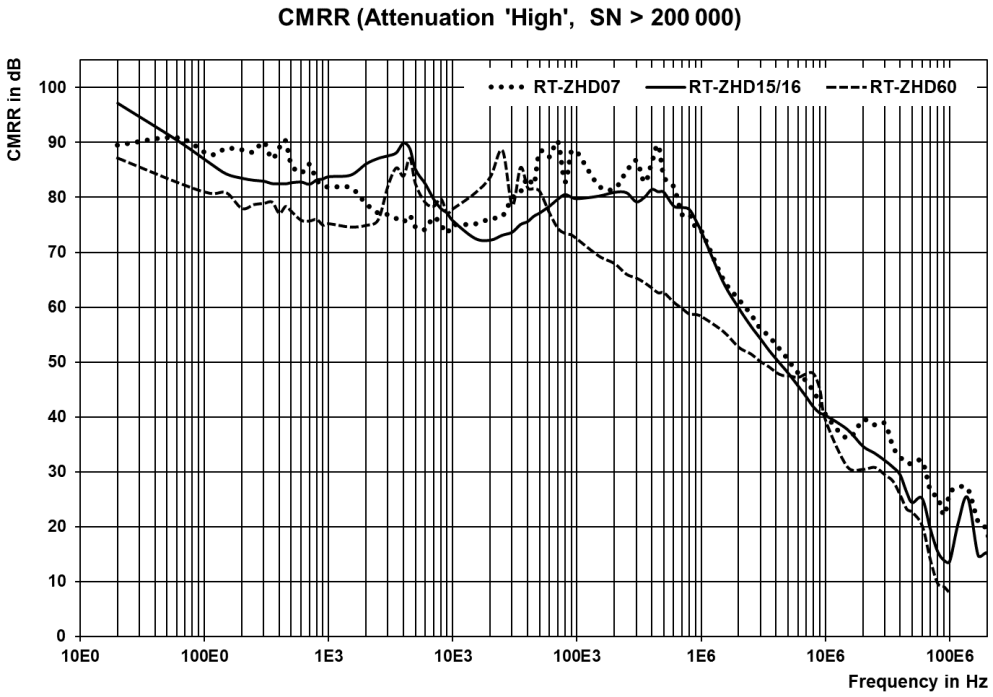


Figure 4-14: Typical CMRR of R&S RT-ZHD probes with serial numbers >200000 as a function of frequency with attenuation 'High'

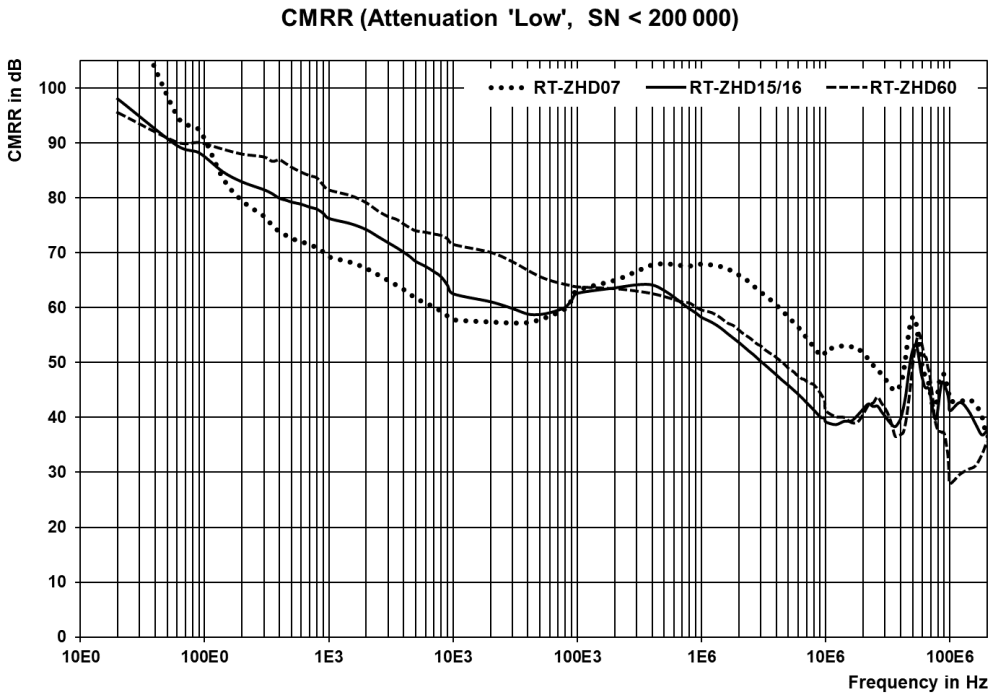


Figure 4-15: Typical CMRR of R&S RT-ZHD probes with serial numbers <200000 as a function of frequency with attenuation 'Low'

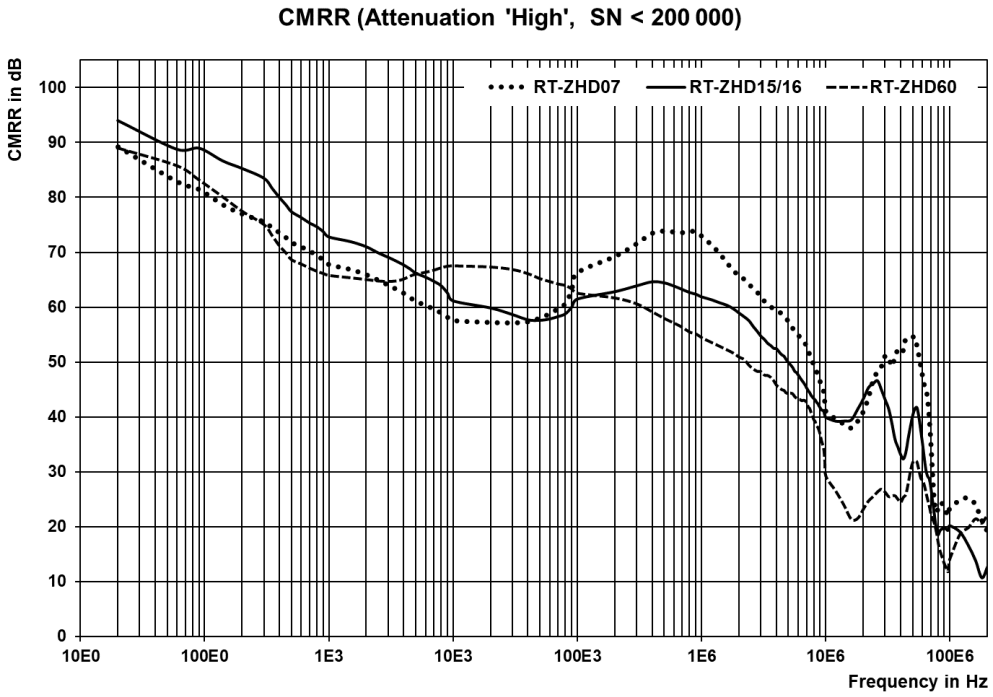


Figure 4-16: Typical CMRR of R&S RT-ZHD probes with serial numbers <200000 as a function of frequency with attenuation 'High'

4.5.5 Signal loading of the input signal

The previous section explained the transfer function and step response of the probe. This section describes how the probe influences the input signal. The input signal loading caused by the probe is determined by its input impedance. In general, the probe causes only low signal loading because its input impedance is usually much greater than the source impedance of the test circuit.

The resulting input impedance versus frequency is indicated in Figure 4-17.

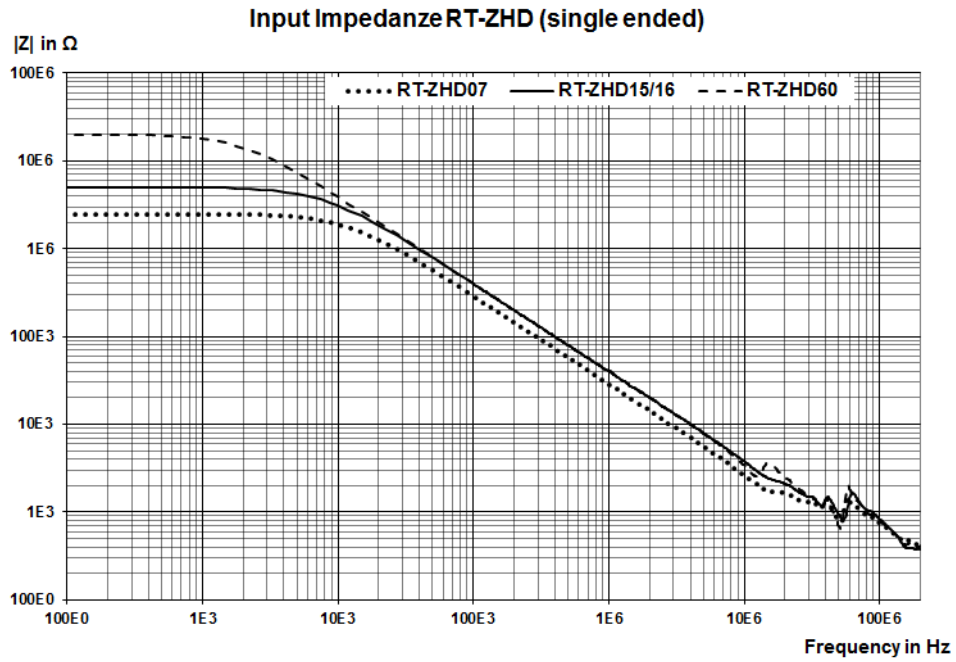


Figure 4-17: Magnitude of the single-ended input impedance of the R&S RT-ZHD probe as a function of frequency

5 Maintenance and service

Like all Rohde & Schwarz products, Rohde & Schwarz probes and adapters are of high quality and require only minimum service and repair. However, if service or calibration is needed, contact your Rohde & Schwarz service center. Return a defective product to the Rohde & Schwarz service center for diagnosis and exchange.

5.1 Cleaning

1. Clean the outside of the product using a soft cloth moistened with either distilled water or isopropyl alcohol. Keep in mind that the casing is not waterproof.

   Note: Do not use cleaning agents. Solvents (thinners, acetone), acids and bases can damage the labeling or plastic parts.

2. Dry the product completely before using it.

5.2 Contacting customer support

Technical support – where and when you need it

For quick, expert help with any Rohde & Schwarz product, contact our customer support center. A team of highly qualified engineers provides support and works with you to find a solution to your query on any aspect of the operation, programming or applications of Rohde & Schwarz products.

Contact information

Contact our customer support center at www.rohde-schwarz.com/support, or follow this QR code:

Figure 5-1: QR code to the Rohde & Schwarz support page

5.3 Returning for servicing

Use the original packaging to return your R&S RT-ZHD to your Rohde & Schwarzservice center. A list of all service centers is available on:

www.services.rohde-schwarz.com

If you cannot use the original packaging, consider the following:

1. Use a sufficiently sized box.
2. Protect the product from damage and moisture (e.g. with bubble wrap).
3. Use some kind of protective material (e.g. crumpled newspaper) to stabilize the product inside the box.
4. Seal the box with tape.
5. Address the package to your nearest Rohde & Schwarz service center.

5.4 Calibration interval

The recommended calibration interval for R&S RT-ZHD high-voltage differential probe is two years. For servicing, send the probe to your nearest Rohde & Schwarz service center (see Chapter 5.3, "Returning for servicing", on page 41).

5.5 Storage and transport

Protect the product against dust. Ensure that the environmental conditions, e.g. temperature range and climatic load, meet the values specified in the data sheet.

Store the product in a shock-resistant case, e.g. in the shipping case.

Unless otherwise specified in the data sheet, the maximum transport altitude without pressure compensation is 4500 m above sea level.

5.6 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.

Do not dispose the product in normal household waste after it has come to the end of its service life.

Rohde & Schwarz has developed a disposal concept for the eco-friendly 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.

5.7 Spare parts

The R&S RT-ZHD is defined as replacement unit. In case of any malfunction, the unit can be replaced by exchanging the probe.

The probes, accessories and test leads can be ordered at the Rohde & Schwarz service center. Use the order numbers provided in the following table.

Table 5-1: Probe and accessory spare parts for R&S RT-ZHD

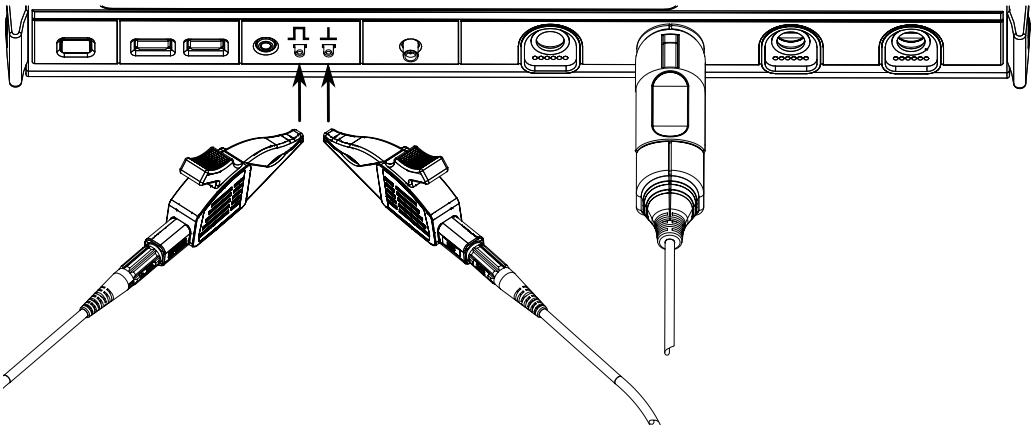
Pos.	Item	Description	Part number
20		R&S RT-ZHD07	1800.2307.02
		R&S RT-ZHD15	1800.2107.02
		R&S RT-ZHD16	1800.2207.02
		R&S RT-ZHD60	1800.2007.02
60		Protector	1800.2488.00
70		R&S RT-ZA22 test leads, 600 V CAT IV	1326.0988.02
80		R&S RT-ZA24 accessory kit	1800.2707.00

Table 5-2: Parts for ESD prevention

Pos.	Item	Material number
1	ESD wrist strap	0008.9959.00
2	ESD grounding cable	1043.4962.00

6 Functional check

The functional check confirms the basic operation of the R&S RT-ZHD high-voltage differential probe. The functional check is not suitable for verifying compliance with the probe specifications.



1. Connect the R&S RT-ZHD probe to an R&S oscilloscope as described in Chapter 3.2, "Connecting the probe to the oscilloscope", on page 21.
2. Connect the safety alligator clip to the square wave output ⎍ of the oscilloscope.
3. Connect the other safety alligator clip to the probe ground connector ⊥ of the oscilloscope.
4. Press the [Preset] key and then the [Autoset] key on the oscilloscope.
5. Set the attenuation ratio on the probe to "Attenuation high" (e.g. 1500 V range).
   A square wave is shown on the display. The voltage values depend on the oscilloscope model, they are listed in the oscilloscope's data sheet.
6. Set the attenuation ratio on the probe to "Attenuation low" (e.g. 150 V for the R&S RT-ZHD15).

   The displayed signal should not change, only the noise is reduced.
7. Activate the bandwidth limit on the probe.

   The limit is shown in the signal icon. The signal must remain on the display.
8. Interchange the safety alligator clips and redo all steps starting with step 4.

   The inverted signal is shown on the display.

Improve the displayed test signal

The high attenuation factor (e.g. 1000 with R&S RT-ZHD60) is responsible for high noise on the relative low test signal. For stable triggering, it is convenient to narrow the trigger bandwidth. Afterwards the noise of the signal could be reduced by averaging (e.g. 20 waveforms).