R&S®QAR
Quality Automotive Radome Tester
User Manual

1178720002
Version 10

ROHDE&SCHWARZ
Make ideas real

This document describes the following R&S®QAR models and options:

- R&S®QAR QAR Panel for reflectivity measurements (1336.6008.02)
- R&S®QAR-Z10 Transmitter module (1336.5401.02)
- R&S®QAR-Z11 OPC client for radome measurement (1340.5219.02)
- R&S®QAR-Z20 Platform (1336.5418.02)
- R&S®QAR-Z21 Platform for radar positioning measurements (1336.5524.02)
- R&S®QAR-Z30 Calibration set (1336.5430.02)
- R&S®QAR-Z40 Verification kit for radome measurements (1336.5447.02)
- R&S®QAR-Z41 Verification kit for bumper measurements (1336.5499.02)
- R&S®QAR-Z42 Verification kit for radar positioning measurements (1336.5530.02)
- R&S®QAR-Z43 Verification kit for 1-cluster measurements (1343.0230.02)
- R&S®QAR-Z50 DUT mounting table (1336.5424.02)
- R&S®QAR-Z60 Reference reflector (1336.5453.02)
- R&S®QAR-Z61 Stand reference reflector (1336.5476.02)
- R&S®QAR-K10 Radome measurements (1336.5501.02)
- R&S®QAR-K20 Grid evaluation (1343.0030.02)
- R&S®QAR-K50 1-Cluster measurements (1343.0018.02)
- R&S®QAR-K60 Bumper measurements (1336.5482.02)
- R&S®QAR-K100 Radar positioning measurements (1336.5518.02)

The document corresponds to the following software versions:

- Radome measurements: 2.1.x.x or higher
- Bumper measurements: 2.1.x.x or higher
- Radar positioning measurements: 2.1.x.x or higher

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

1178.7200.02 | Version 10 | R&S®QAR

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

Contents

1 Safety and Regulatory Information

The product documentation helps you use the R&S QAR safely and efficiently. Follow the instructions provided here and in the safety instructions.

Intended use

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

Where do I find safety information?

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

- In the safety instructions. The same information is provided in many languages as printed "Safety Instructions". The printed "Safety Instructions" are delivered with the R&S QAR.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

1.1 Safety Instructions

The R&S QAR Quality Automotive Radome Tester is manufactured according to the highest technical standards. To use the scanner safely, follow the instructions provided here and throughout the product documentation. Keep the documentation nearby and offer it to other users.

Use the R&S QAR only as intended and within its performance limits. The limits are described in the product documentation, such as the data sheet, manuals and this brochure. If you are unsure about the appropriate use, contact the Rohde & Schwarz customer service.

Using the R&S QAR requires specialists or specially trained personnel. The operators also need sound knowledge of at least one of the languages in which the user interface and the product documentation are available.

If any part of the product is damaged or broken, stop using the product. Never open the casing of the R&S QAR or its components. Only service personnel authorized by Rohde & Schwarz are allowed to repair the product.

Lifting, carrying and installing the R&S QAR

The R&S QAR is heavy and can cause physical injuries when it falls or tips over.

The R&S QAR must be installed and set up by trained staff. When you carry, lift or move the R&S QAR, use the carrying handles on the back side of the R&S QAR. Dur-

ing the installation, make sure that the installation site is only accessible to people working on the installation. Hold the R&S QAR into position until all screws are tight to prevent it from falling over.

Because of its weight, at least two strong people are required to move or install the R&S QAR.

If you have to move the pallet the R&S QAR is delivered on, always use a forklift.

During transport, installation or repair, wear appropriate protective clothing that complies with your local rules and regulations. If you are unsure of which equipment to use, ask your safety inspector.

We recommend to wear:

- Safety shoes with toe cap and ESD protection.
- Protective gloves

ESD protected shoes and gloves also protect the hardware from being damaged.

Choosing the operating site

Use the R&S QAR only indoors. The R&S QAR is not waterproof and water that enters can electrically connect the casing with live parts. This can lead to electric shock, serious personal injury or death if you touch the casing.

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

Installing cables

A R&S QAR installation consisting of the R&S QAR, monitor and transmitter module requires cable connections (power cables, LAN cables etc.). Make sure to secure all cables on the floor and cover them up.

Loose cables are a tripping hazard. Tripping on cables can cause physical injuries.

Properly covered cables also minimize the risk of cable damage.

Supplying the R&S QAR with power

Always complete all connections (LAN, USB etc.) before connecting the R&S QAR to the power supply. Otherwise, the R&S QAR can get damaged.

You can connect the R&S QAR to the power distribution system normally used to supply energy-consuming equipment, such as household appliances and similar loads. Electrically powered products have risks, such as electric shock, fire, personal injury or even death.

Take the following measures for your safety:

- Only use the power cable delivered with the R&S QAR. It complies with country-specific safety requirements. Only insert the plug into an approved grounded outlet.
- For components that need an external AC adapter, only use the one that is delivered with the components.
- Only use intact cables and route them carefully so that they cannot be damaged. Check the power cables regularly to ensure that they are undamaged.

- If the voltage or frequency is higher than 230 V or 50 Hz, the leakage current of the R&S QAR can be above the limits. In that case, a protective ground connection must be established for each panel before connecting them to the power supply.
- Only connect the R&S QAR to supply networks with a fuse protection of maximum 20 A.
- Ensure that you can disconnect the product from the power supply at any time. Pull the power plug to disconnect the product. The power plug must be easily accessible.

Meaning of safety labels

Safety labels on the product warn against potential risks.

	Potential hazard Read the product documentation to avoid personal injury or product damage.
	Electrical hazard Indicates live parts. Risk of electric shock, fire, personal injury or even death.
	Protective conductor terminal Connect this terminal to a grounded external conductor or to protective ground. This protects you against electric shock should an electric problem occur.

1.2 Korea Certification Class B

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

1.3 Regulatory Information

The R&S QAR complies with the following regulations.

1.3.1 Regulations for the USA

FCC compliance

This equipment has been tested and found to comply with the limits for Industrial, Scientific and Medical Equipment (ISM), pursuant to part 18 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in an

industrial installation. This equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference other devices, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Consult Rohde & Schwarz customer service for help.

1.3.2 Regulations for Canada

ICES-001 compliance

This class A ISM device complies with Canadian ICES-001.

Cet appareil ISM de la classe A est conforme à la norme NMB-001 du Canada.

2 Documentation Overview

This section provides an overview of the R&S QAR user documentation.

User manual

Contains a description of the R&S QAR system, including the features available in the R&S QAR application.

A digital version of the user manual is available in the measurement application.

A printed version of the user manual is part of the delivery.

Safety information

Contains safety instructions, operating conditions and further important information. The printed safety instructions are part of the delivery.

Data sheet and brochure

The data sheet contains the technical specifications of the R&S QAR, its options and accessories.

The brochure provides an overview of the R&S QAR and its characteristics.

Open-source acknowledgment (OSA)

The open-source acknowledgment documents provide verbatim license texts of the used open source software.

The OSAs is available in the measurement application ("Info" > "Open Source Acknowledgement") and on the SSD in the folder `C:\OpenSourceAgreement`.

3 R&S QAR Tour

The R&S QAR is a millimeter wave imaging system operating in the frequency band of automotive radar sensors. With its support of spatially resolved reflection and transmission loss measurements, the R&S QAR provides an intuitive and powerful way to evaluate how radomes and bumpers influence the radar performance.

The R&S QAR consists of a panel that contains the measuring electronics like transmitting and receiving antennas. It also contains a PC with dedicated software to operate and control the measurements.

- **Radome measurements**
  The basic configuration allows you to measure the reflection of a radome.
  The high resolution of the resulting images can identify even the smallest disturbance in the radome. The R&S QAR uses the frequency range between 74 GHz and 79 GHz to measure the reflection. Therefore, any faults visible in the millimeter wave image directly correlate to the performance of the radome in combination with a radar sensor.
  An optional transmitter module (R&S QAR-Z10) extends the functionality of the R&S QAR to measure the transmission loss of a radome. For the transmission, the R&S QAR uses the frequency range between 72 GHz and 82 GHz.
  Additional equipment like an optional platform (R&S QAR-Z20) on which you can mount the R&S QAR, or a table for the device under test (DUT mounting table, R&S QAR-Z50) are also available.
  The default setup uses all 12 measurement clusters built in the R&S QAR to analyze radomes. With an additional software option (R&S QAR-K50), you can unlock single cluster measurements that only use one of the built-in clusters.
- **Bumper measurements**
  An optional reference reflector (R&S QAR-Z60) is available to measure the mean transmission loss (attenuation) caused by a bumper.
  The reflector measures the attenuation in 102 points and therefore enables you to evaluate the homogeneity of the bumper painting and its overall radar penetrability.
- **Radar positioning measurements**
  The basic configuration enables you to measure the position of the radar in the car and compare it with the theoretical position indicated in the manufacturer's CAD files.
  You can set acceptance limits and verify in a few seconds if the radar is correctly positioned.
  Additional equipment like an optional platform (R&S QAR-Z21) on which you can mount the R&S QAR, or a verification set (R&S QAR-Z42) are also available.

Parts of delivery

- 1 x R&S QAR
- 1 x power cable

Required equipment to run measurements

- Monitor (with DVI cable)
  We recommend a monitor with a 1920 x 1080 resolution.

- USB Keyboard
- USB Mouse

Connectors

The R&S QAR has several connectors on its back side.

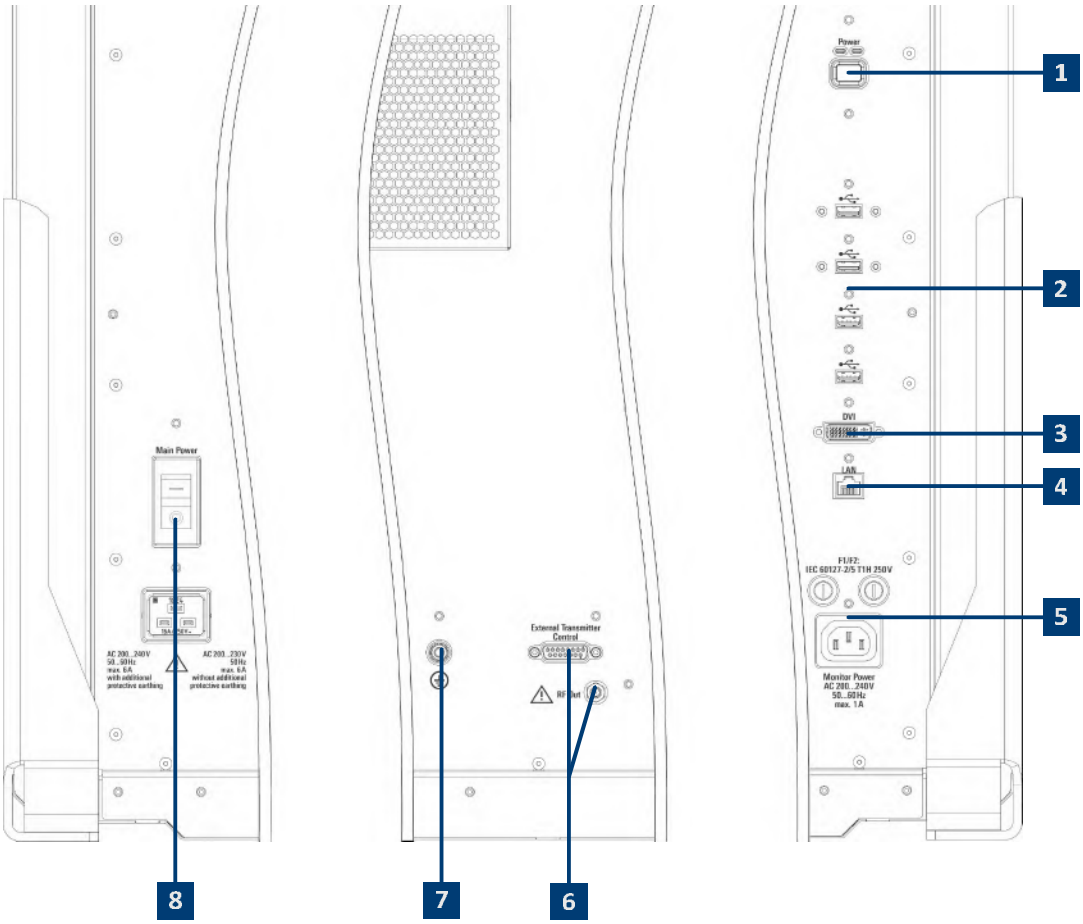


Figure 3-1: Connectors

1 = Power button
2 = USB ports (4x)
3 = Display connector (DVI)
4 = LAN interface
5 = Power supply for a monitor (including 2 fuses)
6 = Transmitter module control
7 = Ground terminal
8 = AC inlet and main power switch

3.1 Main Power Supply

The AC inlet and main power switch are located on the back of the R&S QAR.

The power cable to connect the panel to the power supply is part of the delivery.

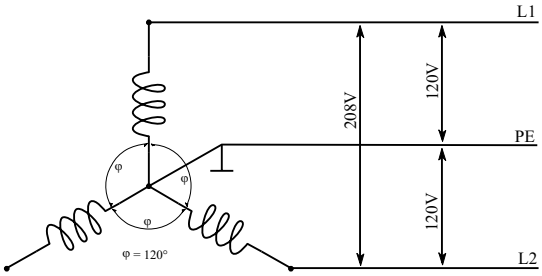
The main power switch contains an RCD (residual-current device) that protects the internal power circuit of the R&S QAR. If the RCD detects electrical anomalies, it will switch off automatically the R&S QAR.

For more information about supplying the panel with power, see Chapter 4.4, "Switching the R&S QAR On and Off", on page 33.

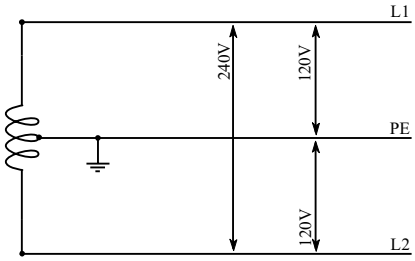
Establishing a ground connection

1. **WARNING!** Risk of electric shock. If the voltage or frequency are greater than 230 V or 50 Hz, the leakage current of the R&S QAR can be above the limits and can cause personal injuries from an electric shock.
   In that case, a protective ground connection must be established before connecting the R&S QAR to the mains supply.
   - 200 V to 230 V AC and 50 Hz
     No additional protective ground needed.
   - 230 V to 240 V AC or a frequency greater than 50 Hz
     Additional protective ground needed.
     Exception: The following two 60 Hz AC distribution systems are tested and work without an additional ground.

     3-Phase Wye

     Single phase, 2 wire

     For the separate protective ground, you need a green/yellow ground wire with a cross section of at least 4 mm^2 in addition to the main protective earthing terminal. The ground wire must be connected permanently to the ground terminal on the side of each R&S QAR panel and earth.
     The ground terminal is located on the back of the scanner. Connect the terminal to the protective grounding system of the building or room where the scanner is installed.

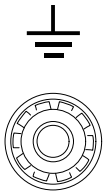
     

     Figure 3-2: Ground terminal

2. Make sure that the power supply is adequately protected against overcurrent. Otherwise the fuse can blow.

We recommend that you use a power cable that is rated for a 16 A (included in the delivery) and connect each panel to a separately protected power circuit (at least 10 A).

If you cannot connect the panels to separate power circuits, make sure that the system is protected:

- By a fuse with at least 20 A in 200 V networks.
- By a fuse with at least 16 A in 230 V networks.

3. If the voltage drops to 70 % for 500 ms, a reboot occurs.

3.2 Power Button

The power button is located on the back of the R&S QAR. Use it to switch the R&S QAR on and off.

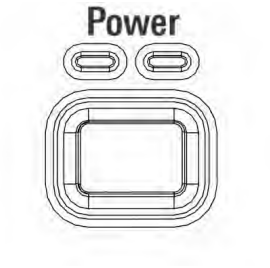
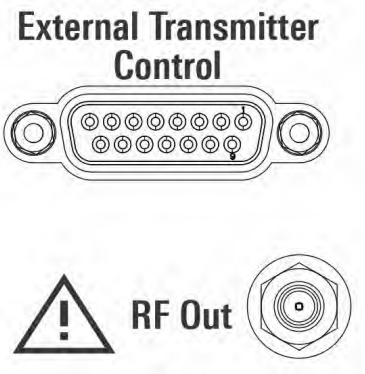


Figure 3-3: Power button

For more information about switching the R&S QAR on and off, see Chapter 4.4, "Switching the R&S QAR On and Off", on page 33.

3.3 Transmitter Module Control

The connectors for the optional transmitter module for transmission loss measurements are located on the back of the R&S QAR.



Transmitter control

The "External Transmitter Control" connector controls the transmitter module.

RF out

The "RF Out" connector (SMA) outputs the signal for the transmission measurement.

Do not feed a DC or RF signal into the RF output, because it is specified as an output only. Otherwise, the R&S QAR can get damaged.

3.4 Monitor Connectors

A DVI interface and power supply (AC outlet) for a monitor are located on the back side of the R&S QAR. Use them to connect an external monitor to operate the R&S QAR.

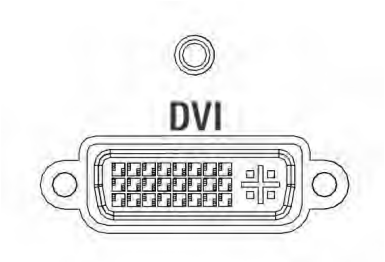


Figure 3-4: DVI interface

Fuses F1 and F2

Two fuses of the same type (1 A, designation: EN 60127-2/5 T1H250V) are located above the AC outlet. In case of defects, check both fuses.

Replacing a fuse

1. Disconnect the R&S QAR from the power supply.
2. Open the fuse holder by turning it counterclockwise, for example with a screwdriver.
3. Replace the fuse.
4. Close the fuse holder.

3.5 LAN Interface

The R&S QAR provides a LAN interface on the back of the R&S QAR. Use it to integrate the R&S QAR into a local network.

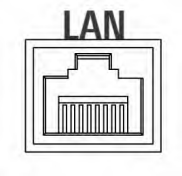


Figure 3-5: LAN interface

3.6 USB Ports

The R&S QAR provides 4 USB ports on the back side. The two top ports are USB 3.0 type A. The two bottom ports are USB 2.0 type A.

They offer multiple uses:

- Connection of a keyboard to operate the R&S QAR.
- Connection of a mouse to operate the R&S QAR.
- Connection of a memory stick (for example to update the software).

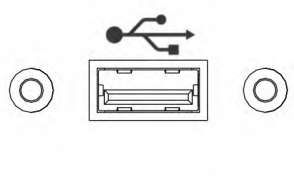


Figure 3-6: USB port (one of four)

4 Preparing for Use

Before you can use the R&S QAR, install it and connect the devices as described in the next subchapters.

4.1 Unpacking the R&S QAR

1. Remove the cardboard box carefully.
2. Remove the wooden supporting elements.
3. Lift the R&S QAR off the pallet using the handles attached to the R&S QAR.

Shipping the R&S QAR

We recommend using the original packaging if the R&S QAR has to be shipped.

4.2 Installing the R&S QAR

Using the R&S QAR requires you to install it firmly to some kind of support fixture in order to prevent it from toppling over. You can install the R&S QAR in different ways, depending on the equipment you have bought.

If you would like to use a fixture different to those described here, contact Rohde & Schwarz.

Required tools

Here is a complete list of tools you need for installation on the platform and the installation of the DUT mounting table and the transmitter module.

- Allen wrench size 5 (for screws ISO 10642 M8x20)
- Allen wrench size 6 (for screws ISO 4762 M8x40)
- Allen wrench size 10 (for screws ISO 4762 M12x55)
- Torx wrench size TX20
- Open-end wrench size 19
- Spirit level
- Torque wrench
- Power drill (for floor installation only)

- Anchor bolts size 12 mm, for example a Fischer FAZ II 12 (for floor installation only)

4.2.1 Installing the R&S QAR on the Floor

You can install the R&S QAR on the floor or on the optional platform. When you do not use the platform, the R&S QAR must be attached to the floor.

Required tools:

- Allen wrench size 5 (for screws ISO 10642 M8x20)
- Allen wrench size 6 (for screws ISO 4762 M8x40)
- Power drill
- Anchor bolts size 12 mm, for example a Fischer FAZ II 12.

The anchor bolts and power drill are not part of the delivery.

If you have one of the the optional platforms, see:

- Chapter 4.2.2, "Installing the R&S QAR on the Platform (R&S QAR-Z20)", on page 21
- Chapter 4.2.5, "Installing the R&S QAR on the Platform (R&S QAR-Z21)", on page 31

1. Drill 4 holes into the ground.
   The locations of the drill holes and distances between each other are indicated in Figure 4-1.

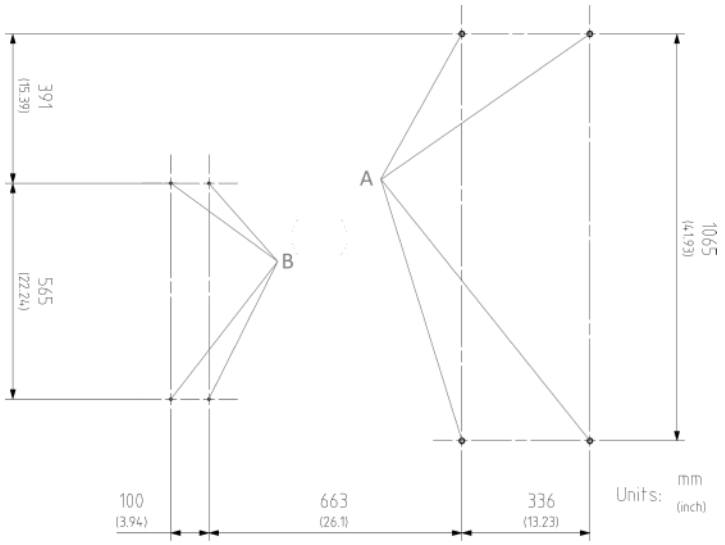


Figure 4-1: Location and distances of drill holes

A = Drill hole location for R&S QAR
B = Drill hole location for DUT mounting table

Whenever you lift, move or carry the R&S QAR, use the handles on its back side.

2. Screw the two supports to the side of the R&S QAR with two socket head screws (ISO 10642 M8x20, Allen wrench size 5) on each side of the R&S QAR (see Figure 4-2).

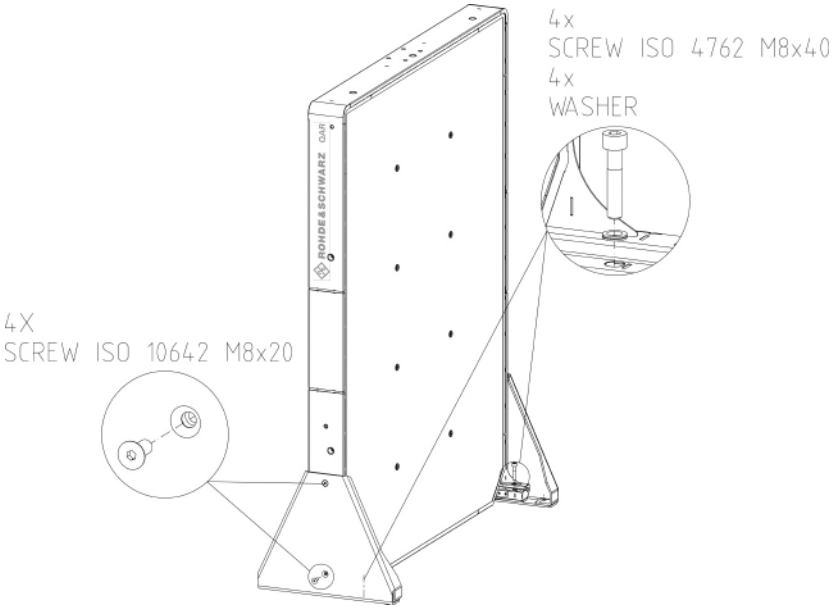


Figure 4-2: R&S QAR installation, including support installation

3. Screw the two supports to the R&S QAR with the socket head screws (ISO 4762 M8x40, Allen wrench size 6) on each side of the R&S QAR (see Figure 4-2).

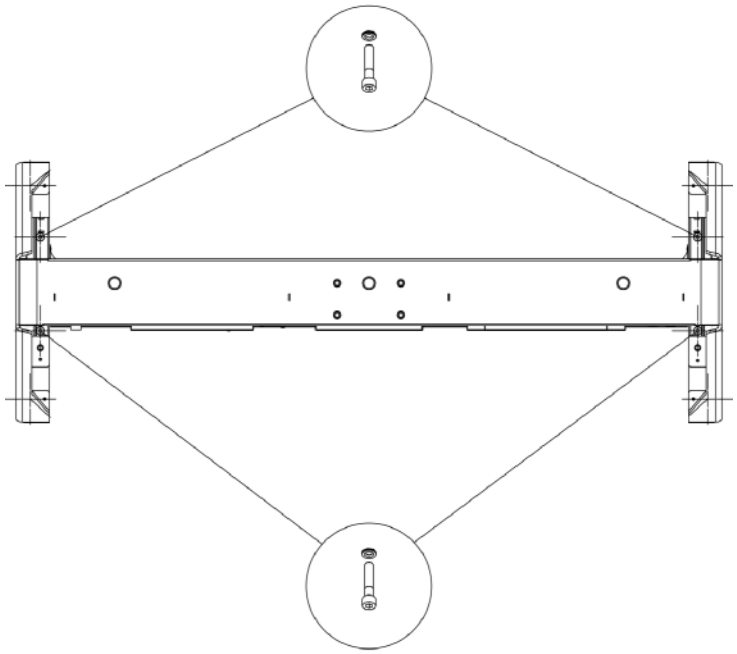


Figure 4-3: Support installation (top view)

4. Lift the R&S QAR into a stable position and in a right angle to the floor.
5. Secure the R&S QAR by screwing the two supports to the floor.
   The drill holes in the floor define the position of the supports. Two anchor bolts with a size of 12 mm secure each support.
   Make sure that all screws are screwed on tightly.

4.2.2 Installing the R&S QAR on the Platform (R&S QAR-Z20)

Required tools:

- Allen wrench size 5 (for screws ISO 10642 M8x20)
- Allen wrench size 6 (for screws ISO 4762 M8x40)
- Allen wrench size 10 (for screws ISO 4762 M12x55)
- Open-end wrench size 19
- Spirit level.

Installing the platform

1. Place the platform on a stable and horizontal surface that can support the weight of the R&S QAR.
2. Check with a spirit level if the platform itself is level.
3. If necessary, remove any irregularities by adjusting the height of the feet until the platform is level.
   - A clockwise movement lowers the corresponding platform area.

- A counterclockwise movement raises the corresponding platform area.

4. Tighten the feet with the check nuts using the open-end wrench.

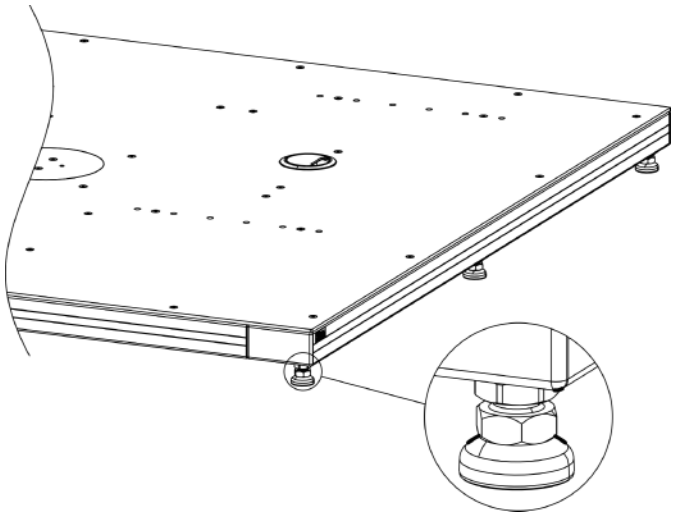


Figure 4-4: Platform alignment

Mounting the R&S QAR

When the platform is in place, you can mount the R&S QAR on the platform.

Whenever you lift, move or carry the R&S QAR, use the handles on its back side.

1. Screw the two supports to the R&S QAR with two socket head screws (size 5) on each side of the R&S QAR (see Figure 4-5).

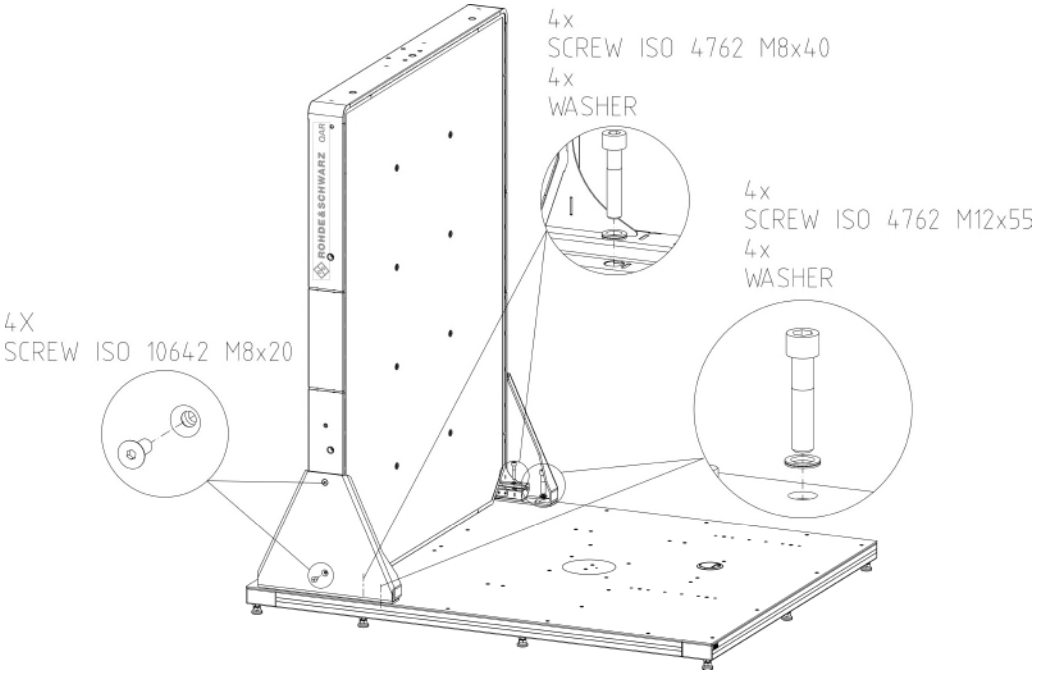


Figure 4-5: R&S QAR installation, including support mounting

2. Lift the R&S QAR onto the platform into a stable position and in a right angle to the floor.
3. Secure the R&S QAR by screwing the two supports to the platform.
   The mounting holes in the platform define the position of the supports.

   Four screws secure each support:
   - Two socket head screws with a size 10 on the outside.
   - Two socket head screws with a size 6 on the inside.

   Note: Insert a washer between screw and support as shown in Figure 4-5.
4. Make sure that all eight screws are screwed on tightly to the platform.

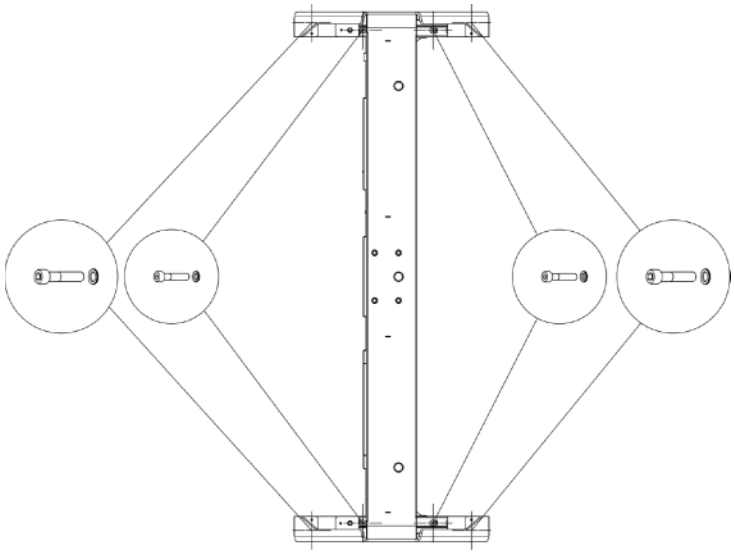


Figure 4-6: Support installation (top view)

4.2.3 Installing the Radome Measurement Elements

Radome measurements require the DUT mounting table and the transmitter module.

Required tools:

- Allen wrench size 5.
- Torx wrench size TX20.
- Power drill (floor installation only).
- Anchor bolts size 12 mm, for example a Fischer FAZ II 6 (floor installation only).

Installing the DUT mounting table on the platform

You can install the optional mounting table on the platform. The platform has several mounting holes that you can use to secure the table. The mounting holes you choose define the distance of the mounting table to the R&S QAR.

1. Place the mounting table on the platform at the distance you need.
2. Screw the mounting table to the platform with the four socket head screws (size 5).

Note: Insert a washer between screw and mounting table as shown in Figure 4-7.

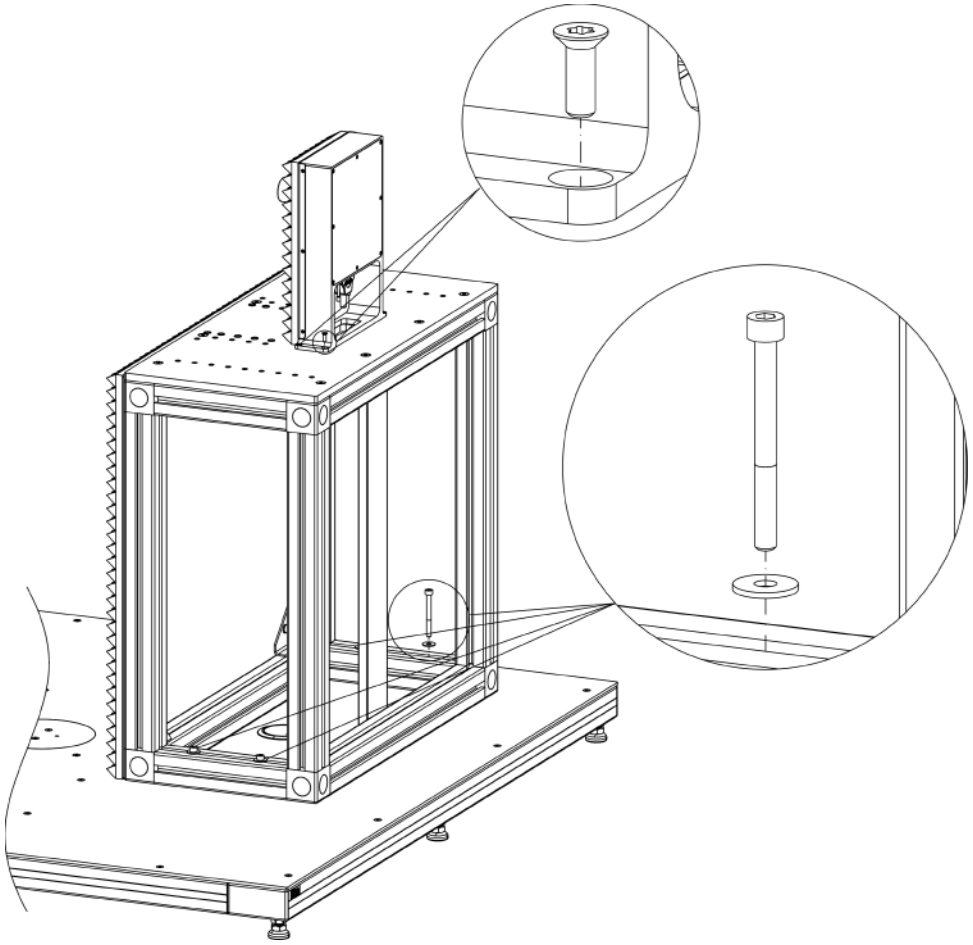


Figure 4-7: DUT mounting table and transmitter module installation

Installing the DUT mounting table on the floor

Altenatively, you can install the DUT mounting table directly on the floor.

1. Drill holes into the floor.
   The locations and distances of the drill holes are indicated in Figure 4-1.
2. Screw the table to the floor with four anchor bolts, size 6 mm, for example a Fischer FAZ II 6.
   The anchor bolts are not included in the delivery.

Attaching the transmitter module to the mounting table

You can install the transmitter module required for transmission loss measurements on top of the DUT mounting table. The DUT mounting table already comes with the necessary mounting holes.

1. Place the transmitter module on top of the mounting table.
2. Screw the transmitter module to the mounting table using the torx wrench.

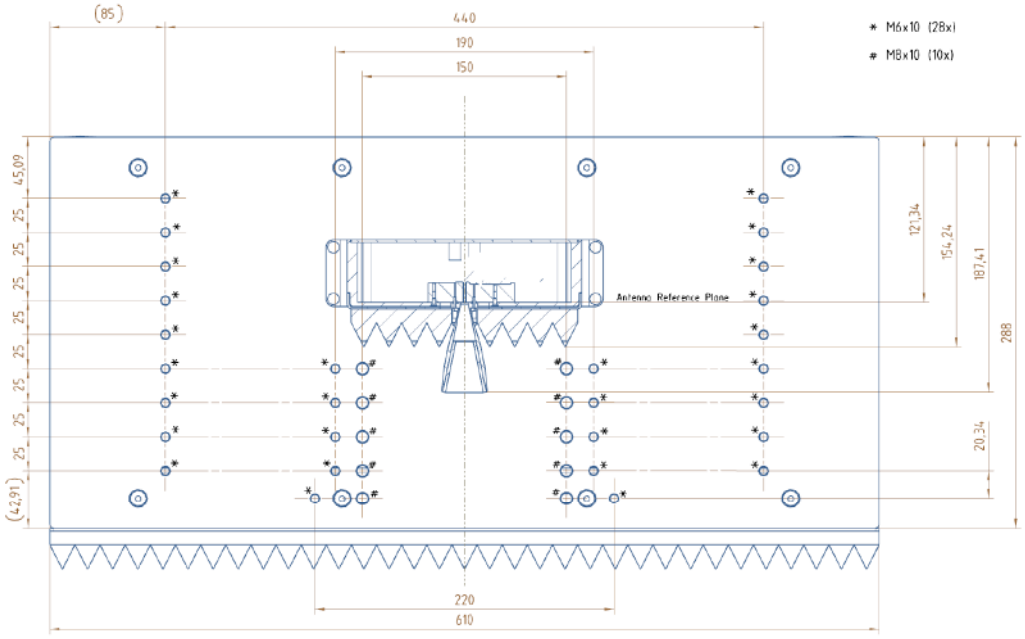


Figure 4-8: DUT mounting table from above

For more information about cable connections, see Chapter 4.3, "Connecting the R&S QAR", on page 32.

4.2.4 Installing the Bumper Measurement Elements

The basic setup for bumper measurements consists of the R&S QAR and a reference reflector, including a stand for the reference reflector.

The reference reflector has to be placed at a specific height and at specific distances from the R&S QAR, as shown in Figure 4-10 and Figure 4-9.

There is a tolerance of +/-2mm (lateral distance) and +/-5.8mm (frontal distance).

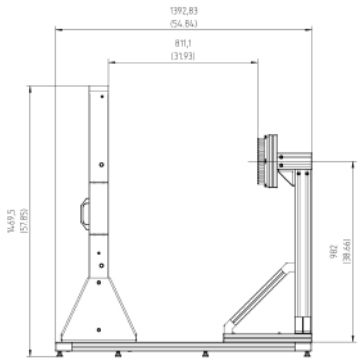


Figure 4-9: Setup for bumper measurements: height and frontal distance

Required tools:

- Allen wrench size 5.

- Allen wrench size 6.
- Torx wrench size TX25.
- Spirit level

Installing the reference reflector stand

1. Put the stand on the platform at the specified location.
2. Screw the stand to the platform with the four socket head screws (size 5). Insert a washer between screw and stand.

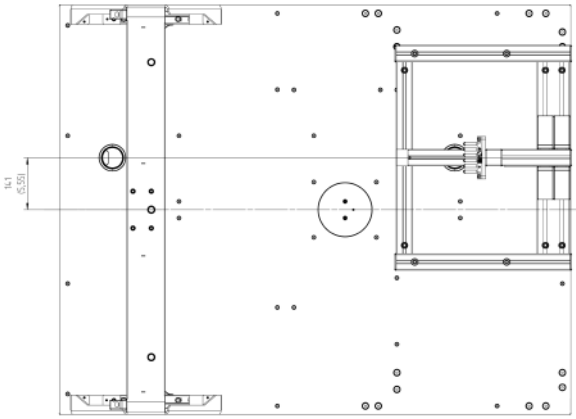


Figure 4-10: Top view - lateral distance

Installing the reference reflector

1. Attach the reference reflector to the stand.
   Verify that the top of the reflector pins are parallel to the R&S QAR front by using, for example, a spirit level. Check the lateral distance by performing the verification described in Chapter 5.3.5, "Verification", on page 70.
2. Align the reference reflector with a spirit level.
   The top of the reflector pins have to be parallel to the front side of the R&S QAR panel.
3. Screw the reference reflector to the stand with the Torx wrench.
4. Normalize the measurement to verify the position of the reference reflector.
   For more information about normalizing the measurement, see Chapter 5.3.3.1, "Normalization", on page 67.
5. Check the results of the normalization measurement.
   If the reference reflector is not aligned correctly, the R&S QAR shows the type of misalignment.

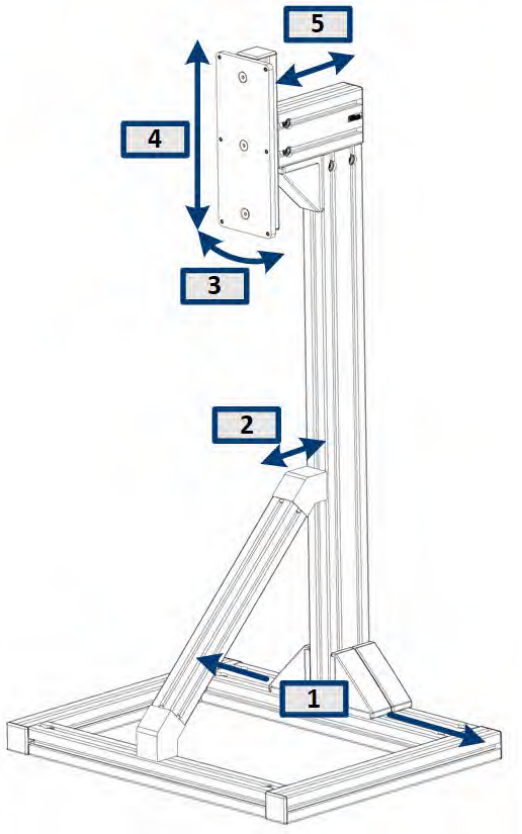


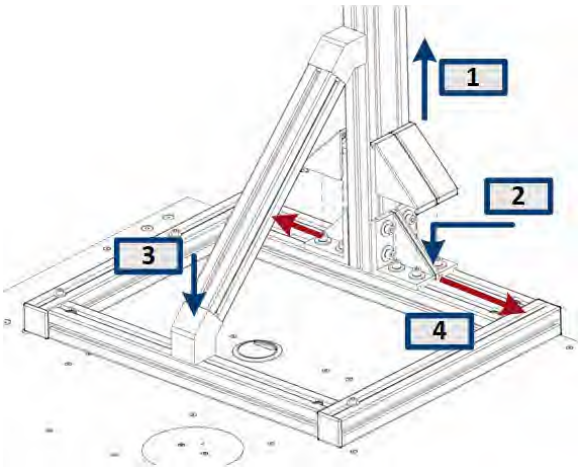
Figure 4-11: Possible misalignments of the reflector stand

1 = Lateral misalignment (x-axis)
2 = Vertical tilt
3 = Horizontal tilt
4 = Vertical misalignment (y-axis)
5 = Horizontal misaligment (z-axis)

6. If the normalization indicates a misalignment, adjust the position of the **reflector stand** as described below.
   Do not change the position of the reference reflector itself.
   Note that the alignment can take several tries, because of the low tolerances.

Correcting a lateral misalignment (x-axis)

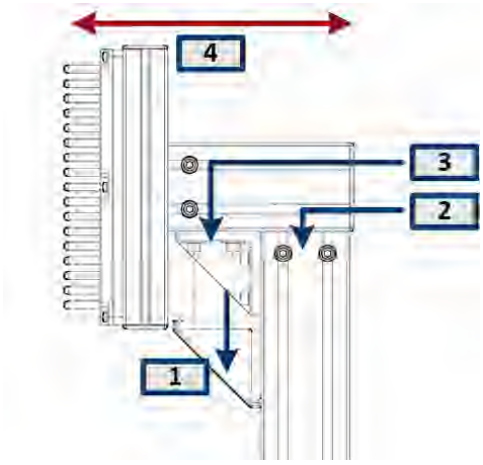
Solves message in user interface: "Shift reference reflector to the right / left".



1. Remove the covers on the base of the stand (2x), for example with a slotted screwdriver.
2. Loosen the screws on the base of the stand with an Allen wrench, size 6 (8x).
3. Loosen the screw on the base of the support bar with an Allen wrench, size 6 (1x).
4. Move the stand to the left or right as necessary.
5. Repeat normalization measurement.
   a) If normalization does no longer indicate a misalignment, reassemble the stand.
   b) If normalization still indicates a misalignment, repeat the adjustment until the error no longer occurs.

Correcting a horizontal misalignment (z-axis)

Solves message in user interface: "Shift reference reflector to toward QAR / from QAR away".

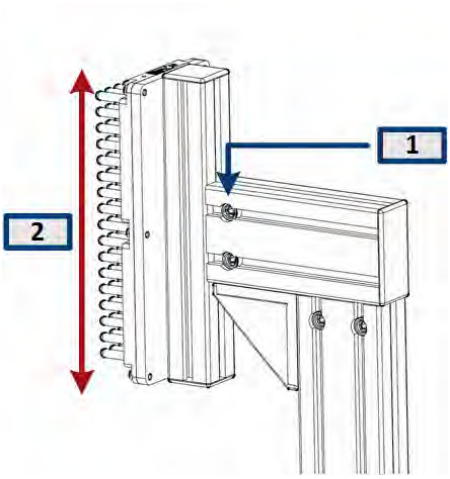


1. Remove the cover on the top of the stand (1x), for example with a slotted screwdriver.
2. Loosen the screws on the main bar of the stand with an Allen wrench, size 6 (2x).
3. Loosen the screws on the support bar with an Allen wrench, size 6 (2x).

4. Move the reflector to the front or back as necessary.
5. Repeat normalization measurement.
   a) If normalization does no longer indicate a misalignment, reassemble the stand.
   b) If normalization still indicates a misalignment, repeat the adjustment until the error no longer occurs.

Correcting a horizontal misalignment (z-axis)

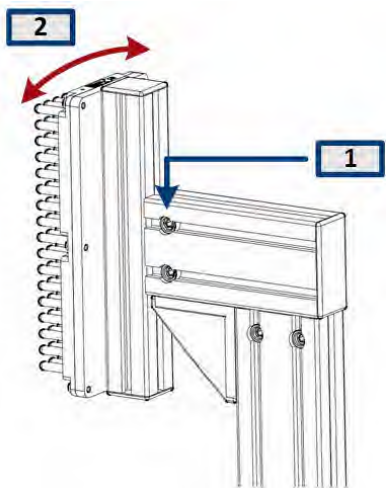
Solves message in user interface: "Shift reference reflector downward / upward".



1. Loosen the screws on the side of the support bar with an Allen wrench, size 6 (2x).
2. Move the reflector up or down as necessary.
3. Repeat normalization measurement.
   a) If normalization does no longer indicate a misalignment, reassemble the stand.
   b) If normalization still indicates a misalignment, repeat the adjustment until the error no longer occurs.

Correcting a horizontal tilt

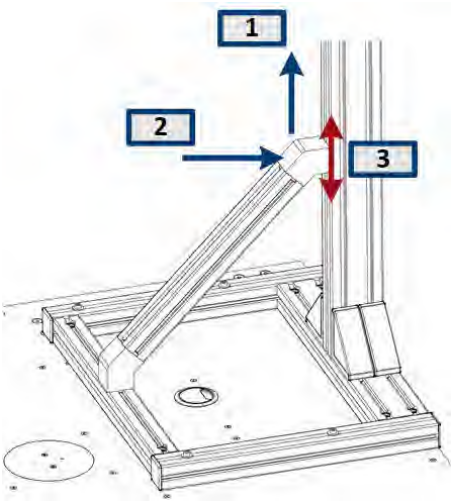
Solves message in user interface: "Rod alignment or rod distance is not correct".



1. Loosen the screws on the side of the support bar with an Allen wrench, size 6 (2x).
2. Turn the reflector to the right or left as necessary.
3. Repeat normalization measurement.
   a) If normalization does no longer indicate a misalignment, reassemble the stand.
   b) If normalization still indicates a misalignment, repeat the adjustment until the error no longer occurs.

Correcting a vertical tilt

Solves message in user interface: "Rod alignment or rod distance is not correct".



1. Remove the cover on the top of the support bar (1x), for example with a slotted screwdriver.
2. Loosen the screw with an Allen wrench size 6 (1x).
3. Move the support bar up or down to correct the vertical angle of the stand.
4. Repeat normalization measurement.
   a) If normalization does no longer indicate a misalignment, reassemble the stand.

b) If normalization still indicates a misalignment, repeat the adjustment until the error no longer occurs.

4.2.5 Installing the R&S QAR on the Platform (R&S QAR-Z21)

Required tools:

- Allen wrench size 5 (for screws ISO 10642 M8x20)
- Allen wrench size 6 (for screws ISO 4762 M8x40)
- Allen wrench size 10 (for screws ISO 4762 M12x55)
- Open-end wrench size 19
- Spirit level.

Installing the platform

1. Place the platform on a stable and horizontal surface that can support the weight of the R&S QAR.
2. Check with a spirit level if the platform itself is level.
3. If necessary, remove any irregularities by adjusting the height of the feet until the platform is level.
   - A clockwise movement lowers the corresponding platform area.
   - A counterclockwise movement raises the corresponding platform area.
4. Tighten the feet with the check nuts using the open-end wrench.

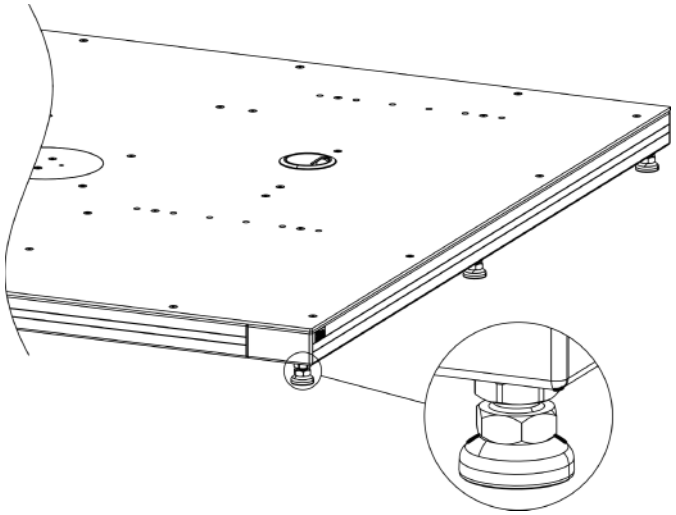


Figure 4-12: Platform alignment

Mounting the R&S QAR

When the platform is in place, you can mount the R&S QAR on the platform.

Whenever you lift, move or carry the R&S QAR, use the handles on its back side.

1. Screw the two supports to the R&S QAR with four socket head screws (size 5) on each side of the R&S QAR (see Figure 4-13).
2. Lift the R&S QAR onto the platform into a stable position and in a right angle to the floor.
   The position is defined by the two pins on the platform as shown in Figure 4-13. Those two pins fit into the two mounting holes on the frame of the R&S QAR.

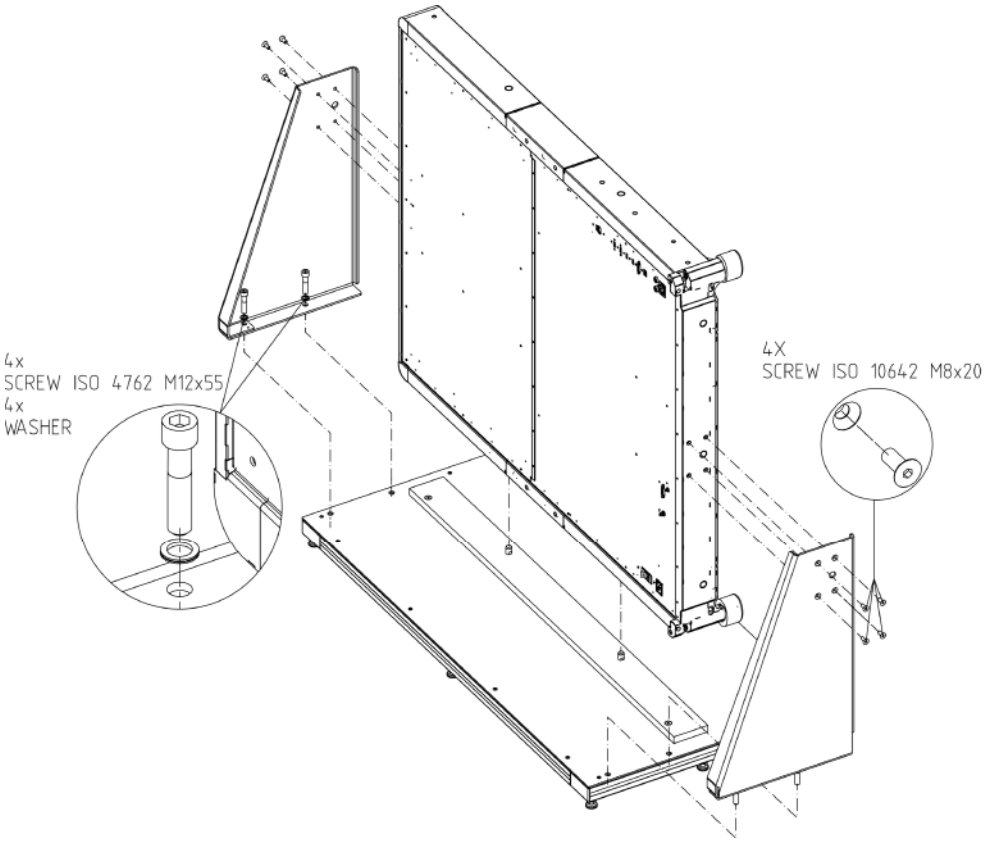


Figure 4-13: R&S QAR installation, including support mounting

3. Secure the R&S QAR by screwing the two supports to the platform. Two socket head screws with a size 10 secure each support.
   The mounting holes in the platform define the position of the supports.

   Note: Insert a washer between screw and support as shown in Figure 4-13.
4. Tighten all four screws to the platform.

4.3 Connecting the R&S QAR

You can connect various devices to the R&S QAR. The following overview shows the possible connections.

Required tools:

- Torque wrench (order no. 0041.1218.00).

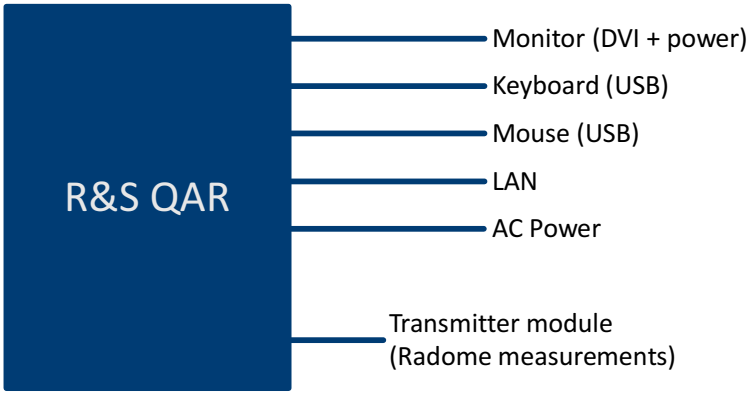


Figure 4-14: Connection overview in a system with optional transmitter module

1. Connect a monitor to the DVI port on the R&S QAR.
   As a power source, you can use a household AC outlet or the integrated power supply to supply the monitor with power (for monitors with a light-current extension cable).

   Note: The monitor should have at least a resolution of 1650 x 1050 (we recommend 1920 x 1080). Lower resolutions can lead to an incorrect display of the measurement data.
   The BIOS supports monitors with a vertical resolution of up to 1080p.
2. Connect a keyboard and a mouse to two of the USB ports.
3. Optional: Establish a connection to your LAN via the LAN interface.
4. Optional (radome measurements): Connect the transmitter module to the R&S QAR via the SMA and transmitter control connectors on both devices.
   Tighten the SMA connector to 0.6 Nm with the torque wrench.
5. Connect the R&S QAR to the mains power supply with the power cord that is part of the delivery.

   Note: Always connect all devices before connecting the R&S QAR to the mains supply.

4.4 Switching the R&S QAR On and Off

Supplying the R&S QAR with power

Always complete all connections (LAN, USB etc.) before connecting the R&S QAR to the mains supply.

Refer to the datasheet for power rating and electrical safety compliance.

1. Make sure that the protective ground connection is established.

For more information, see Chapter 3.1, "Main Power Supply", on page 13.

2. Connect the power cable to the AC inlet.
3. Connect the power cable to the mains supply.
4. Turn on the main power switch (position "I").

   The R&S QAR is supplied with power.
   See Chapter 3.1, "Main Power Supply", on page 13 for more information about the AC inlet and the main power switch.

Turning on the R&S QAR

1. Press the power button to boot the system.
   See Chapter 3.2, "Power Button", on page 15 for more information about the power button.

   Note: When you start the R&S QAR for the first time, you have to enter an option key. The option key and a information about activating the option key is part of the delivery.
2. Select the application you want to use from the application launcher.
   The application launcher automatically starts after you start the system. Alternatively, you can search and select the application from the Windows start menu.
   You can now use the R&S QAR.

Warm-up time
Let the R&S QAR warm up for at least 90 minutes before using it.

Turning off the R&S QAR

► Press the power button.

The system shuts down.
See Chapter 3.2, "Power Button", on page 15 for more information about the power button.

Disconnecting the R&S QAR from the mains supply

1. Turn off the main power switch (position "0").

   The R&S QAR is disconnected from the mains supply.
2. Remove the power cable from the mains supply.

4.5 Operating System

The R&S QAR contains Windows 10 operating system which has been configured according to the R&S QAR's features and needs. Changes in the system setup are only required when you install peripherals like a keyboard or if the network configuration does not comply with the default settings.

The drivers and software installed on the R&S QAR are adapted to the R&S QAR. Only install software updates released by Rohde & Schwarz.

4.5.1 Virus Protection

Take appropriate steps to protect your instruments from infection. Use strong firewall settings and scan any removable storage device used with a Rohde & Schwarz instrument regularly. It is also recommended that you install anti-virus software on the instrument. Rohde & Schwarz does NOT recommend running anti-virus software in the background ("on-access" mode) on Windows-based instruments, due to potentially degrading instrument performance. However, Rohde & Schwarz does recommend running it during non-critical hours.

For details and recommendations, see the following Rohde & Schwarz white paper:

- 1EF96: Malware Protection Windows 10

4.5.2 Service Packs and Updates

Microsoft regularly creates security updates and other patches to protect Windows-based operating systems. These are released through the Microsoft Update website and associated update server. Instruments using Windows, especially those that connect to a network, should be updated regularly.

For details and recommendations, see the following Rohde & Schwarz white paper:

- 1EF96: Malware Protection Windows 10

4.5.3 User Accounts

The Windows 10 operating system installed on the R&S QAR has two predefined user accounts:

- Standard user account with standard windows rights.
  The user name for this account is `Operator`.
  The password is `operator<serialnumber>`, with `<serialnumber>` being a placeholder of the serial number of the R&S QAR.
  Example: `operator123456`
- Administrator account with rights to install software or create user accounts.
  The user name for this account is `Admin`
  The password is `emodar8Administrator<serialnumber>`, with `<serialnumber>` being a placeholder of the serial number of the R&S QAR.
  Example: `emodar8Administrator123456`

Note that for older systems with a Windows 7 operating system, or systems that are updated from Windows 7, the default password does not contain the `<serialnumber>`.

Changing the passwords

For security reasons, we recommend that you to change the passwords.

5 Operating the R&S QAR

The application to operate the R&S QAR is installed on a PC that is integrated into the R&S QAR. It starts automatically when you turn on the R&S QAR.

Warm-up time

Let the R&S QAR warm up for at least 90 minutes before using it.

Activating licenses

Before you can use the measurement software on your R&S QAR, you have to activate the corresponding license. You can activate and manage licenses with the R&S License Server Manager. The R&S License Server Manager is already installed on your R&S QAR.

- Select the R&S License Server Manager icon ( ) from the system tray in the taskbar ("Open Manager").
  The user interface of the R&S License Server Manager opens in a browser.
- Select the "Licenses" tab to manage licenses.
- Select "Activate" to add a new license.
  The license key is part of the delivery of the option you bought.

For a detailed description of the features of the R&S License Manager, refer to its integrated help (available via the "?" icon) or the documentation available on Gloris.

Accessing the measurement application

You can access the application by connecting a monitor, a keyboard and a mouse to the R&S QAR. Alternatively, you can access the application via "Remote Desktop" from another computer, if the R&S QAR is in a LAN.

If the application does not start automatically, you can start it manually with the shortcut on the Windows desktop.

The operation depends on the application you have:

- Chapter 5.1, "Radome Measurements", on page 38
- Chapter 5.3, "Bumper Measurements", on page 63
- Chapter 5.4, "Radar Positioning Measurements", on page 72.

Before you can use the measurement software on your R&S QAR, you have to activate the corresponding license. You can activate and manage licenses with the R&S License Server Manager. The R&S License Server Manager is already installed on your R&S QAR.

- Select the R&S License Server Manager icon ( ) from the system tray in the taskbar ("Open Manager").
  The user interface of the R&S License Server Manager opens in a browser.
- Select the "Licenses" tab to manage licenses.
- Select "Activate" to add a new license.
  The license key is part of the delivery of the option you bought.

For a detailed description of the features of the R&S License Manager, refer to its integrated help (available via the "?" icon) or the documentation available on Gloris.

5.1 Radome Measurements

For radome measurements, the R&S QAR measures the characteristics of a DUT using its full 12 clusters. The data evaluated from the data of 12 clusters provides an image of the DUT with a high resolution. You can see the resulting image in the user interface of the R&S QAR software.

The typical procedure when measuring a radome (DUT) is as follows:

1. Start the R&S QAR to start the system and the measurement application.
   For more information about the functionality of the measurement application, see Chapter 5.1.2, "Graphical User Interface", on page 40.
2. Normalize the test setup.
   For more information about the normalization, see Chapter 5.1.3.1, "Normalization", on page 42.
3. Measure the DUT.
   For more information about the measurement and its results, see Chapter 5.1.3, "Measurements", on page 42.
4. Save and restore measurement data.
   For more information about saving and restoring measurement data, see "Managing measurement results" on page 49.

5.1.1 Test Setup

Basic test setup

The basic test setup for radome measurements consists of the R&S QAR and a DUT that is placed at a certain distance from the R&S QAR.

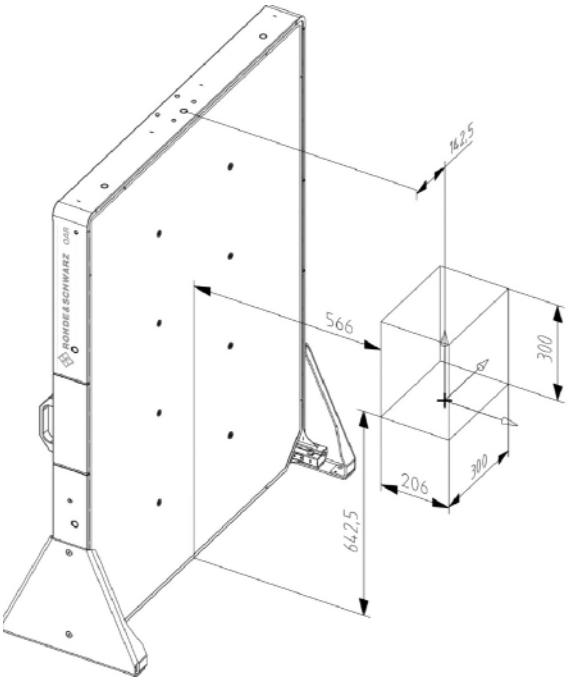


Figure 5-1: Basic test setup (distances in mm)

In Figure 5-1, the box indicates the area in which the R&S QAR takes the image of the DUT. Note that the DUT must be positioned slightly off-center to the center of the R&S QAR as indicated in Figure 5-1 (142.5 mm).

Test setup with platform and DUT mounting table

When you use the optional platform and DUT mounting table, the test setup is already predefined. The R&S QAR is in a given position, and the DUT, when positioned on the table, is already in the necessary distance to the R&S QAR and the floor. Note that the position of the mounting table is variable, depending on the mounting holes you have used to attach the mounting table. For more information, see Chapter 4.2.3, "Installing the Radome Measurement Elements", on page 23.

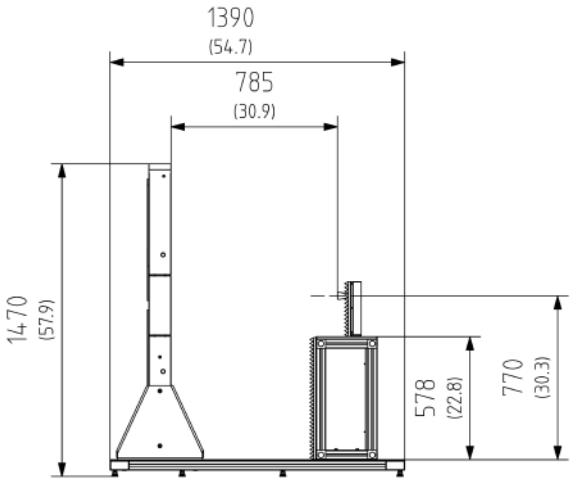


Figure 5-2: R&S QAR test setup with platform, mounting table and transmitter module

Numbers without brackets = dimensions in mm
Numbers in brackets = dimensions in inch

5.1.2 Graphical User Interface

The graphical user interface (GUI) contains several elements.

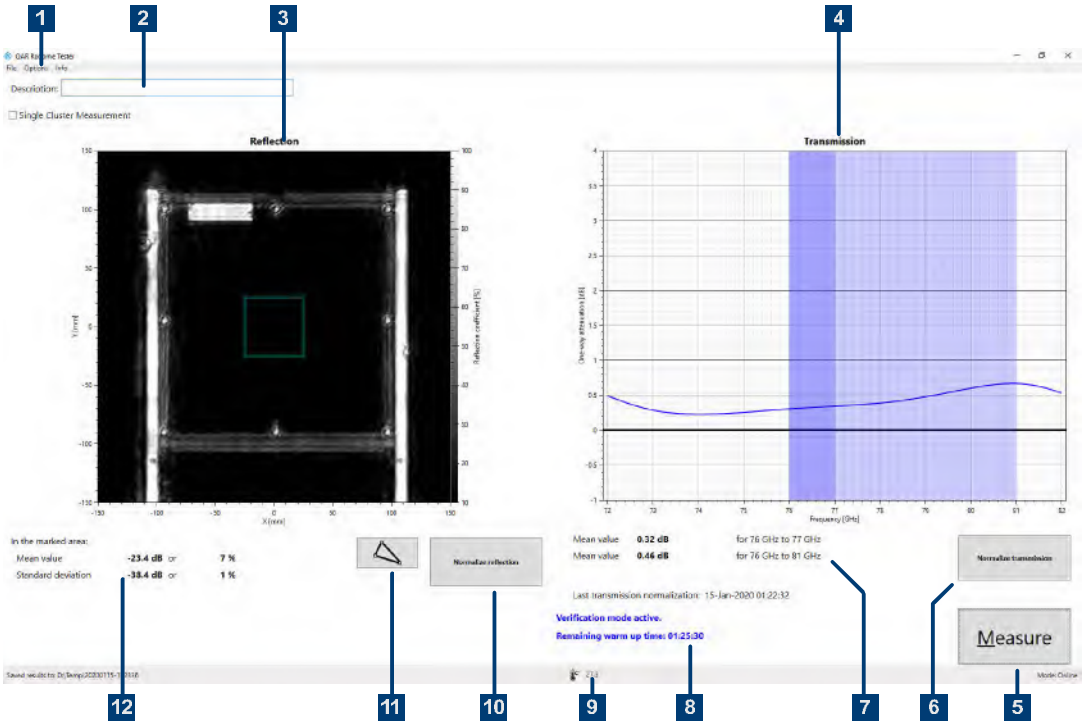


Figure 5-3: Software graphical user interface

1 = Menu bar
2 = Measurement description
3 = Result display (reflection)
4 = Result display (transmission loss)
5 = Measure button
6 = Normalize transmission button
7 = Numeric results (transmission loss)
8 = System messages
9 = Status bar
10 = Normalize reflection measurement
11 = Reflection mask editor
12 = Numeric results (reflection)

Result display

The result display shows the data that was collected during the measurement as a millimeter wave image.

Transmission loss result display

Only available with the optional transmitter module.

The transmission loss result display shows the results of the transmission measurement.

Numeric results

Several numeric results of the reflection and transmission measurements are displayed.

- Mean reflection
- Standard deviation
- Optional: One-way mean attenuation within frequency range 76 GHz to 77 GHz
- Optional: One-way mean attenuation within frequency range 76 GHz to 81 GHz

Settings and control buttons

Several settings and buttons allow you to control the measurement.

- "Measure"
  Initiates a measurement.
  For more information, see Chapter 5.1.3.2, "Reflection Measurement", on page 44 and Chapter 5.1.3.3, "Transmission Measurement", on page 44.
- "Normalize Reflection"
  Initiates the normalization of the reflection measurement.
  For more information, see Chapter 5.1.3.1, "Normalization", on page 42.
- Optional: "Normalize Transmission"
  Initiates the normalization of the transmission measurement.
  For more information, see Chapter 5.1.3.1, "Normalization", on page 42.
- System messages
  Shows various status messages of the system like a missing normalization or the remaining warm-up time. The full warm-up time is 90 minutes.

Menu bar

The menu bar contains various settings.

- "File"
  Contains functionality to import and export measurement results, and functionality to close the software.
- "Options"
  Contains functionality to configure the measurement and result displays.
- "Info"
  Contains various information about the application, including information about open source software licenses and the user manual.

Keyboard shortcuts

The following keyboard shortcuts are available.

Table 5-1: Keyboard shortcuts

Ctrl-S	Saves the currently displayed measurement results. See "Managing measurement results" on page 49 for details.
Ctrl-O	Opens a dialog box to load measurement results. See "Managing measurement results" on page 49 for details.
Ctrl-Q	Closes the application.
F3	Initiates a reflection normalization
F4	Initiates a transmission normalization
F5	Initiates a measurement.

5.1.3 Measurements

The R&S QAR provides several measurement types: reflection measurements and transmission measurements. Transmission measurements require the optional transmitter module. Both measurements usually consist of two steps, normalization and the actual measurement.

Measuring a DUT

1. Set up the normalization.
2. Start the normalization with "Normalize Reflection" (or the F3 key) and "Normalize Transmission" (or the F4 key).
   For details on how to normalize the measurement, see Chapter 5.1.3.1, "Normalization", on page 42.
3. Place the DUT in front of the R&S QAR, for example on the optional mounting table.
4. Start the reflection and transmission measurement with "Measure" (or the F5 key).
   The measurement itself lasts less than a second. The results are displayed after a few seconds.
   For details on how to run the measurement, see Chapter 5.1.3.2, "Reflection Measurement", on page 44 and Chapter 5.1.3.3, "Transmission Measurement", on page 44.

5.1.3.1 Normalization

Normalization is a separate measurement that determines systematic, reproducible measurement deviations. Determining these measurement deviations allows you to

remove those deviations from the actual measurement results, which in turn improves the accuracy of the measurement.

Normalizing reflection measurements

Normalizing the reflection measurement requires a clean, smooth and flat metallic plate for a high reflection, for example aluminum. The recommended size is between 100 mm x 100 mm and 200 mm x 200 mm.

If you have the verification objects, and it fits your setup, you can use the plate labeled E to normalize the reflection.

1. Place the plate at the same location where you are going to mount the DUT for the actual measurement.
   Make sure that the plate is parallel to the R&S QAR. We recommend using the same fixture for the metal plate as for the DUT.
2. Select the "Normalize Reflection" button to initiate the measurement.

   When the normalization measurement is done, the R&S QAR saves the correction data. All subsequent measurements are corrected accordingly.
   A valid normalization results in an image with high reflection. The mean reflection should be approximately 0 dB and should not exceed a certain deviation from that value - refer to the datasheet for exact values.
3. Optional: Scan the metal plate with the "Measure" button to verify the normalization.
   If the results do not meet the expectations, repeat the normalization.
   If the second normalization still yields unexpected results, verify the test setup. For details about the verification procedure, see Chapter 5.1.5, "Verification", on page 51.

Normalizing the transmission measurement

Normalizing the transmission measurement is done by a free-space measurement and requires no additional devices. However, make sure that the line of sight between R&S QAR and transmitter module is free of obstacles.

1. Select the "Normalize Transmission" button to initiate the measurement.

   When the normalization measurement is done, the R&S QAR saves the correction data. All subsequent measurements are corrected accordingly.
2. Optional: scan the free space with the "Measure" button to verify the normalization.
   A valid normalization results in a straight trace at approximately 0 dB attenuation. The trace should not exceed a certain deviation from that value - refer to the datasheet for exact values.
   If the results do not meet the expectations, repeat the normalization.
   If the second normalization still yields unexpected results, verify the test setup. For details about the verification procedure, see Chapter 5.1.5, "Verification", on page 51.

5.1.3.2 Reflection Measurement

The reflection measurement determines the amount of energy that is being reflected by the DUT. This energy does not pass through the radome and contributes to performance degradation as a result. Reflected signals reduce the performance of the radar and can even interfere with the received signals, leading to effects as described in application note 1MA267. Areas with a high reflection can have various causes, for example material defects, undesired interaction between several layers of materials, excessive amount of certain materials, or foreign objects.

The R&S QAR achieves spatially resolved reflection measurements of a DUT by linking the information collected by the distributed transmit and receive antennas in a coherent operation. The resulting millimeter wave image allows for an intuitive evaluation of the DUTs reflection behavior.

Measurement results

The application shows the results of the spatially resolved reflection measurement as a millimeter wave image with a linear scale from 10 % to 100 %. The x- and y-axis show the dimensions of the image in mm (300 mm x 300 mm by default). By default, the image is a grayscale image. Small values, represented by dark areas, correspond to a low reflection, high values, represented by bright areas, correspond to a high reflection. A color map next to the image shows the levels that correspond to each shade of color.

In addition to the image, the mean reflection and the standard deviation of the reflection are calculated as numeric results. Both values are shown under the millimeter wave image in logarithmic units (dB) and as a percentage, with 100 % representing a maximum reflection of 0 dB.

The application calculates the numeric results over a certain area of the complete millimeter wave image. The evaluation area is indicated by a mask that is superimposed on the image. You can customize the size and form of this mask to analyze certain areas in more detail. For more information about working with the mask, see "Working with evaluation masks" on page 45.

The mean reflection indicates the radar transparency of the DUT. The lower the mean reflection, the better the radar transparency of the DUT. A higher mean reflection results in beam refraction, increased transmission loss and standing waves between the DUT and the radar sensor. For optimal radar compatibility, the DUT's mean reflection has to be minimized.

The reflection's standard deviation indicates the homogeneity of the DUT. Inhomogeneous DUTs alter the incident wave's phase fronts, cause angle errors, blind spots and increased side lobes. For optimal radar compatibility, the DUT's reflection standard deviation has to be minimized.

5.1.3.3 Transmission Measurement

Because the incident signal is split in a reflected and a transmitted part, it is of interest to measure not only the reflection but also the transmission properties.

Measuring the transmitted signal, requires the optional transmitter module that is located behind the DUT (on the DUT table). The transmitter uses 64 discrete frequency

points to cover a selected frequency span between 72 GHz and 82 GHz. This allows for an exact evaluation of the DUT's transmission frequency response.

The frequency response yields detailed information regarding the RF transmission loss of the DUT at the exact frequency band intended for radar operation. This is therefore independent of the actual signal waveform utilized by the radar unit, which facilitates the testability and optimization of the radome itself.

The transmission diagram shows the frequency response of the DUT. The minimum and maximum values indicate the degree of frequency matching achieved by the DUT. Ideally, the minimum of the frequency response is located at the operating frequency range of the radar sensor that is to be used in combination with the DUT. Shifted minima indicate issues with the DUT's electrical thickness.

The R&S QAR calculates the one-way mean attenuation for specific frequency ranges (76 GHz to 77 GHz and 76 GHz to 81 GHz). The results are displayed below the diagram in logarithmic units (dB).

The one-way mean attenuation is calculated as follows:

$-20 \cdot \log_{10}(\text{mean transmission coefficient})$

The mean transmission coefficient is calculated over the respective frequency range.

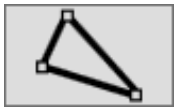
You can also query the minimum attenuation (and its frequency) using SCPI commands. For details ,see Chapter 6.2.4.2, "Measurements (12 Cluster)", on page 89.

5.1.4 Configuration

The R&S QAR provides several tools to configure the radome measurement.

Working with evaluation masks

The evaluation mask available for the reflection measurement defines the area that is evaluated for the mean reflection and the standard deviation of the reflection measurement.



1. Select "Edit Mask".

   In editing mode, you can change the shape and location of the evaluation mask.

2. Move, delete or design an evaluation mask.
   a) Move the mask by dragging it around with the mouse and dropping it in its new location.
   b) Delete a selected mask with the "Del" key on your keyboard. To select a mask, click it.
   c) Create a mask by clicking somewhere in the result display and drawing a line with the mouse.
   One click confirms a line of the mask shape. Add as many lines as you like to design the mask. A double-click confirms the final shape of the mask.
   Using that method, you can design any shape you like around the DUT.

3. Select "Edit Mask" again to exit the editing mode.

The R&S QAR reevaluates the mean reflection and the standard deviation.

4. Optional: Export the evaluation mask.
   a) Select "Options" > "Reflection Mask"
   b) Select "Save Bitmap" to save the shape and location of the mask as a bitmap (`.bmp`file).
   c) Select "Export Coordinates" to save the shape and location of the mask as coordinates in a `.json`file.

   Alternatively, you can design a mask with an external graphics editor or a text editor and import it.
   If you design the mask as a bitmap, make sure that the canvas size is 601 x 601 pixels, and that the image has a single channel. Take a mask you have designed in the application to see what a bitmap looks like.
   If you design a mask as text, make sure that you define the coordinates of the x- and y-axis correctly. Take a mask you have designed in the software to see what the `.json` file looks like.

Importing evaluation masks

If you have designed and saved an evaluation mask previously, you can import it any time you need it.

Before importing a mask, make sure that the mask editing mode is off.

1. Select "Options" > "Reflection Mask"
2. Select "Load Bitmap" to import the shape and location of the mask from a bitmap (`.bmp`file).
3. Select "Import Coordinates" to import the shape and location of the mask from coordinates in a `.json`file.

Selecting the image color scheme

The R&S QAR provides several color schemes for the image of the reflection measurement.

1. Select "Options" > "Display".
2. Select one of the color schemes from the "Colormap" dropdown menu.

   The R&S QAR adjusts the colors accordingly.

Defining an evaluation grid

Requires R&S QAR-K20.

An evaluation grid helps you to find the areas with highly differing reflection coefficients on your DUT more easily. The principle is to divide the DUT into several small areas (cells), and evaluate the characteristics of each cell separately instead of the complete DUT.

Before you can start to evaluate results based on a grid, you have to design a grid.

You can design two layers in the grid ("Grid 1" and "Grid 2") and thus refine the evaluation areas. Using two grids can be useful to increase the defect localization resolution without sacrificing the averaging over a larger cell size.

1. If you already have defined a grid previously, select "Options" > "Grid Evaluation Settings" > "Load Grid Definition" to restore a grid.
   If you need a new one or do nor have one yet, you have to create a grid.
2. Select "Options" > "Grid Evaluation Settings" > "Edit Grid Definition".
   The preview in the upper part of the dialog shows the current design of the grid(s).
3. Define the absolute size of the grid in mm (height and width).
   The grid can have any size, as long as it is not larger than the millimeter wave image itself.
4. Define the size of the grid in terms of the number of cells.
   Grid cells are numbered 1 to x, beginning at the top left cell.
   Note that "Grid 2" always has one (horizontal or vertical) cell less than "Grid 1".
5. Define the location of the grid in terms of an offset from the center of the image.
   - A positive x offset moves the grid to the right of the center.
   - A negative x offset moves the grid to the left of the center.
   - A positive y offset moves the grid upwards.
   - A negative y offset moves the grid downwards.
6. Define an alarm threshold.
   The R&S QAR evaluates the reflection values in each cell against a limit (defined by a threshold). The threshold is a deviation from the mean reflection of all master cells.
   If the mean reflection in one of the cells exceeds the threshold (in both directions), the corresponding cell turns red to indicate a failed limit check.

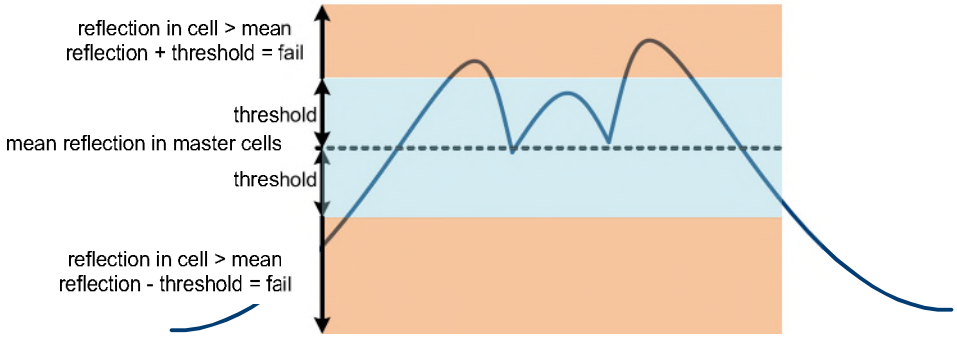


Figure 5-4: Grid evaluation logic

7. Select cells that you want to exclude from the evaluation (for both grids).
   Excluded cells are not evaluated at all. These cells are not used to calculate the mean reflection and not tested against the alarm threshold. In the grid definition dialog, excluded cells appear in red color.
   There are two ways to add cells into the input field.

a) Select the grid whose cells you want to exclude "Grid 1" or "Grid 2". Excluding cells is not possible while both grids are displayed in the preview.
b) Write the cell numbers into the input field, separated by a ":", for example: "1:2:4:5".
c) Select the input field (put the cursor in the field) and double-click the cells to add them to the list.

8. Define master cells.
Master cells are those cells that contribute to the mean reflection result. All other cells are ignored for the calculation of the mean reflection. If you do not define master cells, the R&S QAR does not calculate the mean reflection at all. In the grid definition dialog, master cells appear in green color.
Note that the mean reflection is evaluated separately for "Grid 1" and "Grid 2".
Master cells and undefined cells (= cells that are not excluded and are not master cells and thus remain white in the grid definition dialog) are both evaluated against the alarm threshold.

Figure 5-5: Grid design preview

1 = Excluded cell (red)
2 = Master cell (green)
3 = Undefined cell (white)

9. Confirm the grid definition with "OK" (closes the dialog) or "Apply".
10. Save your grid with "Save Grid Definition As".
11. Select "Options" > "Grid Evaluation Settings" > "Grid Evaluation" to apply the grid to the image.
Turning on the grid superimposes an image of the grid over the reflection result display.
Master cells are green. Excluded cells are not displayed. If the reflection in one of the cells violates the threshold limit you have defined, the corresponding cell turns red.

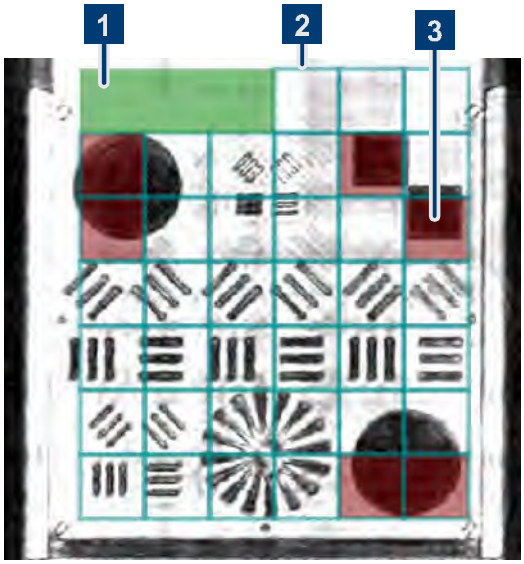


Figure 5-6: Grid evaluation example

1 = Green cells indicate master cells
2 = Blue grid indicates cells of "Grid 1" (not shown: a yellow grid indicates cells of "Grid 2")
3 = Red cells indicate a violation of the threshold somewhere in the area the cell covers

Managing measurement results

You can export the measurement data, for example to store it on an external memory device or copy it to a different computer for further analysis with different software. You can also restore data that you have taken at some point and review it in the application.

1. Select "Options" > "Recording".
2. Define the default directory in which to save the results in the "Result Folder" input field.
   For each measurement, the R&S QAR creates a folder that contains the measurement data.
3. Select "Autosave" to use the auto save functionality.
   When you are using the autosave feature, the R&S QAR automatically stores the results after each measurement.

   Tip: You can always save the measurement results deliberately with the keyboard shortcut Ctrl-S or from the "File" menu.
4. Select the data you want to save from the "Results To Save" dropdown menu.

   A measurement dataset contains the following files.
   - `<yyyy-mm-dd-hh-mm-ss>_cfg.txt`
     `<yyyy-mm-dd-hh-mm-ss>_PanelConf.mat`
     Contains information about the configuration of the R&S QAR during the measurement.
   - `<yyyy-mm-dd-hh-mm-ss>_image.png`
     `<yyyy-mm-dd-hh-mm-ss>_transmissionloss.png`

Image of the reflection and transmission loss measurement.

- `Protocol.csv`
  Contains the numerical measurement results.
- `<yyyy-mm-dd-hh-mm-ss>_results.mat`
  Contains the raw 2D imaging data.
  Only if you have selected the data package "Statistics + Pictures + Data". This data package is necessary if you want to restore the measurement results later on.
- `<yyyy-mm-dd-hh-mm-ss>_volume.mat`
  Contains the raw 3D imaging data.
  Only if you have selected the data package "Statistics + Pictures + Data + Volume".
  This data package requires approx. 500 MB of disk space for each image. It also takes a long time to save this data package, approx. 30 seconds for each image.
- For grid evaluation:
  `<yyyy-mm-dd-hh-mm-ss>_GridResult.csv`
  Contains the mean values of every grid cell, the mean value of the master cells, the threshold value and an evaluation if the limit check in a cell has failed.
- For grid evaluation:
  Configuration file (`.json`) of the specified grid.

Tip: You can restore measurement results at any time with the keyboard shortcut Ctrl-O or from the "File" menu.
Restoring measurement results requires at least the raw 2D imaging data (`results.mat`). The data package "Statistics + Pictures" only contains the images (`.png`) and statistics (numerical results etc.) and is therefore not sufficient to restore results.

Taking pictures with a webcam

You can connect a webcam to the R&S QAR that takes a picture of the DUT during the measurement. This picture is stored together with the measurement data.

The R&S QAR supports all webcams that are recognized as an "Imaging Device" in the Windows 10 device manager. Note that the webcam feature of the R&S QAR always uses the first imaging device in the list to take pictures.

1. Select "Options" > "Recording".
2. Select "Save Webcam Picture".

Using a barcode scanner

You can connect a barcode scanner to the R&S QAR to scan the barcode of a DUT and use this as a reference that the DUT with a certain barcode has passed or failed the test. The barcode is displayed in the user interface and is stored together with the other measurement data.

The R&S QAR supports the barcode scanner Honeywell Xenon 1900 by Honeywell International Inc.

1. Select "Options" > "Recording".
2. Select "Use Barcode Scanner".
3. Select the (serial) port the barcode scanner is connected to from the dropdown menu.

5.1.5 Verification

The R&S QAR provides a verification procedure to validate the quality of the measurements. Verification consists of a series of measurements with standardized DUTs which are located at a fix distance from the R&S QAR.

All verification objects are delivered with a quality approved surface finish. Any surface features are either intentional or are considered to be uncritical for the intended purpose.

If verification fails, validate the verification setup. If verification fails several times in a row, despite a valid setup, contact Rohde & Schwarz customer support to calibrate the R&S QAR and check the hardware.

Warm-up time

Let the R&S QAR warm up for at least 90 minutes before using it.

Verification requires one of verification sets available for radome measurements.

- Verifying 12-cluster measurements requires R&S QAR-Z40 or -Z43.
- Verifying single cluster measurements requires R&S QAR-Z43.

The setup and installation of the verification sets R&S QAR-Z40 and -Z43 is similar. The difference is that the frame and objects of the R&S QAR-Z43 are higher.

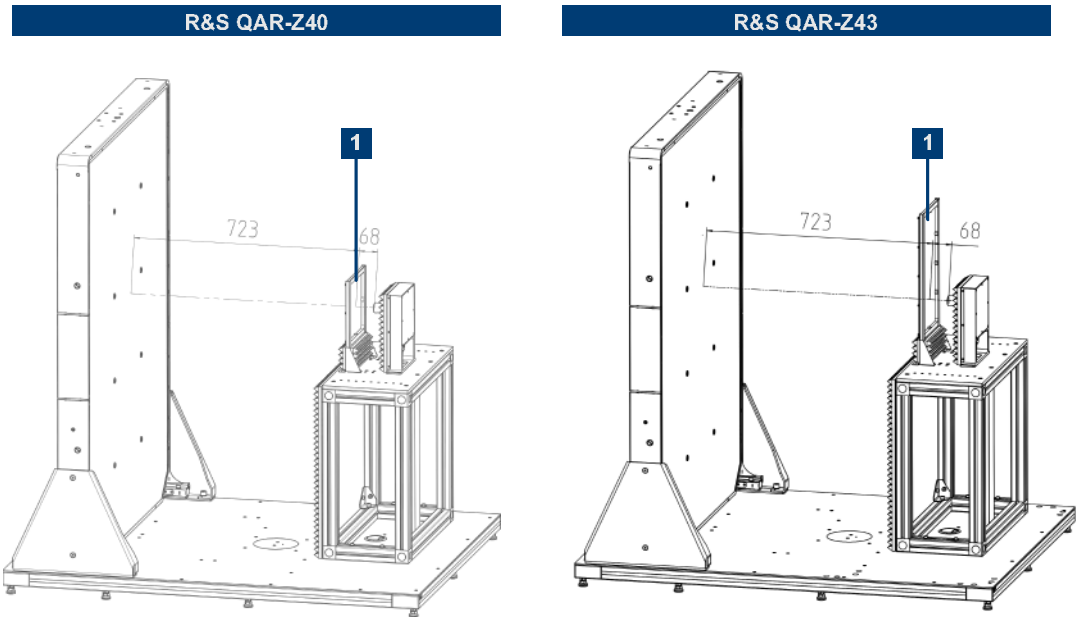


Figure 5-7: Test setup for verification of radome measurements

1 = Verification frame holding verification object

Required equipment

All required equipment is included in the delivery of the verification set.

- Verification objects
  - 1 x metal plate
  - 1 x metal plate with cut-outs
  - 3 x plastic plate with different thicknesses
- Frame for verification objects
- Allen wrench size 5

Mounting the frame for the verification objects

The verification objects come with a frame that holds the objects. Screw the frame to the DUT mounting table. The frame base that you screw to the table is the same for both verification sets.

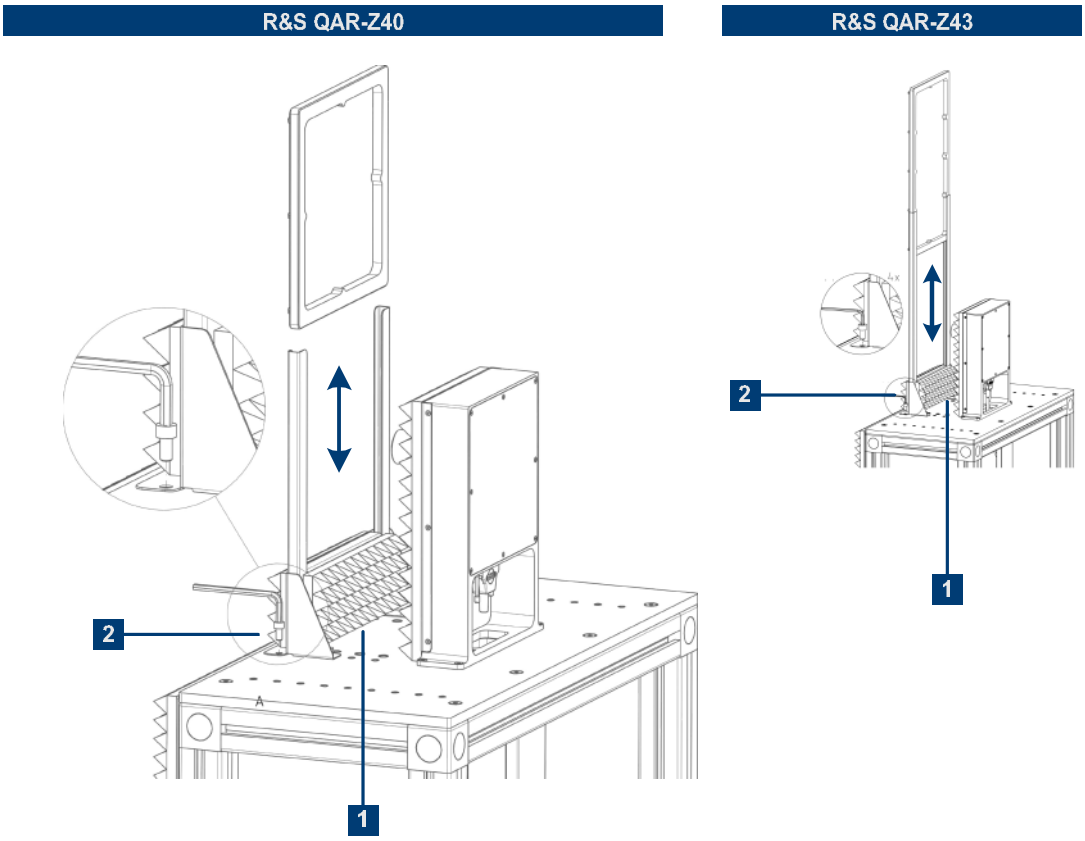


Figure 5-8: Verification object frame installation

1 = Position of the frame
2 = Frame screws (4 x)

1. Place the frame on the mounting table. The position of the frame is defined by the mounting holes in the DUT mounting table.
2. Screw the frame to the mounting table with the Allen wrench. The required socket head screws (4 x) are included in the delivery of the R&S QAR-Z40.

Verifying the system

The verification process consists of five consecutive measurements with the verification objects (square plates). The verification objects are labeled A to E.

1. Select verification mode in the application ("Options" > "Verification").
   In verification mode, the R&S QAR eliminates unwanted responses in the signal by applying a time gate to evaluate the data. For verification, using this method is mandatory.
2. **NOTICE!** Handling the verification objects.
   - Store the verification objects in the bag they were delivered in.
   - Keep the verification objects clean and without fingerprints.
   - Do not scratch the verification objects.
   - Clean the objects with a lint-free duster or a damp rag. Do not use chemicals.

   Normalize the reflection measurement.

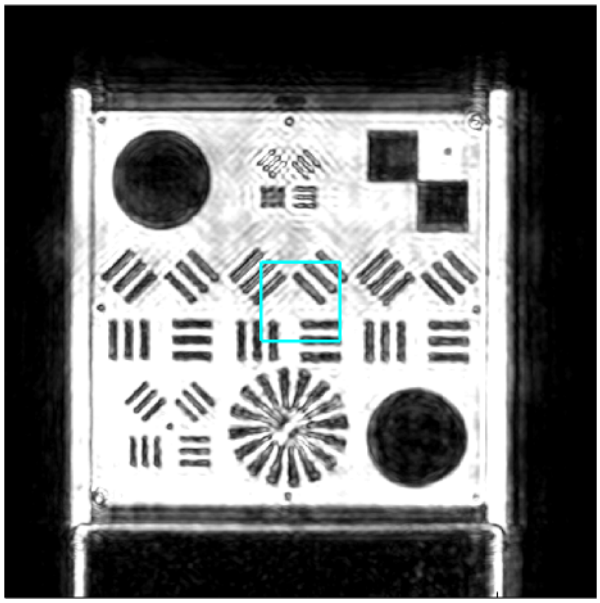
a) Put the metal plate labeled "E" into the frame.
b) Select "Normalize Reflection" to initiate a measurement.
c) Wait until the results are displayed.
d) Remove the metal plate from the frame.

The resulting image should show a homogeneous image (the colors should not deviate too much). The mean reflection should be around 0 dB.
The limits for the normalization of the reflection measurement are universal, not device-specific.

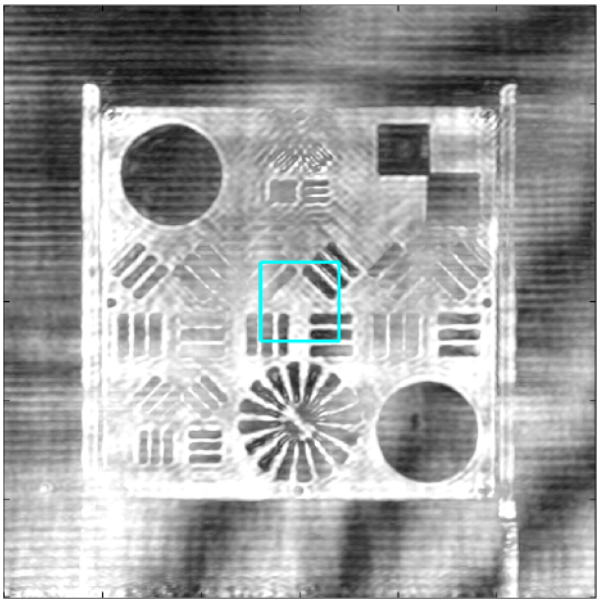
3. Verify the reflection measurement.

a) Put the metal plate with cut-outs labeled D into the frame.
b) Initiate a measurement.
c) Remove the metal plate from the frame.
The resulting image should show a clear image of the verification object. The patterns should be clearly visible.

Verification OK



Verification not OK



4. If you are using the transmitter module:
Normalize the transmission measurement.

a) Remove all objects in front of the R&S QAR (except for the table and the frame).
b) Select "Normalize Transmission" to initiate a free-space measurement.

The resulting trace should be a straight line at approximately 0 dB attenuation.

5. If you are using the transmitter module:
Verify the transmission measurement.

a) Put the plastic plate labeled A into the frame.
b) Initiate a measurement.
c) Remove the plastic plate from the frame.

d) Do the same for the other two plastic plates labeled B and C.

After each measurement, check the mean transmission loss against the limits a_{77} and a_{81} specified on the stickers attached to the verification plates. The sticker shows the attenuation characteristics of the plate and the deviation the result may have.
Each sticker contains two values.
The first value "a_{77}" is the one-way mean attenuation in the frequency range from 76 GHz to 77 GHz.
The second value "a_{81}" is the one-way mean attenuation in the frequency range from 76 GHz to 81 GHz.
The limits for the transmission verification measurement are plate-specific.
If you are using the R&S QAR-Z43 verification set, the plates also have a third value (r_{77}), which is irrelevant for the verification of the radome measurements that uses all clusters.

5.2 Single Cluster Radome Measurements

The single cluster application is similar to radome measurements. The difference is that the single cluster application measures the DUT characteristics using only a single cluster instead of all 12 clusters.

The typical procedure when measuring a radome (DUT) with one cluster is as follows:

1. Start the R&S QAR to start the system and the measurement application.
   For more information about the functionality of the measurement application, see Chapter 5.2.2, "Graphical User Interface", on page 57.
2. Normalize the test setup.
   For more information about the normalization, see Chapter 5.2.3, "Measurements", on page 58.
3. Measure the DUT.
   For more information about the measurement and its results, see Chapter 5.2.3, "Measurements", on page 58.
4. Save and restore measurement data.
   For more information about saving and restoring measurement data, see Chapter 5.2.4, "Configuration", on page 61.

5.2.1 Test Setup

The basic test setup for radome measurements consists of the R&S QAR and a DUT that is placed at a certain distance from the R&S QAR.

Note that there has to be at least 30 cm of free space behind the DUT for valid measurement results.

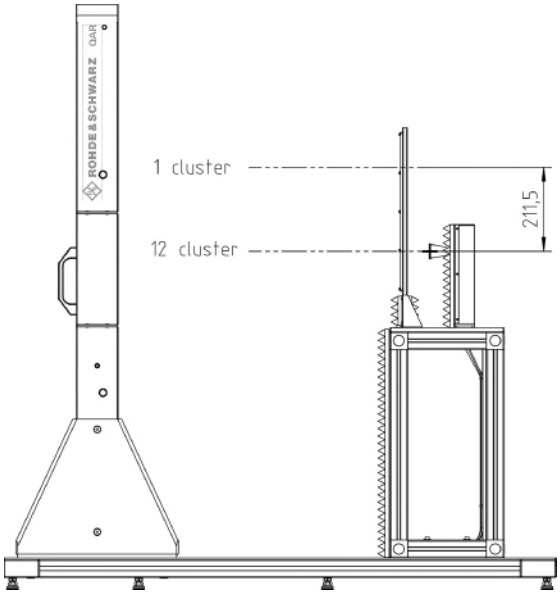


Figure 5-9: Setup for single cluster measurements

The DUT must be positioned directly opposite to the cluster that measures the DUT and therefore slightly off-center to the center of the R&S QAR.

In Figure 5-10, the box indicates the area in which the R&S QAR takes the image of the DUT.

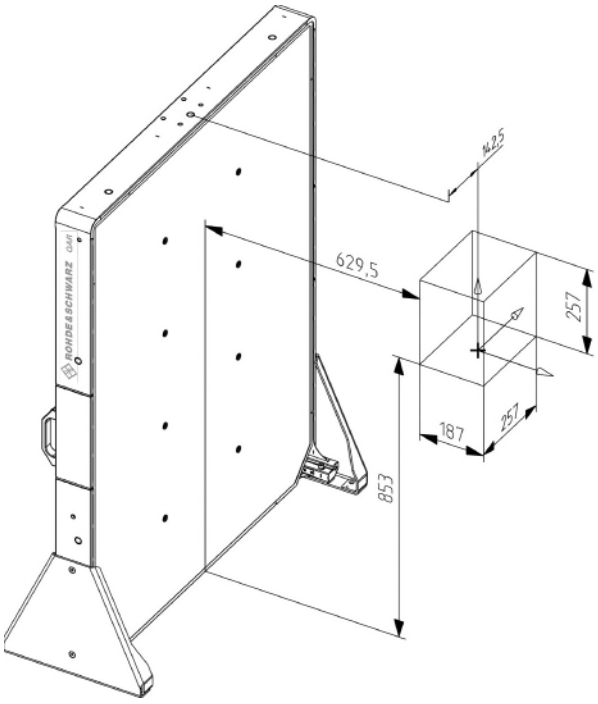


Figure 5-10: Scan volume for single cluster measurements

5.2.2 Graphical User Interface

The graphical user interface (GUI) contains several elements.

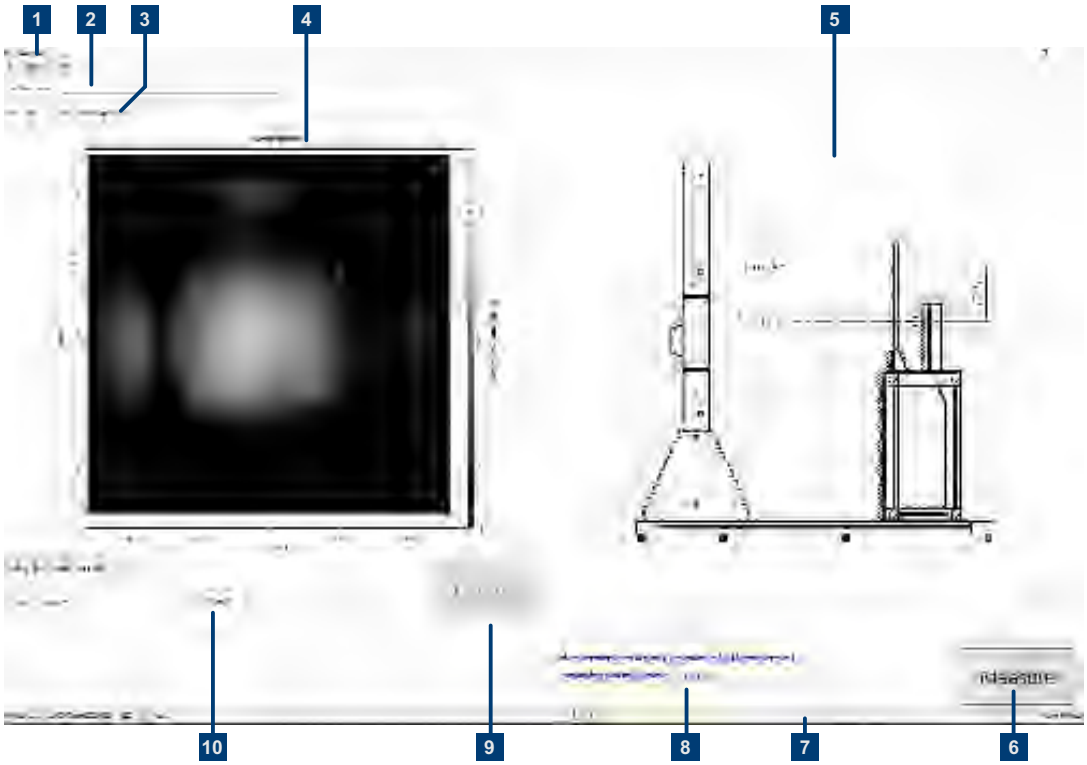


Figure 5-11: Software graphical user interface for single cluster measurements

1 = Menu bar
2 = Measurement description
3 = Single cluster measurement selection
4 = Result display (reflection)
5 = Overview test setup
6 = Measure button
7 = Status bar
8 = System messages
9 = Normalize measurement
10 = Numeric results

Result display

The result display shows the data that was collected during the measurement as a millimeter wave image.

Numeric results

Several numeric results of the reflection and transmission measurements are displayed.

- Mean reflection

Settings and control buttons

Several settings and buttons allow you to control the measurement.

- "Measure"
  Initiates a measurement.
  For more information, see Chapter 5.2.3, "Measurements", on page 58.
- "Normalize Reflection"
  Initiates the normalization of the reflection measurement.
  For more information, see Chapter 5.2.3, "Measurements", on page 58.
- System messages
  Shows various status messages of the system like a missing normalization or the remaining warm-up time. The full warm-up time is 90 minutes.

Menu bar

The menu bar contains various settings.

- "File"
  Contains functionality to import and export measurement results, and functionality to close the software.
- "Options"
  Contains functionality to configure the measurement and result displays.
- "Info"
  Contains various information about the application, including information about open source software licenses and the user manual.

Keyboard shortcuts

The following keyboard shortcuts are available.

Table 5-2: Keyboard shortcuts

Ctrl-S	Saves the currently displayed measurement results. See "Managing measurement results" on page 49 for details.
Ctrl-O	Opens a dialog box to load measurement results. See "Managing measurement results" on page 49 for details.
Ctrl-Q	Closes the application.
F3	Initiates a reflection normalization
F5	Initiates a measurement.

5.2.3 Measurements

For the single cluster application, the R&S QAR provides a reflection measurement. The reflection measurement usually consists of two steps, normalization and the actual measurement.

The concept of the single cluster reflection measurement is the same as the reflection measurement that uses all clusters - see Chapter 5.1.3.2, "Reflection Measurement",

on page 44 for details. For single cluster measurements, the R&S QAR uses the cluster indicated in Figure 5-12 and a fix bandwidth of 1 GHz, a typical bandwidth for automotive radar applications.

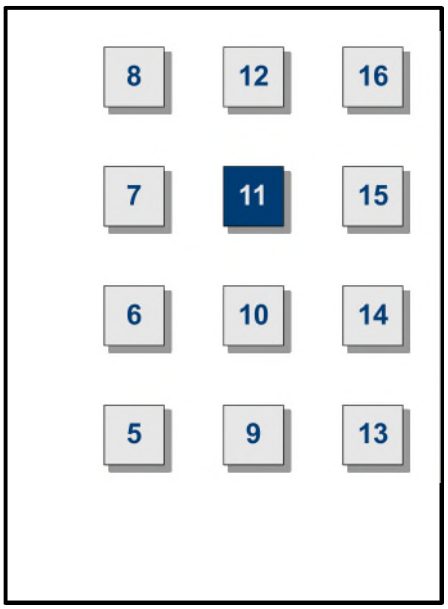


Figure 5-12: Cluster used in single cluster measurements

Using only a single cluster with a fix bandwidth of 1 GHz does not yield the same image resolution compared to measurements with the full set of clusters. The resulting image therefore gets blurry and details of the DUT are no longer visible.

However, the application does yield results that correlate to the results that you get using a conventional network analyzer. Since setups with a network analyzer are usually complicated, the single cluster application of the R&S QAR is a good tool to verify the absolute reflection values of a DUT. If the mean reflection is too high or too low, you can then use the full cluster application to find the faulty locations. This technique can be useful in an environment with a high throughput of DUTs, for example production areas.

In the image, each color corresponds to a certain (range of) reflection values as indicated in the color map next to the image.

The displayed mean reflection corresponds to a small area (100 x 100 mm) in the center of the DUT, highlighted by a colored rectangle in the image. In this area, the R&S QAR calculates the mean reflection over all measurement points that deviate no more than 3 dB from the maximum reflection value.

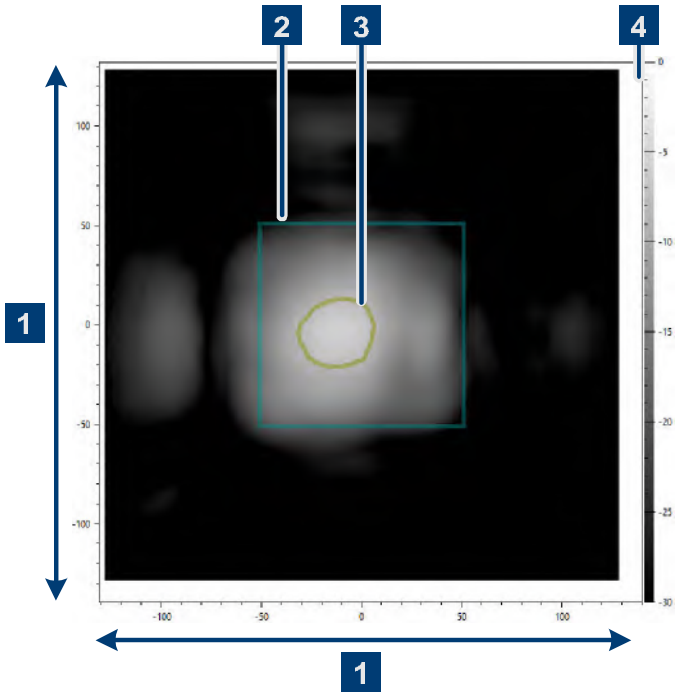


Figure 5-13: Image of a homogenous DUT

1 = Size of the image (in mm)
2 = Evaluation area
3 = Area that contains values for mean reflection
4 = Color map

The measurement points (or areas of measurement points) that the R&S QAR uses to calculate the mean reflection with are also highlighted. Note that there can be several such areas in the image, depending on the characteristics of the DUT.

Measuring a homogenous (= flat, highly reflective) DUT usually results in a Gaussian distribution of reflection values (due to the aperture weights of the antenna array). The evaluated values are therefore concentrated to a single area in the image.

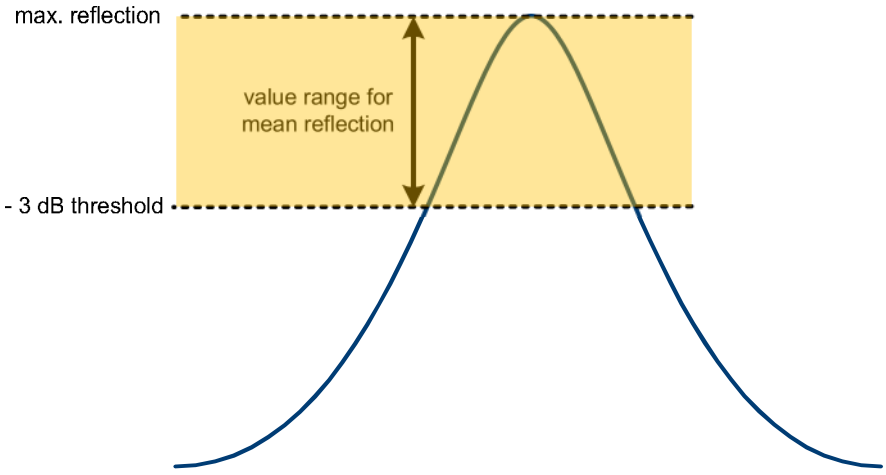


Figure 5-14: Mean reflection on a homogenous DUT

For inhomogeneous DUTs, the distribution can be different, so there maybe several highlighted areas in the image, but the evaluation remains the same.

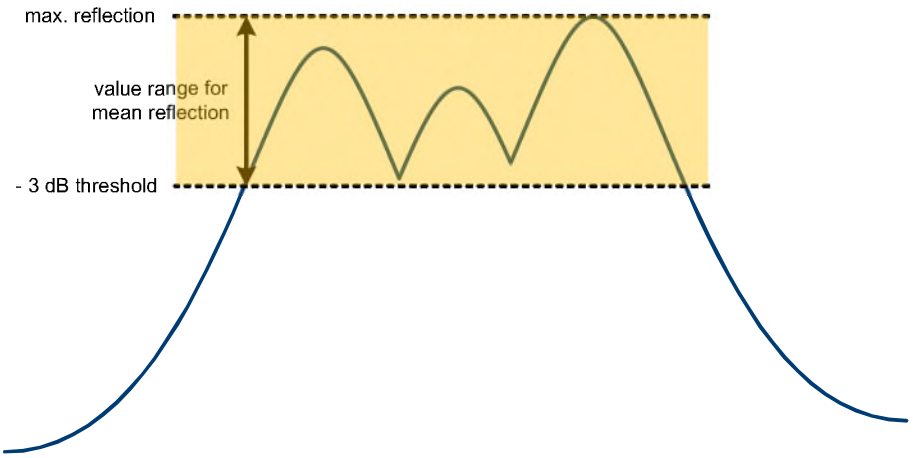


Figure 5-15: Mean reflection on an inhomogeneous DUT

Performing the measurement sequence

Similar to measurements using all clusters, you have to normalize the setup before beginning the actual measurement. For a comprehensive description of the normalization see "Normalizing reflection measurements" on page 43.

1. Normalize the setup with a suitable object.
   We recommend using the plate labeled E from the verification kit R&S QAR-Z43.
2. Replace the normalization object with the DUT.
3. Measure the DUT.

5.2.4 Configuration

The configuration tools for single cluster measurements are similar to those available for 12 cluster radome measurements.

For a comprehensive description, see:

- "Selecting the image color scheme" on page 46
- "Managing measurement results" on page 49
  The folder that contains single cluster measurement data has a suffix `_SC`. Otherwise, the data is the same.
- "Taking pictures with a webcam" on page 50
- "Using a barcode scanner" on page 50

5.2.5 Verification

The R&S QAR provides a verification procedure to validate the quality of the measurements. Verification consists of a series of measurements with standardized DUTs which are located at a fix distance from the R&S QAR.

All verification objects are delivered with a quality approved surface finish. Any surface features are either intentional or are considered to be uncritical for the intended purpose.

If verification fails, validate the verification setup. If verification fails several times in a row, despite a valid setup, contact Rohde & Schwarz customer support to calibrate the R&S QAR and check the hardware.

Warm-up time

Let the R&S QAR warm up for at least 90 minutes before using it.

The setup is the similar to the verification setup for the standard radome measurements. To verify single cluster measurements, however, you have to use the verification set R&S QAR-Z43. For details, see Chapter 5.1.5, "Verification", on page 51.

Performing verification

The verification process consists of five consecutive measurements with the verification objects (square plates). The verification objects are labeled A to E.

1. **NOTICE!** Handling the verification objects.
   - Store the verification objects in the bag they were delivered in.
   - Keep the verification objects clean and without fingerprints.
   - Do not scratch the verification objects.
   - Clean the objects with a lint-free duster or a damp rag. Do not use chemicals.

   Normalize the reflection measurement.

   a) Put the metal plate labeled "E" into the frame.
   b) Select "Normalize Reflection" to initiate a measurement.
   c) Wait until the results are displayed.
   d) Remove the metal plate from the frame.

   The resulting image should show a homogeneous image (the colors should not deviate too much). The mean reflection should be around 0 dB.
   The limits for the normalization of the reflection measurement are universal, not device-specific.

2. Verify the reflection measurement.

   a) Put the plastic plate labeled A into the frame.
   b) Initiate a measurement.
   c) Remove the plastic plate from the frame.
   d) Do the same for the other two plastic plates labeled B and C.

After each measurement, check the mean reflection against the limits r_{77} specified on the stickers attached to the verification plates. The sticker shows the reflection characteristics of the plate and the deviation the result may have.
The other two values a_{77} and a_{81} are irrelevant for the verification of the single cluster application.

5.3 Bumper Measurements

In real cases, the vehicle built-in radar sends a signal that crosses the bumper, is reflected and crosses the bumper again. Similarly, the R&S QAR antennas send signals that cross the bumper, are reflected from the reference reflector pins and cross the bumper back. The received signals are measured and compared to the free-space measurement (normalization) to obtain the transmission loss (or two-way attenuation) caused by the bumper in multiple points.

The R&S QAR uses 64 discrete frequency points to cover the frequency range 76 GHz - 81 GHz. Thanks to the multistatic imaging of the reflector pins, the analyzed bumper is irradiated from different angles (from -38° to +24°), as shown in figure Figure 5-16.

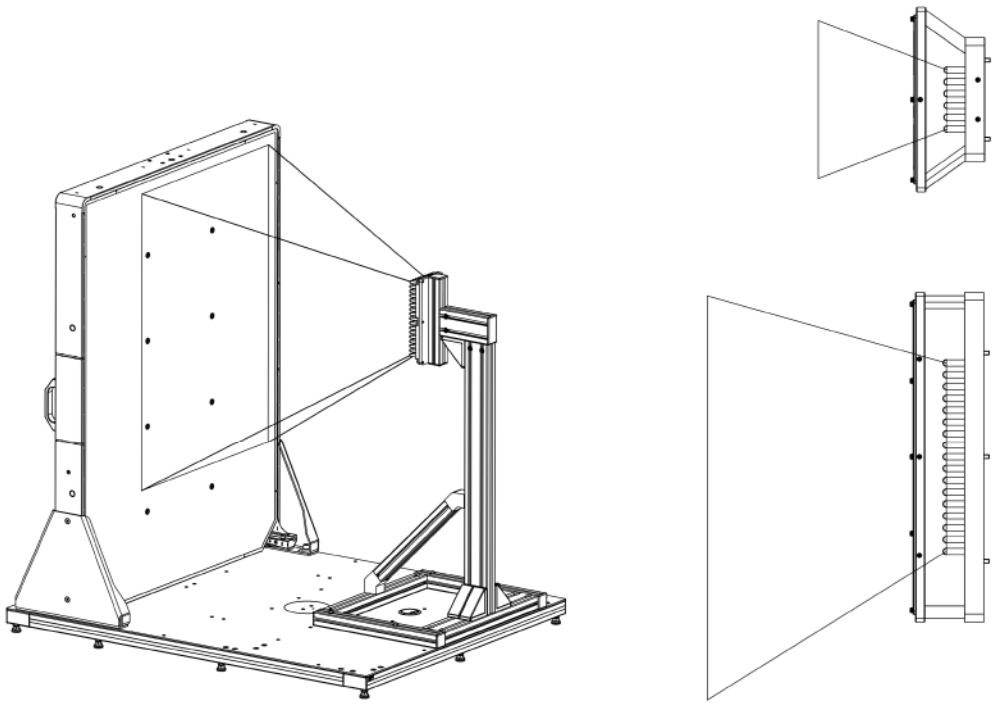


Figure 5-16: Irradiation area: 3D, top view and lateral view

The mean two-way attenuation is calculated as follows:

$-20 \cdot \log_{10}$(mean attenuation coefficient).

The mean attenuation coefficient is calculated as an average between the values obtained for all discrete frequency points and for all the reflector pins used.

The typical procedure when measuring the transmission loss (attenuation) caused by a bumper is as follows:

1. Start the R&S QAR.
   The software starts automatically. For more information, see Chapter 5.3.2, "Graphical User Interface", on page 64.
2. Normalize the measurement, as described in Chapter 5.3.3.1, "Normalization", on page 67.
3. Place the bumper to measure in the right position, as described in Chapter 5.3.1, "Test Setup", on page 64.
4. Measure the attenuation, as described in Chapter 5.3.3.2, "Attenuation Measurement", on page 67.
5. Save the measurement results, if needed.
   See also "Managing measurement results" on page 68.

5.3.1 Test Setup

► Place the bumper between the R&S QAR and the reference reflector, at a minimum distance of 30 mm from the reflector pins.

5.3.2 Graphical User Interface

The graphical user interface (GUI) contains several elements.

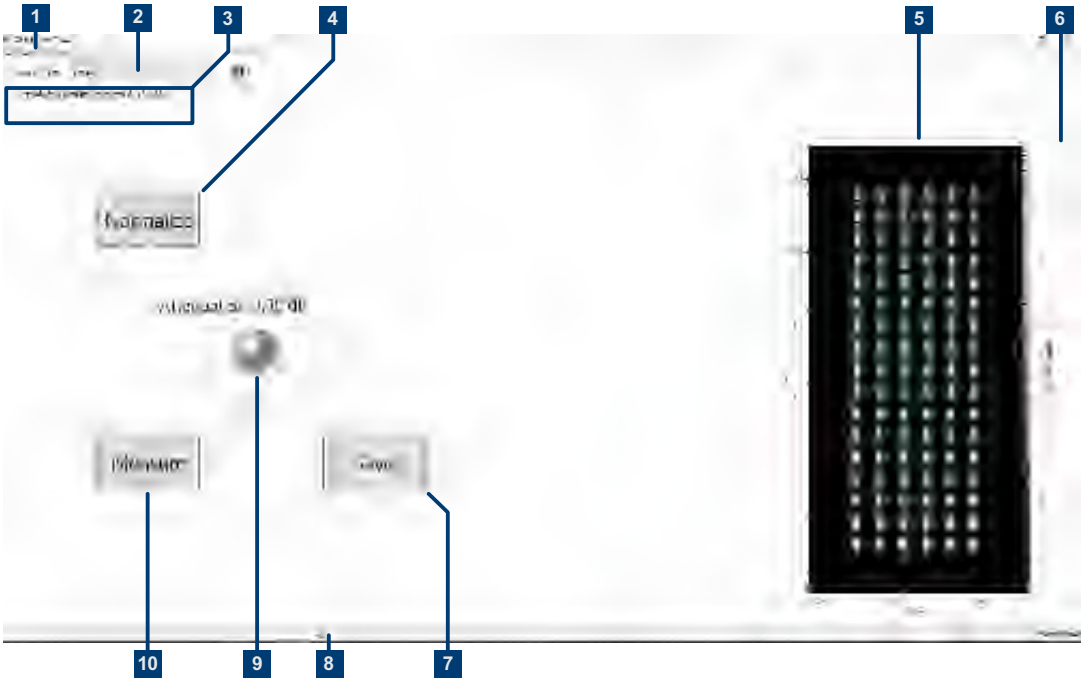


Figure 5-17: Software user interface

1 = Menu bar
2 = Bumper type selection
3 = System messages
4 = Normalize button
5 = Result display
6 = Result display hide / unhide
7 = Save button
8 = Status bar
9 = Numeric results (mean attenuation), incl. result indicator
10 = Measure button
10 = Result display

Result display

Shows the millimeter wave image of the data collected from the reference reflector pins during the scan.

The image indicates the effects of the presence of the object and enables you to evaluate immediately its characteristics, for example, the homogeneity.

You can hide and unhide the image with the arrow icon ( ).

Numeric results and indicator

Two-way mean attenuation within the frequency range 76 GHz - 81 GHz, calculated as the arithmetical mean of the values registered by the pins used.

If the attenuation is below the threshold, the indicator is green.

Bumper type selection

Selects the configuration for the measurement (type of bumper you are measuring).

The configuration determines which pins of the reference reflector to use for the measurement. The "default" configuration uses all pins.

Settings and control buttons

Several settings and buttons allow you to control the measurement.

- "Measure"
  Starts a measurement.
  For more information, see Chapter 5.3.3.2, "Attenuation Measurement", on page 67.
- "Save"
  Saves the measurement results.
  For more information, see "Managing measurement results" on page 68.
- "Normalize"
  Starts the normalization.
  For more information, see Chapter 5.3.3.1, "Normalization", on page 67.
- System messages
  Shows various status messages of the system like a missing normalization or the remaining warm-up time. The full warm-up time is 90 minutes.

Menu bar

The menu bar contains various settings.

- "File"
  Contains functionality to import and export measurement results, and functionality to close the software.
- "Options"
  Contains functionality to configure the measurement and result displays.
  For more information, see "Managing measurement results" on page 68.
- "Info"
  Contains various information about the application, including information about open source software licenses and the user manual.

Keyboard shortcuts

The following keyboard shortcuts are available.

Table 5-3: Keyboard shortcuts

Ctrl-S	Saves the currently displayed measurement results. See "Managing measurement results" on page 68 for details.
Ctrl-O	Opens a dialog box to load measurement results. See "Managing measurement results" on page 68 for details.
Ctrl-Q	Closes the software.
F5	Initiates a measurement.

5.3.3 Measurements

For bumper measurements, the R&S QAR provides a reflection measurement. Bumper measurements require the optional reference reflector. The measurement usually consist of two steps, normalization and the actual measurement.

Measuring a DUT

1. Set up the normalization.
2. Start the normalization with "Normalize".
   For details on how to normalize the measurement, see Chapter 5.3.3.1, "Normalization", on page 67.
3. Place the DUT between the R&S QAR and the reference reflector.
4. Start the reflection measurement with "Measure" (or the F5 key).
   The measurement itself lasts less than a second. The results are displayed after a few seconds.

For details on how to run the measurement, see Chapter 5.3.3.2, "Attenuation Measurement", on page 67.

5.3.3.1 Normalization

Normalization is a measurement done in the free space, to obtain a reference value for the bumper measurements. You do not need any object to measure or additional element.

Normalization enables you also to check the positioning and the status of the reference reflector. If the position is wrong, or the reflector is damaged, you get a warning.

Perform the following steps:

1. Make sure that nothing is obstructing the view between R&S QAR and the reference reflector.
2. Choose the configuration needed from the "bumper type" drop-down menu.
3. Click the "Normalize" button to start the measurement.

   The R&S QAR measures the deviations and saves the correction data. All subsequent measurements are corrected accordingly.
4. Optional: scan the free space by clicking the "Measure" button to verify the normalization.
   The expected result is an attenuation around 0 dB. For a range of acceptable results, see the datasheet.
   If the results do not meet the expectations, repeat the normalization.
   If the second normalization still yields unexpected results, perform the verification, as described in Chapter 5.3.5, "Verification", on page 70.

5.3.3.2 Attenuation Measurement

1. Set a threshold, if needed, by choosing "Options" > "Threshold".
2. Click the "measure" button. Or press F5.
   Do not move the bumper during the measurement.
   The measurement takes a few seconds, then the results appear on the GUI. See "Numeric results and indicator" on page 65 and "Result display" on page 65.

If you change the position of the reference reflector, or set a different configuration to use in the "bumper type" drop-down list, perform a new normalization before measuring.

5.3.4 Configuration

The R&S QAR provides several tools to configure the radome measurements.

Managing bumber types

To get valid results in the bumper measurement, you have to select the bumper model you want to measure first.

Upon delivery, the R&S QAR does not contain any bumper data. For each bumper type you want to measure, you have to add the corresponding bumper characteristics first, based on the CAD data of your bumpers.

If you want to add new bumper types, contact your Rohde & Schwarz representative.

1. For bumper models that are already available on the R&S QAR:
   Select the model from the "Bumper Type" menu. This menu contains the data of all bumper types that are currently stored on your R&S QAR.
2. For bumper models that are not yet available on the R&S QAR:
   a) Copy the bumper data that you got from us into the following directory on your R&S QAR:
   `C:\Program Files (x86)\Rohde-Schwarz\QARBumperUI\config`
   b) Start or restart the software.
   c) Select the bumper model from the "Bumper Type" menu.

Managing measurement results

You can export the measurement data, for example to store it on an external memory device or copy it to a different computer for further analysis with different software. You can also restore data that you have taken at some point and review them in the software.

1. Select "Options" > "Recording".
2. Define the default directory in which to save the results in the "Result Folder" input field.
   For each measurement, the R&S QAR creates a folder that contains the measurement data.
3. Select "Autosave" to use the auto save functionality..
   When you are using the autosave feature, the R&S QAR automatically stores the results after each measurement.

   Tip: You can always save the measurement results deliberately with the keyboard shortcut Ctrl-S or from the "File" menu.
4. Select the data you want to save from the "Results To Save" dropdown menu.

   A measurement dataset contains the following files.
   - `<yyyymmdd-hhmmss>_cfg.txt`
     Contains information about the configuration of the R&S QAR during the measurement.
   - `<yyyymmdd-hhmmss>_check_results.json`

Contains information about options.

- `<yyyymmdd-hhmmss>_image.png`
  Image of the measurement.
- `<yyyymmdd-hhmmss>_result_QARQT.mat`
  The contents depend on your selection.
  – If you have selected the data package "Statistics + Pictures + Data", the file contains the raw 2D imaging data. This data package is necessary if you want to restore the measurement results later on.
  – If you have selected the data package "Statistics + Pictures + Data + Volume", the file also contains the 3D imaging data.
  This data package requires approx. 500 MB of disk space for each image. It also takes a long time to save this data package, approx. 30 seconds for each image.

Tip: You can restore measurement results at any time with the keyboard shortcut Ctrl-O or from the "File" menu.
Restoring measurement results requires at least the raw 2D imaging data (`result_QARQT.mat`). The data package "Statistics + Pictures" only contains the images (`.png`) and statistics (numerical results etc.) and is therefore not sufficient to restore results.

Taking pictures with a webcam

You can connect a webcam to the R&S QAR that takes a picture of the DUT during the measurement. This picture is stored together with the measurement data.

The R&S QAR supports all webcams that are recognized as an "Imaging Device" in the Windows 10 device manager. Note that the webcam feature of the R&S QAR always uses the first imaging device in the list to take pictures.

1. Select "Options" > "Recording".
2. Select "Save Webcam Picture".

Using a barcode scanner

You can connect a barcode scanner to the R&S QAR to scan the barcode of a DUT and use this as a reference that the DUT with a certain barcode has passed or failed the test. The barcode is displayed in the user interface and is stored together with the other measurement data.

The R&S QAR supports the barcode scanner Honeywell Xenon 1900 by Honeywell International Inc.

1. Select "Options" > "Recording".
2. Select "Use Barcode Scanner".
3. Select the (serial) port the barcode scanner is connected to from the dropdown menu.

5.3.5 Verification

The R&S QAR provides a verification procedure to validate the quality of the measurements. Verification consists of a series of measurements with standardized DUTs which are located at a fix distance from the R&S QAR.

All verification objects are delivered with a quality approved surface finish. Any surface features are either intentional or are considered to be uncritical for the intended purpose.

If verification fails, validate the verification setup. If verification fails several times in a row, despite a valid setup, contact Rohde & Schwarz customer support to calibrate the R&S QAR and check the hardware.

Warm-up time

Let the R&S QAR warm up for at least 90 minutes before using it.

Required equipment

All required equipment is included in the delivery of the R&S QAR-Z41.

- Verification objects
  - 3 x plastic plate with different thicknesses
- Frame for verification objects
- Allen wrench size 5

Mounting the frame

The verification objects come with a frame that can hold the verification objects. The frame can be screwed to the reference reflector stand.

1. Place the frame onto the reference reflector.

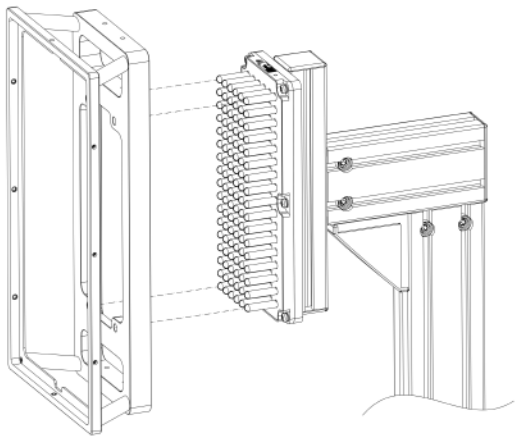


Figure 5-18: Placing the frame

2. Attach the verification plate to the frame. An arrow on the sticker indicates the correct orientation.

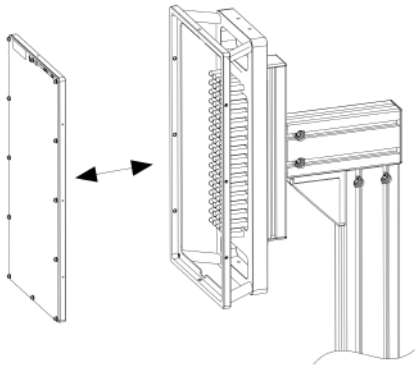


Figure 5-19: Placing the verification plate

Performing verification

The verification process consists of three consecutive measurements using the verification plates.

The plates are labeled "A" to "C". Each plate has a sticker with an arrow indicating the correct orientation and the expected attenuation value with acceptable error margin.

1. **NOTICE!** Handling the verification objects.
   - Store the verification objects in the bag they were delivered in.
   - Keep the verification objects clean and free from fingerprints.
   - Do not scratch the verification objects.
   - Clean the objects with a lint-free duster or a damp rag. Do not use chemicals.

   Normalize the measurement as described in Chapter 5.3.3.1, "Normalization", on page 67.
2. Put the plate labeled "A" into the support, as shown in Figure 5-18.
3. Set the "default" bumper type.
4. Initiate a measurement.
5. Check the mean attenuation against the values specified on the sticker.
6. Remove the plate from the support by pushing from the back of the plate.
7. Repeat the steps for the plates labeled "B" and "C".

If the verification fails, calibrate the R&S QAR, as described in the service manual, or call your local R&S representative.

If after calibration the verification fails again, check the hardware for defects.

5.4 Radar Positioning Measurements

The typical procedure when measuring a radar position is as follows:

1. Start the R&S QAR to start the system and the software.
   For more information about the functionality of the software, see Chapter 5.4.2, "Graphical User Interface", on page 73.
2. Park the car in front of R&S QAR.
   See Chapter 5.4.1, "Test Setup", on page 72.
3. Measure the DUT.
   See Chapter 5.4.3, "Measurement", on page 75.
4. Save measurement data.
   See "Managing measurement results" on page 79.

5.4.1 Test Setup

For radar positioning measurements, the test setup consists of the R&S QAR and the DUT, for example a radar module installed behind the bumper of a car. To measure the position of the radar module, you simply park the car in front of the R&S QAR. Make sure to park the car at the correct position as indicated in Figure 5-20 to get valid measurement results.

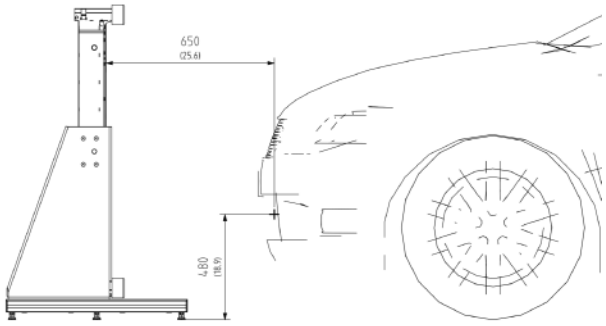


Figure 5-20: Test setup for radar positioning measurements (side view)

The optimal distance to the front of the car depends on the location of the radar module relative to the radome's location on the car.

- The distance between R&S QAR and radar module is between 60 cm and 80 cm.
- The distance from floor to radar module is between 34 cm and 68 cm.
- The offset of the radar module relative to the center of the R&S QAR panel is 14.5 cm to the right of the center of the panel.

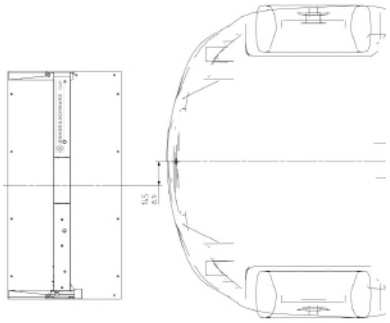


Figure 5-21: Test setup for radar positioning measurements (view from above)

5.4.2 Graphical User Interface

The graphical user interface (GUI) contains several elements.

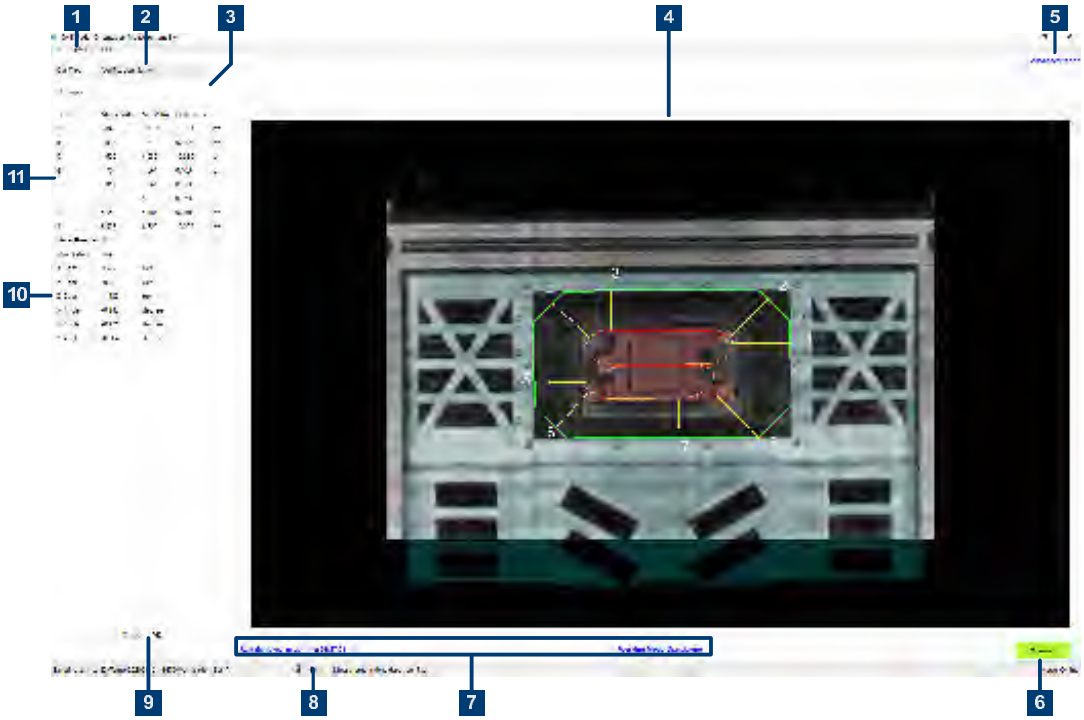


Figure 5-22: Software graphical user interface

1 = Menu bar
2 = Car type
3 = Description
4 = Graphical results
5 = Display mode
6 = Start measurement
7 = System messages
8 = Status bar
9 = Overall result
10 = Numeric detection results
11 = Numeric positioning results

Result display (graphic and numeric)

Graphic and numeric measurement results. For more information, see Chapter 5.4.3, "Measurement", on page 75.

Settings and control buttons

Several settings and buttons allow you to control the measurement.

- "Car Type"
  Selects the measurement configuration (CAD data of the car). For more information, see "Selecting the working mode" on page 77.
- "Description"
  Optional description of the measurement. The description is part of the folder name in which the results are stored.
- "Measure"
  Initiates a measurement.
  For more information, see Chapter 5.1.3.2, "Reflection Measurement", on page 44 and Chapter 5.1.3.3, "Transmission Measurement", on page 44.
- System messages
  Shows various status messages of the system like a missing normalization or the remaining warm-up time. The full warm-up time is 90 minutes.

Menu bar

The menu bar contains various settings.

- "File"
  Contains functionality to import and export measurement results and configurations, and functionality to close the software.
- "Options"
  Contains functionality to configure the measurement and result displays.
- "Info"
  Contains various information about the application, including information about open source software licenses and the user manual.

Status bar

Shows various information:

- The folder where measurements are saved.
- The temperature of the connected R&S QAR.
  Double-click on the temperature icon to view the temperature of the last few hours.
- The connection state ("Online": successful boot up of the connected hardware).

Keyboard shortcuts

The following keyboard shortcuts are supported:

Table 5-4: Keyboard shortcuts

Ctrl-S	Saves the currently displayed measurement results. See "Managing measurement results" on page 79 for details.
Ctrl-O	Opens a dialog box to load measurement results. See "Managing measurement results" on page 79 for details.

5.4.3 Measurement

The radar positioning measurement verifies the correct positioning of a radar module, for example behind the bumper of a car.

To measure the position of the radar module, the R&S QAR generates a three-dimensional point cloud of the car that is in front of it. This image shows the bumper and the location of the radar sensor mounted behind the bumper. To determine the correct location of the radar sensor, the R&S QAR compares the recorded image to the CAD data of the radar sensor and the bumper or radome.

After the position and orientations of both radar and sensor and have been found in the image, the R&S QAR uses the CAD model of the radar sensors emission cone to calculate the intersection area of the emission cone and the radome.

Finally, the R&S QAR calculates the shortest distance between the intersection area of the radar emission cone and the boundaries of the allowed area.

Measuring the DUT

1. Select the configuration from the "Car Type" drop-down list.
2. Select "Options" > "Alarm Limits" to define acceptance limits.
   For more information, see "Managing measurement results" on page 79.
3. Select "Measure".
   The R&S QAR measures the DUT, which takes a few seconds. Do not move the radar during the measurement.

   After a few seconds, the results appear in the user interface.

Graphic results

The image shows the CAD data and, as an overlay, the measurement results.

The colors have the following meaning:

- The green contour corresponds to the border polygon.
- The orange contour corresponds to the theoretical radar beam intersection.
- The red contour corresponds to the measured radar beam intersection.
- The yellow lines correspond to the measured distances.

You can display the graphical results as a 2D screenshot or as 3D image.

► Select "Options" > "Save Settings" > "Save Screenhot".

- If you turn on "Save Screenhot", the image is a 2D image that shows the DUT from the front.
- If you turn off "Save Screenhot", the image is a 3D image. You can turn the image in any direction and view it from different angles. To do so, select the image with the mouse pointer and move it in the direction you want.

Numeric results

Only available in advanced mode.

The numeric results show the measured distances and angles.

- Numeric results that are within the tolerance limits are displayed in a black font.
- Numeric results that are outside the tolerance limits are displayed in a red font.

The decision if a radar sensor is positioned correctly is based on the evaluation of eight measurement points. For each measurement point, the R&S QAR calculates the shortest distance between the radar beam intersection on the radome and a specified border polygon (green contour in the graphic results).

The upper part of the table of the numeric result summary shows the deviation between specified distances and measured distances for all eight measurement points. By default, the results are shown in ascending order, from smallest to largest distance. You can also define a different order based on the index number of the measurement point.

1. Select "Options" > "View Positions".
2. Select "Show following view positions", and define the order of measurement points, for example "1:2:3:4:5:6:7:8".

The lower part of the table shows the deviation of the DUT to the specified position in absolute terms.

- The minimum distance is the smallest distance that has been measured at one of the measurement points.
- The gap values indicate the deviation of the position in the corresponding direction. For example, an x-gap of 1 mm indicates that the DUT has a wrong position on the longitudinal axis.
- The angle values indicate that the DUT is tilted by a certain amount in the corresponding direction. For example, an x-angle of 5 ° indicates that the DUT is tilted slightly by its x-axis.

Overall test result

The overall test passes if all values are within the tolerances and limits.

- In simple mode, the overall test result is indicated by a green (pass) or red (fail) traffic light.
- In advanced mode, all numerical values must have a black font ("Status" = "OK"). A single value in red font results in a failed test ("Status" = "Not OK").

5.4.4 Configuration

The R&S QAR provides several tools to configure the measurement.

Selecting the user interface

The radar positioning measurement application provides two user interfaces, simple and advanced.

► Select "Options" > "Advanced Mode" to switch between user interfaces.

- The simple user interface shows the graphical result and the overall test result (pass or fail).
- The advanced user interface also shows the numerical results.
  A checkmark in front of the "Advanced Mode" menu item indicates that advanced mode is active.

Selecting the working mode

The system mode selects the radar positioning measurement test setup you are using. You can either integrate the R&S QAR in a custom automated system ("Inline" mode) or use it in a stand-alone setup.

Inline mode: The R&S QAR is part of an automated system. An adjustment of the imaging height for the R&S QAR is not necessary. Instead, the system mechanically adjusts the location of the R&S QAR in relation to the location of the radar sensor.

Stand-alone mode: The R&S QAR is installed on the platform (R&S QAR-Z21). For a valid measurement, the R&S QAR has to adjust its imaging height in relation to the location of the radar sensor. The R&S QAR takes this information from the car type configuration.

► Select "Options" > "Inline".

  A checkmark in front of the "Inline" menu item indicates that inline mode is active.

Selecting the car type

The car type configuration provides information about the car, the location of the radar sensor and the measurement points (positions). The configuration is based on the CAD data of the car.

In stand-alone working mode, the car type configuration also defines the imaging height of the R&S QAR.

Because every car type has different characteristics, you have to load the corresponding configuration.

1. Select "File" > "Configuration" > "Import Configuration"
2. Select the configuration from the "Car Type" dropdown menu.

   The R&S QAR loads the corresponding data and adapts its imaging volume and height. Loading another car type takes about 3 minutes.

3. Optional: If you change any settings that have an effect on the car type configuration (for example limits), select "File" > "Configuration" > "Export Configuration" to export the updated configuration.

Defining alarm limits

Alarm limits define by how much the position of the radar module may deviate from the ideal position. If the results show a deviation greater than the limits, the test fails.

1. Select "Options" > "Alarm Limits" to open the corresponding dialog box.

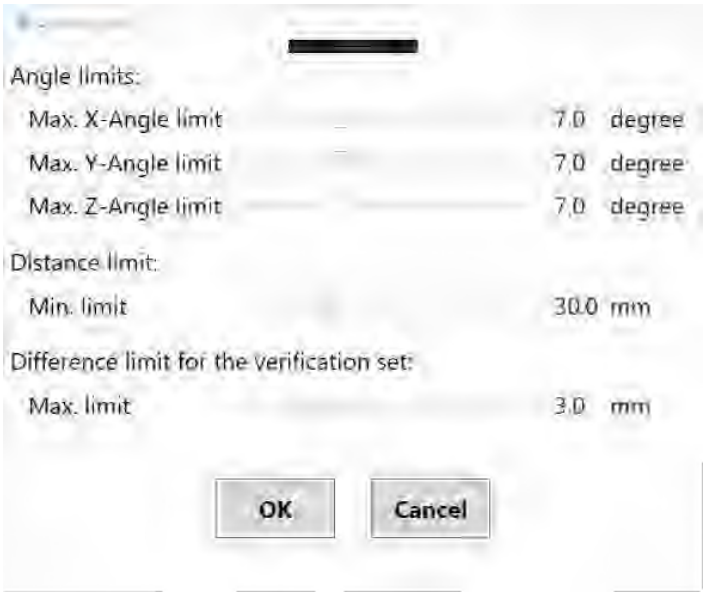


Figure 5-23: Set alarm limits dialog box

2. Define the limits as necessary.
   - Angle limits
     Maximal difference between theoretical and measured rotation angles. If the measured difference is higher than the maximum limit, it means that the radar is too turned around an axis and you get a "Not OK" status (red traffic light).
   - Distance limit
     Minimum distance from the radar window border. If the measured distance is lower than the minimum limit, it means that the radar beam is too close to the border and you get a "Not OK" status (red traffic light).
   - Difference limit for the verification set
     Only applicable when using the verification sets. Maximal difference between theoretical and measured position. If the measured difference is higher than the maximum limit, you get a "Not OK" status (red traffic light).
     If verification fails, check the position of all devices (R&S QAR, verification kit and verification plate). Also check if you have selected the correct verification plate from the "Car Type" dropdown menu.
     If verification still fails, contact Rohde & Schwarz. Stop any further measurements.

Selecting the user interface language

You can display the user interface in various languages.

► Select "Options" > "Languages".
Changing the language requires a restart of the application.

Managing measurement results

You can export the measurement data, for example to store it on an external memory device or copy it to a different computer for further analysis with different software. You can also restore data that you have taken at some point and review it in the application.

1. Select "Options" > "Save Settings".
2. Define the default directory in which to save the results in the "Result Folder" input field.
   For each measurement, the R&S QAR creates a folder that contains the measurement data.
3. Select "Autosave After Measurement" to use the auto save functionality.
   When you are using the autosave feature, the R&S QAR automatically stores the results after each measurement.

   Tip: You can always save the measurement results deliberately with the keyboard shortcut Ctrl-S or from the "File" menu.
4. Select "Save Screenshot" to store a screenshot of the graphical result.
5. Select the data you want to save from the "Save Option" dropdown menu.

   A measurement dataset contains the following files.
   - "Result"
     Stores the numeric results in a `.txt`file.
   - "Result and Volume"
     Contains the numeric results and the raw measurement data (3D view) in a `.mat`file.

   Tip: You can restore measurement results at any time with the keyboard shortcut Ctrl-O or from the "File" menu.

   If you restore 3D volume data ("Result and Volume"), the results show:
   - A 3D view in the graphic result display.
   - All numeric results.

   If you restore the numeric results ("Result") and a screenshot ("Save Screenshot"), the results show:
   - A screenshot of the results in the graphic result display.
   - All numeric results.

   If you restore the results only ("Result") without a screenshot, the results show:
   - Nothing in the graphic result display.
   - All numeric results.

Remote controlling radar positioning measurements

You can remote control radar positioning measurements via a Modbus protocol.

1. Select "Options" > "Modbus Communication".

   Several new input fields and control buttons appear in the user interface.

2. Define a local or remote IP address.

3. Select "Connect" to connect with the remote computer.

Using a barcode scanner

You can connect a barcode scanner to the R&S QAR to scan the barcode of a DUT and use this as a reference that the DUT with a certain barcode has passed or failed the test. The barcode is displayed in the user interface and is stored together with the other measurement data.

The R&S QAR supports the barcode scanner Honeywell Xenon 1900 by Honeywell International Inc.

1. Select "Options" > "Recording".

2. Select "Use Barcode Scanner".

3. Select the (serial) port the barcode scanner is connected to from the dropdown menu.

5.4.5 Verification

The R&S QAR provides a verification procedure to validate the quality of the measurements. Verification consists of a series of measurements with standardized DUTs which are located at a fix distance from the R&S QAR.

All verification objects are delivered with a quality approved surface finish. Any surface features are either intentional or are considered to be uncritical for the intended purpose.

If verification fails, validate the verification setup. If verification fails several times in a row, despite a valid setup, contact Rohde & Schwarz customer support to calibrate the R&S QAR and check the hardware.

Required equipment

All required equipment is included in the delivery of the R&S QAR-Z42.

- 3 Verification objects with different characteristics
- Mounting frame for verification objects

Installing the mounting frame for the verification objects

The verification set includes a mounting frame that holds the verifications objects. For verification, you have to place the mounting frame in front of the R&S QAR at a defined location. If the distances deviate from the ones mentioned here, verification is invalid.

- The distance between the R&S QAR and the front edge of the mounting frame is 65 cm.

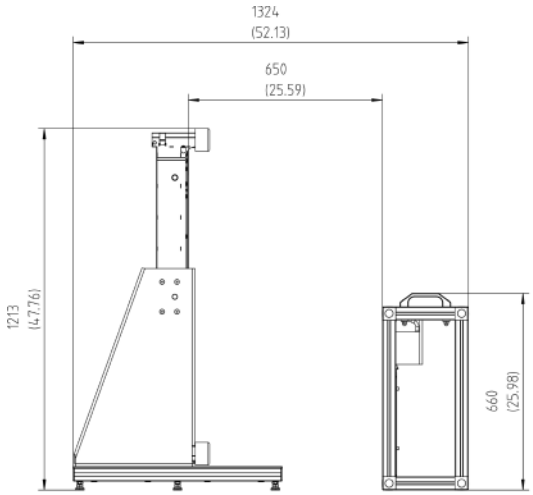


Figure 5-24: Verification setup (side view)

- The verification object has an offset of 14.5 cm to the right of the center of the R&S QAR.

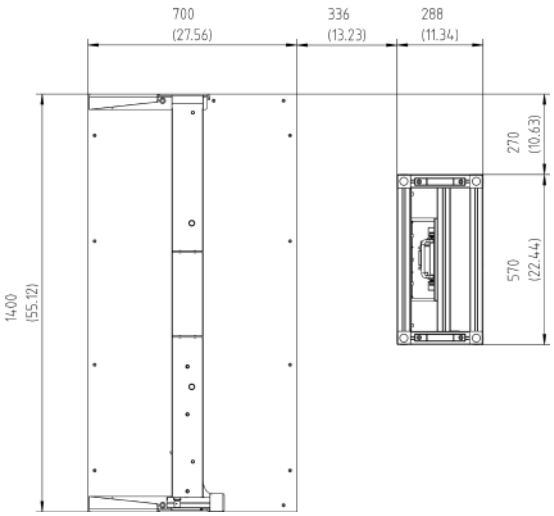


Figure 5-25: Verification setup (view from above)

Verifying the system

The verification is a series of three consecutive measurements with the verification objects. The verification objects are labeled A to C.

1. Let the R&S QAR warm up for at least 90 minutes.
2. **NOTICE!** Handling the verification objects.

- Store the verification objects in the bag they were delivered in.
- Keep the verification objects clean and free from fingerprints.
- Do not scratch the verification objects.
- Clean the objects with a lint-free duster or a damp rag. Do not use chemicals.

Insert one of the verification objects into the mounting frame.

3. Select the corresponding DUT configuration from the "Car Type" dropdown menu.
4. Start a measurement ("Measure").
5. Repeat the procedure for all three verification objects.

   Verification passes if the measurement results for all three objects are within the limits (measurement result is "OK").
6. Optional: If necessary, change the verification limits ("Options" > "Alarm Limits" > "Difference Limit for the Verification Set").
   However, we recommend to use the default limits (3 mm).

6 Remote Control - SCPI

6.1 Remote Control Interface and Protocol

For the R&S QAR, the remote control interface is the LAN interface. The LAN interface consists of a connector, a network interface card and protocols.

The network card can be operated with the following interfaces:

- 10 Mbit/s Ethernet IEEE 802.3
- 100 Mbit/s Ethernet IEEE 802.3u
- 1Gbit/s Ethernet IEEE 802.3ab

For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ45 cable (shielded or unshielded twisted pair category 5). The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library must be installed on the PC (controller).

IP address

Only the IP address or a valid DNS host name is required to set up the connection. The host address is part of the "VISA resource string" used by the programs to identify and control the instrument.

The VISA resource string has the form:

```
TCPIP::host address[::LAN device name][::INSTR]
```

where:

- **TCPIP** designates the network protocol used
- **host address** is the IP address or host name of the device
  `inst0` selects the VXI-11 protocol
- **LAN device name** defines the protocol and the instance number of a sub-instrument;
- **INSTR** indicates the instrument resource class (optional)

Example:

- Instrument has the IP address *192.1.2.3*; the valid resource string using VXI-11 protocol is:
  `TCPIP::192.1.2.3::INSTR`

Identifying instruments in a network

If several instruments are connected to the network, each instrument has its own IP address and associated resource string. The controller identifies these instruments by the resource string.

VISA library

A VISA installation is a prerequisite for remote control using the LAN interface.

VISA is a standardized software interface library providing input and output functions to communicate with instruments. High level programming platforms use VISA as an intermediate abstraction layer.

The I/O channel (LAN or TCP/IP) is selected at initialization time by one of the following:

- The channel–specific address string ("VISA resource string")
- An appropriately defined VISA alias (short name).

For more information about VISA, refer to the VISA user documentation.

VXI-11 protocol

The VXI-11 standard is based on the open network computing remote procedure call (ONC RPC) protocol which in turn relies on TCP/IP at the network/transport layer. The TCP/IP network protocol and the associated network services are preconfigured.

TCP/IP ensures connection-oriented communication, where the order of the exchanged messages is adhered to and interrupted links are identified. With this protocol, messages cannot be lost.

SCPI compatibility

SCPI commands (standard commands for programmable instruments) are used for remote control. The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of instrument-specific commands, error handling and the status registers. The tutorial "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00) offers detailed information on concepts and definitions of SCPI. The instrument supports the SCPI version 1999.

Commands that are not taken from the SCPI standard follow the SCPI syntax rules.

Communication ports

You have to open several ports in the firewall to be able to communicate via SCPI. By default, these ports are already open on the R&S QAR. If you want to close these ports, you can run a script that closes these ports.

- To close the ports, run the script `.\firewall\firewall-disableaccess.bat`.
  Closing the ports disables remote control functionality.
- To reopen the ports, run the script `.\firewall\firewall-setting.bat`.

6.2 Remote Commands

6.2.1 Data Management

MEASurement:LOAD <Directory>

This command restores a set of measurement results.

Setting parameters:

<Directory> String that contains the location of the results.
The location is always a complete directory, because measurement results are made up out of several files.

Example: //Restore measurement results
```
MEAS:LOAD 'c:\qar\results\measurement'
```

Usage: Setting only

MEASurement:RESult:DIRectory <Directory>

This command defines the folder in which the measurement results are stored.

Parameters:

<Directory> String containing the path to the lcoation in which results should be stored.

*RST: 'c:\temp'

Example: //Define result folder
```
MEAS:RES:DIR 'c:\results'
```

MEASurement:RESult:SAVE:AUTO <State>

This command turns automatic saving of the measurement results on and off.

Parameters:

<State> **ON | 1**
Automatically saves the results after the measurement is done.

OFF | 0
Results are not saved automatically.

*RST: ON

Example: //Turn on automatic saving of results
```
MEAS:RES:SAVE:AUTO ON
```

MEASurement:RESult:SAVE:WHAT <Data>

This command selects which data to store when saving.

Parameters:

<Data>

0
Stores statistics and pictures.

1
Stores statistics, pictures and data.

2
Stores statistics, pictures, data and volume.

*RST: 1

Example: //Select data to be stored
```
MEAS:RES:SAVE:WHAT 0
```

MEASurement:SAVE <Description>

This command saves the current measurement results.

Prerequisites for this command

- Measurement results must be available.
- Define the location in which the results should be stored (`MEASurement:RESult:DIRectory`).

Setting parameters:

<Description> String that is the basis of the folder name in which the R&S QAR saves the results.
In addition to the folder description, the R&S QAR adds a time stamp to the folder name. For example, a description `NewResults` would create a folder `20180101-125959_NewResults`.

Example: //Save measurement results
```
MEAS:STAR
MEAS:RES:DIR 'c:\results'
MEAS:SAVE 'NewResults'
```

Usage: Setting only

6.2.2 General Configuration

MEASurement:RESult:BCS:PORT <Port>

This command defines the port the barcode scanner is connected to.

Prerequisites for this command

- Turn on barcode scanner (`MEASurement:RESult:BCS:USE`).

Parameters:

<Port> String that contains the (serial) port the barcode scanner uses.

Example: //Select barcode scanner port

```
MEAS:RES:BCS:USE ON
MEAS:RES:BCS:PORT 'COM1'
```

MEASurement:RESult:BCS:USE <State>

This command turns the usage of a barcode scanner on and off.

Parameters:

<State>

ON | 1
Turns on the barcode scanner.

OFF | 0
Turns off the barcode scanner.

*RST: OFF

Example: //Turn on barcode scanner

```
MEAS:RES:BCS:USE
```

MEASurement:RESult:SAVE:WBC <State>

This command turns the webcam on and off.

Parameters:

<State>

ON | 1
Webcam takes a picture of the DUT during the measurement.

OFF | 0
Turns off the webcam.

*RST: ON

Example: //Turn off webcam

```
MEAS:RES:SAVE:WBC OFF
```

6.2.3 Measurement Control

MEASurement:STARt

This command initiates a measurement.

We recommend to define a timeout of at least 10 seconds to allow for the measurement to finish.

Example: //Initiate measurement
`MEAS:STAR`

Usage: Event

6.2.4 Radome Measurements

6.2.4.1 Application Selection

SYSTem:MODE:DEFault

This command selects the 12 cluster radome measurement.

Example: //Select 12 cluster measurement
`SYST:MODE:DEF`

Usage: Event

SYSTem:MODE:GETMode?

This command queries the current measurement mode.

Return values:

<Mode> **0**
12 cluster measurement

1
SIngle cluster measurement

Example: //Query measurement mode
`SYST:MODE:GETM?`

Usage: Query only

SYSTem:MODE:SC

This command selects single cluster measurements.

Example: //Select single cluster measurement
`SYST:MODE:SC`

Usage: Event

6.2.4.2 Measurements (12 Cluster)

Remote commands described elsewhere:

- `MEASurement:LOAD` on page 85
- `MEASurement:SAVE` on page 86
- `MEASurement:STARt` on page 88

MEASurement:REFLection:NORMalize:REQuired?

This command queries the normalization state of the reflection measurement.

Return values:

<State> **0**
Measurement is normalized.

1
Measurement is not normalized. In that case, you should normalize the measurement before starting it.

Example: //Query normalization state
`MEAS:REFL:NORM:REQ?`

Usage: Query only

MEASurement:REFLection:NORMalize:STARt

This command initiates the normalization of a reflection measurement.

We recommend to define a timeout of at least 10 seconds to allow for the measurement to finish.

Example: //Normalize reflection measurement
```
MEAS:REFL:NORM:STAR
```

Usage: Event

MEASurement:REFLection:STATistics<n>:MEAN?

This command queries the mean reflection.

Prerequisites for this command

- Reflection measurement results must be available.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result
You can query the unit of a result with `MEASurement:REFLection:STATistics<n>:UNIT?`.

Return values:

<Reflection> The unit is either dB or PCT.

Example: //Query mean reflection
```
MEAS:STAR
MEAS:REFL:STAT2:MEAN?
```

Usage: Query only

MEASurement:REFLection:STATistics<n>:MINTomax?

This command queries the ratio of the minimum and maximum reflection that have been measured.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result
You can query the unit of a result with `MEASurement:REFLection:STATistics<n>:UNIT?`.

Return values:

<Reflection> The unit is either dB or PCT.

Example: //Query reflection ratio
```
MEAS:STAR
MEAS:REFL:STAT2:MINT?
```

Usage: Query only

MEASurement:REFLection:STATistics<n>:STD?

This command queries the standard deviation of the reflection measurement.

Prerequisites for this command

- Reflection measurement results must be available.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result
You can query the unit of a result with `MEASurement:REFLection:STATistics<n>:UNIT?`.

Return values:

<Deviation> The unit is either dB or PCT.

Example:

```
//Query standard deviation of the reflection measurement
MEAS:STAR
MEAS:REFL:STAT:STD?
```

Usage: Query only

MEASurement:REFLection:STATistics<n>:UNIT?

This command queries the unit of the reflection measurement results.

Prerequisites for this command

- Reflection measurement results must be available.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result

Return values:

<Unit> String containing the unit.

Example:

```
//Query result unit
MEAS:STAR
MEAS:REFL:STAT:UNIT?
```

Usage: Query only

MEASurement:TRANsmission:BAND<n>:STARt:FREQuency?

This command queries the start frequency of the transmission measurement.

Suffix:

<n> 1: First evaluated frequency band.
2: Second evaluated frequency band.

Return values:

<StartFrequency> Default unit: GHz

Example: //Query start frequency of second frequency band
`MEAS:TRAN:BAND2:STAR:FREQ?`

Usage: Query only

MEASurement:TRANsmission:BAND<n>:STATistics<m>:MEAN?

This command queries the one-way mean attenuation of the transmission measurement.

Suffix:
<n> 1: First evaluated frequency band.
2: Second evaluated frequency band.

<m> 1: Logarithmic result.
2: Linear result.
You can query the unit of a result with `MEASurement:TRANsmission:BAND<n>:STATistics<m>:UNIT?`.

Return values:
<Transmission> Default unit: dB

Example: //Query logarithmic result of second frequency band
`MEAS:TRAN:BAND2:STAT1:MEAN?`

Usage: Query only

MEASurement:TRANsmission:BAND<n>:STATistics<m>:UNIT?

This command queries the unit of a result.

Suffix:
<n> 1: First evaluated frequency band.
2: Second evaluated frequency band.

<m> 1: Logarithmic result.
2: Linear result.

Return values:
<Unit> String that contains the unit of a result.

Example: //Query unit of the first result in the second frequency band.
`MEAS:TRAN:BAND2:STAT1:UNIT?`

Usage: Query only

MEASurement:TRANsmission:BAND<n>:STOP:FREQuency?

This command queries the stop frequency of the transmission measurement.

Suffix:
<n> 1: First evaluated frequency band.
2: Second evaluated frequency band.

Return values:
<StopFrequency> Default unit: GHz

Example: //Query stop frequency of second frequency band
`MEAS:TRAN:BAND2:STOP:FREQ?`

Usage: Query only

MEASurement:TRANsmission:MINFrequency?

This command queries the frequency at which the minimum transmission loss has been measured.

Return values:
<Frequency> Default unit: Hz

Example: //Query frequency of the minimum transmission loss
`MEAS:TRAN:MINF?`

Usage: Query only

MEASurement:TRANsmission:MINLoss?

This command queries the minimum transmission loss that has been measured.

Return values:
<TransmissionLoss> Default unit: dB

Example: //Query the minimum transmission loss
`MEAS:TRAN:MINL?`

Usage: Query only

MEASurement:TRANsmission:NORMalize:REQuired?

This command queries the normalization state of the transmission measurement.

Return values:
<State> **0**
Measurement is normalized.

1
Measurement is not normalized. In that case, you should normalize the measurement before starting it.

Example: //Query normalization state
`MEAS:TRAN:NORM:REQ?`

Usage: Query only

MEASurement:TRANsmission:NORMalize:STARt

This command initiates the normalization of a transmission measurement.

We recommend to define a timeout of at least 10 seconds to allow for the measurement to finish.

Example: //Normalize transmission measurement
`MEAS:TRAN:NORM:STAR`

Usage: Event

MEASurement:TRANsmission:VMOD <State>

This command turns the verification mode for a transmission loss measurement on and off.

Setting parameters:
<State> ON | OFF | 1 | 0
*RST: OFF

Example: //Turn on verification mode
`MEAS:TRAN:VMOD ON`

6.2.4.3 Measurements (Single Cluster)

Remote commands described elsewhere:

- `MEASurement:LOAD` on page 85
- `MEASurement:SAVE` on page 86
- `MEASurement:STARt` on page 88
- `MEASurement:REFLection:NORMalize:STARt` on page 89
- `MEASurement:REFLection:NORMalize:REQuired?` on page 89

MEASurement:REFLection:SCSTatistics<n>:MEAN?

This command queries the mean reflection.

Prerequisites for this command

- Select single cluster measurement.
- Reflection measurement results must be available.

Suffix:
<n> 1: Result in dB
2: Result in %
3: Linear result
You can query the unit of a result with `MEASurement:REFLection:SCSTatistics<n>:UNIT?`.

Return values:
<Reflection> The unit is either dB or PCT.

Example: //Query mean reflection
```
MEAS:STAR
MEAS:REFL:SCST2:MEAN?
```

Usage: Query only

MEASurement:REFLection:SCSTatistics<n>:STD?

This command queries the standard deviation of the reflection measurement.

Prerequisites for this command

- Select single cluster measurement.
- Reflection measurement results must be available.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result
You can query the unit of a result with `MEASurement:REFLection:SCSTatistics<n>:UNIT?`.

Return values:

<Deviation> The unit is either dB or PCT.

Example: //Query standard deviation of the reflection measurement
```
MEAS:STAR
MEAS:REFL:SCST:STD?
```

Usage: Query only

MEASurement:REFLection:SCSTatistics<n>:UNIT?

This command queries the unit of the reflection measurement results.

Prerequisites for this command

- Select single cluster measurement.
- Reflection measurement results must be available.

Suffix:

<n> 1: Result in dB
2: Result in %
3: Linear result

Return values:

<Unit> String containing the unit.

Example: //Query result unit
```
MEAS:STAR
MEAS:REFL:SCST:UNIT?
```

Usage: Query only

6.2.4.4 Configuration

Remote commands described elsewhere:

- MEASurement:RESult:BCS:PORT on page 87
- MEASurement:RESult:BCS:USE on page 87
- MEASurement:RESult:DIRectory on page 85
- MEASurement:RESult:SAVE:AUTO on page 85
- MEASurement:RESult:SAVE:WBC on page 87
- MEASurement:RESult:SAVE:WHAT on page 86

MEASurement:REFLection:MASK:EXPort <FileName>

This command exports the coordinates of an evaluation mask and stores them in the `.json` file format.

Setting parameters:

<FileName> String that contains the file name and its location. Note that the file name must have the `.json` file extension.

Example: //Export mask coordinates
`MEAS:REFL:MASK:EXP 'c:\masks\mymask.json'`

Usage: Setting only

MEASurement:REFLection:MASK:IMPort <FileName>

This command imports the coordinates of an evaluation mask.

Setting parameters:

<FileName> String that contains the file name and its location. Note that the file name must have the `.json` file extension.

Example: //Import mask coordinates
`MEAS:REFL:MASK:IMP 'c:\masks\mymask.json'`

Usage: Setting only

MEASurement:REFLection:MASK:LOAD <FileName>

This command imports the shape of an evaluation mask.

Setting parameters:

<FileName> String that contains the file name and its location. Note that the file name must have the `.bmp` file extension.

Example: //Import mask image
```
MEAS:REFL:MASK:LOAD 'c:\masks\mymask.bmp'
```

Usage: Setting only

MEASurement:REFLection:MASK:SAVE <FileName>

This command exports the shape of an evaluation mask and stores them in the `.bmp` file format.

Setting parameters:

<FileName> String that contains the file name and its location. Note that the file name must have the `.bmp` file extension.

Example: //Export mask image
```
MEAS:REFL:MASK:SAVE 'c:\masks\mymask.bmp'
```

Usage: Setting only

6.2.5 Bumper Measurements

6.2.5.1 Measurements

Remote commands described elsewhere:

- `MEASurement:LOAD` on page 85
- `MEASurement:SAVE` on page 86
- `MEASurement:STARt` on page 88

MEASurement:ATTenuation:MEAN?

This command queries the mean attenuation.

Prerequisites for this command:

- Attenuation measurement results must be available.

Return values:

<Attenuation> Default unit: dB

Example: //Query mean attenuation
```
MEAS:STAR
MEAS:ATT:MEAN?
```

Usage: Query only

MEASurement:ATTenuation:STD?

This command queries the standard deviation of the attenuation measurement.

Prerequisites for this command:

- Attenuation measurement results must be available.

Return values:

<Deviation> Default unit: dB

Example: //Query standard deviation of the attenuation measurement

```
MEAS:STAR
MEAS:ATT:STD?
```

Usage: Query only

MEASurement:ATTenuation:UNIT?

This command queries the unit of the attenuation measurement.

Prerequisites for this command:

- Attenuation measurement results must be available.

Return values:

<Unit> String containing the unit

Example: //Query unit of the attenuation measurement

```
MEAS:STAR
MEAS:ATT:UNIT?
```

Usage: Query only

MEASurement:BTYPe <BumperType>

This command sets the bumper type.

Parameters:

<BumperType> String containing the bumper type name

Example: //Set the bumper type.

```
MEAS:BTYP 'RR_L'
```

MEASurement:NORMalize:REQuired?

This command queries the normalization state of the attenuation measurement.

Return values:

<State> **0**
Measurement is normalized.

1
Measurement is not normalized. In that case, you should normalize the measurement before starting it.

Example: //Query normalization state
```
MEAS:NORM:REQ?
```

Usage: Query only

MEASurement:NORMalize:STARt

This command initiates the normalization of an attenuation measurement.

We recommend to define a timeout of at least 10 seconds to allow for the measurement to finish.

Example: //Normalize transmission measurement
```
MEAS:NORM:STAR
```

Usage: Event

MEASurement:OK?

This command returns *1* if the measured mean attenuation at a specified location is below threshold.

Prerequisites for this command:

- Attenuation measurement results must be available.

Return values:

<State> **1**
Measured attenuation is below threshold.

0
Measured attenuation is above threshold.

Example: //Query if attenuation is below threshold
```
MEAS:STAR
MEAS:OK?
```

Usage: Query only

MEASurement:THReshold <BumperType>, <Threshold>
MEASurement:THReshold? <BumperType>

This command sets/queries the threshold value of a bumper type.

Parameters:

<Threshold> Threshold value in dB

Parameters for setting and query:

<BumperType> String containing the bumper type name

Example: //Query the threshold value for the bumper type *RR_L*
```
:MEAS:THR? 'RR_L'
```
//Set a new threshold value for the bumper type *RR_L*
```
:MEAS:THR 'RR_L', 1.0
```

6.2.5.2 Configuration

Remote commands described elsewhere:

- `MEASurement:RESult:BCS:PORT` on page 87
- `MEASurement:RESult:BCS:USE` on page 87
- `MEASurement:RESult:DIRectory` on page 85
- `MEASurement:RESult:SAVE:AUTO` on page 85
- `MEASurement:RESult:SAVE:WBC` on page 87
- `MEASurement:RESult:SAVE:WHAT` on page 86

6.2.6 System

SYSTem:ERRor:CODE?

This command queries system errors.

Return values:
<ErrorCode>

Example: //Query system error code
```
SYST:ERR:CODE?
```

Usage: Query only

Code	Message	Description
0	Ok	No error
101	Calibration data missing	Restore calibration data in `C:\CalDataK1`
102	Could not load QAR configuration	Reinstall software
103	Invalid operation mode	Reinstall software
104	No configuration found for operation mode '<opmode>'	Reinstall software

Code	Message	Description
106	Error occurred during initialization	Contact service
107	QAR hardware not initialized	Contact service
108	Invalid measurement type '<type>'	Correct measurement type
109	Invalid configuration '<config>'	Correct measurement configuration
110	Results are invalid	Dismiss measurement results and repeat the measurement.
111	Measurement has failed	Dismiss measurement results and repeat the measurement.

SYSTem:ERRor:MESSage?

This command queries system errors.

Return values:

<ErrorMessage> String containing the error message.
For a list of messages, see `SYSTem:ERRor:CODE?`.

Example: //Query system error message
```
SYST:ERR:MESS?
```

Usage: Query only

SYSTem:EXIT

This command closes the R&S QAR software GUI.

Example: //Close GUI
```
SYST:EXIT
```

Usage: Event

SYSTem:REBoot

This command reboots the R&S QAR.

Example: //Reboot system
```
SYST:REB
```

Usage: Event

SYSTem:OPTions?

This command queries the installed software options.

Return values:

<Options> String that contains the option name.

Example: //Query installed options
```
SYST:OPT?
```

Usage: Query only

SYSTem:SHUTdown

This command switches off the R&S QAR.

Example: //Switch off system
`SYST:SHUT`

Usage: Event

SYSTem:STATus:CODE?

This command queries the system status.

Return values:
<StatusCode>

Example: //Query system status
`SYST:STAT:CODE?`

Usage: Query only

Code	Message	Description
0	Ready for measurement	
1	Device initializing	Wait until hardware initialization is done.
2	Error	Check log files for initialization errors.

SYSTem:TEMPerature?

This command queries the system temperature.

Return values:
<Temperature> Default unit: ° Celsius

Example: //Query system temperature
`SYST:TEMP?`

Usage: Query only

7 Remote Control - OPC

OLE for process control (OPC) is an interface to communicate with the R&S QAR through a programmable logic controller (PLC).

Rohde & Schwarz provides an optional OPC client integrated in the GUI software (R&S QAR-K11), that connects to an OPC server that hosts the variables used for communication with the PLC.

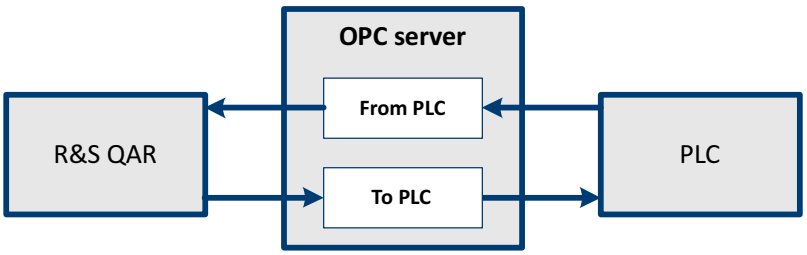


Figure 7-1: OPC communication between R&S QAR and PLC

7.1 Installation

The OPC client is integrated into the user interface and can be activated with a license key.

Contact your sales contact to order a license for this option.

7.2 OPC Variables

The following tables contain all variables supported by the R&S QAR application. For a correct functioning of the OPC control, every variable has to be defined on the server in the following file (the path depends on the application):

```
C:\Program Files (x86)\Rohde-Schwarz\QAR\config\
opc_client_cfg.json
```

or

```
C:\Program Files (x86)\Rohde-Schwarz\QARBumperUI\config\
opc_client_cfg.json
```

7.2.1 Reference

You can split the variable into two groups: variables for communication from PLC to R&S QAR, and variables for communication from R&S QAR to PLC. The source writes the variable, the target reads the variable.

All variable names have a prefix that describes the path to the variable. The path depends on your system.

- Communication from PLC to R&S QAR (**FromPLC**):
  `<path>.FromPLC.<variable>`
- Communication from R&S QAR to PLC (**ToPLC**):
  `<path>.ToPLC.<variable>`

Table 7-1: Variables for communication from PLC to R&S QAR ("FromPLC")

Name	Type	Description
Common variables		
`Type_Measurement`	String	Measurement type. • "standard" • "reflection_normalization" • "transmission_normalization" (radome measurements only)
`Path_Results`	String	Path to store measurement results (i.e. "C:\QAR\Results")
`Path_Diagnostics`	String	Path to store measurement results (i.e. "C:\QAR\Results")
`Trigger.Measure`	Bool	Trigger to start measurement
`Trigger.Diagnostics`	Bool	Trigger to start diagnostics
`Heartbeat`	Bool	Signal pulse to ensure communications
`Results_Received`	Bool	Signal to acknowledge reception of results
Variables for radome measurements		
`Config_Measurement`	String	Application type. • "Default" (12 cluster application) • "SCluster" (1 cluster application)
`RadomeMeasurement.Transmission.Verification_Mode`	Bool	Verification mode.
`Statistics_Mask_File`	String	The path to the evaluation mask file, either relative to the R&S QAR executable or as total path e.g. config\default_mask.bmp or `C:\Program Files (x86)\Rohde-Schwarz\QAR\config\default_mask.bmp`
`RadomeMeasurement.Reflection.Window.Width` [1]	Double	Reflection statistics window width.
`RadomeMeasurement.Reflection.Window.Height` [1]	Double	Reflection statistics window height.
`RadomeMeasurement.Reflection.Window.XCenter` [1]	Double	Reflection statistics window x center.
`RadomeMeasurement.Reflection.Window.YCenter` [1]	Double	Reflection statistics window y center.
Variables for bumper measurements		
`Configuration`	String	Measurement configuration (i.e. "G05-Base")

[1] Obsolete for R&S QAR softwares with OPC integration into the user interface (versions > 2.1.0.459). Use the reflection mask option in the user interface instead.

Table 7-2: Variables for communication from R&S QAR to PLC ("ToPLC")

Name	Type	Description
Common variables		
`Configuration_x.Configuration_<dd>`	String	Available measurement or bumper configurations (i.e. "G05-Base"). `<dd>` is a two digit number from 00 to 50. Example: `Configuration_x.Configuration_01`
`Error_Code`	Integer	Error code.
`Error_Flag`	Bool	Error indicator. True if error occurred.
`Error_Msg`	String	Error message.
`Process_Time_Sec`	Float	Elapsed time in seconds for analyzing the current measurement.
`Heartbeat`	Bool	Signal pulse to ensure communications
`State.Initializing`	Bool	True if the R&S QAR is initializing.
`State.Malfunction`	Bool	True if the R&S QAR failed the diagnostics test.
`State.Processing`	Bool	True if the R&S QAR is analyzing a measurement.
`State.Ready_ToMeasure`	Bool	True if the R&S QAR is ready for a measurement.
`State.Results_Ready`	Bool	True if R&S QAR measurement results (BumperMeasurement.*) can be read by the PLC.
Variables for radome measurements		
`RadomeMeasurement.Reflection.Statistics_<n>.Mean`	Float	Reflection mean value.
`RadomeMeasurement.Reflection.Statistics_<n>.Std_Dev`	Float	Reflection standard deviation.
`RadomeMeasurement.Reflection.Statistics_<n>.Min2Max`	Float	Reflection ratio (min. to max. reflection)
`RadomeMeasurement.Reflection.Statistics_<n>.Unit`	String	Reflection units (i.e. "dB", "%", "Linear").
`RadomeMeasurement.Reflection.Normalize_Required`	Bool	True if reflection normalization is required (12 cluster measurement).
`RadomeMeasurement.ReflectionSC.Normalize_Required`	Bool	True if reflection normalization is required (1 cluster measurement).
`RadomeMeasurement.Timestamp`	String	Current measurement timestamp.
`RadomeMeasurement.Transmission.Band_<n>.Statistics_<m>.Mean`	Float	Transmission mean value.

Name	Type	Description
RadomeMeasurement.Transmission.Band_<n>.Statistics_<m>.Unit	String	Transmission unit (i.e. "dB", "Linear").
RadomeMeasurement.Transmission.Normalize_Required	Bool	True if transmission normalization is required.
RadomeMeasurement.Transmission.Band_<n>.StartFrequency.Value	Float	Transmission start frequency value.
RadomeMeasurement.Transmission.Band_<n>.StartFrequency.Unit	String	Frequency unit (i.e. "GHz").
RadomeMeasurement.Transmission.Band_<n>.StopFrequency.Value	Float	Transmission stop frequency value.
RadomeMeasurement.Transmission.Band_<n>.StopFrequency.Unit	String	Frequency unit (i.e. "GHz").
RadomeMeasurement.Transmission.Min_Loss	Float	Min. transmission loss in dB.
RadomeMeasurement.Transmission.Min_Frequency	Float	Frequency of min. transmission loss in GHz.
Variables for single cluster radome measurements		
RadomeMeasurement.ReflectionSC.Statistics_<n>.Mean	Float	Reflection mean value.
RadomeMeasurement.ReflectionSC.Statistics_<n>.Std_Dev	Float	Reflection standard deviation.
RadomeMeasurement.ReflectionSC.Statistics_<n>.Unit	String	Reflection units (i.e. "dB", "%", "Linear").
Variables for bumper measurements		
Normalize_Required	Bool	True if normalization is required.
BumperMeasurement.Attenuation_Mean	Float	Current measurement attenuation mean value.
BumperMeasurement.Attenuation_Std_Dev	Float	Current measurement attenuation mean value.
BumperMeasurement.Timestamp	String	Current measurement timestamp.
BumperMeasurement.Unit	String	Current measurement units (i.e. "dB").
BumperMeasurement.Error_Flag	Bool	True if measurement results are invalid.
For reflection measurements, the index <n>= 1|2|3 selects the statistic values with specific unit (db, %, linear). For transmission measurements, the index <n>= 1|2 selects the frequency band of the statistics. Index <m>= 1|2 selects statistic values with specific unit (db, Linear).		

7.2.2 Data Types

The following table displays the number of bits required for each data type.

Table 7-3: Variables data types

Data type	Number of bits
Bool	1
Float	32
Double	64
Integer	32

All variables with data type "String" are represented by a byte array containing the string data (`.DATA`) and the number of characters in the string (`.LEN`). For example, if variable V has type "String", it is represented as `V.DATA /V.LEN`. The OPC variable `V.DATA` is a byte array and `V.LEN` is a 32 bit Integer.

The following table displays the maximum length of the string variables.

Table 7-4: String variables length

Variable name	Maximum string length
`Configuration_x.Configuration_<dd>`	83
`Error_Msg`	320
`Path_Results`	260
`Path_Diagnostics`	260
`Timestamp`	32
`*.Unit`	8

7.2.3 Examples

The following example contain a configuration for radome and bumper measurements.

If you move to a GUI integrated OPC control, you can copy your previous configuration file into the config folder. The software converts the configuration to the current format.

The path to the variable in this example is `CompactLogix.CompactLogix_PLC.Global.QAR.`. Change this path, depending on your system. You can configure the OPC node paths for each variable in the following file (path depends on the application):

```
C:\Program Files (x86)\Rohde-Schwarz\QAR\config\
opc_client_cfg.json
```

```
C:\Program Files (x86)\Rohde-Schwarz\QARBumperUI\config\
opc_client_cfg.json
```

Common variables

```
"plc_nodes": {
 "from_plc": {
  "trigger": {
   "diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.
Diagnostics",
   "measure": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.Measure"
  }
  "path_diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Path_Diagnostics",
  "path_results": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Path_Results",
  "type_measurement": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Type_Measurement",
"configuration": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Configuration",
  "results_received": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Results_Received",
  "heartbeat": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Heartbeat"
}
}
```

Variables for radome measurements

```
{
 "plc_nodes": {
  "from_plc": {
   "trigger": {
    "diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.
Diagnostics",
    "measure": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.Measure"
   }
   "path_diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Path_Diagnostics",
   "path_results": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Path_Results",
   "type_measurement": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Type_Measurement",
   "configuration": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Configuration",
   "results_received": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Results_Received",
   "statistics_mask_file": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Statistics_Mask_File",
   "heartbeat": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Heartbeat"
  }
  "to_plc": {
   "radome": {
    "radome_measurement": {
     "timestamp": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Timestamp",
     "error_flag": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Error_Flag",
```

```
      "reflectionSC": {
       "statistics_stem": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
RadomeMeasurement.ReflectionSC.Statistics_",
       "num_statistics": 3,
       "normalize_required": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
RadomeMeasurement.ReflectionSC.Normalize_Required"
      },
      "reflection": {
       "statistics_stem": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Reflection.Statistics_",
       "num_statistics": 3,
       "normalize_required": CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Reflection.Normalize_Required"
      }
      "transmission": {
       "verification_mode": CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
RadomeMeasurement.Transmission.Verification_Mode",
       "band_stem": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Transmission.Band_",
       "num_bands": 2,
       "num_statistics": 2,
       "normalize_required": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement
Transmission.Normalize_Required"
       "min_frequency": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Transmission.Min_Frequency",
       "min_loss": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.RadomeMeasurement.
Transmission.Min_Loss"
      }
     }
     "state": {
      "initializing": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Initiliazing",
      "malfunction": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Malfunction",
      "processing": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Processing",
      "ready_to_measure": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.
Ready_ToMeasure",
      "results_ready": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Results_Ready"
     }
     "process_time_sec": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Process_Time_Sec",
     "error_flag": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Flag",
     "error_msg": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Msg",
     "error_code": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Code",
     "heartbeat": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Heartbeat"
    }
   }
}
}
```

Variables for bumper measurements


```
{
 "plc_nodes": {
  "from_plc": {
   "trigger": {
    "diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.
Diagnostics",
    "measure": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Trigger.Measure"
   }
   "path_diagnostics": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Path_Diagnostics",
   "path_results": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Path_Results",
   "type_measurement": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Type_Measurement",
   "configuration": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Configuration",
   "results_received": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.
Results_Received",
   "heartbeat": "CompactLogix.CompactLogix_PLC.Global.QAR.FromPLC.Heartbeat"
  }
  "to_plc": {
   "qt": {
    "bumper_measurement": {
     "attenuation_mean": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
BumperMeasurement.Attenuation_Mean",
     "attenuation_std": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
BumperMeasurement.Attenuation_Std_Dev",
     "timestamp": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.BumperMeasurement.
Timestamp",
     "unit": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.BumperMeasurement.Unit",
     "error_flag": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.BumperMeasurement.
Error_Flag"
     "normalize_required": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
Normalize_Required"
    },
    "state": {
     "initializing": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Initiliazing",
     "malfunction": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Malfunction",
     "processing": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Processing",
     "ready_to_measure": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.
Ready_ToMeasure",
     "results_ready": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.State.Results_Ready"
    },
    "configuration_stem": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.
Configuration_x.Configuration_",
    "num_configuration": 50,
    "normalize_required": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Normalize_Required",
    "process_time_sec": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Process_Time_Sec",
    "error_flag": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Flag",
    "error_msg": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Msg",
```

```
    "error_code": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Error_Code",
    "heartbeat": "CompactLogix.CompactLogix_PLC.Global.QAR.ToPLC.Heartbeat"
   }
  }
}
}
```

7.3 Device States

While operating, the R&S QAR runs through different states as shown in Figure 7-2.

1. The initialization runs after the software has started successfully:
   - If initialization succeeds, the next state is `State.Ready_ToMeasure`.
     You can now trigger a measurement.
   - If errors occur during initialization, the next state is `State.Malfunction`.
     It indicates that the device needs repair or replacement.
2. After data acquisition, the data analysis starts and the device switches to `State.Processing`.
   While R&S QAR has this state, you can move the DUT.
3. The next state is:
   - `State.Results_Ready` - the PLC can now read the results.
   - `State.Malfunction` - if you trigger diagnostics but they fail.
4. When the PLC receives the results, it returns `Results_Received`.
   The R&S QAR clears and deletes the current measurement results and goes back to `State.Ready_ToMeasure`.

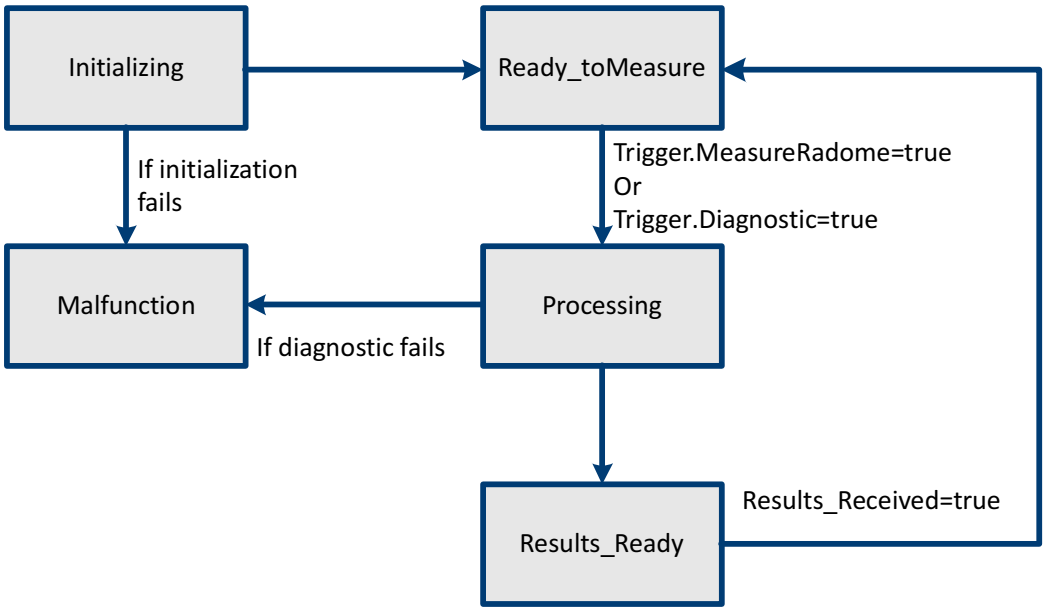


Figure 7-2: R&S QAR states

7.4 Timing Diagram

The timing of communication for measurements and diagnostics between the PLC and the R&S QAR is identical. After the R&S QAR sets `State.Results_Ready`, PLC can read the results. R&S QAR discards measurement results after the PLC sets `Results_Received`.

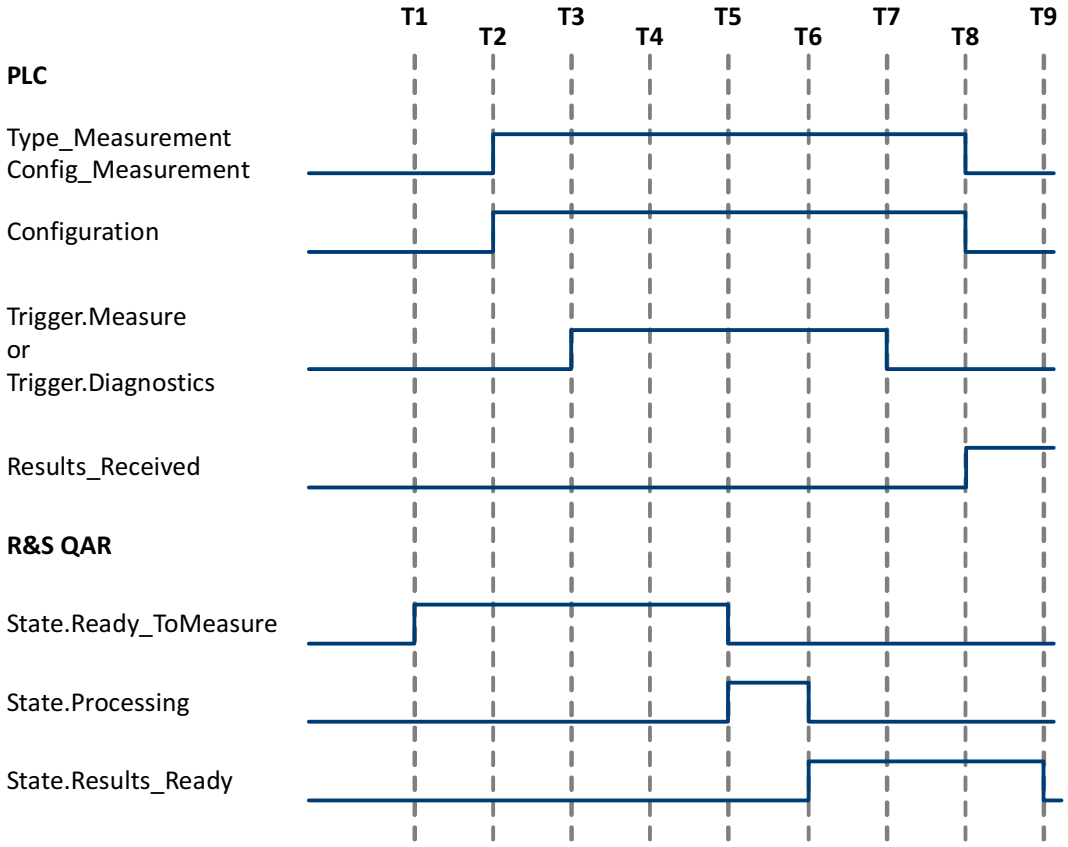


Figure 7-3: Timing diagram for measurements and diagnostics

7.5 Error Handling

Errors can occur during R&S QAR initialization or while performing measurements.

- Initialization errors
  You cannot resolve errors that occur during device initialization. The application saves the errors to a log, sets the state to `State.Malfunction` and goes into an offline mode.
- Measurement errors
  If errors occur during a measurement, the `Error_Flag`, `Error_Msg`and `Error_Code` are set and the device switches to `State.Results_Ready`.

Table 7-5: Initialization errors

Error code	Error message	Description	Solution

102 [1]	Could not load R&S QAR configuration	Application cannot load the configuration.	Restore directory `config` in
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientRadome`
			or
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientBumper`

103 [1]	Invalid operation mode	Application configuration is corrupt.	Restore
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientRadome\config\qar_cfg.json`
			or
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientBumper\config\qar_cfg.json`

104 [1]	No configuration found for operation mode '<opmode>'	No measurement configurations present.	Restore
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientRadome\config`
			or
			`C:\Program Files (x86)\Rohde-Schwarz\QAROPCClientBumper\QARMeasurementConfigs`

106 [1]	Error occurred during initialization		Replace the R&S QAR device. Send the log files to service. Log files are here:
			`C:\Program Files (x86)\Rohde-Schwarz\QAR`
			or in
			`C:\Program Files (x86)\Rohde-Schwarz\QARBumperUI`

107	R&S QAR hardware not initialized		Replace the R&S QAR device. Send the log files to service. Log files are here:
			`C:\Program Files (x86)\Rohde-Schwarz\QAR`
			or in
			`C:\Program Files (x86)\Rohde-Schwarz\QARBumperUI`

[1] Obsolete with integration OPC into UI

Table 7-6: Measurement Errors

Error code	Error message	Description	Solution
108	Invalid measurement type '<measType>'	Invalid type of measurement given.	Set correct measurement type.
109	Invalid configuration '<config>'	Invalid measurement configuration given.	Set correct measurement configuration.
110	Results are invalid	Measurement results are invalid.	Ignore measurement results. Repeat the measurement.
111	Measurement has failed	Measurement has failed.	Ignore measurement results. Repeat the measurement.
112	Measurement has failed	Reference reflector verification failed	Check the correct reference reflector in the bumper measurement UI
113	Invalid result path	`Path_Results` does not exist.	Set `Path_Results` to a valid path.
114	Could not create result directory '<directory>'	The directory for saving the results cannot be created.	Check whether `Path_Results` has write permissions.
115	Failed to save results.	Measurement result could not be saved.	Ignore measurement results. Repeat the measurement.
116	Diagnostics failed.		Try to repeat diagnostics.
117	Invalid measurement type '<config_Measurement>'	Invalid application configuration given	Set correct application.
118	Please do the normalization for the configuration '<configuration>' first.	Normalization data for the specific configuration is missing.	Normalize the configuration.
130	Option Key K50 missed	No option key K50 found on the QAR	Check activated licenses in the R&S License Server Manager.

8 Maintenance

Daily maintenance or inspection is not required for the R&S QAR.

We recommend to do a verification at least every six months.

Additional technical training on the R&S QAR is part of a service level agreement (SLA). For further information, contact your Rohde & Schwarz sales representative.

8.1 Cleaning Information

The R&S QAR and its accessories are sensitive devices. Clean the R&S QAR in an appropriate manner to prevent the components from getting damaged.

Cleaning the R&S QAR panel

1. Clean the front side of the R&S QAR panel only if necessary (visible dirt particles). If cleaning the front side becomes necessary, do so carefully with a dry, lint-free duster or a vacuum cleaner with a soft attachment.
   The cover attached to the front side is sensitive to mechanical influences and can break if you apply too much pressure.
   Do not use liquids to clean the front side. Using liquids on front side of the R&S QAR can lead to inaccurate measurements.
2. Clean the frame and rear side of the R&S QAR with a lint-free duster. In the case of stubborn dirt, you can also wipe the frame and rear side with a damp rag.
3. Clean the platform using a broom or vacuum cleaner.
   Remove any stubborn dirt using a damp rag. A neutral, non-abrasive cleaning agent can be added to the cleaning water.
   While cleaning the platform, take care not to damage the front side of the panels.
   Make sure that the platform does not become too wet during cleaning. Too much liquid can damage the base. Any escaped liquid (including water) must be removed immediately.
   Never clean the platform with a floor cleaning machine.

Cleaning the mounting equipment (R&S QAR-Z50, -Z61 and -Z42)

1. Before cleaning the mounting equipment, remove the measuring equipment like the cables, the transmitter module or the reference reflector. If this is not possible, do not touch the measuring equipment. The measuring equipment has to be cleaned with different standards (see below).

2. Clean the mounting equipment with a soft, lint-free dust cloth. If necessary, you can dampen the cloth.
   Do not use chemical cleaning agents or solvents like alcohol or cellulose lacquer thinners.

Cleaning the transmitter module (R&S QAR-Z10)

1. Clean the horn antenna, cables and cable connectors carefully with a dry and soft, lint-free dust cloth. Other cleaning materials can leave residue on the rubber coating of the absorber.
   If there are bigger dirt particles in the inside of the horn antenna, pick them out carefully with tweezers.
2. Clean the rest of the transmitter module with a soft, lint-free dust cloth. If necessary, you can dampen the cloth.
   If you are using a damp cloth, make sure that the horn antenna and cable connectors do not get wet.

Cleaning the reference reflector (R&S QAR-Z60)

► Clean the reference reflector carefully with a dry and soft, lint-free dust cloth.
If there are bigger dirt particles between the pins, pick them out carefully with tweezers.

8.2 Software Update

A software update requires an executable file that you can download and copy to a memory stick.

Ask your local Rohde & Schwarz support for the corresponding file.

Updating the measurement software

1. Copy the file into the root directory of the memory stick. No other files should be present.
2. Connect the memory stick to one of the USB ports on the R&S QAR.
3. Log in as an administrator.
4. Open the Windows Explorer and navigate to the memory stick.
5. Run the installer file.
   The software update takes a few minutes.

   When the software update is done, the system restarts.

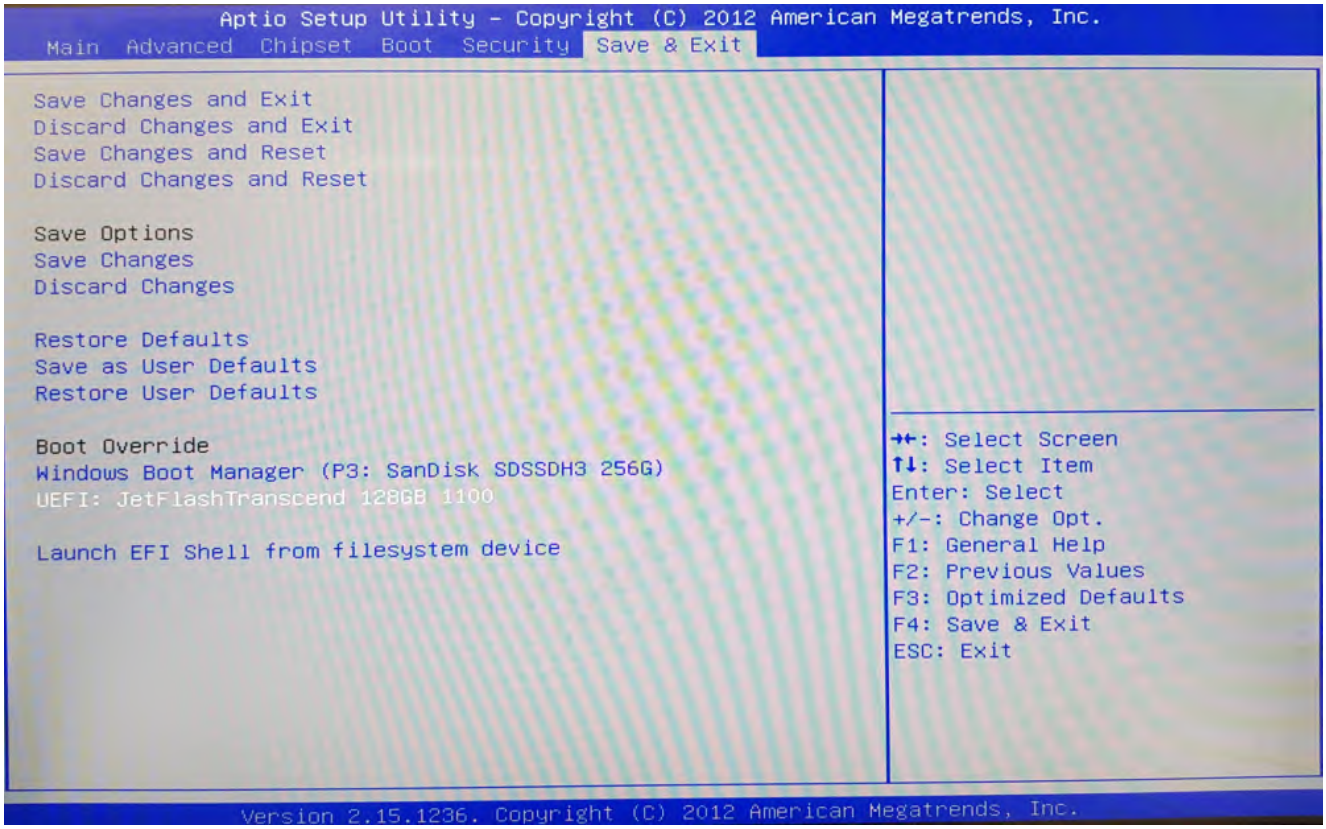
Upgrading the operating system with the recover stick

1. Connect a monitor with a resolution ≤ 1080p to the R&S QAR.
2. Connect a keyboard and mouse to the R&S QAR.

3. Start the R&S QAR.
4. Close all software that is still running and log out of the system.
5. Log into the system as an administrator.
6. **NOTICE!** Backup your data. Before you upgrade the operating system, back up the current image and your personal data to an external memory device, for example an external hard disk. The system configuration and all personal data on the system drive is lost after the upgrade.

   Select "Settings" > "System" > "About" from the Windows Start menu to find out the computer name (`QAR-xxxxxx`, with xxxxxx = serial number of your R&S QAR). Write down the computer name.
7. Connect the USB stick (order no. 1343.0530.02) with the Windows 10 upgrade to one of the upper USB (3.0) ports on the R&S QAR.
8. Run `flashbios.cmd` in the root directory of the USB stick to install a new BIOS (make sure you are logged in as an administrator before you do this).
9. Shut down the R&S QAR.
10. For devices with a serial number ≤100665:
    Connect the second USB stick with the smart card to the R&S QAR. The smartcard is needed to run the R&S QAR software after the upgrade.
    (Devices with a serial number > 100665 already have the smartcard integrated in the system.)
11. Start the R&S QAR and press the ESC or DEL keys until the BIOS starts.
12. Select the "Save & Exit" tab in the BIOS boot menu.
13. **NOTICE!** Risk of instrument damage. Do not turn off the R&S QAR during the upgrade.
    Turning off the R&S QAR during the upgrade can cause serious damage to the R&S QAR.

    Select the "JetFlashTranscend" menu item to start the upgrade.



The upgrade consists of the following processes:

- Booting WinPE to create a recovery partition. When this is done, the R&S QAR restarts.
- Copying the calibration data to the USB stick.
- Installing the Windows 10 image.
- Copying the calibration data back to the R&S QAR.
- Installing the R&S QAR measurement application.

The whole process takes about 15 to 30 minutes (depending on the amount of calibration data).

14. Select "Settings" > "System" > "About" from the Windows Start menu to rename the computer to the name recorded in step 6(`QAR-xxxxxx`).
15. Restart the R&S QAR.

Activating the Windows license

After the upgrade, you have to activate the Windows 10 license. To upgrade the license, you have to log into the system as an administrator (user name = `Admin`, password = `emodar8Administrator`).

1. Start the `slui` application (search for `slui` in the Start menu).
2. Enter the product key from the license sticker and confirm with "Next".
3. Follow the instructions on the screen.

4. Attach the license sticker to R&S QAR frame, next to the USB ports.

   Your R&S QAR is now running Windows 10 and ready to use. We recommend changing the default user account passwords for improved security.
   If there are any issues with software availability, stability or missing licenses, feel free to reach out to your local sales force.

If your R&S QAR has no internet connection, the activation after you have entered the product key in the `slui` application will fail. Instead you have to activate the license by phone. If this is the case, proceed as follows.

1. After you have entered the product key (it must be the correct one), activation fails. Close the license activation window.
2. Start the `slui 4` application (search for `slui 4` in the Start menu).
3. Follow the instructions on the screen.

   After a telephone call to the Microsoft support center, who will give you the confirmation ID, the R&S QAR is ready to use.
4. Attach the license sticker to R&S QAR frame, next to the USB ports.

8.3 Storage

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

We recommend to use the original packaging to store the R&S QAR. If the original packaging is not available, use sufficient padding to prevent the scanner from moving around inside the box.

8.4 Transport

Lifting and carrying

See Chapter 1.1, "Safety Instructions", on page 7.

Packing

Use the original packaging material designed for the R&S QAR.

If you do not have the original packaging, use similar materials that provide the same level of protection.

Securing

When moving the R&S QAR in a vehicle or using transporting equipment, make sure that the R&S QAR is properly secured. Only use items intended for securing objects.

Transport altitude

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

8.5 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 8-1: 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.

9 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 9-1: QR code to the Rohde & Schwarz support page

Glossary

C

Calibration: Determines reproducible system characteristics and reduces the corresponding measurement deviations, thus increasing measurement accuracy significantly.
The calibration set is available as accessory (R&S QAR-Z30).

D

DUT: Device under test. For the R&S QAR, the DUT is usually a radome or a bumper.

M

Mean reflection: Mean value of the reflection measured in the analyzed area of the DUT.
A low mean reflection corresponds to a high transparency of the DUT.

Measurement software: Software to configure, control and run measurements with the R&S QAR.
The software is installed on the R&S QAR.

Mounting table: Pedestal that holds the DUT and the transmitter module.
Available as accessory (R&S QAR-Z50).

N

Normalization: Process that takes the current measurement results as a reference and subtracts them from subsequent measurement results.

Normalization object: A shiny metal plate required for the normalization of the reflection measurement.

O

OLE: Object linking and embedding

OPC: OLE for process control

P

Platform: Flat plate where to fix the R&S QAR and its accessories.
Available as accessory (R&S QAR-Z20 / -Z21).

PLC: Programmable logic controller

R

Radome: Protective cover of radar antennas, whose RF characteristics you want to test with the R&S QAR.

Reflection: The part of the signal that is reflected by the DUT.

Result display: Diagram that shows the measurement results.

S

Standard deviation: Result that indicates the dispersion of the measured reflection values. The standard deviation indicates the homogeneity of the DUT.

T

Transmission loss: Measure of attenuation of the DUT over a certain frequency range.
Transmission loss measurements require the optional transmitter module.

Transmitter module: Device required to measure transmission loss.
Available as accessory (R&S QAR-Z10).

V

Verification: Test procedure to check if the R&S QAR yields accurate measurement results.
It requires the verification plates.

Verification kit: Objects required for the verification of the R&S QAR.
The verification kit is available as an accessory (R&S QAR-Z40, -Z41, -Z42 and -Z43).

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