R&S®ZCxxx Converters Getting Started

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Version 05

ROHDE&SCHWARZ
Make ideas real

This manual describes the R&S®ZCxxx family of frequency converters, jointly manufactured by Rohde & Schwarz and RPG-Radiometer Physics, a Rohde & Schwarz company:

- R&S®ZC75, millimeterwave converter WR15 (order no. 1323.8259.02)
- R&S®ZC90, millimeterwave converter WR12 (order no. 1323.7600.02)
- R&S®ZC90E, millimeterwave converter WR12 with electronic attenuator (order no. 1323.7600.04)
- R&S®ZC110, millimeterwave converter WM-2540 (order no. 1323.7617.02)
- R&S®ZC140, millimeterwave converter WM-2032 (order no. 1323.7623.02)
- R&S®ZC170, millimeterwave converter WM-1651 (order no. 1323.7630.02)
- R&S®ZC220, millimeterwave converter WM-1295 (order no. 1323.7646.02)
- RPG ZC260, millimeterwave converter WM-1092 (order no. 3628.5682.02)
- R&S®ZC330, millimeterwave converter WM-864 (order no. 1323.7669.02)
- RPG ZC400, millimeterwave converter WM-710 (order no. 3656.9220.02)
- R&S®ZC500, millimeterwave converter WM-570 (order no. 1323.7681.02)
- RPG ZC750, millimeterwave converter WM-380 (order no. 1323.7717.02)
- RPG ZC1100, millimeterwave converter WM-250 (order no. 1323.7723.02)

Throughout this manual, the converter R&S®ZC330 is used as a representation for converters of the R&S®ZCxxx family.

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1177.5156.02 | Version 05 | R&S®ZCxxx

Throughout this manual R&S® is abbreviated as R&S.

Contents

1 Safety and regulatory information

The product documentation helps you use the product safely and efficiently. Follow the instructions provided here and in the following chapters.

Intended use

Millimeterwave converters R&S ZCxxx are designed to be used with Rohde & Schwarz vector network analyzers R&S ZNA, R&S ZVA or R&S ZVT. They are intended for the development, production and verification of electronic components and devices in industrial, administrative, and laboratory environments. Only use them for their designated purpose. Observe the operating conditions and performance limits stated in the 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:

- Multilingual safety information is delivered with the converter power supply R&S ZCPS and your Rohde & Schwarz vector network analyzer.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

1.1 Labels on the product

Labels on the casing inform about:

- Product and environment safety
- Identification of the product

Table 1-1: Labels regarding environment safety

	Labeling in line with EN 50419 for disposal of electrical and electronic equipment after the product has come to the end of its service life. For more information, see "Disposing electrical and electronic equipment" on page 36.

1.2 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.

NOTICE

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

1.3 Korea certification class B

이 기기는 가정용(B급) 전자파 적합기기로서 주로 가정에서 사용하는 것을 목적으로 하며, 모든 지역에서 사용할 수 있습니다.

2 Key features

Intended use

Millimeterwave converters R&S ZCxxx extend the frequency range of a R&S ZNA, R&S ZVA or R&S ZVT up to 1.1 THz.

They feature wide dynamic range and high output power. Except for R&S ZC90, R&S ZC90E, R&S ZC110 and RPG ZC1100, the R&S ZCxxx converters have an integrated variable mechanical attenuator.

Thanks to their unique USB interface, all relevant operating parameters of an individual converter are automatically transferred to the base VNA without the need to enter these parameters manually.

When used together with an R&S ZNA, the R&S ZCxxx converters can play to their strength:

- They seamlessly integrate into the user interface of the base VNA.
- The R&S ZNA supports mixed configurations with different converter models and native test ports without converter, which is particularly useful for frequency-converting measurements.
- Automatic level control (ALC), in conjunction with the integrated output power linearization ("leveling") functionality, allow the converters to provide precise and stable source power over a wide power range.

Millimeterwave converters R&S ZCxxx supervise their own health state regarding temperature, fan operation and DC supply.

The R&S ZC90E is equipped with an electronic attenuator and a corresponding control interface.

- The R&S ZVA supports this control interface via hardware option R&S ZVA-B8.
  For a description of the corresponding connectors, their cabling and operational aspects, see the Getting Started of the predecessor R&S ZVA-Z90E. It can be downloaded from the manual page of the R&S ZVA-Zxxx converter family (https://www.rohde-schwarz.com/manual/zvaz/).
- R&S ZNA and R&S ZVT do not offer the external attenuator control interface. With these analyzers, you can use the R&S ZC90E like a regular R&S ZC90, but with lower maximum output power and dynamic range. See the data sheet of the R&S ZCxxx family for details.

3 Preparing for use

Here, you can find basic information about setting up the product for the first time.

3.1 Unpacking and checking

When you receive the converter, please take the following steps:

1. Unpack the converter and the other contents from the cardboard shipping box.
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.
   The shipment must include the following items:
   - Converter
   - DC supply cable
   - USB cable
   - IF cable EXT REF
   - IF cable EXT MEAS
   - External attenuator control cable (R&S ZC90E only)
   - Plastic case with 8 flange screws 4-40 UNC 7.6 and 4 flange screws 4-40 UNC 9.24
   - Plastic case with 8 precision dowels 1.566 mm ± 0.001 mm
   - 3/32” hex ball driver
   - Getting Started (this document)
4. Inspect the frequency converter, especially the test port adapter and the test port flange surface, to make sure that no damages occurred during shipment. If you observe any damages, immediately notify the shipping company and keep the packing material.

3.2 Choosing the operating site

Specific operating conditions ensure proper operation and avoid damage to the product and connected devices. For information on environmental conditions such as ambient temperature and humidity, see the data sheet.

3.3 Setting up the converter

The frequency converter is designed for use under laboratory conditions on a flat bench top or mounted on a wafer probe station. Four M8 threads are provided on all long sides of the converter to allow for mounting the converter on a flat surface. Some on-wafer measurement applications can require the converter to be tilted to bring the test port closer to the chuck. In these cases, an additional bent waveguide adapter can be necessary in front of the test port adapter to compensate for the tilt angle.

Adjusting the feet of the converter

The instrument can be used with four feet attached to the respective bottom side (depending on the orientation). When the DUT is mounted between two converters (see "Mounting a DUT" on page 14), use the feet for alignment of the complete setup. A bubble level can help you to align each converter horizontally before fitting the DUT.

3.4 Considerations for test setup

Cable selection and electromagnetic interference (EMI)

Electromagnetic interference (EMI) can affect the measurement results.

To suppress electromagnetic radiation during operation:

- Use high-quality shielded RF cables.
- Always terminate open cable ends.

Signal input and output levels

Information on signal levels is provided in the data sheet. Keep the signal levels within the specified ranges to avoid damage to the product and connected devices.

Preventing electrostatic discharge (ESD)

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

► **NOTICE!** Risk of electrostatic discharge. 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.

3.5 Connecting the converter to the DC supply

The converter power supply R&S ZCPS has been designed for use with converters of the R&S ZCxxx family. Do not use other power supplies.

1. Switch the converter power supply R&S ZCPS off.
2. Connect the R&S ZCxxx to either output CONVERTER 1 or CONVERTER 2 of the R&S ZCPS, using the enclosed DC supply cable.

3.6 Switching the converter on

Before switching on the connected converter power supply, make sure that the following conditions are fulfilled:

- Converter covers are in place and all fasteners are tightened.
- Ventilation openings are unobstructed.
- The converter is dry and does not show condensation.

To power up the converter:

► Switch on the connected converter power supply R&S ZCPS

After a short time, both the LED of the power output to which the converter is connected and the LED on the rear panel of the converter should light up green.

If the converter LED lights up red, at least one supply voltage is missing. Contact R&S service in this case. For the meaning of the LED colors, refer to Chapter 4.3.1, "Power supply connector and status LED", on page 17.

After power-up, a warm-up time of one hour is required to ensure accurate measurements.

3.7 Connecting the converter to the VNA via USB

Connect the R&S ZCxxx to the VNA using the enclosed USB cable.

A R&S ZCxxx must be connected to the VNA at least once to transfer the characteristic data of the converter to the VNA. After that, the converter remains known to the VNA and can be selected (by type and serial number) in the corresponding converter configuration GUI.

4 Instrument tour

This chapter gives an overview of the controls and connectors of the frequency converter.

4.1 Test port adapter (waveguide flange)

The test port with a mounted test port adapter is located at the front of the instrument. The device under test (DUT) has to be connected to the test port adapter.

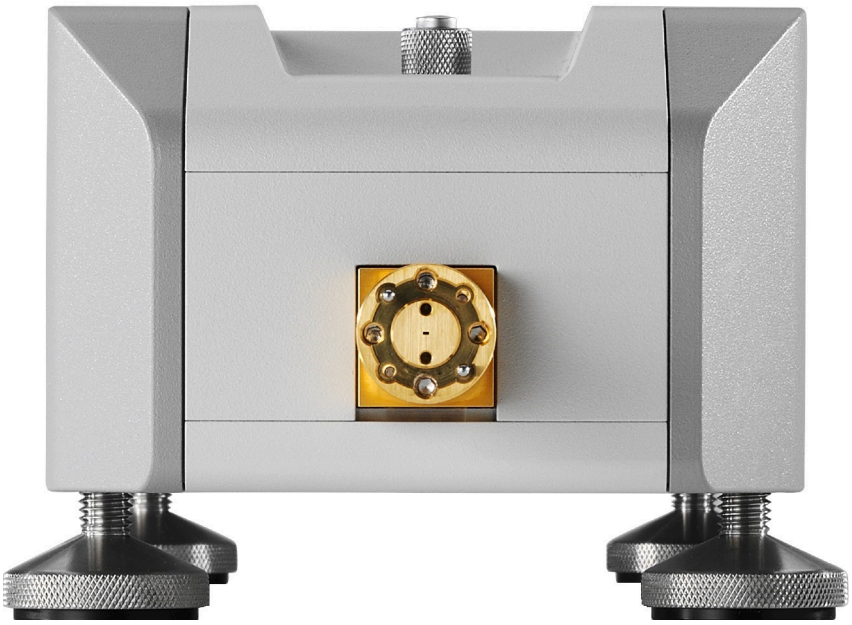


Figure 4-1: Front of the converter R&S ZC330

The precision waveguide flange of the test port adapter, which is compatible to standard IEEE 1785, consists of an outer ring and a protruding inner contacting surface with the waveguide. On the outer ring there are four UNC 4-40 threads, two dowels and two holes as counterparts of the DUT dowels (see Figure 4-2). Two additional holes in the inner flange surface allow the insertion of precision dowels (delivered with the converter). To enhance the accuracy of the connection, use additional dowels if the flange of the DUT also has holes for them.

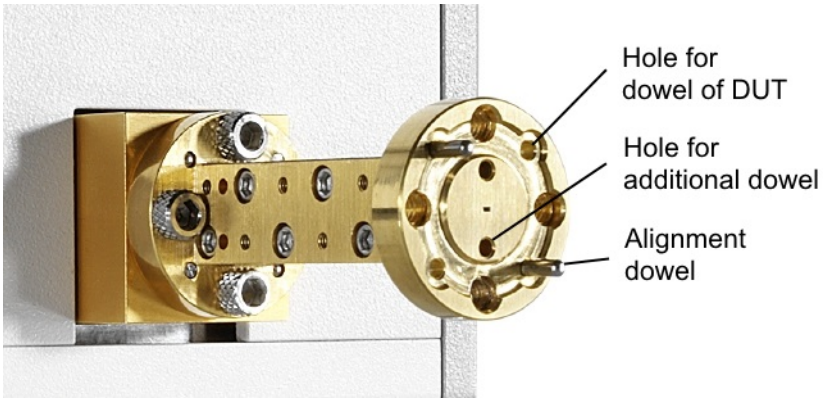


Figure 4-2: Test port adapter of R&S ZC330

NOTICE

Risk of damaging waveguide flanges

The waveguide flanges of the converter and of the test port adapters must be protected against scratches and other mechanical damages. Furthermore the waveguides must be shielded from dust.

Protect the waveguide flange of the converter by leaving the test port adapter mounted. When the converter is not in use, slip a protective cap onto the adapter.

Mounting a DUT

Mount the DUT to the test port adapter at the front of the converter. Use the included screws and hex ball driver. For higher precision, a torque-controlled hex ball driver R&S ZV-Z1000 is available as an accessory (order number 1314.5467.02).

An angled hex ball driver facilitates working in the tight space between rear side of the test port adapter flange and converter front side (see Figure 4-3). Rohde&Schwarz offers three variants:

- R&S ZCAW (order number 1175.1960.00) without torque control
- R&S ZCTW with 0.58 N·m torque limit (order no. 1175.2014.02)
- R&S ZCTW with 0.2 N·m torque limit (order no. 1175.2014.03)

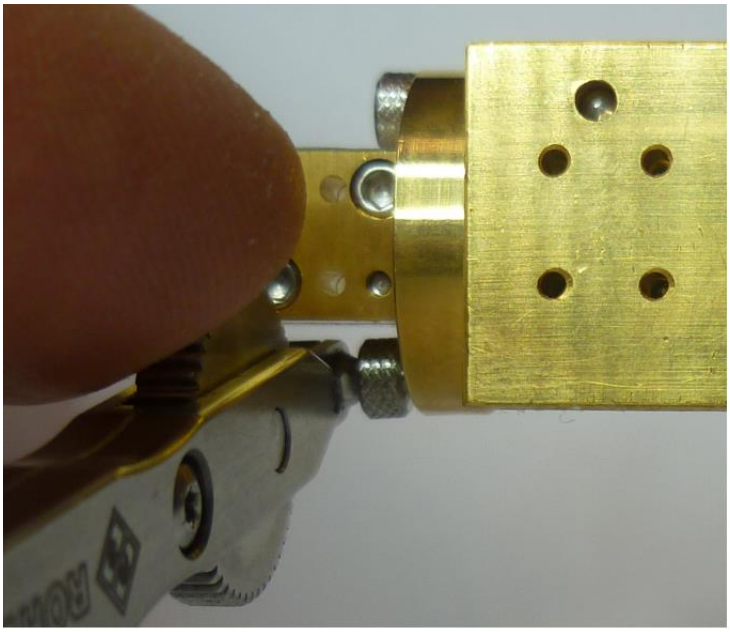


Figure 4-3: Angled hex ball driver R&S ZCAW (accessory)

For precision calibrations and measurements, use the inner dowels at the test port adapter. A tight and accurate connection is important to ensure precise measurement results.

For a two- or n-port measurement, setup converters and DUT have to be aligned accurately, using the adjustable instrument feet. Use a bubble level for proper alignment.

4.2 Output power-adjusting knob

The knurled knob steeped in the upper surface of the converter housing adjusts an integrated variable mechanical attenuator that allows you to control the output power at the waveguide test port manually. Such an attenuator is available for all R&S ZCxxx converters, except the R&S ZC90, R&S ZC90E, R&S ZC110 and RPG ZC1100.

Turning the knob clockwise reduces the output power while turning it counter-clockwise increases the output power. The minimum power is reached at the stop in clockwise direction while maximum power is reached at the stop in counter-clockwise direction. The knob cannot be turned so far in counter-clockwise sense that it protrudes the upper surface of the R&S ZCxxx. So there is no danger that the mechanism of the variable attenuator is damaged when the frequency con-

verter is mounted upside down, e.g. on a wafer prober. If you turn the knob, a receiver power calibration remains valid, while a system error calibration has to be repeated if it refers to more than one port.

To set a flat output power over frequency just by entering a dBm value in the VNA firmware, the leveling functionality of option R&S ZNA-K8 can be used. Leveling records the frequency-dependent relationship between the input power at RF IN and the output power at the waveguide port. The resulting data set can then be applied by the VNA firmware. For further details, refer to the R&S ZNA online help.

Since version 2.40, the leveling functionality is part of the R&S ZNA firmware. It is enabled with option R&S ZNA-K8, and integrated into the standard power calibration routines.

The output power of the VNA is set to a fixed value optimized for the selected type of converter.

4.3 Rear panel

The rear panel of the frequency converter provides the connectors and control elements described in the following subsections.

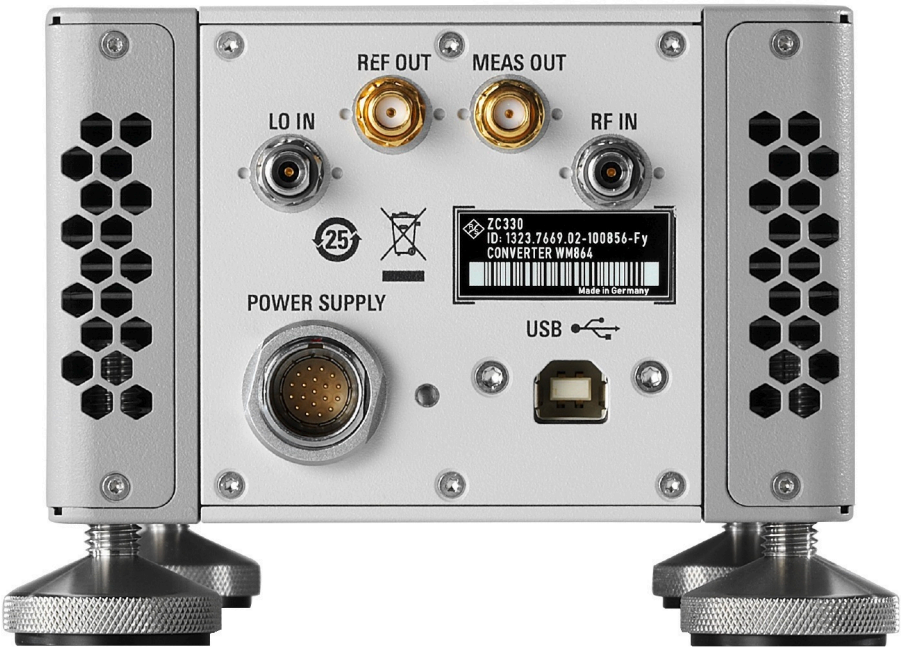


Figure 4-4: Rear view of the frequency converter

4.3.1 Power supply connector and status LED

To supply the R&S ZCxxx with power, connect it to the external DC power supply R&S ZCPS. Always switch the power supply off before removing the DC cable. For details, see the User Manual of the R&S ZCPS.

The following table lists all possible colors of the converter LED, along with their associated error condition:

Table 4-1: R&S ZCPS LED colors and error conditions

Color	Error conditions
green	No error.
yellow	At least one fan is not working properly (rotational speed is out of range or fan stands still).
orange	Temperature is out of range. If it exceeds a critical level, the power supply is switched off.
red	At least one supply voltage is out of range or missing.

If an error occurs, a warning message on the VNA indicates the current error condition (fan, voltage, temperature). Warning message and converter LED remain in the respective state as long as the error condition persists. If more than one error condition applies, warning message and LED show the most severe one.

4.3.2 RF connectors – IN

Two 2.92 mm female input connectors: LO IN (local oscillator signal input) and RF IN (RF source signal input).

For correct cabling, refer to Chapter 5.2, "Input connectors (RF IN, LO IN)", on page 23.

4.3.3 RF connectors – OUT

Two SMA female output connectors: MEAS OUT (measurement signal output) and REF OUT (reference signal output).

For correct cabling, refer to Chapter 5.3, "Output connectors (MEAS OUT, REF OUT)", on page 24.

4.3.4 USB connector

The USB Type B connector is used to connect the R&S ZCxxx to the VNA (control connection).

4.3.5 Attenuator control connector (R&S ZC90E only)

The R&S ZC90E is equipped with an electronic attenuator that can be controlled from the R&S ZVA via hardware option R&S ZVA-B8. The three-pin control connector receives the control signal.

R&S ZNA and R&S ZVT do not offer the external attenuator control interface.

Connecting the control cable

Connect the control connector to one of the EXTATT CTRL front panel connectors of an R&S ZVA equipped with option R&S ZVA-B8. The required cable is supplied with the converter. The numbers below the EXTATT CTRL connectors denote the controlled analyzer ports. Control connector numbers and analyzer port numbers must always be the same.

For more details, see the Getting Started of the predecessor R&S ZVA-Z90E. It can be downloaded from the manual page of the R&S ZVA-Zxxx converter family (https://www.rohde-schwarz.com/manual/zvaz/).

5 RF connections

The R&S ZNA offers various possibilities to connect and operate one or more frequency converters R&S ZCxxx.

In the following descriptions, we focus on the **standard setups** for 2 and 4 converters, which use the following hardware options:

- Direct IF access (R&S ZNA-B26)
- Converter LO output (R&S ZNA-B8)

With the standard setup, two (four) converters can be operated with a two-port (four-port) R&S ZNA, without external generator.

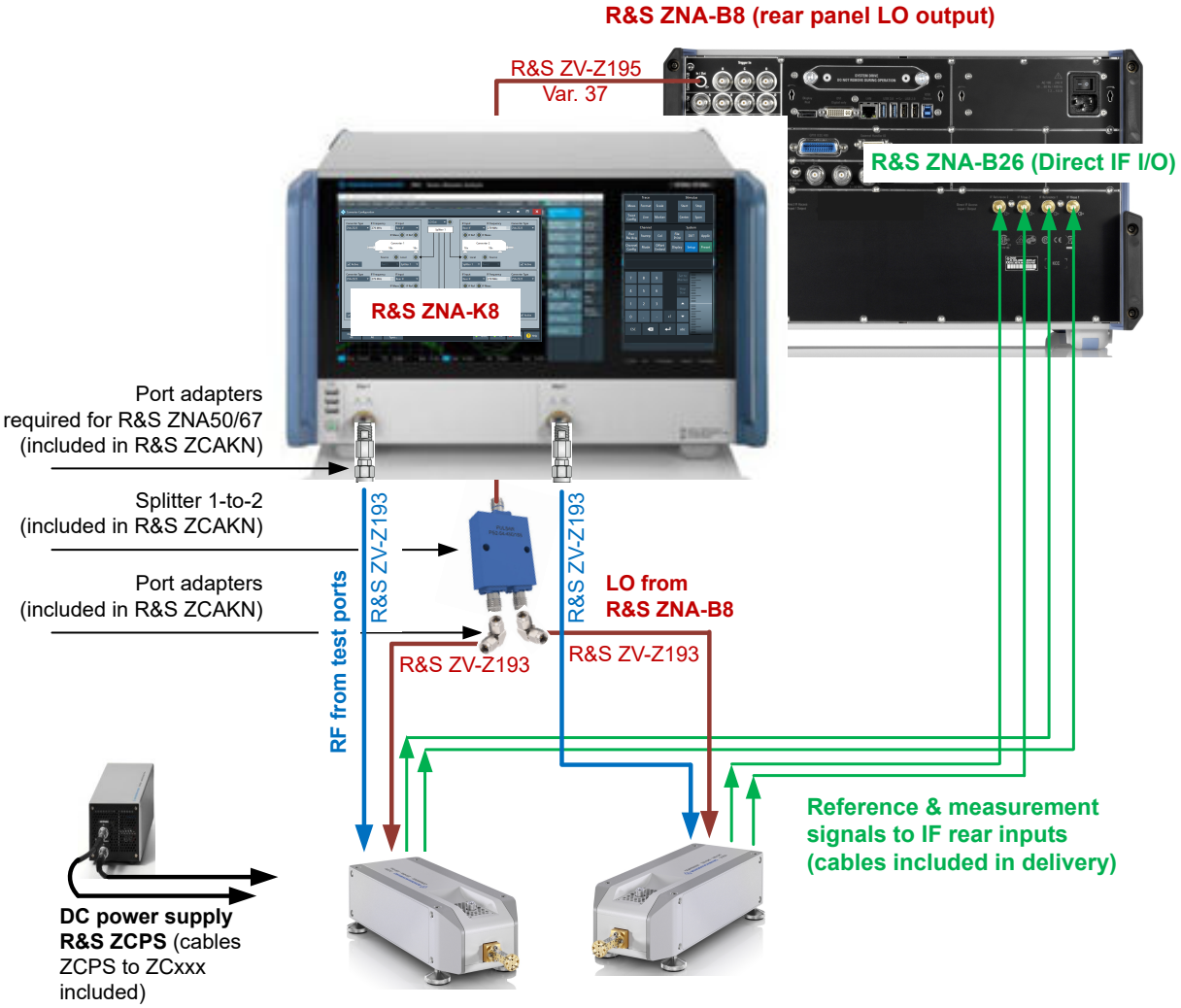


Figure 5-1: Standard 2-port setup (with Rohde & Schwarz accessories)

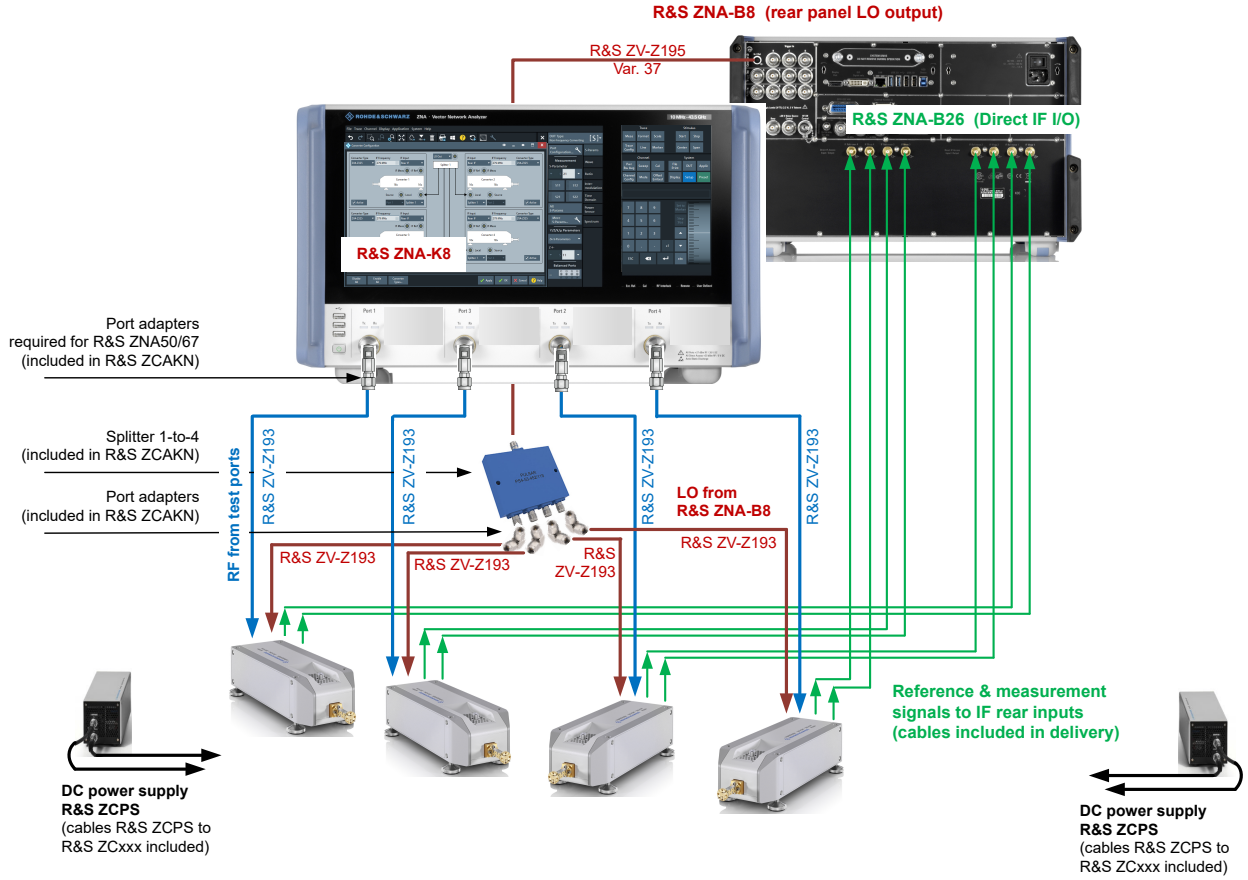


Figure 5-2: Standard 4-port setup (with Rohde & Schwarz accessories)

- Except otherwise stated, the accessories shown above are **not** part of the delivery and must be ordered separately. Use your own cables, adapters and splitters, if you like. For most converters, the RF IN and LO IN frequencies do not exceed 20 GHz and hence 3.5 mm cables are sufficient. Only RPG ZC750 and RPG ZCZC1100 require LO frequencies up to 21 GHz and 23 GHz, respectively.
- In addition, the standard setup relies on the frequency converter control software option R&S ZNA-K8 (available for R&S ZNA firmware V1.90 and higher). Without this option, configuring the port powers and frequencies is extremely tedious and error-prone, and can be hazardous w.r.t. excessive RF and LO input power levels at the converters.

Tightening RF cables

Tightening RF cables too strongly, can damage cables and connectors. Loose tightening can result in inaccurate measurement results.

Therefore always use an appropriate torque wrench, suitable for the type of connector. Rohde & Schwarz offers an optional 5/16” torque wrench that fits for SMA, 3.5 mm, 2.92 mm and 1.85 mm connectors (R&S ZN-ZTW variant 35). Similar wrenches are available for other sizes of spanner, too. For ordering information, see the R&S ZCxxx data sheet or product brochure.

5.1 Connection procedure

The RF input power at the connectors RF IN and LO IN of the R&S ZCxxx must not exceed the maximum values quoted in the data sheet. Because these maximum values are below the maximum RF source power of the R&S ZNA, the R&S ZNA has to be configured carefully, before establishing these connections.

A converter configuration via the graphical user interface of software option R&S ZNA-K8 ensures compatible source powers. Therefore, proceed as follows:

1. Make sure the R&S ZNA is already running.
2. Connect the frequency converters to their power supply R&S ZCPS and power up the R&S ZCPS.
3. Establish USB connections between the frequency converters and the R&S ZNA.
   The R&S ZNA then registers the converter, i.e. it reads and persists the characteristic data of the R&S ZCxxx.
4. At the analyzer GUI:
   a) Make sure the R&S ZNA firmware has registered all your converters. Otherwise reestablish the USB connection.
   b) Define and configure your converter setup, as described in Chapter 6.3, "Configuring the converter setup", on page 27.

   Now the RF and LO cables can be connected safely.

- Once the R&S ZNA firmware has registered a converter, the USB connection is no longer required.
- Repeat step 4 whenever you are not sure whether a suitable converter configuration is already active. Switching the VNA off and on preserves the converter configuration.
  Converter configurations can be saved and loaded via the graphical user interface of software option R&S ZNA-K8 (System – [Setup] key > "Frequency Converter" tab > "Save Converter Topology"/"Load Converter Topology").

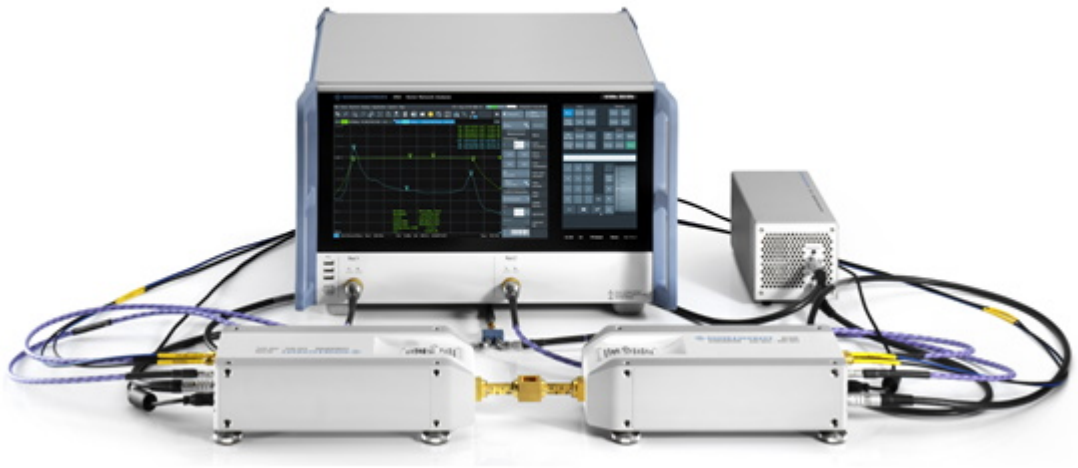
5.2 Input connectors (RF IN, LO IN)

For the R&S ZNA standard setup, proceed as follows:

1. Connect test ports of the R&S ZNA to the RF IN ports of the converters.
2. Use a power splitter to connect the R&S ZNA-B8 Converter LO Out port of the R&S ZNA to the LO IN ports of the converters.

High-quality cablings using R&S ZV-Z195 and R&S ZV-Z193 test cables are shown in Figure 5-1 and Figure 5-2. The adapters and splitters that are required for this cabling, are offered as complementary adaption kits (see Chapter 5.4, "Adaption kits R&S ZCAKN", on page 24).

The required cable lengths depend on the desired converter arrangement. Always use cables with low attenuation and excellent phase stability.



5.3 Output connectors (MEAS OUT, REF OUT)

For the R&S ZNA standard setup, proceed as follows:

1. Connect the MEAS OUT connectors of the converters to the IF Meas connectors of the R&S ZNA.
2. Connect the REF OUT connectors of the converters to the IF Reference connectors of the R&S ZNA.

   Use the same VNA port number for the RF IN, MEAS OUT, and REF OUT connection of a converter.

Suitable cables for connecting the output connectors to the network analyzer are included in the converter shipment. The connectors of these cables are labeled accordingly.

5.4 Adaption kits R&S ZCAKN

The standard setups shown in Figure 5-1 and Figure 5-2 use the following Rohde & Schwarz network analyzer accessories:

- Cables
  - R&S ZV-Z195: Test port cable 0 Hz to 40 GHz, 2.92 mm (f) – 2.92 mm (m)

  - R&S ZV-Z193: Test port cable 0 Hz to 26.5 GHz, 3.5 mm (f) – 3.5 mm (m)

  Available in different lengths.

- Splitters
  - R&S ZN-Z1229: LO 1-to-2 power divider, 2.92 mm (f) connectors
  - R&S ZN-Z1230: LO 1-to-4 power divider, 2.92 mm (f) connectors

  Distribute the R&S ZNA-B8 Converter LO Out signal to the converters.
- Adapters
  - R&S ZN-Z1119: Adapter 2.92 mm (m/m) 90°
    Used at the splitter outputs.
  - R&S ZV-Z1829: Adapter 1.85 mm (f) / 2.92 mm (m)
    Used at the R&S ZNA50|67 test ports.

Rohde & Schwarz offers the required splitters and adapters as adaption kits R&S ZCAKN.

Table 5-1: Adaption kits R&S ZCAKN (order no 1332.6178.xx)

Standard setup	**Kit variant xx**	**Kit content**		
		Splitter	**Adapters**	
			R&S ZN-Z1119	**R&S ZV-Z1829**
2 converters R&S ZNA26|43	43	R&S ZN-Z1229	x 2	–
2 converters, R&S ZNA50|67	67			x 2
4 converters, R&S ZNA26|43	44	R&S ZN-Z1230	x 4	–
4 converters, R&S ZNA50|67	68			x 4

6 Basic operation

This chapter describes how to configure the standard setup with an R&S ZNA network analyzer and two frequency converters R&S ZC330, for 2-port transmission measurements.

Measurements using other converters of the R&S ZCxxx family are performed in an analogous way.

6.1 Required equipment

In general, the standard setup with *n* frequency converters requires an R&S ZNA with at least *n* test ports, equipped with the following hardware options:

- Direct IF access (R&S ZNA-B26)
- Converter LO output (R&S ZNA-B8)

The standard RF cabling and the required accessories are described in Chapter 5, "RF connections", on page 20.

To calibrate the measurement setup, the following equipment is required:

- For power calibration and leveling, a power meter that covers the measured frequency range:
  - VDI Erickson PM5 or PM4 (with suitable taper) for waveguide ports
  - Alternatively, R&S NRP75TWG or R&S NRP110TWG for waveguide ports up to 110 GHz (scalar power calibration only)
  - A supported coaxial power meter with an upper frequency limit of 23 GHz or higher for calibrating the LO IN and RF IN signals at the converter (scalar power calibration)
- For system error correction, a calibration kit for the respective WM-xxxx waveguide

6.2 Configuration and measurement steps

Follow the connection sequence described in Chapter 5.1, "Connection procedure", on page 22.

Configuring the measurement setup and measuring the DUT involves the following steps:

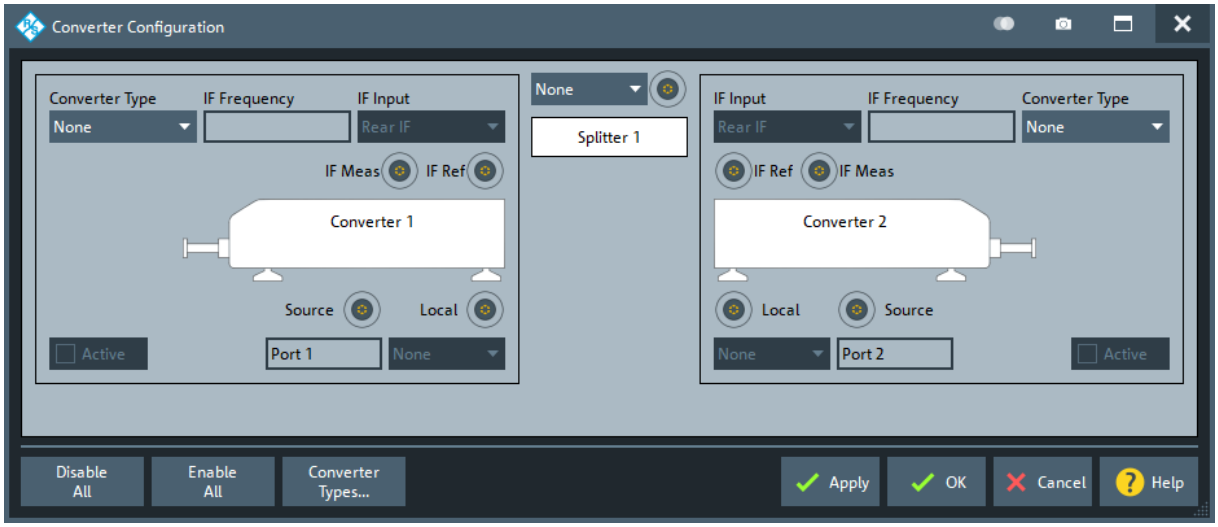
1. Configuring the converter setup
2. Establishing the RF connections between the R&S ZNA and the converters
   See Chapter 5, "RF connections", on page 20.
3. Scalar power calibration and leveling (optional for S parameter measurements)
4. System error correction, using a suitable waveguide calibration kit
5. Connecting and measuring the DUT

6.3 Configuring the converter setup

Convenient converter configuration is provided with software option R&S ZNA-K8, which is available since R&S ZNA firmware version 1.90.

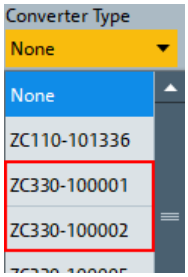
Once the R&S ZNA has registered your converters, the setup can be configured.

1. At the graphical user interface of the R&S ZNA , open the "Converter Configuration" dialog (System – [Setup] key > "Frequency Converter" tab > "Frequency Converter ...").



"Converter 1" is the converter connected to VNA port 1, "Converter 2" the converter connected to VNA port 2.

2. In the "Converter Configuration" dialog, verify that your R&S ZNA has registered your converters.



The "Converter Type" combo-boxes list R&S ZCxxx converters as "ZCxxx-<serial>". If one of your converters is missing, reestablish the USB connection and wait for it to show up.

3. Still In the "Converter Configuration" dialog, configure the standard setup with two converters:
   a) Select the converter connected to VNA port 1 as "Converter 1", and the converter connected to VNA port 2 as "Converter 2".
   b) For both converter ports, select "Rear IF" as "IF Input".
   c) In the combo box above the "Splitter 1" symbol, select "Conv. LO" as LO source.
   d) For both converter ports, select "Splitter 1" as the source for the "Local" port.

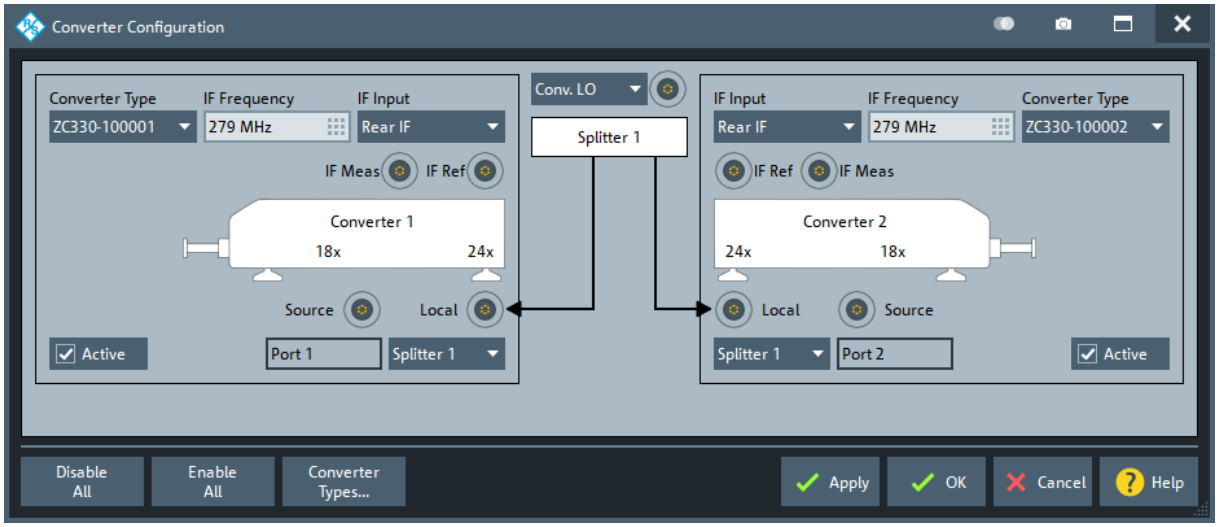
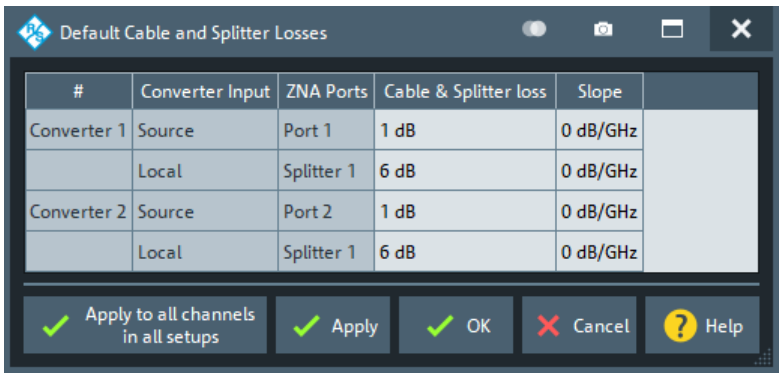


Figure 6-1: Standard setup with two converters

4. Select "OK" to apply the converter configuration and close the dialog.

   The R&S ZNA now adjusts the frequencies and source power levels. The frequencies correspond to the maximum frequency range of the configured converters, the source power levels also take the cable and splitter losses into account.
   Furthermore, low phase noise mode is activated, and automatic level control (ALC) is deactivated.

5. If you do not use the Rohde & Schwarz cables and accessories displayed in Figure 5-1, adjust the cable and splitter losses in the "Default Cable and Splitter Losses" dialog (System – [Setup] key > "Frequency Converter" tab > "Default Cable and Splitter Losses ...").



The resulting frequency and source power levels can be viewed – and tweaked – in the port settings dialog (Channel – [Channel Config] key > "Port Config" tab > "Port Settings ..."). For details, see the R&S ZNA help system or user manual.

6.4 Establishing the RF connections

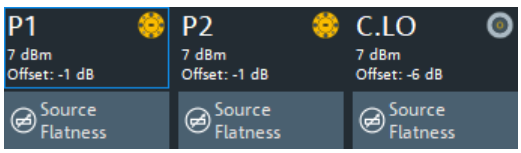
Refer to Chapter 5, "RF connections", on page 20.

6.5 Scalar power calibration and leveling (optional)

The output power can be manually set using the adjusting knob (see Chapter 4.2, "Output power-adjusting knob", on page 15). For standard S parameter measurements which do not require precise power levels at the DUT, a power calibration is not required.

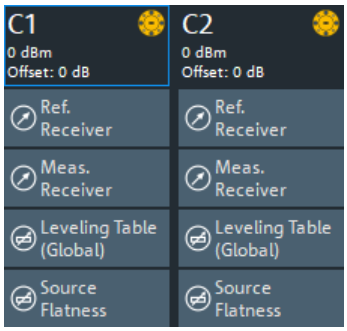
To take control of the converter input and output levels, proceed as follows:

1. At the graphical user interface of the R&S ZNA, run the scalar power calibration wizard (Channel – [Cal] key > "Start Cal" tab > "Scalar Power Cal ...")
2. On the first page of the wizard, you can perform source flatness calibrations at the converter inputs.

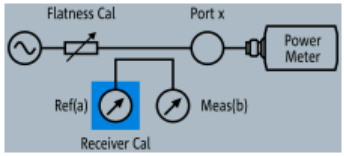


Perform a source flatness calibration, if the default values for cable and splitter losses deviate significantly from the actual ones (sum deviation > 2 dB). See step 5 in Chapter 6.3, "Configuring the converter setup", on page 27.

3. The second page of the wizard offers several calibration types:

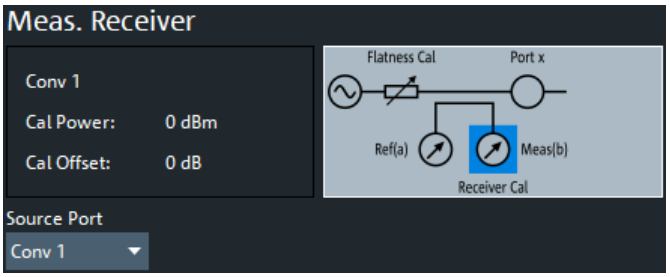


a) "Ref. Receiver"
To perform a reference receiver calibration, connect a power meter with suitable frequency range to the waveguide port of the respective converter. During the calibration, the R&S ZNA performs a frequency sweep and uses the power meter readings to correct the readings of the related reference receiver (transfer calibration). For supported power meters, see the R&S ZNA help system or user manual.

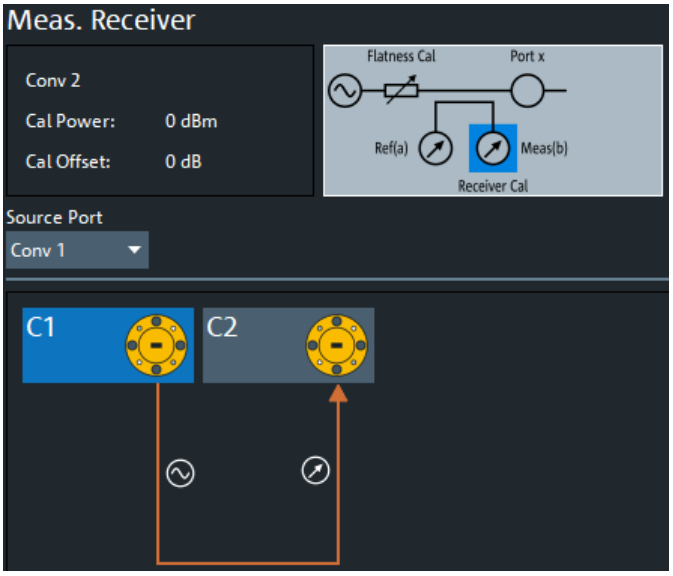


With the default power calibration method of the R&S ZNA, subsequent measurement receiver and source flatness calibrations rely on an existing reference receiver calibration. For output power leveling, an existing reference receiver calibration of the respective port is a prerequisite.

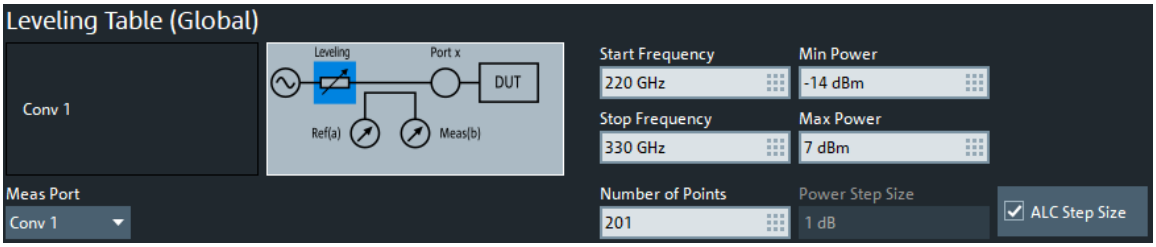
b) "Meas. Receiver"
A measurement receiver calibration adjusts the power readings at the receive port, by default based on an existing reference receiver calibration. With an existing reference receiver calibration for port 1, to calibrate the measurement receiver of port 1, connect a Short to the waveguide port of converter 1 and select port 1 as source.



To calibrate the measurement receiver of port 2, connect the waveguide ports of the converters directly and again use port 1 as source.

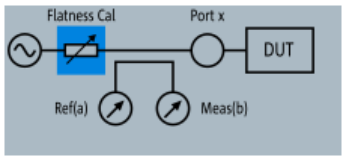


c) "Leveling Table (Global)"
Perform leveling if you want the power levels at the waveguide port to be constant over frequency. Also perform leveling if you want to have frequency-independent, variable, known power levels at the waveguide port. The latter is necessary for power sweeps, but also for automatic level control (ALC). ALC, in turn, is recommended for all measurements that require precise power levels at the waveguide port, in particular for measuring non-linear characteristics of a DUT (compression, intermodulation, spectrum...). For details on ALC, see the R&S ZNA help system or user manual.
Based on an existing reference receiver calibration, the leveling procedure records the output power on a two-dimensional power/frequency grid with equidistant RF IN power levels and frequencies. The leveling logic then uses two-dimensional interpolation to determine the appropriate RF IN level for the desired output level at a given frequency.



Since version 2.40 of the R&S ZNA firmware, leveling is part of software option R&S ZNA-K8.

d) "Source Flatness"
Based on an existing reference receiver calibration, the R&S ZNA varies the frequency and adjusts its source power so that the reference receiver readings correspond to the desired output power at the waveguide port of the converter.



If leveling data is available for a port, a source flatness calibration is not necessary for this port.
For converter setups, reduce the convergence factor to 0.3, or 0.1 for high frequency converters (Channel – [Cal] key > "Power Cal Settings" tab > "Convergence").

6.6 System error correction

For precise S-parameter measurements, a system error correction is recommended. System error correction requires a calibration kit for the waveguide band of the specific R&S ZCxxx converter.

The (universal data of the) R&S ZVA-WRxx kits are pre-installed in the R&S ZNA firmware. They are assigned, however, to R&S WM-xxxx connectors, as far as the WRxx waveguide bands are identical to the newer WM-xxxx bands. In addition to these kits, dedicated R&S ZC-WM-xxxx kits are provided for the WM-xxxx bands. Their characteristic data are supplied on USB sticks, and must be installed manually, before they can be used. The standards in these calibration kits allow for OSM, TOSM, UOSM, TOM, TRM and TRL calibrations.

With an additional reference receiver calibration at one of the converter ports, a full n-port system error correction at n > 1 converter ports of the same waveguide band can be extended to a SMARTerCal. A SMARTerCal enables phase *and* level accurate measurements of all involved a- and b-waves.

Refer to the documentation of your calibration kit and to the R&S ZNA help system or user manual for details.

6.7 Measurement

After power calibration and system error correction, mount the DUT (see "Mounting a DUT" on page 14).

Measurements involving converters can be performed like other measurements. All measured quantities (S parameters, wave quantities, ratios etc.) are available. Power sweeps and ALC can only be activated, if leveling data are available (see Chapter 6.5, "Scalar power calibration and leveling (optional)", on page 30). The "Port Settings" dialog (Channel – [Channel Config] key > "Port Config" tab > "Port Settings ...") shows the frequency and power sweep ranges of all implied signals, including RF IN, LO IN and IF output.

Refer to the R&S ZNA help system or user manual for details.

- After power-up, a warm-up time of one hour is required to ensure accurate measurements.
- Measurement results can be degraded if the setup is exposed to an electromagnetic field at the IF frequency (default: 279 MHz).
- For pulsed signals, the default IF frequency of 279 MHz cannot be used, because a narrow-band filter is applied at this frequency. Use the "Converter Configuration" dialog to select an IF frequency in the direct path between 30 kHz and 30 MHz instead (see Figure 6-1).
- If a power splitter is used and the phases of S_{ij} and S_{ji} deviate or drift by equal magnitude, but opposite sign, check the phase stability of the LO paths of the converters.

6.8 Additional information

For a comprehensive description of the frequency converter mode, including remote control, refer to the R&S ZNA help system or user manual.

More information is available on the R&S internet site:

- R&S ZCxxx product pages: https://www.rohde-schwarz.com/product/zcxxx/
- R&S ZNA product pages: https://www.rohde-schwarz.com/product/zna/

7 Maintenance and disposal

The product does not require regular maintenance. It only requires occasional cleaning. It is however advisable to check the nominal data from time to time.

7.1 Cleaning

Cleaning the product

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

Do not use any liquids for cleaning. Cleaning agents, solvents (thinners, acetone), acids and bases can damage the front panel labeling, plastic parts and display.

7.2 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.

Disposing electrical and electronic equipment

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

Figure 7-1: Labeling in line with EU directive WEEE

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.

8 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 8-1: QR code to the Rohde & Schwarz support page

Annex

A Setup and operation with R&S ZVA/ZVT

A.1 Connecting the RF cables

The connectors RF IN, LO IN, MEAS OUT and REF OUT have to be connected to the VNA; LO IN can alternatively be connected to an external generator.

Switch off the converter power supply R&S ZCPS before connecting the RF cables.

NOTICE

Risk of connector and cable damage

Tightening the cables too strongly may damage cables and connectors. Loose tightening may result in inaccurate measurement results.

Therefore always use an appropriate torque wrench, suitable for the type of connector. Rohde & Schwarz offers an optional 5/16” torque wrench that fits for SMA, 3.5 mm, 2.92 mm and 1.85 mm connectors (order number 1328.8534.35). Similar wrenches are available for other sizes of spanner, too. See ordering information in R&S ZCxxx data sheet or product brochure.

A.1.1 Input powers RF IN and LO IN

The RF input power at the connectors RF IN and LO IN must not exceed the maximum values quoted in the data sheet. These maximum values are below the maximum RF source power of the network analyzer. The frequency converter modes for the R&S ZCxxx models that are provided by the R&S ZVA/ZVT firmware V3.40 and higher, ensure compatible source powers. Therefore, activate this mode before you connect your frequency converter's RF IN and LO IN to the VNA.

Connection Procedure

1. Connect the frequency converter to the power supply R&S ZCPS and power up R&S ZVA/ZVT and R&S ZCPS.
2. Establish a USB connection between frequency converter and VNA
   .
3. At the analyzer GUI, when prompted to configure a two-port measurement setup, select "Yes"

   Now the RF and LO cables can be connected safely.

You have to repeat this procedure whenever you are not sure if the frequency converter mode for your particular R&S ZCxxx model is already active.

Switching the VNA off and on preserves the selected frequency converter mode.

A.1.2 Connecting the input connectors (RF IN, LO IN)

The type of cable required for connecting the input connectors depends on the type of the network analyzer / external generator. Since the converter inputs are fitted with 2.92 mm female connectors, the cable should ideally have male connectors of the same type (e.g. R&S ZV-Z195, order number 1306.4536.xx). Alternatively, 3.5 mm or SMA male connectors are possible. These are mechanically compatible with 2.92 mm connectors while providing tolerable electrical mismatch (e.g. R&S ZV-Z193, order number 1306.4520.xx).

For a complete test setup for a 2-port transmission measurement – as shown in Figure A-1 – a cable length of about 1 m is recommended. For a setup with only one converter shorter cables may be sufficient. Always use cables with low attenuation and excellent phase stability.

Depending on the VNA model, additional 1.85 mm to 2.92 mm adapters may be required to connect the cables.

1. Connect port 1 or port 2 of the analyzer to RF IN of the converter.
2. Connect port 3 or port 4 of the analyzer to LO IN of the converter.
   For VNAs with 4 sources (R&S ZVA24 var. 28, R&S ZVA40 var. 48 or R&S ZVA67), connect LO IN to **port 4 only**. For these VNA models, or in case

an external generator is used, a power splitter is required for a two-port converter setup. If the outputs of the splitter are so close that two cables cannot be mounted in parallel, additional angled adapters are required. This setup is shown in Figure A-1 below.
If a power splitter is used and the phases of S_{21} and S_{12} deviate or drift by equal magnitude, but opposite sign, check the phase stability of the LO paths of both converters.

The required adapters and splitters are offered as complementary adaption kits (see Chapter A.1.4, "Adaption Kits R&S ZCAK", on page 41).

Figure A-1: Test setup for 2-port transmission measurement with a VNA with two sources

A.1.3 Connecting the output connectors (MEAS OUT, REF OUT)

Suitable cables for connecting the output connectors to the network analyzer are included in the converter shipment. The connectors of these cables are labeled accordingly.

R&S ZVA50 and R&S ZVA67 require additional 1.85 mm to 2.92 mm adapters to connect the cables. These adapters are offered as complementary adaption kits (see Chapter A.1.4, "Adaption Kits R&S ZCAK", on page 41).

1. Connect MEAS OUT of the converter to the VNA. Use the MEAS IN connector of the VNA port that provides the RF source signal.
2. Connect REF OUT of the converter to the REF IN connector of the same VNA port.

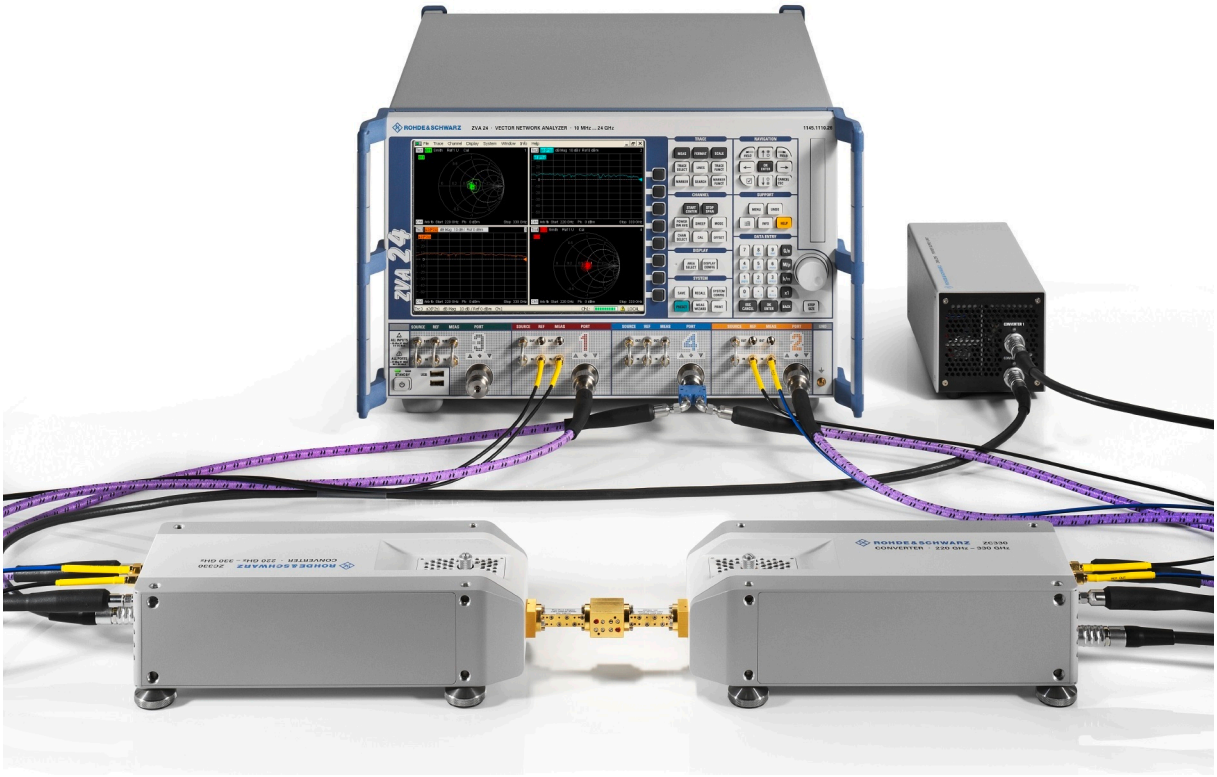


Figure A-2: Test setup for 2-port transmission measurement with a VNA with four sources

A.1.4 Adaption Kits R&S ZCAK

As explained in the previous sections, depending on the VNA model, additional adapters, power splitters and angled adapters may be required to connect the cables. Rohde & Schwarz offers three different adaption kits R&S ZCAK to meet the requirements of different VNAs:

- For the R&S ZVA24 var. 28 and the R&S ZVA40 var. 48 (VNAs with four sources), Rohde & Schwarz offers the adaption kit R&S ZCAK Var. 24 (order number 1323.7746.24).

It includes a power splitter and two right angled SMA (m-m) adapters.

- For the R&S ZVA50, Rohde & Schwarz offers the adaption kit R&S ZCAK Var. 50 (order number 1323.7746.50).
  It includes four 1.85 mm (f) to 2.92 mm (m) adapters and four 1.85 mm (m) to 2.92 mm (f) adapters.
- For the R&S ZVA67, Rohde & Schwarz offers the adaption kit R&S ZCAK Var. 67 (order number 1323.7746.67).
  It includes a power splitter and two right angled SMA (m-m) adapters, three 1.85 mm (f) to 2.92 mm (m) adapters and four 1.85 mm (m) to 2.92 mm (f) adapters.

A.2 Basic Operation

This chapter describes the use of an R&S ZVA vector network analyzer and two frequency converters R&S ZCxxx for 2-port transmission measurements.

Measurements using other converters of the R&S ZCxxx family are performed in an analogous way.

A.2.1 Required equipment

Measurements with frequency converters can be carried out with the following equipment:

- n frequency converters for an n-port measurement
- Vector network analyzer (VNA) R&S ZVA or R&S ZVT with an upper frequency limit of 20 GHz or higher (R&S ZVT20, R&S ZVA24, R&S ZVA40 ...).
  The network analyzer must provide one test port for each converter. In addition, a common LO signal must be applied to all converters. For R&S ZVT20 with at least 4 ports, R&S ZVA24 var.26, R&S ZVA40 var. 42 and R&S ZVA50 var. 52 the LO can be supplied by two different test ports that are fed by the same internal source. If the VNA is a four-source model R&S ZVA24 var. 28, R&S ZVA40 var. 48 or R&S ZVA67, the signal must be supplied by a single port and split by an external power splitter. For the R&S ZVA67, a mm-wave adapter kit (order number 1323.7746.00) is available which includes the power splitter and all necessary adapters.
  The required adapters and splitters are offered as complementary adaption kits (see Chapter A.1.4, "Adaption Kits R&S ZCAK", on page 41).

- Option R&S ZVAxx-B16/R&S ZVT20-B16, "Direct Generator/Receiver Access" at each port
- Option R&S ZVA-K8, "Converter Control"
- Calibration kit for the respective WM-xxxx waveguide

Special requirements for particular converter models

- The electronic attenuator of an R&S ZC90E can only be controlled by an R&S ZVA that is equipped with hardware option R&S ZVA-B8. The R&S ZVT does not offer this option.
  For a description of the corresponding connector, see Chapter 4.3.5, "Attenuator control connector (R&S ZC90E only)", on page 18. For cabling and operational aspects, see the Getting Started of the predecessor R&S ZVA-Z90E. It can be downloaded from the manual page of the R&S ZVA-Zxxx converter family (https://www.rohde-schwarz.com/manual/zvaz/).
- The RPG ZC1100 requires an R&S ZVA40 or R&S ZVA67. Operation with an R&S ZVT20 is not possible.

Firmware and Operating System Requirements

Support of the R&S ZCxxx converters requires firmware version 3.40 or higher to be installed on the VNA. If the operating system of the VNA is Windows® XP, make sure that it has been upgraded at least up to service pack 2. Otherwise USB communication between VNA and converter is not possible. In case an upgrade of the operating system is needed, please contact your local Rohde & Schwarz service.

A.2.2 Measurement principle

The measurement involves the following steps:

1. Activation of the converter mode
2. Connection of the frequency converters
3. Calibration using a suitable waveguide calibration kit
4. Connection of the DUT and measurement

A.2.3 Activating the frequency converter mode

To activate the converter mode for a setup without external generator, establish a USB connection between converter and VNA. Wait for the dialog box to appear and confirm the prompt "Configure Two-Port Measurement Setup…?". The VNA then readd the characteristic data of the R&S ZCxxx via USB and automatically enter the appropriate converter mode.

Analyzer settings with active frequency converter

In frequency converter mode, the frequency and level settings of the network analyzer are automatically set to be compatible with the selected frequency converters. If the VNA allows for low phase noise mode, it is activated. Automatic Level Control (ALC) is disabled. Frequency and source power levels of all ports are displayed in the port configuration dialog ("Channel > Mode > Port Config").

If a USB connection between VNA and converter is not possible, but has been established previously, the characteristic data of the frequency converter are already available at the VNA. In this case, open the "System Configuration" dialog ("System > System Config") and activate the "Frequency Converter" tab. Select the adequate converter model in the "Type" combobox, select the LO sources in "Use of External Sources", check the port assignment table and press "Apply" to activate the setting.

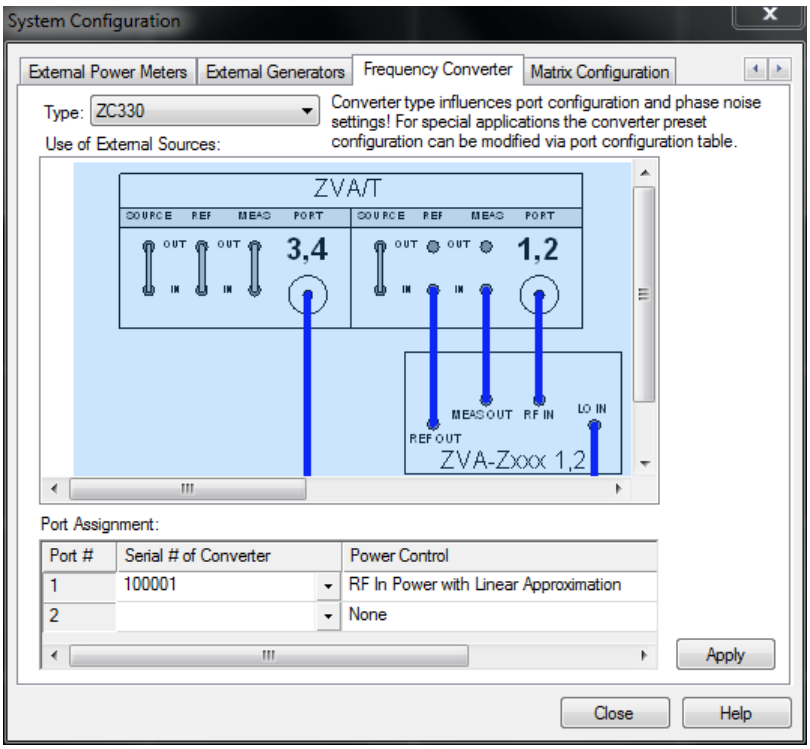


Figure A-3: Frequency Converter tab in System Configuration dialog

A.2.4 Connecting the frequency converters

Each frequency converter must be connected to power supply, analyzer and DUT. Please refer to the following sections for details.

- Power supply: Chapter 3.5, "Connecting the converter to the DC supply", on page 11
- Analyzer ports: Chapter A.1, "Connecting the RF cables", on page 38
- DUT (usually connected after calibration): "Mounting a DUT" on page 14

A.2.5 Calibration

The output power can be manually set using the adjusting knob (see Chapter 4.2, "Output power-adjusting knob", on page 15). A normal power flatness calibration via "Channel" > "Calibration" > "Start Power Cal" > "Source Power Cal" can be performed, but requires a small convergence factor (0.3 down to 0.1 for high frequency converters). With the help of a receiver power calibration, however, precise monitoring of the output power of a converter port is possible by measuring

the corresponding a-wave. See section "Power Calibration for Converters without Electronic Attenuators" in the R&S ZVA/ZVT online help for details.

Accepting some limitations w.r.t. temperature stability, the R&S ZVA Frequency Converter Leveling Tool can be applied for the linearization of output power in the frequency range of interest. For further details, refer to the R&S ZVA/ZVT online help (description of "RF In Power (and Electronic Attenuator) with Data Set" option), and the Getting Started document of R&S ZVA Frequency Converter Leveling Tool.

For precise S-parameter measurements, a system error correction is recommended. System error correction requires a calibration kit for the waveguide band of the specific R&S ZCxxx converter. Activating the frequency converter mode for a R&S ZCxxx does not imply automatic installation of a suitable R&S waveguide kit in the analyzer firmware, as it is the case for the R&S ZVA-Zxxx converters. To have at least one cal kit defined when getting started with a R&S ZCxxx converter, the R&S ZVA-WRxx kits have been pre-installed in the R&S ZVA/ZVT firmware. They are assigned, however, to WM-xxxx connectors, as far as the WRxx waveguide bands are identical to the newer WM-xxxx bands.

The standards in the calibration kits allow for OSM, TOSM, UOSM, TOM, TRM and TRL calibrations. Refer to the documentation of the calibration kit or the R&S ZVA/ZVT online help for details.

A.2.6 Measurement

After power calibration and system error correction, the mm-wave measurement can be performed like any other network analyzer measurement. The port configuration dialog ("Channel > Mode > Port Configuration") shows the frequency and power sweep ranges of all implied signals, including RF IN, LO IN and IF output. All measured quantities (S-parameters, wave quantities, ratios etc.) are available.

Flat power and power sweep are only available if a power correction data set has been previously taken with the R&S Converter Leveling Tool.

The R&S Converter Leveling Tool is a separate software that can be installed on the R&S ZVA/ZVT or on a separate PC. Installer and documentation are available on the R&S ZVA software page https://www.rohde-schwarz.com/software/zva/.

Please note that measurement results can be degraded if the setup is exposed to an electromagnetic field at the R&S ZVA/ZVT receiver frequency (typically 279 MHz).

A.2.7 Additional information

For a comprehensive description of the frequency converter mode, including remote control, refer to the R&S ZVA/ZVT online help system or to the printable operating manual, which is available for download from the Rohde & Schwarz web site (www.rohde-schwarz.com).

Application notes related to frequency converters are also available for download (currently for the R&S ZVA-Zxxx series only).

The text book "Fundamentals of Vector Network Analysis" by Michael Hiebel is an ideal complement for the information given in the user documentation. The book combines theoretical background and practical measurements on an R&S ZVA network analyzer. If you are interested, please contact your local R&S office.

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