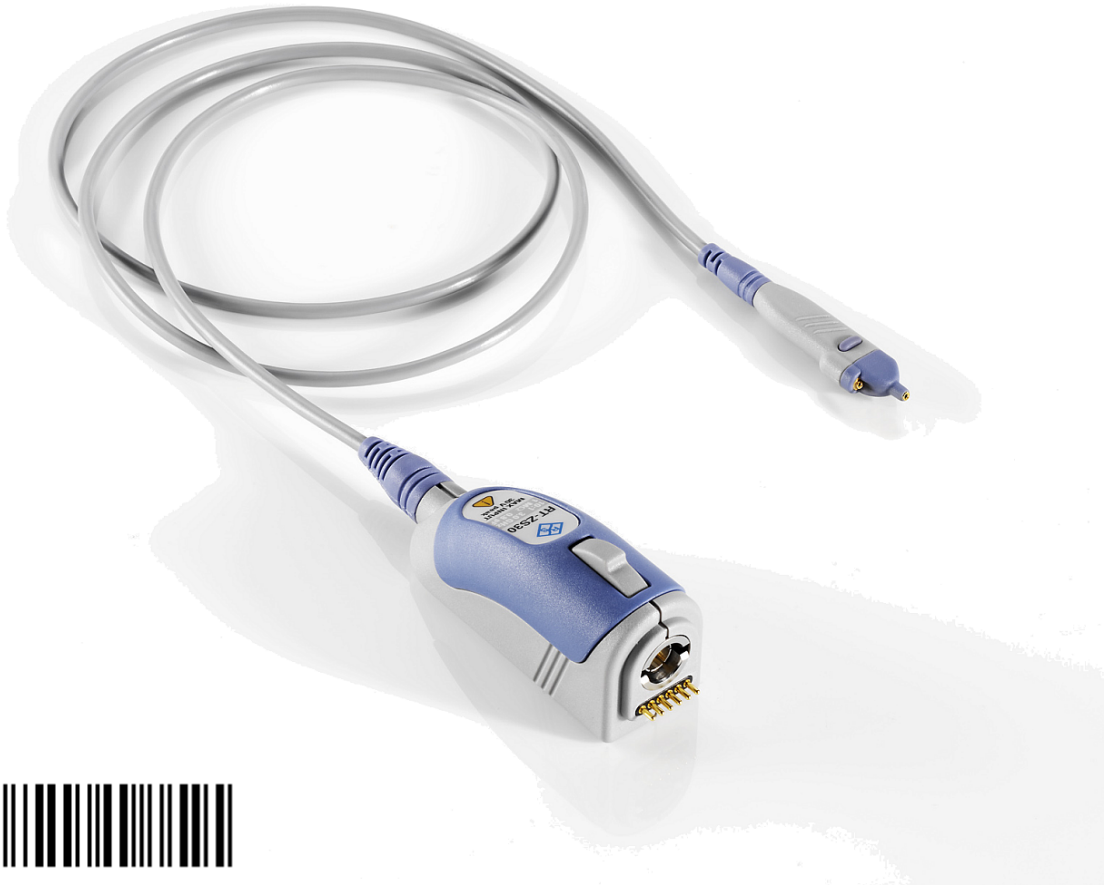
R&S®RT-ZS10E/10/20/30
Active Voltage Probe
User Manual



1410.3531.02 – 02

ROHDE&SCHWARZ

Test & Measurement

User Manual

The User Manual describes the following R&S®RT-ZS10E/10/20/30 models and options:

- R&S®RT-ZS10 (1410.4080.02)
- R&S®RT-ZS10E (1410.7007.02)
- R&S®RT-ZS20 (1410.3502.02)
- R&S®RT-ZS30 (1410.4309.02)

The firmware of the instrument makes use of several valuable open source software packages. the most important of them are listed below, together with their corresponding open source license. The verbatimlicense texts are provided on the user documentation CD-ROM.

Package	Link	License
Atmel	http://www.atmel.com/dyn/products/tools_card.asp?tool_id=4092	
Boost	http://www.boost.org	1.0

Rohde&Schwarz would like to thank the open source community for their valuable contribution to embedded computing.

Muehldorfstr. 15, 81671 Munich, Germany
Phone: +49 89 4129-0
Fax: +49 89 4129-12164
e-mail: info@rohde-schwarz.com
Internet: http://www.rohde-schwarz.com

The following abbreviations are used throughout this manual:
R&S®RT-ZS10E/10/20/30 is abbreviated as R&S RT-ZS10E/10/20/30.
R&S®ProbeMeter is abbreviated as R&S ProbeMeter

ROHDE&SCHWARZ

CE Declaration of Conformity

CE

Certificate No.: 2010-41

This is to certify that:

Equipment type	Stock No.	Designation
RT-ZS10	1410.4080.02	1,0 GHz Tastkopf / 1.0 GHz voltage probe
RT-ZS10E	1418.7007.02	1,0 GHz Tastkopf / 1.0 GHz voltage probe

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electrical equipment for use within defined voltage limits (2006/95/EC)
- relating to electromagnetic compatibility (2004/108/EC)

Conformity is proven by compliance with the following standards:

EN 61326-1: 2006
EN 61326-2-1: 2006
EN 55011: 2007 + A2: 2007

For the assessment of electromagnetic compatibility, the limits of radio interference for Class B equipment as well as the immunity to interference for operation in industry have been used as a basis.

ROHDE & SCHWARZ GmbH & Co. KG
Mühldorfstr. 15, D-81671 München

Munich, 2010-05-04 Central Quality Management MF-QZ / Radde

ROHDE&SCHWARZ

EC Certificate of Conformity

CE

Certificate No.: 2009-25

This is to certify that:

Equipment type	Stock No.	Designation
RT-ZS20	1410.3502.02	1,5 GHz Tastkopf / 1.5 GHz voltage probe
RT-ZS30	1410.4309.02	3,0 GHz Tastkopf / 3.0 GHz voltage probe

complies with the provisions of the Directive of the Council of the European Union on the approximation of the laws of the Member States

- relating to electromagnetic compatibility (2004/108/EC)

Conformity is proven by compliance with the following standards:

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ROHDE & SCHWARZ GmbH & Co. KG
Mühldorfstr. 15, D-81671 München

Munich, 2009-07-15 Central Quality Management MF-QZ / Chadzelek

Table of Contents

Documentation Overview

The user documentation for the R&S RT-ZS10/20/30 is divided as follows:

User Manual

All instrument functions for the R&S RT-ZS10/20/30 active voltage probe are described in detail in this user manual. Information on maintenance, instrument function, cleaning and functional check is also provided. For details on general data, specifications and ordering information refer to the data sheet.

The user manual includes the following chapters:

Chapter 1 Product Description

Chapter 2 Putting into Operation

Chapter 3 Connecting the Probe to the DUT

Chapter 4 Measurement Principles

Chapter 5 Maintenance and Service

Chapter 6 Functional Check

Service Manual

This manual is available in PDF format on the CD delivered with the RT-ZK1 Service Kit. It describes how to check compliance with rated specifications, instrument function, repair, troubleshooting and fault elimination.

The service manual includes the following chapters

Chapter 1 Performance Test

Chapter 2 Adjustment

Chapter 3 Repair

Chapter 4 Software Update

Chapter 5 Documents

1 Product Description

The R&S RT-ZS10/20/30 is a single-ended active voltage probe with high input impedance. It allows the user to make ground-referenced voltage measurements from DC to 1.0 GHz, 1.5 GHz and 3 GHz, respectively. The comprehensive accessory set allows the R&S RT-ZS10/20/30 probe to be connected to a wide variety of devices under test (DUT). Provided with special features such as the R&S ProbeMeter and the micro button, the R&S RT-ZS10/20/30 is designed to meet tomorrow's challenges in probing.

Since the probe is equipped with Rohde & Schwarz probe interface, it can be connected to any Rohde & Schwarz base unit that is compatible with this interface. When connected to the front panel of an R&S oscilloscope, the probe is controlled via the software menus of the oscilloscope.

Using a specially developed adapter (see Optional Accessories on page 11), the probe can be connected to any other base unit.

1.1.1 R&S RT-ZS10E

The R&S RT-ZS10E probe is a cost-efficient alternative to the R&S RT-ZS10 probe. The electrical specifications of both probes are identical. The two probes are of the same high quality, for example, in terms of frequency response, dynamic range, input resistance, input capacitance as well as zero and gain error. In contrast to the R&S RT-ZS10, however, the R&S RT-ZS10E features only a limited range of accessories and does not offer the additional functions of offset compensation, micro button and R&S ProbeMeter. The R&S RT-ZS10E is ideally suited for customers who value the high signal fidelity of Rohde & Schwarz probes and who, for their specific applications, can do without a large set of accessories and the additional functions.

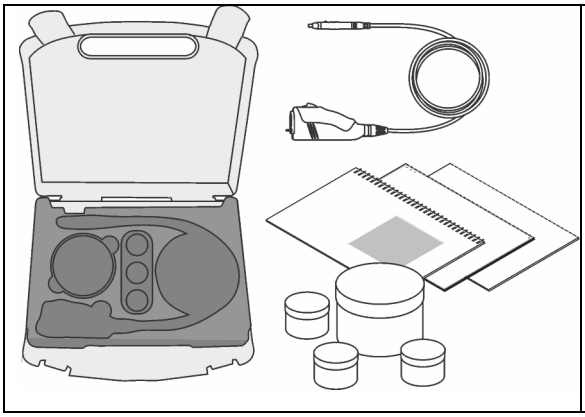
In the following, the R&S RT-ZS10E and the R&S RT-ZS10 are equivalent, with the following exceptions:

- The R&S RT-ZS10E does not come with a carrying case or its contents.
- The R&S RT-ZS10E does not offer the offset compensation, micro button and R&S ProbeMeter functions.
- The R&S RT-ZS10E has only a limited set of accessories.

1.2 Unpacking the Instrument

The carrying case contains the following items:

Figure 1-1: Equipment supplied



(1) R&S RT-ZS10/20/30 probe
(2) Carrying case
(3) Accessory vials
(4) Operating manual
(5) R&S RT-ZS10/20/30 data sheet
(6) Calibration certificate
(7) Documented calibration values (if ordered)

1.2.1 Inspecting the Contents

- Inspect the package for damage.
  Keep a damaged package and the cushioning material until the contents have been checked for completeness and the instrument has been tested.
  If the packaging material shows any signs of stress, notify the carrier as well as your Rohde & Schwarz service center. Keep the package and cushioning material for inspection.

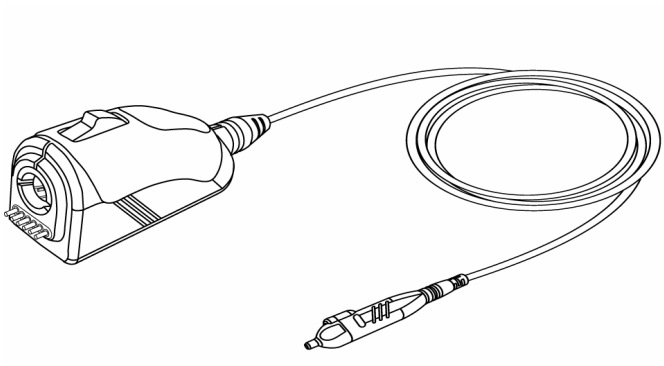
- Inspect the probe.
  If there is any apparent damage or defect, or if the R&S RT-ZS10/20/30 active voltage probe does not operate properly, notify your Rohde & Schwarz service center.

- Inspect the accessories.
  Accessories supplied with the instrument are listed in the Accessories Supplied section on page 10. If the contents are incomplete or damaged, notify your Rohde & Schwarz service center.

1.3 Key Characteristics and Key Features

The key characteristics of the probe are listed below:

Figure 1-2: Key characteristics and key features



- Bandwidth:
  DC to 1 GHz (R&S RT-ZS10)
  DC to 1.5 GHz (R&S RT-ZS20)
  DC to 3 GHz (R&S RT-ZS30)
- Dynamic range:
  ±8 V with ±12 V offset capability
  16 V AC (V_{pp})
- Input resistance: 1 MΩ
- Input capacitance: 0.8 pF
- Extremely low zero and gain errors throughout the entire temperature range
- Micro button
- R&S ProbeMeter with measurement error <0.1 %
- Rohde & Schwarz probe interface

- The micro button is located at the probe head. The micro button can be configured via the base unit. By pressing it, the user can remotely control different functions on the base unit. For details, refer to the Micro Button section on page 18.

- 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 in parallel to the time domain measurement. If activated on the base unit, the measurement value is displayed on the screen of the R&S oscilloscope (see R&S ProbeMeter on page 19).

- The probe includes an integrated data memory with individual probe correction parameters (e.g. gain, delay, offset). These correction parameters are read out and processed by the R&S oscilloscope. As a result, the probe offers a very high degree of accuracy so that additional calibration procedures are not required.

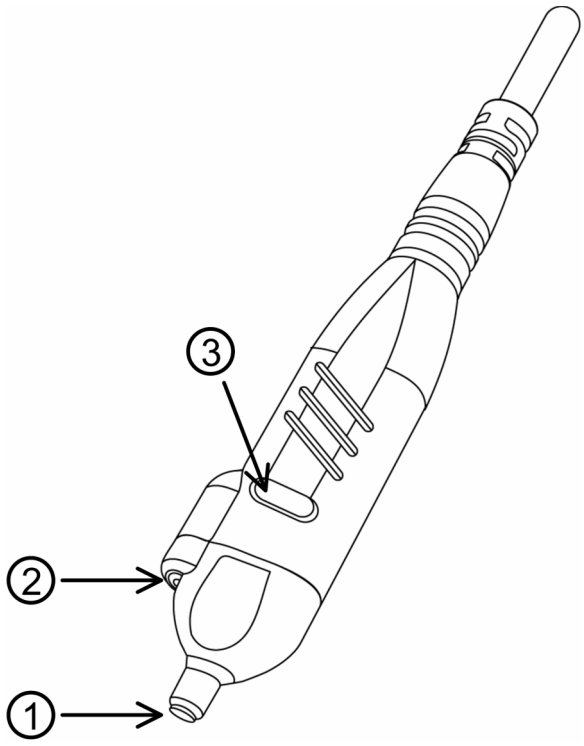
1.4 Description of the Probe

The probe consists of the probe head for connection to the DUT, the probe box for connection to the oscilloscope, and the probe cable.

1.4.1 Probe Head

The small and lightweight probe head is designed for easy handling and high-performance measurements. The probe head is used for connecting the probe and the DUT. Different accessories for the signal socket and the ground socket allow the probe head to be connected to a wide range of DUTs.

Probe head



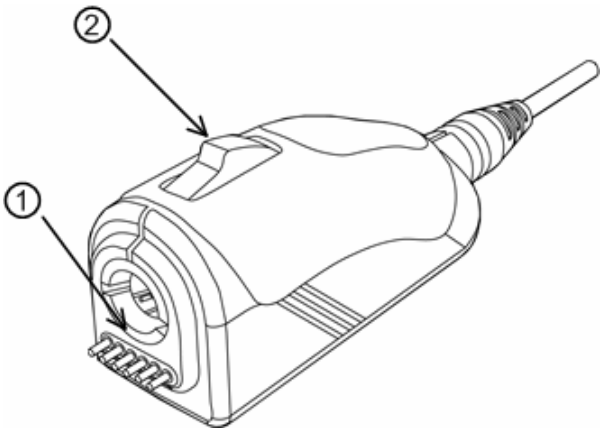
(1) Signal socket
(2) Ground socket
(3) Micro button

The accessories supplied for the probe head sockets are listed in Table 1-1. Signal and ground sockets are compatible with 0.64 mm (25 mil) square pins and 0.6 mm to 0.8 mm (24 mil to 35 mil) round pins.

1.4.2 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 for simultaneously transmitting analog signals and digital data. All the analog voltages required by the probe are generated in the probe box. This approach ensures that it will be possible to operate future probes on any base unit that features a Rohde & Schwarz probe interface.

Probe box

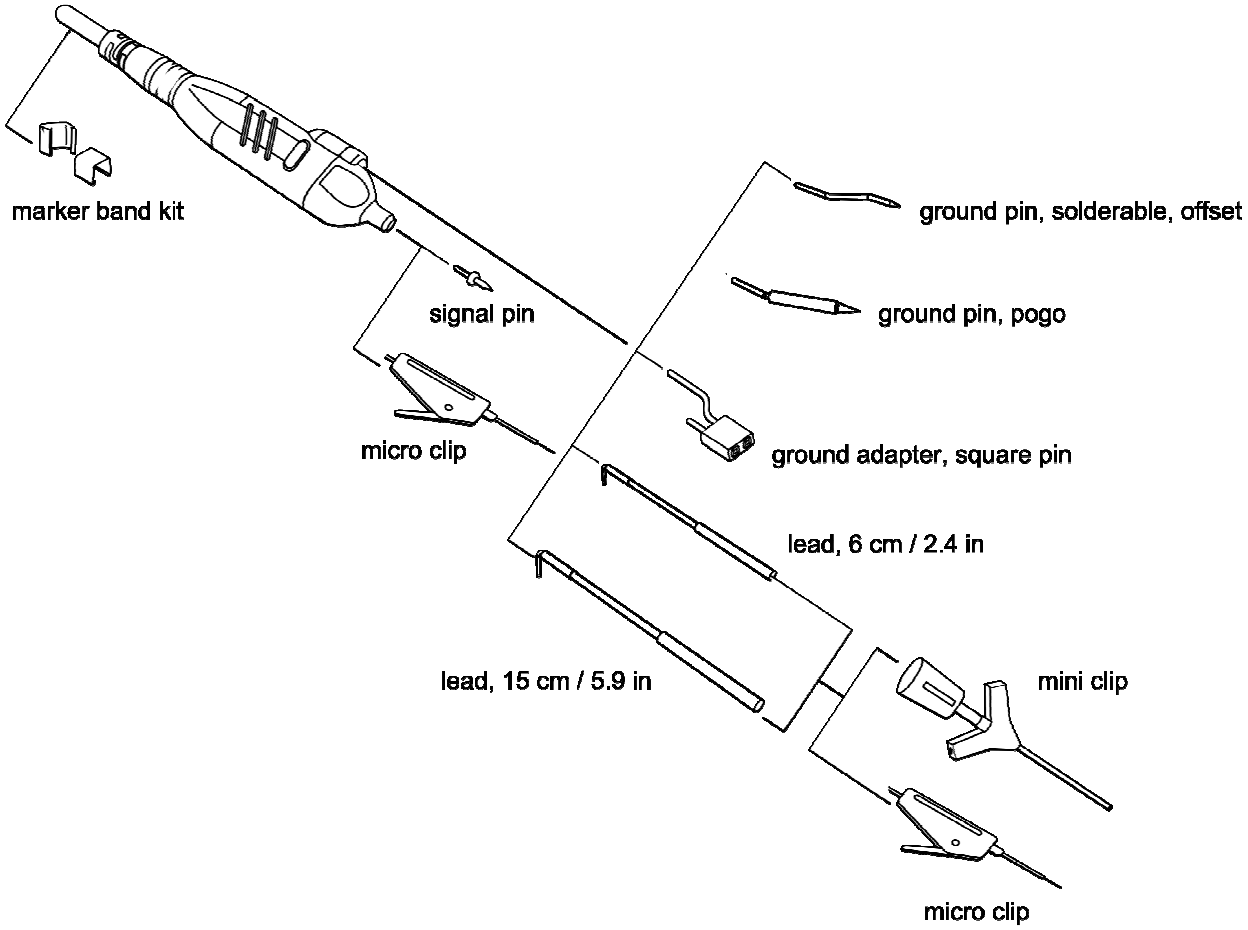


(1) Rohde & Schwarz probe interface with BNC-compatible 7 mm (276 mil) connector and 6 pogo pins
(2) Release knob

1.5 Accessories and Items

Figure 1-3 shows all the accessories that are available for the R&S RT-ZS10/20/30 probe.

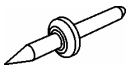
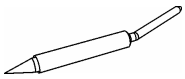
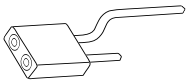
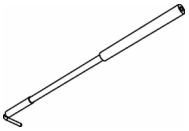
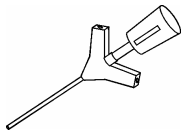
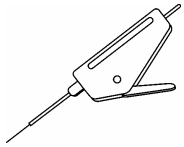
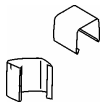
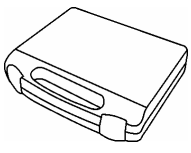
Figure 1-3: Available accessories



1.5.1 Accessories Supplied

The following table shows the accessories supplied with the R&S RT-ZS10/20/30 probe.

Table 1-1: Accessories supplied

Item	Quantity		Description
	ZS10/20/30	ZS10E	
	10	5	Signal pin
	5	2	Ground pin, pogo
	10	2	Ground pin, solderable, offset
	2	-	Ground adapter, square pin
	2	-	Lead, 6 cm / 2.4 in
	2	1	Lead, 15 cm / 5.9 in
	2	1	Mini clip
	2	-	Micro clip
	1	1	Marker band kit
	1	-	Carrying case with foam inlay

1.5.2 Optional Accessories

If the included accessories do not meet individual customer requirements, Rohde & Schwarz offers different accessories for sale.

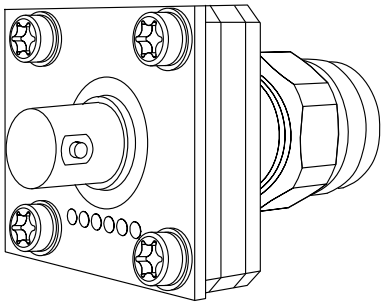
R&S RT-ZA2 Spare Accessory Set		
Item	**Quantity**	**Description**
– Signal pin	10	This set contains all the accessories supplied with the R&S RT-ZS10/20/30.
– Ground pin, pogo	5	
– Ground pin, solderable, offset	10	
– Ground adapter, square pin	2	
– Marker band kit	1	
– Mini clip	2	
– Micro clip	2	
– lead, 6 cm / 2.4 in	2	
– lead, 15 cm / 5.9 in	2	
– Accessory box and vials	1	
– Carrying case with foam inlay	1	
– R&S RT-ZS10/20/30 operating manual	1	

R&S RT-ZA3 Pin Set		
Item	**Quantity**	**Description**
– Signal pin	20	This set contains the pins available for the R&S RT-ZS10/20/30.
– Ground pin, pogo	5	
– Ground pin, solderable, offset	20	
– Ground adapter, square pin	2	
– Marker band kit	1	

R&S RT-ZA4 Mini Clips		
Item	**Quantity**	**Description**
– Mini clip	10	This set contains mini clips.

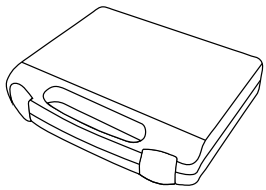
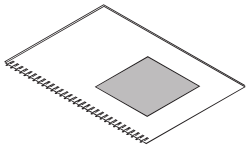
R&S RT-ZA5 Micro Clips		
Item	**Quantity**	**Description**
– Micro clip	4	This set contains micro clips.

R&S RT-ZA6 Lead Set		
Item	**Quantity**	**Description**
– lead, 6 cm / 2.4 in – lead, 15 cm / 5.9 in	5 5	This set contains short and long leads.

R&S RT-ZA9 Probe to N Adapter	
	The adapter can be used to connect the R&S RT-ZS10/20/30 active voltage probe to any other oscilloscope or any other measurement instrument (e.g. a network or spectrum analyzer). Via the USB interface of the adapter, the probe can be powered and controlled from any conventional PC.

1.5.3 Service Accessories

The following accessories are optionally available for servicing the probe.

R&S RT-ZK1 service kit	
	The R&S RT-ZK1 service kit is used for calibrating the R&S RT-ZS10/20/30 active voltage probe, for making performance tests and for servicing. The service kit includes all adapters and accessories to match the probe to the required measuring instruments.
R&S RT-Z service manual	
	The service manual contains a detailed description of the performance test for verifying the probe specifications.

All service accessories and items can be ordered from your Rohde & Schwarz service center.

2 Putting into Operation

The R&S RT-ZS10/20/30 active voltage probe has been designed to withstand a moderate amount of physical and electrical stress. You should treat the probe with care. It can be damaged if excessive force is applied to the probe tip.

NOTICE

Exercise care to prevent the probe from receiving mechanical shock.

Always handle the probe by the probe head or probe box.

Avoid putting excessive strain on the probe cable or exposing it to sharp bends.

Store the probe in a shock-resistant case such as the foam-lined shipping case that came with the probe.

The probe is electrically protected against static voltage.

NOTICE

Voltages above the specified limits of the R&S RT-ZS10/20/30 active voltage probe may damage the probe tip amplifier.

Do not exceed the specified limits.

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

2.1 Installation

This section provides a quick introduction to the use of the R&S RT-ZS10/20/30 active voltage probe.

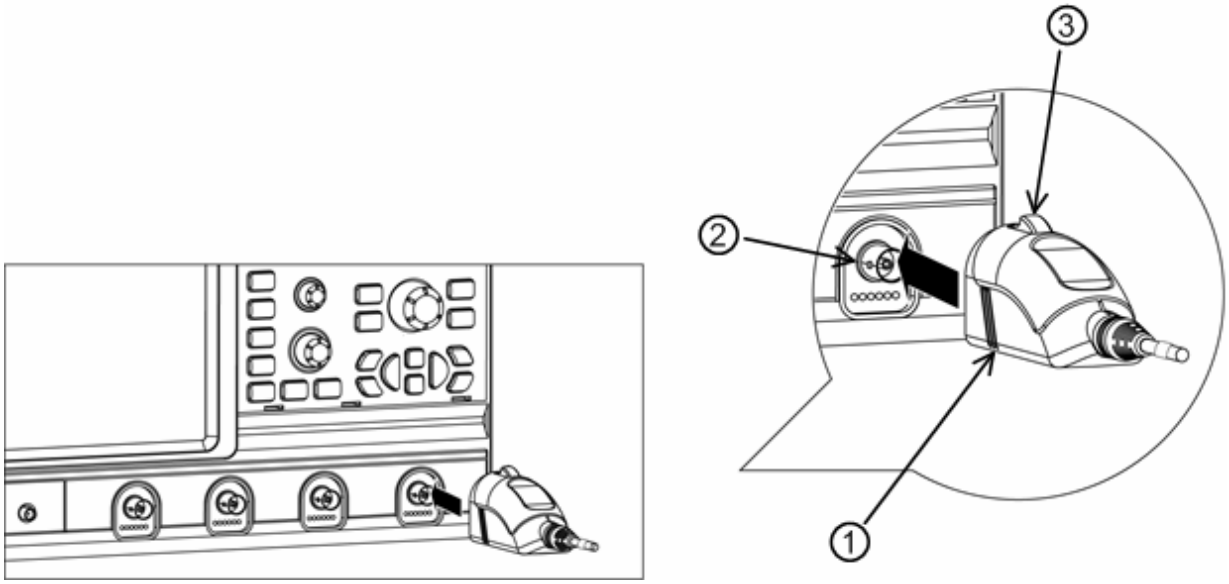
All settings of the base unit described in this section refer to the R&S RTO oscilloscope. If any other oscilloscope is used, differences in settings and menu navigation may be possible.

2.1.1 Connecting the Probe to the R&S RTO Oscilloscope

The R&S RT-ZS10/20/30 active voltage probe has been designed for use with R&S RTO oscilloscopes. Connect the probe box (1) to the Rohde & Schwarz probe interface of the base unit (2). The probe will snap in when connected properly to the port.

To disconnect, press the release button (3) and pull the probe box away from the front panel of the base unit.

Figure 2-1: Connecting the probe to the R&S RTO oscilloscope



2.1.2 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.

As soon as the probe is connected to the oscilloscope and the settings are adjusted, the trace is started for the channel to which the probe is connected.

Probe-specific settings and information are displayed in the probe menu of the oscilloscope:

► "Vertical" > "Probe Setup" > “Ch”

2.1.3 Auto Zero

This procedure performs an automatic correction of the zero error displayed on the oscilloscope’s screen. The trace is set to 0 V on the horizontal centerline of the oscilloscope.

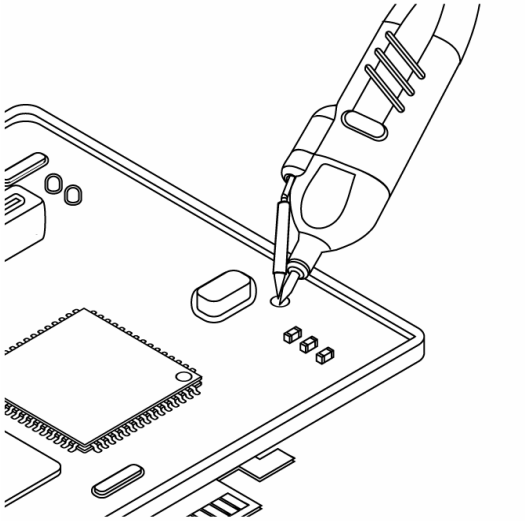
The zero error of the R&S RT-ZS10/20/30 probe itself is very small, typically in the range of a few hundred micro volts referred to the probe input. However, differences in DUT and oscilloscope ground levels may cause larger zero errors to be displayed on the oscilloscope’s screen. If the DUT is not floating but ground-referenced, an auto zero routine may improve the measurement results.

Follow these steps to perform the Auto Zero function using the micro button (see Micro Button on page 18).

1. Connect the probe to the R&S RTO oscilloscope
2. Configure the base unit settings:

► "Vertical > Probe Setup > Ch > Probe Button Action ‘Auto zero’ "

3. Short the signal pin and the ground pin together and connect them to the ground of the DUT.



4. Press the micro button.

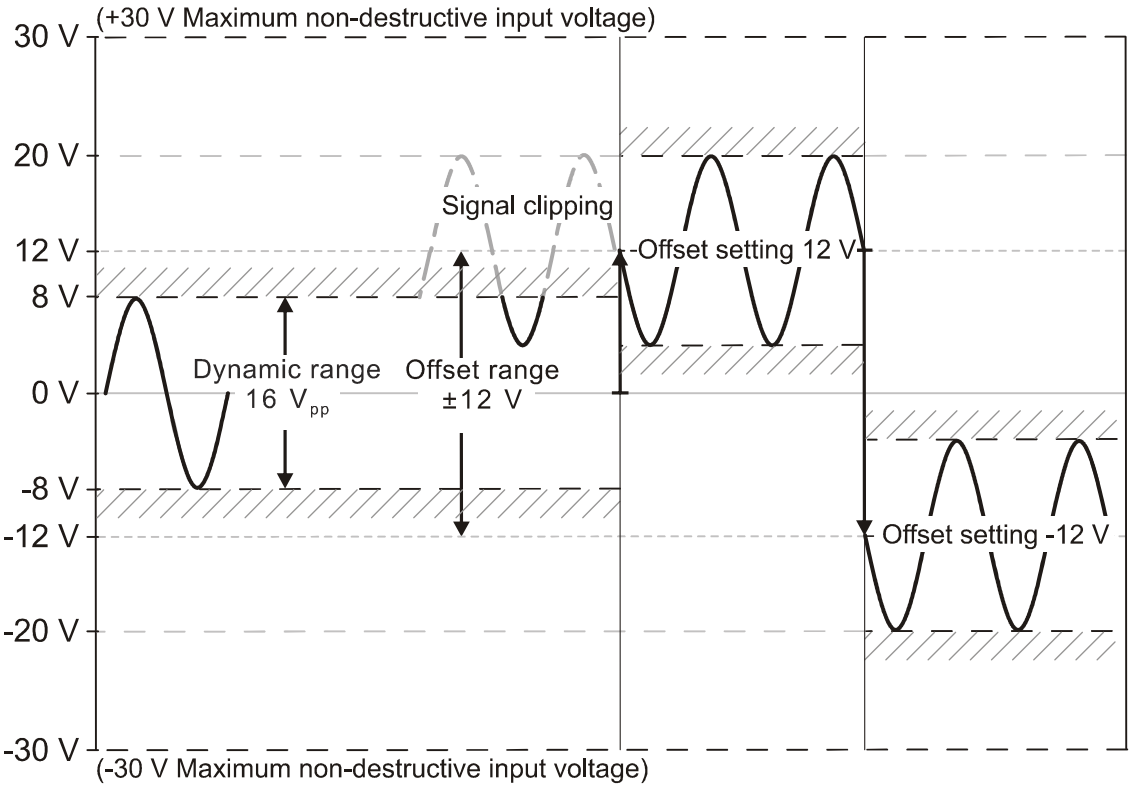
As an alternative, the Auto Zero function can be performed using the following menu in the oscilloscope.

► "Vertical > Probe Setup > Ch> Auto zero"

2.2 Offset Compensation

The Offset Compensation function makes it possible to compensate for a DC component of the input signal, even in front of the active amplifier in the probe tip. As a result, the entire dynamic range of the probe is maintained. This function is useful when measuring AC signals with high superimposed DC component.

Figure 2-2: Offset compensation voltage and dynamic range



You can set the offset compensation voltage by pressing and turning the Vertical Position button on the base unit.

Alternatively, you can set the offset compensation voltage via the probe menu.

► "Vertical > Probe Setup > Ch > Set offset to mean"

For more details on setting the offset compensation voltage, refer to the "User Manual" of the R&S oscilloscope.

As an additional feature, the probe offers automatic offset compensation by means of the micro button. A single push on the button compensates the DC component of the measurement signal (see Micro Button on page 18).

To do this, the Offset to mean function must first be assigned to the micro button:

► "Vertical > Probe Setup > Ch > Probe Button Action ‘Set offset to mean’ "

Using the Offset to mean function and pressing the micro button enables quick and convenient measurements of input signals with different DC offsets.

NOTICE

The maximum input voltage is ±30 V. A higher input voltage may destroy the probe.

2.3 Micro Button

The micro button provides easy and quick access to important functions of the R&S oscilloscope. After a function has been assigned, pressing the micro button remotely controls this specific function on the base unit. For example, Continuous Trigger and Auto Zero are commonly assigned to the micro button.

To assign a function to the micro button with the R&S RTO oscilloscope, proceed as follows:

"Vertical" > "Probe Setup" > “Ch” > "Probe Button Action"

For more details on the available functions and settings for the micro button, refer to the "User Manual" of the R&S oscilloscope.

2.4 R&S ProbeMeter

The integrated voltmeter makes it possible to measure DC voltages between probe tip and ground connection with very high precision compared to the oscilloscope's DC accuracy. The DC measurement is performed continuously and in parallel to the time domain measurement of the oscilloscope. High-precision measurements are achieved through immediate digitization of the measured DC voltage inside the probe.

To activate the R&S ProbeMeter, make the following settings on the R&S RTO oscilloscope:

► "Vertical > Probe Setup > Ch > R&S ProbeMeter 'on'"

After the R&S ProbeMeter has been activated, the measured values are displayed on the screen of the oscilloscope.

Advantages of the R&S ProbeMeter:

- Enables the user to check DC voltages with different levels without having to adjust the measurement range of the oscilloscope.
- Provides a simple means of setting the oscilloscope's trigger level and vertical scaling if a waveform is not visible.
- Independent of oscilloscope settings for offset, position, vertical scale and horizontal scale.
- True DC measurement (integration time > 100 ms), not mathematical average of displayed waveform.
- Measurement range ±8 V + offset compensation setting. Maximum measurement accuracy is achieved when offset compensation is switched off.
- High measurement accuracy and low temperature sensitivity, typically 0.1% of reading over the entire temperature range.

The R&S ProbeMeter enables the ground-referenced measurement of voltages. A difference in the ground levels of oscilloscope and DUT can cause an unwanted zero error. Should this happen, use the Auto Zero function (refer to Auto Zero on page 15).

3 Connecting the Probe to the DUT

This chapter describes the different ways of connecting the probe to the DUT. In addition, the accessories supplied are described and their use is explained.

In order to achieve optimum RF performance, the connections should always be as short as possible. If long connections cannot be avoided, they should preferably be used for the ground socket.

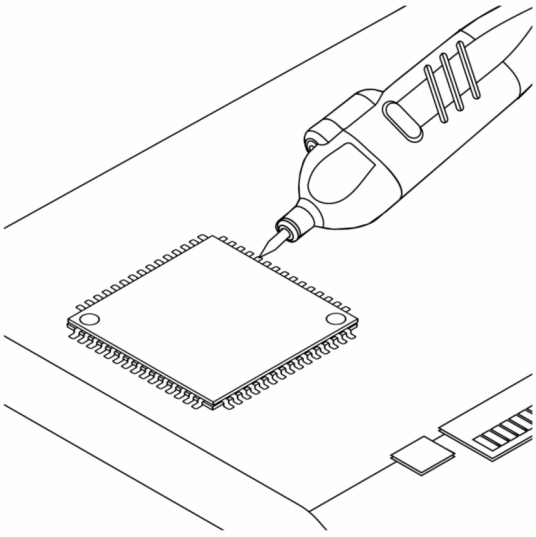
CAUTION

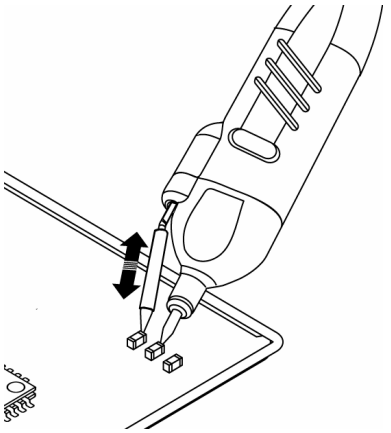
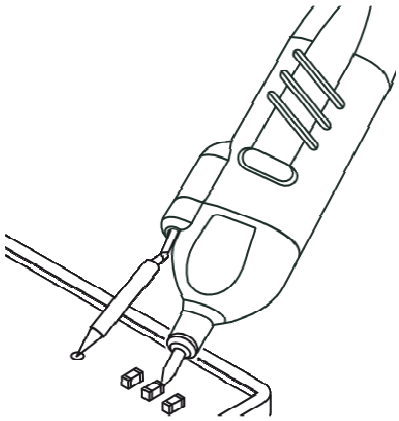
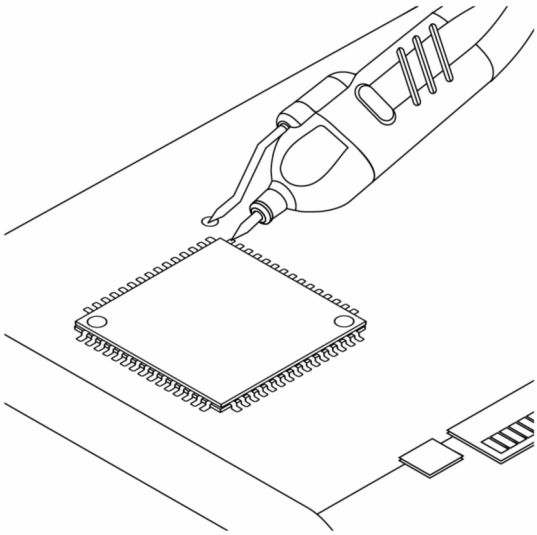
Risk of injuries

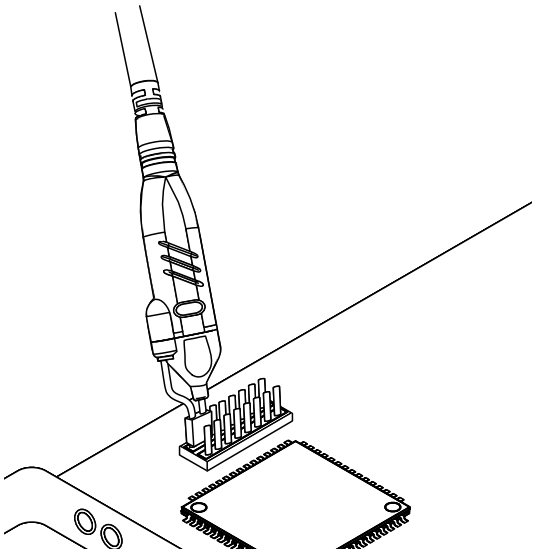
The included probe pins are exceptionally sharp and must be handled with extreme care. To prevent injuries, always use pliers when inserting or removing pins. Probes must be used in a manner consistent with the Rohde & Schwarz instructions.

Tips on using standard accessories

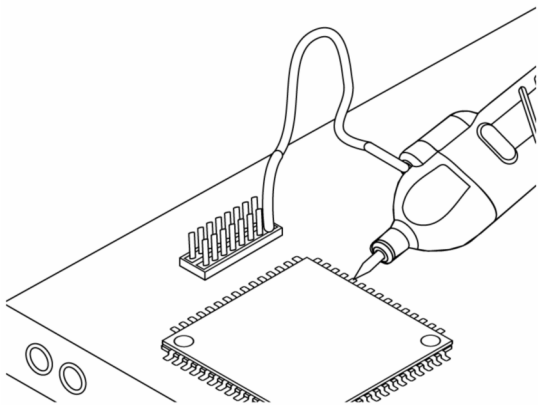
Pins

Signal pin	
	The signal pin is held to the DUT in order to tap off the measurement signal. It fits into the signal socket and is designed for various applications, e.g. measurements on SMT resistors, IC pins, conductors or vias. If necessary, the signal pin can also be soldered to the DUT.

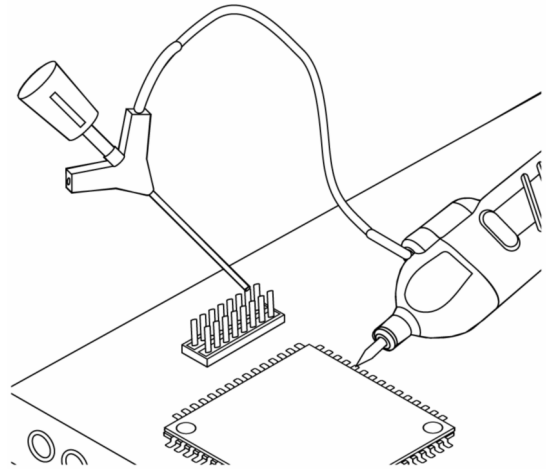
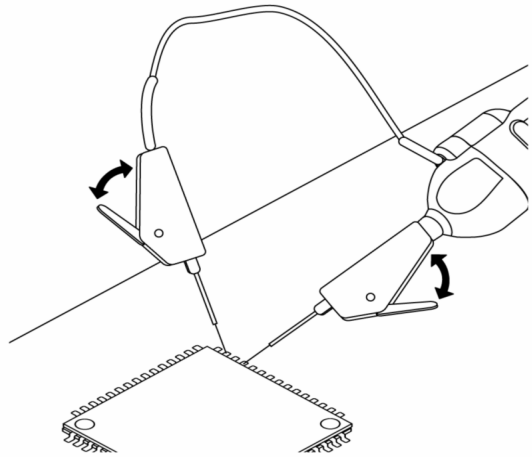
Ground pin, pogo	
 	The spring-loaded ground pin allows handheld probing. Because it compensates for minor unevenness and movements, this ground pin is capable of establishing a firm contact with the test point. It fits into the ground socket of the probe head. The distance to the signal pin can be varied by turning the ground pin. Distance range: 0 mm to 10 mm (0 mil to 400 mil)
Ground pin, solderable, offset	
	The rigid ground pin is soldered to a test point on the DUT and provides a reliable and permanent connection to the DUT. The soldered probe should be stabilized by using appropriate means (e.g. adhesive tape, probe positioner) in order to protect the solder joint from excessive mechanical stress. The distance to the signal pin can be varied by turning the ground pin. Distance range: 2.54 mm to 8 mm (100 mil to 315 mil)

Ground adapter, square pin	
	The ground adapter is used for plugging the probe onto pin strips with 0.64 mm square pins (typical pitch 2.54 mm, 100 mil). For probing on pin strips, the signal socket is directly plugged onto the pin strip (without signal pin). The ground adapter is plugged onto the ground socket of the probe. The required distance to the signal socket is set by turning the ground adapter. Distance range: 2.54 mm to 8 mm (100 mil to 315 mil)

Leads

Short and long lead	
	The lead provides a flexible connection to the DUT. It is plugged onto a pin on the DUT and can be used to connect either the signal socket or the ground socket. In addition, it allows micro and mini clips to be connected to the probe. Length: Short lead: 6 mm (236 mil) Long lead: 15 mm (591 mil)

Clips

Mini clip	
	The mini clip is designed for probing large IC pins, wires and through-hole components. For probing, clamp the mini clip to a pin and connect it to the signal socket or the ground socket using a lead.
Micro clip	
	The micro clip is designed for probing IC pins and thin wires in fine-pitch applications. The micro clip fits directly into the signal socket or the ground socket using a lead.

4 Measurement Principles

The R&S RT-ZS10/20/30 active voltage 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, will transfer the input signal in altered form. A good probe causes only minimum alterations.

- 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 as soon as the probe is connected. A good probe should cause only a minimum change to the signal, so that the function of the DUT is not adversely affected.

The extent to which the probe can fulfill these requirements is largely determined by its bandwidth and its input impedance. The bandwidth and input impedance of a probe are usually specified for a minimally short connection between the probe and the DUT. With longer connections, the connection inductance has a significant effect on the measurement.

The high-frequency behavior of active probes is typically characterized in a 50 Ω measurement environment. The probe is connected to a 50 Ω line that is fed by a source with 50 Ω internal impedance and that is terminated into 50 Ω. Figure 4-1 shows the equivalent circuit model of a probe that is connected to the DUT.

Figure 4-1: Equivalent circuit model of the R&S RT-ZS10/20/30 probe

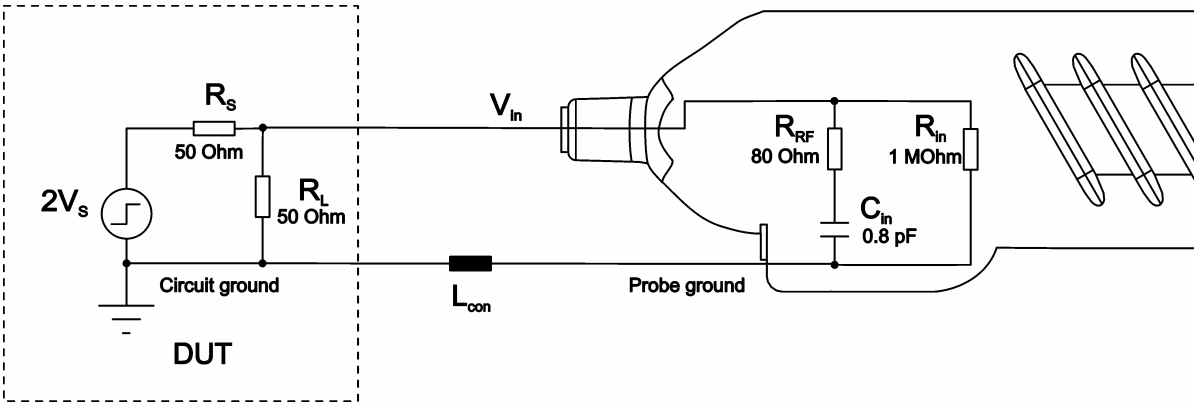


Table 4-1: Designations

Abbreviation	Description
V_S	Voltage at the test point without probe connected
R_S	Source resistance of the DUT
R_L	Load resistance of the DUT
V_{in}	Voltage at the test point with probe connected, corresponds to the input voltage of the probe
R_{in}	DC input resistance
C_{in}	Input capacitance of the probe
R_{RF}	RF input resistance of the probe
L_{con}	Parasitic inductance of the ground connection
V_{out}	Probe output voltage displayed by the oscilloscope

In a 50 Ω system, the output resistance of the source, the load resistance and the characteristic impedance of all lines equal exactly 50 Ω. However, the behavior of the probe in the circuit is determined by the effective source impedance which is the impedance present in the DUT between the probe tip and ground.

Effective source impedance: $R'_S = R_S \,||\, R_L = 25\Omega$

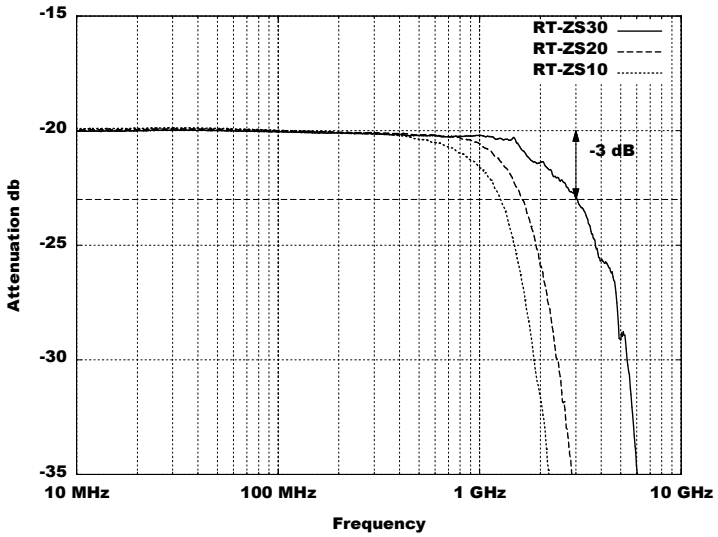
4.1 Signal Integrity of the Transferred Signal

The following sections describe the effect that bandwidth and connection inductance have on signal integrity.

4.1.1 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 4-2: Amplitude frequency response of the R&S RT-ZS10/20/30



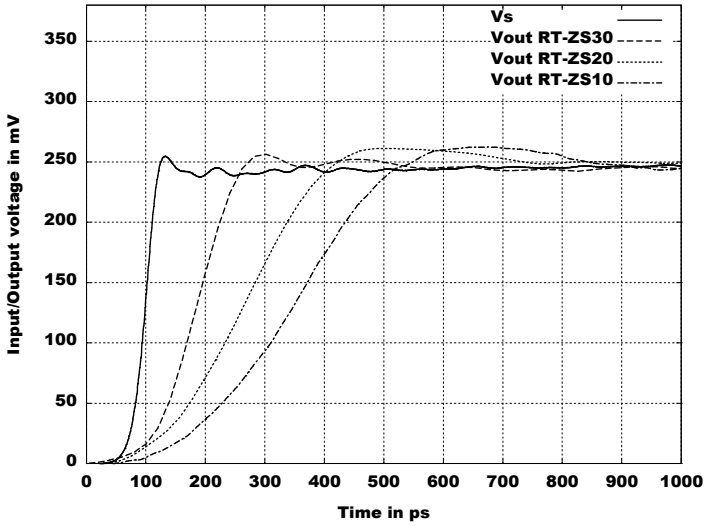
The bandwidth

- Specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 70 % (–3 dB) of its amplitude, see Figure 4-2.
- Specifies the transferable spectrum for other waveforms. E.g. with squarewave 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:

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

Figure 4-3 shows a typical step response of an R&S RT-ZS10/20/30 probe.

Figure 4-3: Step response of the R&S RT-ZS10/20/30



In addition to bandwidth, a constant amplitude frequency response of the probe is decisive for high signal integrity. Fig. 4-2 shows the typical amplitude frequency response of an R&S RT-ZS10/20/30 probe. All frequency components are transferred with the same gain so that the input signal is displayed without distortion.

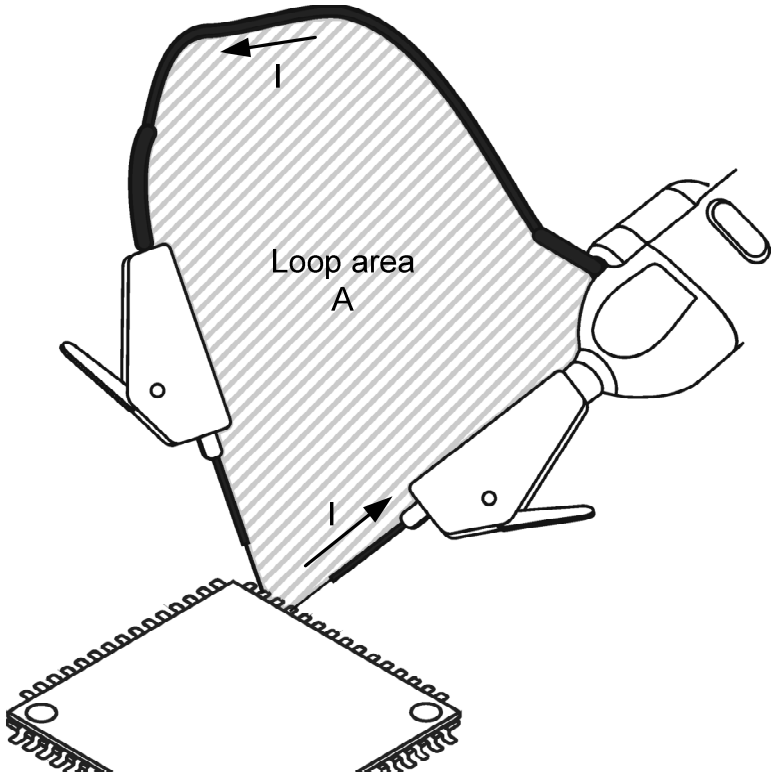
4.1.2 Connection Inductance

The connection inductance L_{con} is caused by connecting the probe to the DUT. In contrast to the probe-specific bandwidth, the connection inductance mainly depends on the type of connection that the user selects.

The connection inductance

- Increases with the length of the connection and the size of the resulting loop area A (Figure 4-4).
- Reduces the usable bandwidth and causes ringing with signals having a short rise time (due a series resonance with the input capacitance).
- Should be as small as possible (short lead length) in order to maintain high signal integrity.
- Long leads on the signal input are especially problematic.

Figure 4-4: Ground connection and connection inductance



L_{con} proportional to A

$$f_{resonance} \approx \frac{1}{2\pi\sqrt{L_{con} \cdot C_{in}}}$$

BW proportional to $\frac{1}{\sqrt{L_{con}}}$

The following figures (Table 4-2, Figure 4-5 to Figure 4-7) show different types of connections between probe and DUT as well as the associated connection inductance L_{con} and the step responses.

Table 4-2: Connection inductance L_{con} and resulting bandwidth with different types of connection

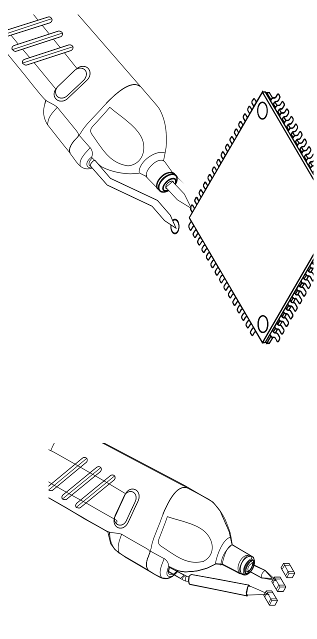
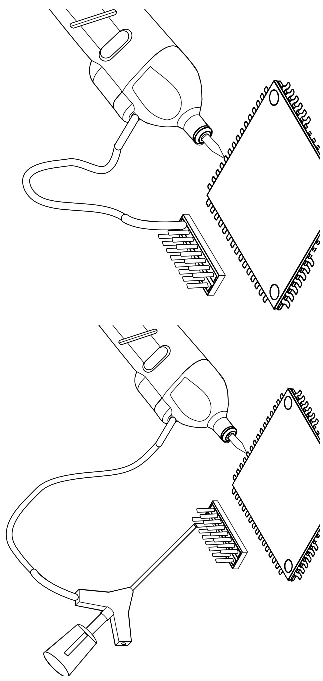
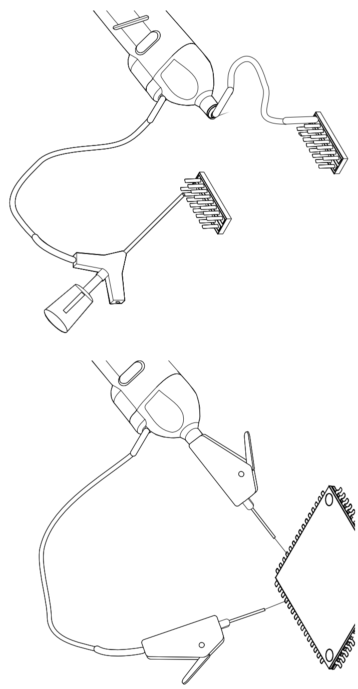
No	Type of connection	Connection: Signal socket	Connection: Ground socket	Connection inductance L_{con}	Resulting bandwidth	Rise time
1.		Signal pin	Ground pin	~4 nH	RT-ZS10: 1.0 GHz RT-ZS20: 1.5 GHz RT-ZS30: 3.0 GHz	RT-ZS10: < 350 ps RT-ZS20: < 250 ps RT-ZS30: < 135 ps
2.		Signal pin	Ground lead	~20 nH	RT-ZS10: 1.0 GHz RT-ZS20: 1.2 GHz RT-ZS30: 1.3 GHz	RT-ZS10: < 400 ps RT-ZS20: < 300 ps RT-ZS30: < 270 ps
3.		Clip / Lead	Ground lead	~60 nH	700 MHz	> 1 ns

Figure 4-5: Step response of the R&S RT-ZS30 with a type 1 connection

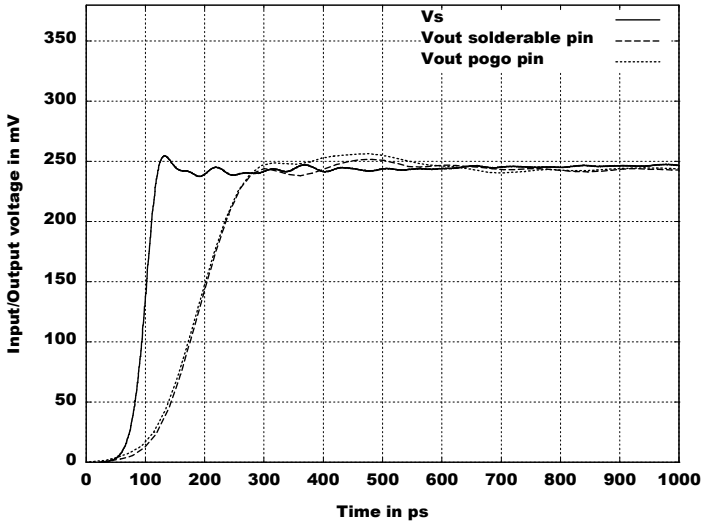


Figure 4-6: Step response of the R&S RT-ZS30 with a type 2 connection

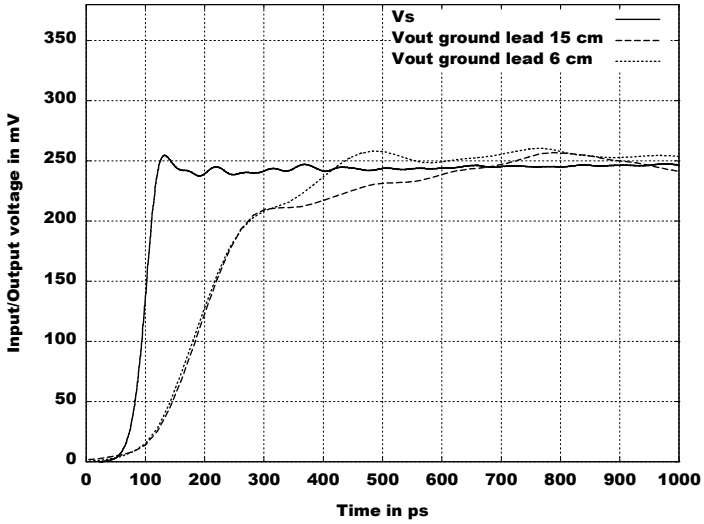
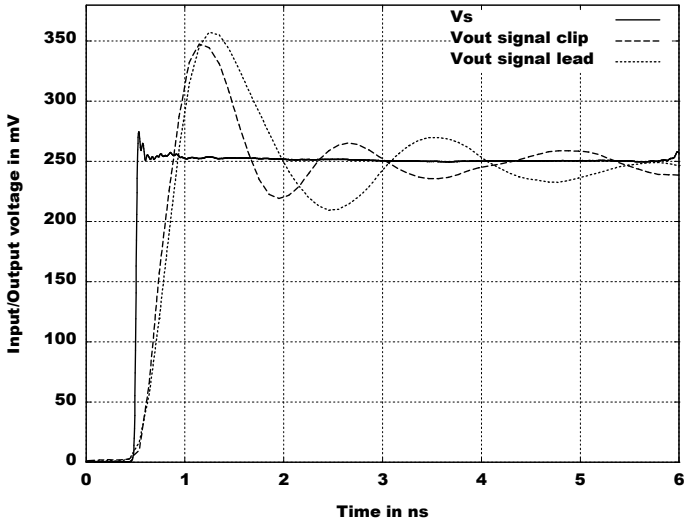


Figure 4-7: Step response of the R&S RT-ZS30 with a type 3 connection



4.2 Signal Loading of the Input Signal

The previous section dealt with the transfer function and step response of the probe. This section describes how the probe influences the input signal.

4.2.1 Input Impedance

The input signal loading caused by the probe is determined by its input impedance Z_{in}. Figure 4-1 presents an equivalent circuit model.

Z_{in} consists of the following probe-specific parameters.

- Input resistance Rin
- Input capacitance Cin
- RF resistance RRF

The resulting input impedance versus frequency is indicated in Figure 4-8. The trace shows three characteristic areas that can be assigned to R_{in}, C_{in} and R_{RF}. The resulting loading of a step signal at the input of the probe is given in Figure 4-9.

The connection inductance L_{con} has only a minor effect on the signal loading and is therefore not taken into account in the following.

Figure 4-8: Magnitude of the input impedance of the R&S RT-ZS10/20/30 probe as a function of frequency

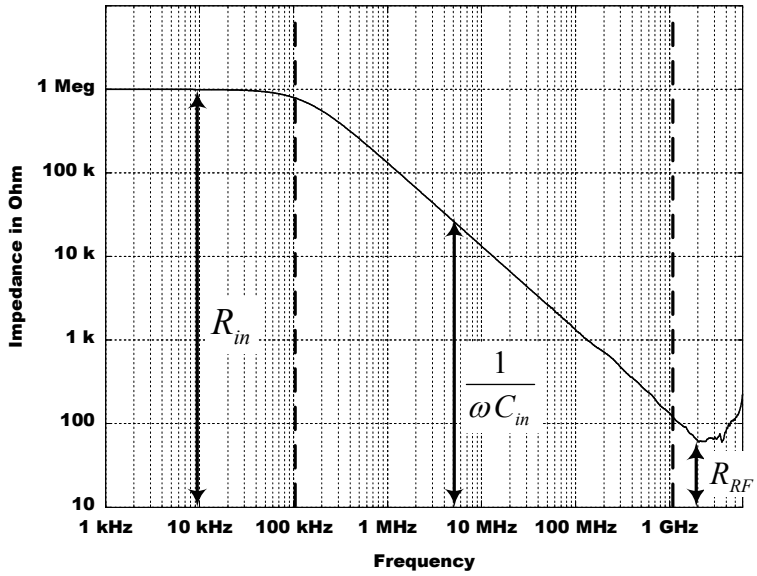
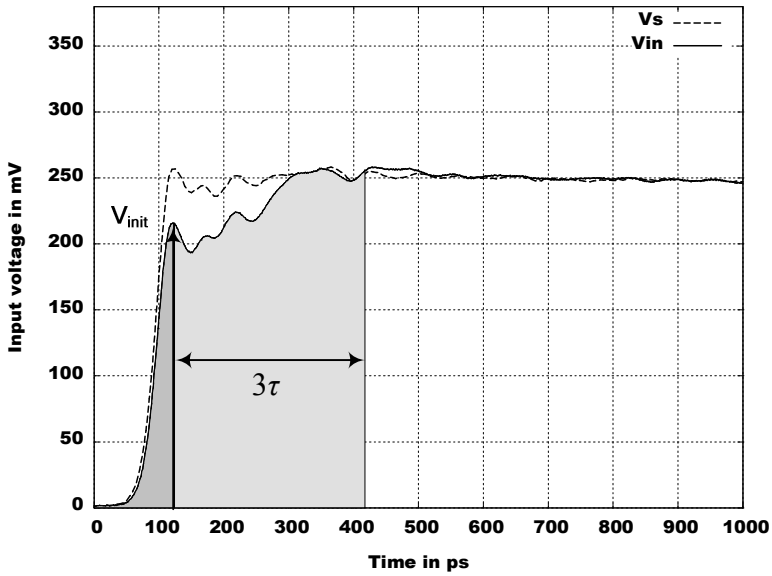


Figure 4-9: Signal loading caused by the R&S RT-ZS10/20/30 probe at an effective source impedance of 25 Ω



where

$$\tau \approx C_{in} \cdot (R_{RF} + R'_S)$$

$$V_{init} \approx V_S \cdot \frac{R_{RF}}{R'_S + R_{RF}}$$

4.2.1.1 Input Resistance R_{in}

- Determines the loading of the DUT at DC and very low frequencies (< 100 kHz).
- This effect is negligible with the R&S RT-ZS10/20/30 probes due to their very high input resistance of 1 MΩ.

Note that a low input resistance can also disturb measurements of high-frequency signals as it influences the DC operating point of active components.

4.2.1.2 Input Capacitance C_{in}

- Causes the input impedance to decrease in the medium-frequency range (100 kHz to 1.0 GHz).
- Makes the measurement result dependent on the source impedance of the DUT.
- Affects the settling time 3τ of the input voltage in the case of fast transients, see Figure 4-9.

4.2.1.3 RF Resistance R_{RF}

- Determines the minimum input impedance and thus the maximum loading at very high frequencies (above 1.0 GHz).
- Makes the measurement result dependent on the source impedance of the DUT.
- Prevents the input voltage from rising immediately to its final value in the case of fast transients. The initial voltage V_{init} depends on R_{RF}, see Figure 4-9.

4.3 Probing Philosophy

The previous sections made clear that probes exert a load on the signal to be measured and change its characteristic. The signal at the test point where the probe makes contact (V_{in}) is therefore different from the signal that was present before the probe was connected (V_S). This effect cannot be avoided and occurs with all real probes – independent of type and manufacturer.

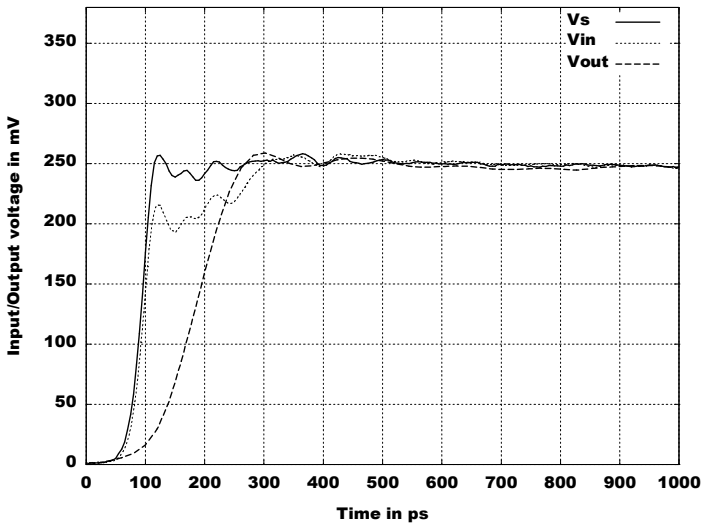
This has resulted in a difference of opinion as to which of the following two signals should be output by the probe:

1. The initial signal that is not loaded by the probe (V_S) and that corresponds to the signal at the test point without the probe being connected.
2. The input signal that is additionally loaded with the input impedance of the probe (V_{in}) and that is actually present between the probe tips.

Both approaches are physically correct and have their individual advantages and disadvantages. In theory, it is even possible to mathematically convert the two measurement results into each other, but only by performing a complex transformation to and from the frequency domain. Probe manufacturers will use one or the other of these two approaches.

Rohde & Schwarz has decided in favor of the user-friendly approach. In our opinion, most users want to know the signal present in the DUT before it was altered by the influence caused by the probe. After all, users want to characterize their own DUTs, not the Rohde & Schwarz probe. As long as measurements are carried out in a 50 Ω (or a comparable) environment, the signal displayed on the R&S RT-ZS10/20/30 probe is always a direct representation of the unloaded signal V_S, as can be seen in Figure 4-10.

Figure 4-10: Step response of the R&S RT-ZS30



5 Maintenance and Service

5.1 Service Strategy

The R&S RT-ZS10/20/30 active voltage probe is a high-precision, high-performance instrument that extends the limits of today's technological possibilities. Like all Rohde & Schwarz instruments, the R&S RT-ZS10/20/30 active voltage probe is of high quality and requires only minimum service and repair. However, if the probe needs to be serviced, contact your Rohde & Schwarz service center. Return a defective probe to the Rohde & Schwarz service center for diagnosis and exchange.

You can return the R&S RT-ZS10/20/30 active voltage probe for calibration. The service personnel will then perform the required tests and readjust the R&S RT-ZS10/20/30 active voltage probe, if necessary.

5.2 Returning the Probe for Servicing

Use the original packaging to return the R&S RT-ZS10/20/30 active voltage probe to your Rohde & Schwarz service center. If for any reason you cannot use the original packaging, make sure to consider the following:

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

5.3 Cleaning

To clean the exterior of the probe, use a soft cloth moistened with either distilled water or isopropyl alcohol. Before using the probe again, allow it to dry completely.

NOTICE

Instrument damage caused by cleaning agents

- Cleaning agents contain substances that may damage the instrument; for example, solvent may damage the labeling or plastic parts

Never use cleaning agents such as solvents (thinners, acetone, etc.), acids, bases or other substances

5.4 Calibration Interval

The recommended calibration interval is two years. For servicing, send the probe to your nearest Rohde & Schwarz service center (see the Returning the Probe for Servicing section on page 35).

6 Functional Check

The functional check is used to perform a quick check of the most important functions of the R&S RT-ZS10/20/30 active voltage probe using simple measurement equipment.

The following functions are checked:

- Initialization
- DC Offset
- DC Accuracy
- Offset

The functional check is not suitable for verifying compliance with the probe specifications, since the test results are influenced by the oscilloscope used.

To verify compliance with the probe specifications, it is necessary to run an independent performance test. This test is described in detail in the R&S RT-Z service manual. The performance test also requires the R&S RT-ZK1 service kit.

NOTICE

All base unit settings described here refer to an R&S RTO oscilloscope. The use of other oscilloscopes may result in different settings and menus.

The following test description always refers to channel 1 (CH1) as the reference channel. The test can also be performed on any other channel of the R&S RTO oscilloscope.

Test equipment

The following list contains the equipment required for the functional check.

Table 6-1: Required test equipment

Description	Minimum requirements	Recommended equipment
R&S RTO oscilloscope		
DC voltage source	±8 V, floating output	Keithley 2420/2601 source meter
Digital multimeter (DMM)	−12 V to +12 V, accuracy ± 0.01 % of measured value	Agilent 34401A
BNC to 4 mm dual banana adapter		Pomona Model 1269
Two banana leads (red, black)		Multi-Contact ZG410
Probe accessories	2 mini clips 2 leads, 15 cm	

Let the probe and oscilloscope warm up for 15 minutes prior to the test.

Self-alignment

Prior to the functional check, a self-alignment of the R&S RTO oscilloscope must be carried out. Proceed as follows:

Test setup:	● R&S RTO oscilloscope
R&S RTO oscilloscope settings:	► "Preset" ► "File > Selfalignment > Control > All > Start Alignment"
Measurement:	After a successful self alignment, the label UNCAL will no longer be displayed.

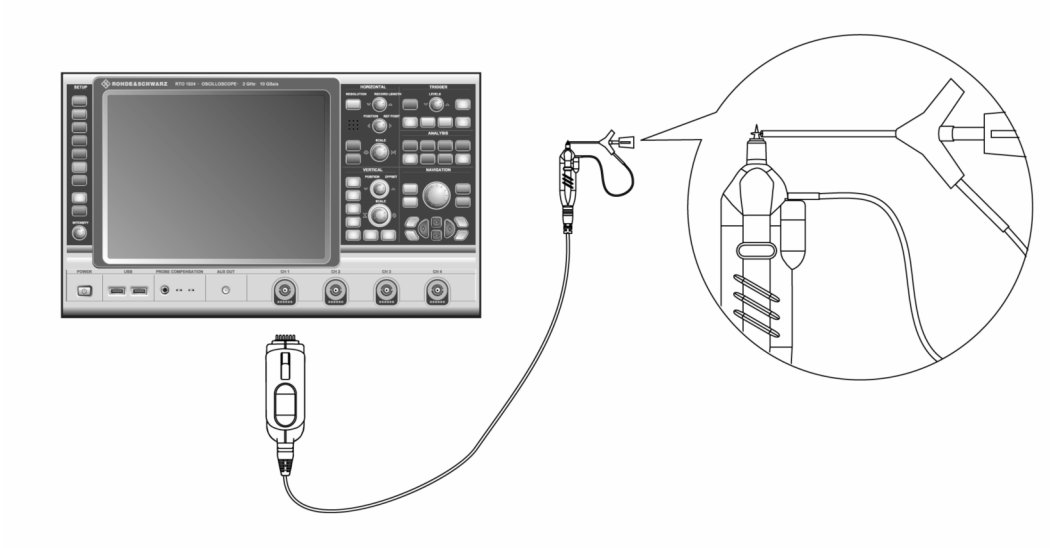
6.1 Initialization

Correct initialization of the probe by the oscilloscope is checked.

Test setup:	● Probe connected to CH1 of the R&S RTO oscilloscope
R&S RTO oscilloscope settings:	► "Vertical" > "Probe Setup" > “Ch1”
Measurement:	If initialization is correct, the following values should be displayed under the Setup tab of the Probe menu, e.g. for the R&S RT-ZS30: Type: active single ended Name: RT-ZS30 Probe attenuation: 10:1 Bandwidth: 3.0 GHz

6.2 DC Offset

The zero error of the probe-oscilloscope system and the zero error of the R&S ProbeMeter are checked.



Test setup:

- Probe connected to CH1 of the R&S RTO oscilloscope
- Signal and ground terminal of the probe shortened by mini clip; make sure that there is no other ground connection

R&S RTO oscilloscope settings:

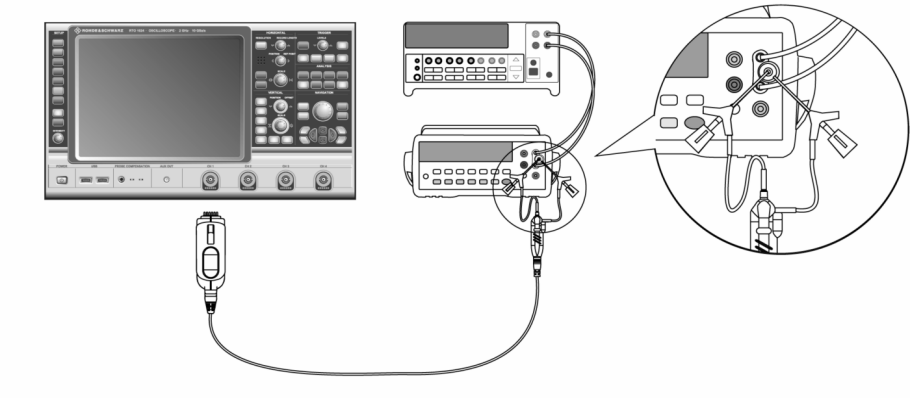
- ► "Horizontal scale 10 µs / div"
- ► "Vertical scale 10 mV / div”
- ► "Trigger Ch1, Auto, Run cont"
- ► "Horizontal > Acquisition > Decimation ‘High res’ > Waveform Arithmetics ‘Average’ > Average Count 16”
- ► "Meas > Setup > Source ‘Ch1’ > Main Measurement ‘Mean’ > State ‘on’ "
- ► “Vertical > Channels > Ch1 > Offset 0 V, Position 0 div"
- ► "Vertical > Probe Setup > Ch1 > ProbeMeter ‘on’ > Probe Button Action ‘Auto zero’"

Measurement:

1. Check displayed values:
   "Measurement Results”:
   ‘Mean’: 0 V ± 10 mV
   ‘ProbeMeter’: 0 V ± 750 µV
2. Press micro button: The Auto Zero function automatically compensates the zero error of the probe-oscilloscope combination
3. Recheck displayed values:
   "Measurement Results”:
   ‘Mean’: 0 V ± 2 mV

6.3 DC Accuracy

The gain of the probe-oscilloscope system and the accuracy of the integrated DC voltmeter are checked.



Test setup:

- Probe connected to CH1 of the R&S RTO oscilloscope
- INPUT HI/LO of the DMM connected to OUTPUT HI/LO of the DC voltage source by banana leads
- BNC to 4 mm dual banana adapter plugged onto the banana leads on the DMM – ensure that BNC shield is connected to LO
- Signal and ground terminal of the probe connected by mini clips to the BNC to 4 mm dual banana adapter; make sure that probe ground is connected to BNC shield

R&S RTO oscilloscope settings:

- ► "Horizontal scale 10 µs / div"
- ► "Vertical scale 1.6 V / div”
- ► "Trigger Ch1, Auto, Run cont"
- ► "Horizontal > Acquisition > Decimation ‘High res’ > Waveform Arithmetics ‘Average’ > Average Count 16”
- ► "Meas > Setup > Source ‘Ch1’ > Main Measurement ‘Mean’ > State ‘on’ "
- ► “Vertical > Channels > Ch1 > Offset 0 V > Position 0 div"
- ► "Vertical > Probe Setup > Ch1 > ProbeMeter ‘on’ “

Measurement:

1. Set the voltage on the DC voltage source so that the DMM displays exactly +5.000 V
2. Check displayed values.
   "Measurement Results":
   ‘Mean’: +5 V ± 250 mV
   ‘ProbeMeter’: +5 V ± 10 mV
3. Repeat procedure for −5.000 V
4. Recheck displayed values:
   "Measurement Results":
   ‘Mean’ –5 V ± 250 mV
   ‘ProbeMeter’: –5 V ± 10 mV

6.4 Offset Compensation

The offset compensation is checked.

Test setup:

- Same as with DC attenuation

R&S RTO oscilloscope settings:

- ► "Horizontal scale 10 µs / div"
- ► "Vertical scale 1.6 V / div”
- ► "Trigger Ch1, Auto, Run cont"
- ► "Horizontal > Acquisition > Decimation ‘High res’ > Waveform Arithmetics ‘Average’ > Average Count 16”
- ► "Meas > Setup > Source ‘Ch1’ > Main Measurement ‘Mean’ > State on "
- ► “Vertical > Channels > Ch1 > Offset 0 V > Position 0 div"
- ► "Vertical > Probe Setup > Ch1 > ProbeMeter ‘on’ > Probe Button Action ‘Set offset to mean’ "

Measurement:

1. Set the voltage on the DC voltage source so that the DMM displays exactly +5.000 V
2. Press the micro button: The Offset to mean function of the probe automatically compensates the applied DC voltage
3. The oscilloscope trace should now be on the horizontal centerline
4. Switch measurement range:
   "Vertical scale 10 mV / div”
5. Check displayed values:
   "Measurement Results":
   ‘Mean’: +5 V ± 50 mV

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