OVER-THE-AIR AND ANTENNA TESTING

ROHDE&SCHWARZ

Make ideas real

Wireless devices are commonplace, but the technology behind them is complex and sophisticated. Our test and measurement solutions help you master this complexity – from new technology standardization to product design and production. Our complete, unmatched portfolio helps you bring your solutions to market quickly.

Rohde&Schwarz provides individual solutions using our world-renowned test equipment combined with specially developed system software and components sourced as needed. As the market leader in EMC and OTA testing, our systems are known for their unrivaled accuracy, durability and expandability, facilitating seamless integration of emerging wireless standards. The system's modularity ensures upgradeability, flexibility and future-readiness from entry-level R&D to large form factor solutions.

This brochure gives you an overview of our over-the-air (OTA) and antenna test solutions that, once in your lab, can help you push the boundaries of what's possible.

Find more details about our over-the-air (OTA) and antenna test solutions on the Rohde&Schwarz website.

CONTENTS

MOBILE DEVICE (UE) TESTING

Driven by wireless advancements like 5G NR, Wi-Fi 7, NTN, Bluetooth® LE and UWB, mobile devices (user equipment) have evolved into versatile platforms for diverse communications needs. Ensuring compliance with the latest industry standards and regulations is crucial before these devices enter the market. This requires meticulous testing for electromagnetic compatibility (EMC), protocol adherence, RF performance, location based services (LBS) and over-the-air (OTA) performance.

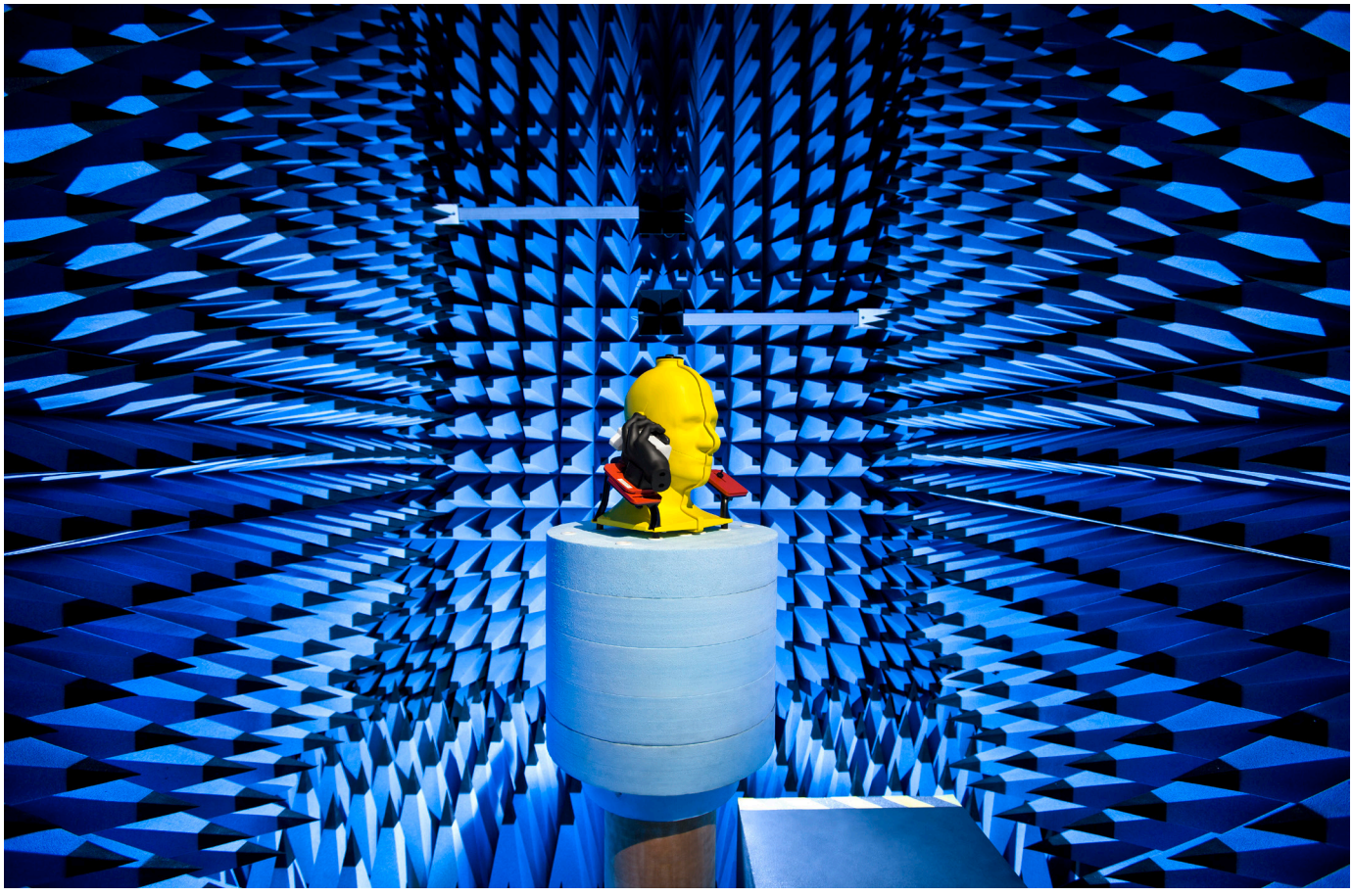
Modular solutions to ensure upgradeability and future-readiness

The R&S®TS8991 OTA performance test system assesses and optimizes device radiated performance, verifying antenna patterns and evaluates transmitter and receiver chains. It provides R&D measurements, precompliance testing and even fully validated conformance testing in line with CTIA or 3GPP.

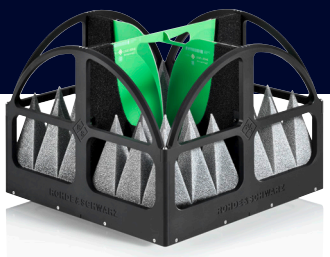
It supports all common technologies across multiple frequency bands from 400 MHz to 8 GHz and accommodates various UE form factors, such as phones, tablets and smart devices. For 5G NR FR2, additional systems based on compact antenna test ranges are available.

Key OTA measurements include the total radiated power (TRP) as a figure of merit for transmitter performance and total isotropic sensitivity (TIS, per CTIA) or total radiated sensitivity (TRS, per 3GPP) for receiver performance utilizing bit error rate (BER), block error rate (BLER) or packet error rate (PER) measurements.

View into an R&S®WPTC anechoic chamber where a UE is tested with a phantom head



R&S®TS8991: OTA performance system in a nutshell

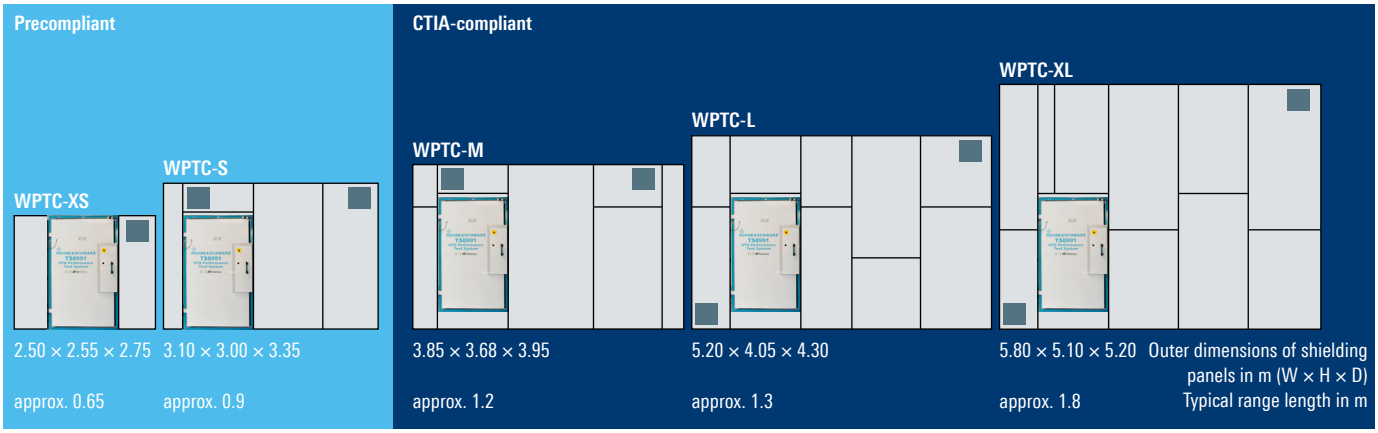


R&S®TC-TA18 dual polarized probe antenna

The R&S®TS8991 is a full turnkey solution that includes an anechoic chamber, positioner equipment, test instruments and automated measurement software, e.g. R&S®AMS32 OTA performance measurement software.

We offer wireless performance test chambers in different sizes along with positioning systems for different types of measurements. Probe antennas are available for frequency ranges from 400 MHz to 85 GHz.

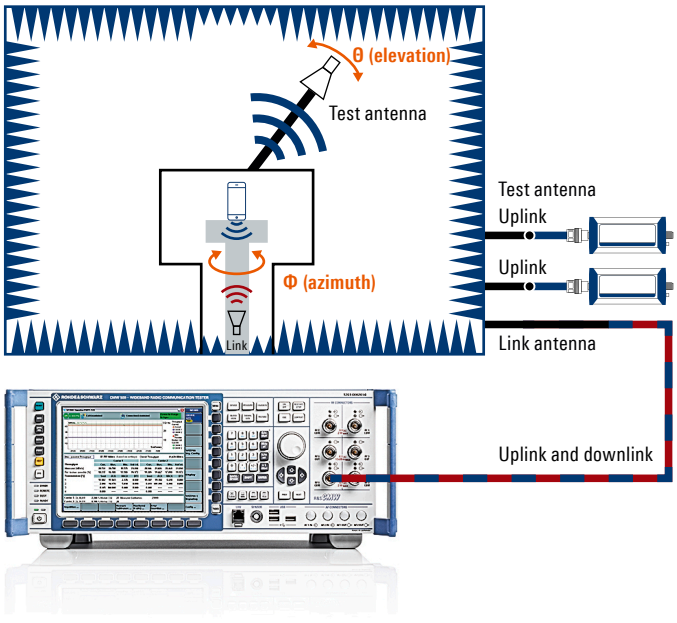
Different sizes of fully anechoic test chambers are available



The block diagram to the right shows a typical setup for TRP and EIRP measurements. For most cellular OTA testing, radiocommunication testers like the CMW500 and CMX500 emulate the base station to which the UE is connected during an active call. The link is established with a dedicated link antenna located in the base of the positioner. The actual measurement of the uplink signal (e.g. TRP or EIRP) is then performed with the measurement probe and a pair of power sensors allowing simultaneous capture of the two principal polarizations (Θ/Φ or H/V) in a simple and cost-effective way.

Noncellular technologies like A-GNSS, Bluetooth® or Wi-Fi as well as the coexistence of multiple radio access technologies can also be measured in the R&S®TS8991 OTA performance system. Depending on the technology, the addition of amplifiers or instruments like vector signal generators (e.g. R&S®SMBV100B) or vector signal analyzers (e.g. FSW) in combination with the R&S®OSP open switch platform is required to upgrade an existing system.

TRP and EIRP measurements



All equipment is automatically controlled by R&S®AMS32 software, which also handles calibration, provides test templates and visualization as well as reporting measurement results.

Precise far-field characterization of antennas, modules or UEs up to 170 GHz with the R&S®ATS1800C

This mmWave test chamber, based on the compact antenna test range (CATR) principle, provides the ideal environment for testing 5G FR2 antennas, modules and mobile devices throughout the entire lifecycle from R&D to conformance. With its small footprint and wide frequency range, the R&S®ATS1800C offers great functions and test coverage in a very small footprint of only 1.3 m^2.

Depending on which feed antenna and high quality parabolic reflector are selected, it covers frequencies from 6 GHz to 170 GHz with quiet zone sizes from 30 cm to 40 cm which fulfill 3GPP conformance test requirements.

With our large variety of Rohde&Schwarz measurement instruments and accessories, this solution is an ideal OTA test environment. For instance, during design optimization, specific beam characterizations can be measured to verify the beamforming capabilities of modules and devices using the very accurate two-axis positioner with integrated hardware triggering. Even out-of-band testing with the R&S®CATR-FESWA automatic feed switcher option and 3D assessment under extreme temperature conditions (e.g. from –40 °C to +85 °C) with the R&S®CATR-TEMP2 enclosure option are possible.

R&S®ATS1800C

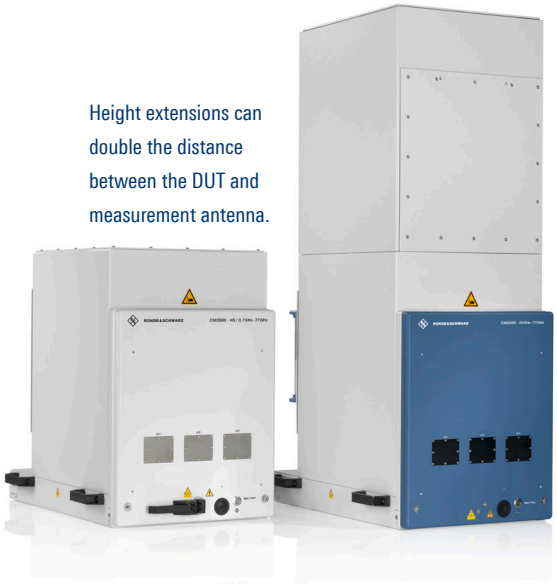
R&S®ATS800R ultra compact CATR solution for antenna characterization and 5G FR2 device testing

If even more compactness is a requirement, the R&S®ATS800R rack-mountable CATR chamber may be an option. It supports the frequency range from 20 GHz to 50 GHz and offers a quiet zone size of 20 cm with a footprint of approximately 0.7 m^2.

The fully shielded chamber can be placed directly onto the lab bench or mounted in a movable rack compartment offering space for measurement instruments.

There are many options available, such as a two-axis positioner allowing 3D characterization of devices or an enclosure for extreme temperature measurements.

R&S®ATS800R with base rack



Height extensions can double the distance between the DUT and measurement antenna.

Direct far field OTA measurements from 0.3 GHz to 77 GHz with the R&S®CMQ

Three models are available with different frequency ranges and specific absorbers to ensure anechoic testing conditions with legacy, 5G NR, FR2 and mmWave technologies.

A manual or automatic opening/closing mechanism let the R&S®CMQ shielding cube be used in both R&D and fully automated mass production environments.

The R&S®CMQ is a compact shielding solution fits into 19" racks and enables over-the-air RF measurements under direct far field conditions. The quiet zone is big enough for medium-sized devices and white box measurements, when the antenna locations inside the DUT are known. If a larger quiet zone is needed, an optional height extension can increase the distance between measurement antenna and DUT for reliable RF measurements within the Fraunhofer distance.

R&S®TS7124AS RF shielded box with automatic closing

Reliable and reproducible measurements from 300 MHz to 18 GHz with the R&S®TS7124 RF shielded boxes

The robust construction and rugged design ensure a long service life. The automatic R&S®TS7124 model is designed especially for automated production processes.

An antenna ring can be integrated with numerous antennas giving users the flexibility to create a specific radiation patterns or measure radiated power for selected orientations.

The shielding of the R&S®TS7124 exceeds 80 dB and a wide variety of accessories like feedthroughs, link or measurement antennas are available.

Accurate radiated testing of wireless devices from 400 MHz to 18 GHz with the R&S®DST200

The highly effective shielding of the R&S®DST200 anechoic RF diagnostic chamber exceeds 110 dB and the chamber supports a wide range of radiated test applications. It is particularly helpful with product design and optimization.

An automated 3D positioner lets the radiated antenna pattern (total radiated power; TPR) be measured along with the receiving characteristics (total isotropic sensitivity; TIS). The DUT is attached to a removable holder at the center of the positioner and rotated independently over the azimuth and elevation axes with two servomotors.

The layout of the pyramidal RF absorbers ensures free-space conditions at the DUT position.

R&S®DST200 with automated 3D positioner

Remarkable shielding effectiveness and superior coupling characteristics up to 8 GHz with the R&S®CMW-Z10

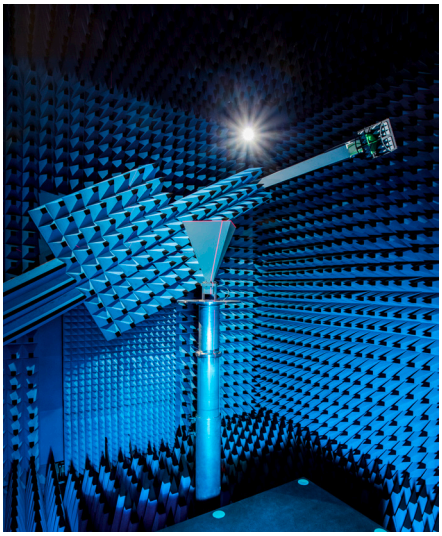
A reliable over-the-air (OTA) connection is required when mobile devices must be tested via RF link but external antenna connectors are not available.

The R&S®CMW-Z10 RF shield box can be used for an OTA connection between a DUT and a radiocommunications tester. The box cover is lined with absorber material to minimize reflections. The integrated broadband spiral antenna has been optimized for an excellent radio connection with low coupling attenuation.

When second antenna is in case a circular polarized antenna element allows 2x2 MIMO systems or systems with transmit diversity antennas to be tested.

R&S®CMW-Z10 with positioned DUT

ANTENNA AND RF MODULE TESTING SOLUTIONS FOR ALL SIZES AND BUDGETS

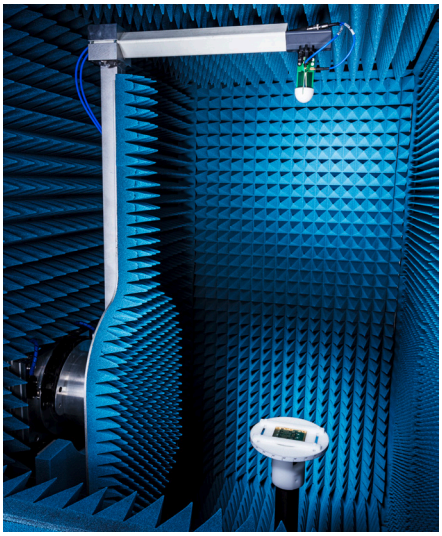


WPTC-XL chamber with high-precision conical cut positioner

Wireless performance test chambers (WPTC) suitable for multiple applications

Passive antennas and active RF modules with antenna functionality can be characterized in the same wireless performance test chambers (WPTC) as those used for UE testing. Utilizing a high precision conical cut positioning system allows very accurate measurements of the antenna characteristics under far-field conditions or by utilizing transformation algorithms for large AUTs measured in the near-field. Complete turnkey solutions including all RF system components (e.g. frequency converters, amplifiers, probes) are available for the frequency range from 400 MHz to 90 GHz.

Sometimes space in laboratories is limited and installing a WPTC chamber is not possible. In such cases, ultra-compact, movable R&S®ATSx chambers are an excellent option.



R&S®ATS1000 inside view with R&S®TC-TA85CP broadband probe

5G and mmWave antenna testing with the R&S®ATS1000 antenna test system

The R&S®ATS1000 antenna test system, for example, is the ideal environment for 5G NR FR2 antenna and module characterization in the R&D environment. With the R&S®ZNA vector network analyzer it can be used to characterize antennas and active modules in the frequency range from 18 GHz to 67 GHz. For measurements on modulated signals, the FSW spectrum analyzer and/or the R&S®SMW200A vector signal generator can alternatively be used. A key component of this solution is the R&S®TC-TA85CP cross-polarized Vivaldi probe antenna. Its broadband, low-RCS design allows simultaneous measurements of vertical and horizontal polarization, which reduces measurement times significantly. Based on the wide frequency coverage, there is no need to exchange the measurement probe. Hence, system calibration is needed less often and can be done in just a few minutes.

R&S®ATS1000 with R&S®SMW200A and FSW, running R&S®AMS32 software

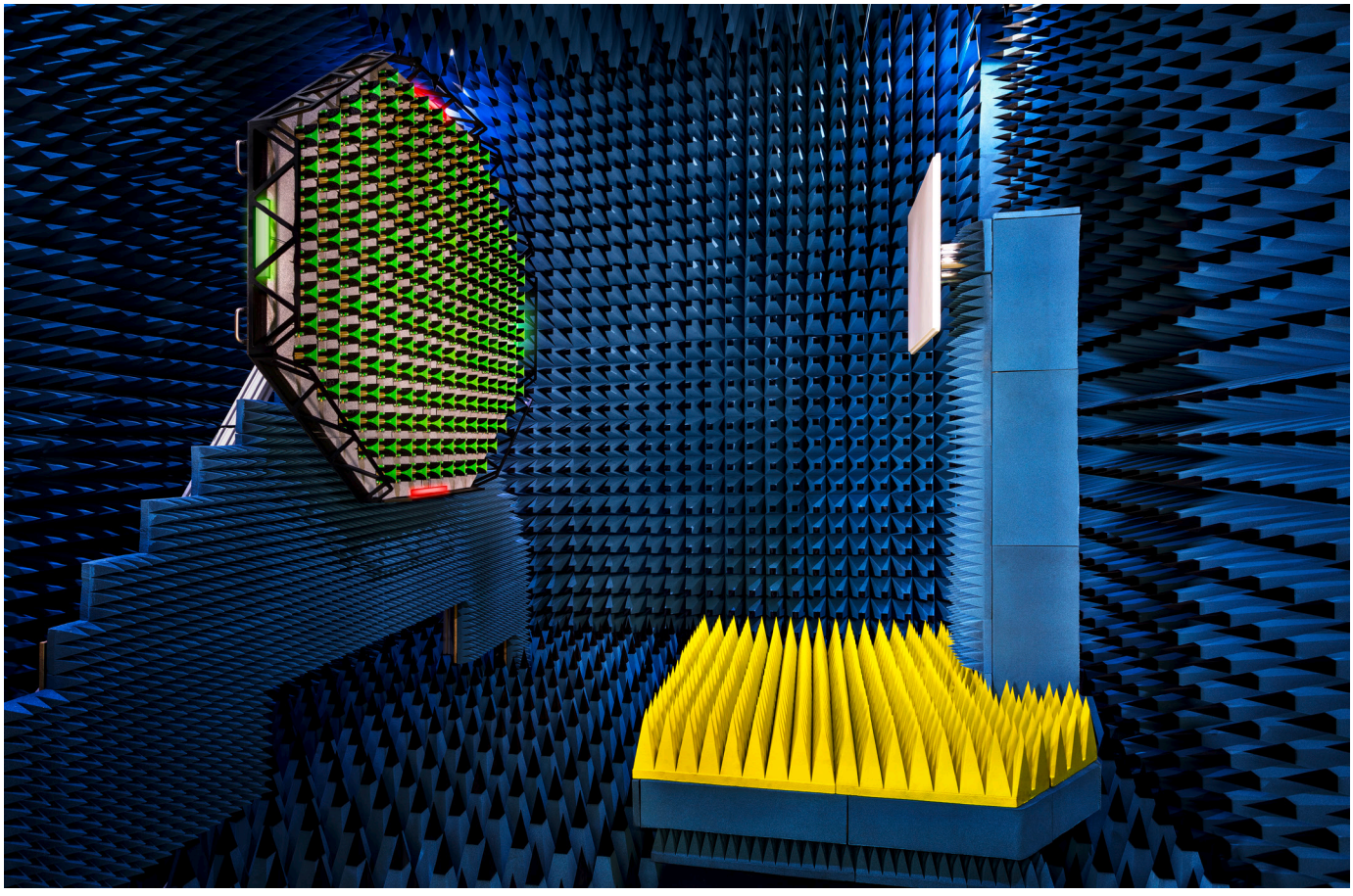
BASE STATION TESTING

The increasing complexity of mobile network infrastructure, driven by the demand for cost efficiency and rapid deployment, necessitates innovative testing solutions. Particularly with 5G New Radio, challenges arise due to MIMO complexity, wider bandwidths and new spectrum bands like mmWave. As networks become more interconnected, ensuring base stations can coexist with nonterrestrial networks is crucial, requiring expanded testing scopes.

Compact solution to test 5G massive MIMO base stations

Rohde&Schwarz offers leading mobile network infrastructure testing solutions to meet these demands and leverage 5G opportunities. For instance, the R&S®PWC200 plane wave converter facilitates 5G massive MIMO base station testing for R&D and quality assurance, including over-the-air conformance testing. Its unique design, based on a bidirectional array of 156 wideband Vivaldi antennas, enables real-time measurements within a specified quiet zone.

Anechoic test chamber with R&S®PWC200 and 3D positioner



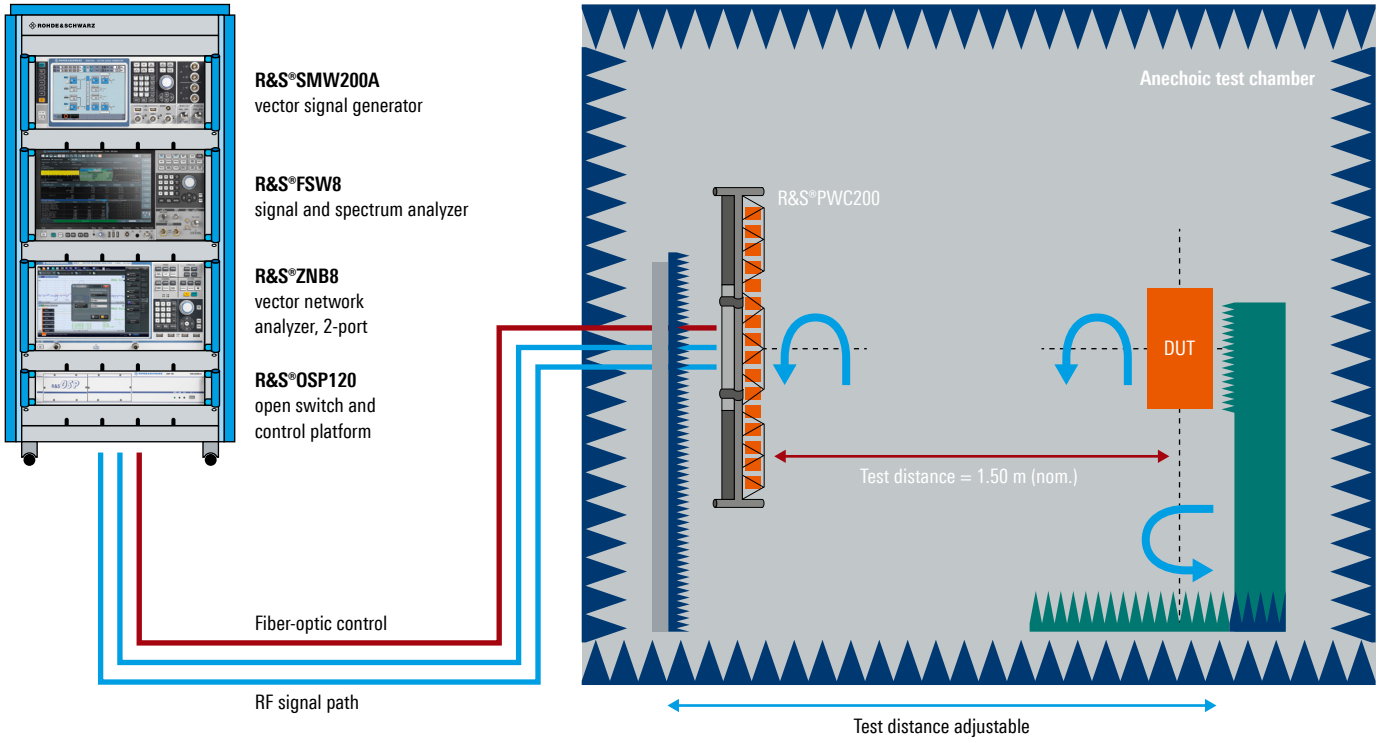
High precision with a reduced test footprint – the R&S®PWC200

The R&S®PWC200 plane wave converter is tailored for FR1 OTA base station testing, and in the 1.7 GHz to 5 GHz range with a quiet zone size of up to 1.35 m, in a compact chamber measuring at least 5.8 m × 3.6 m × 3.7 m (W × H × D).

Recognized as an official method for 3GPP BS radiated conformance testing (TR 37.941), it boasts high power handling capability, linear measurements and a dynamic range to 105 dB. RF self-test capability and extensive 3GPP conformance test case coverage further enhance its utility. Compared to compact antenna test ranges (CATR systems), the R&S®PWC200 offers reduced system size, similar or better quiet zone uniformity and large test case coverage.

A typical test setup as shown below includes the R&S®PWC200, a high precision positioner for the DUT, an anechoic chamber and a system rack with the R&S®SMW200A vector signal generator, the FSW signal and spectrum analyzer, the R&S®ZNB vector network analyzer and the R&S®OSP open switch platform.

Test setup for R&D measurements with a 3D positioner



R&S®PWC200 system setup including measurement equipment

The R&S®PWC200 system software provides several options that support plane wave synthesis with flexible configuration, RF self-test and near-field scanning of the power density radiated by your device under test.

With the powerful R&S®AMS32 performance measurement software, you can automate your test cases, create clearly structured documentation of results and control the complete system.

AUTOMOTIVE RADAR TESTING

Radar is a key enabler for autonomous driving, advanced driver-assistance systems (ADAS) and safety-critical features such as emergency braking. The radar module and its chipset must comply with relevant regulations and fulfill the performance requirements of sensor and car manufacturers, which is why sensor calibration plays an important role in radar development and production.

R&S®ATS1500C antenna test chamber for automotive radar

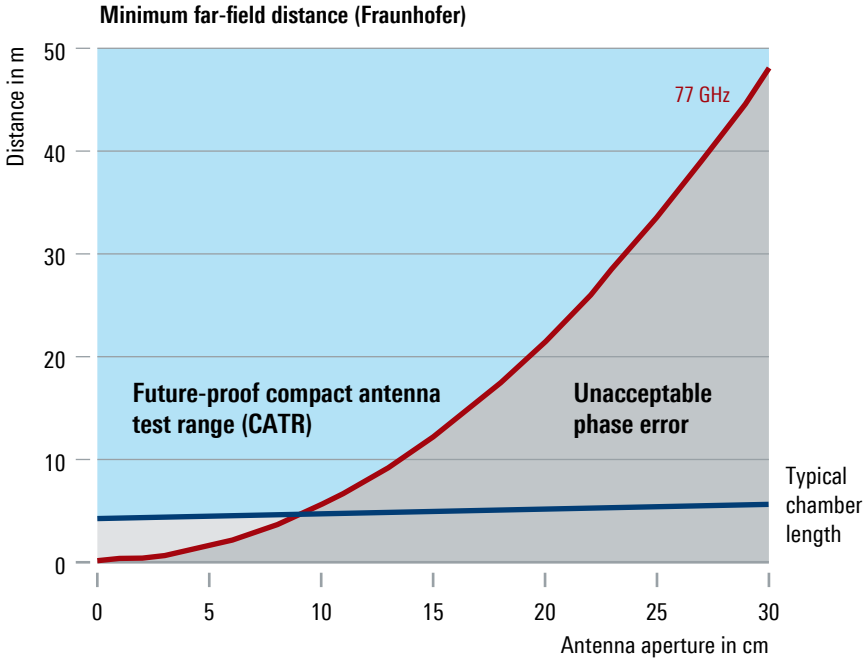
The trend towards higher angular resolution and improved object classification capabilities comes with an increasing number of channels and antenna apertures. Accurate EIRP is a key parameter for characterizing radar sensor RF performance, and far-field measurements with a plane radar wave are needed. The Fraunhofer formula defines the minimum distance between the radar and the feed antenna in a direct coupling setup. 4D imaging radars may require distances of more than 10 m. The R&S®ATS1500C CATR chamber with a parabolic reflector transforms spherical radar waves into plane waves and generates a quiet zone with far-field conditions, all in a very small footprint.

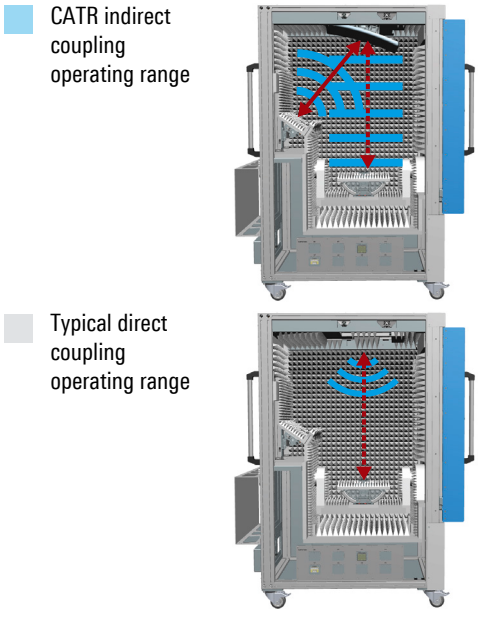
The optimized absorber layout of the R&S®ATS1500C minimizes unwanted reflections and provides an anechoic environment for the calibration of the most sensitive radar sensors.

An optional enclosure for extreme temperature tests covers the complete automotive radar module temperature range from –40 °C to +85 °C and helps reduce test time.

R&S®ATS1500C including R&S®ARC-TEMP option

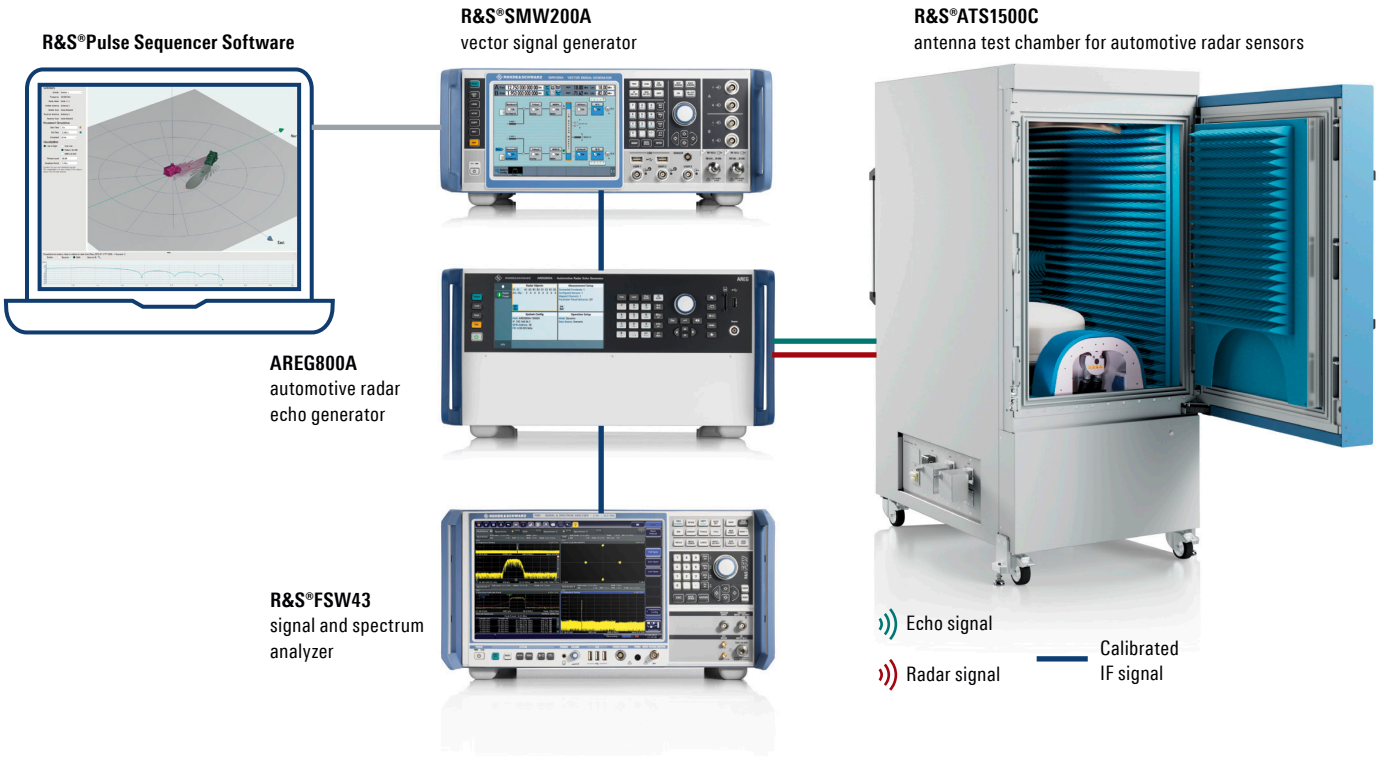
Minimum measuring distance required for far-field conditions





Complete solution for automotive radar and antenna testing

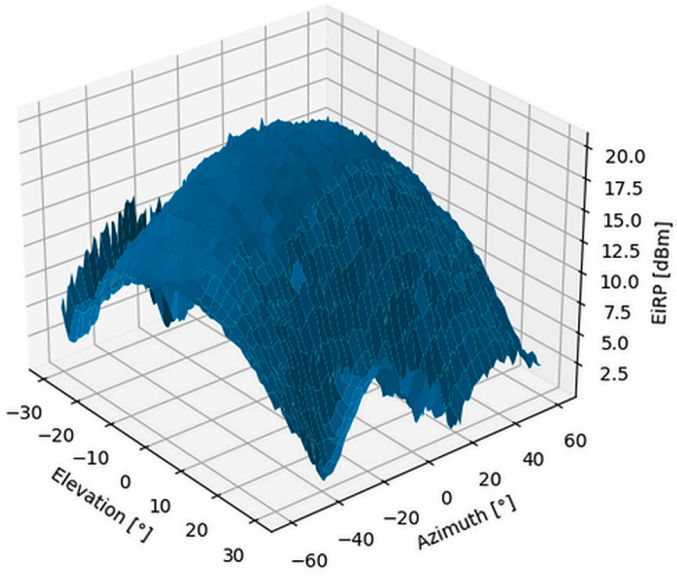
The AREG800A radar target simulator is connected to the antenna feed in the R&S®ATS1500C and does the IF down/ upconversion. It generates accurate reference targets at variable distance, radial velocity and radar cross section down to the airgap and provides calibrated IF paths.



Robustness against interference becomes more and more important for radar manufacturers. The R&S®SMW200A vector signal generator with the R&S®Pulse Sequencer Software can generate complex modulated waveforms or replay captured signals to superimpose on the generated targets.

With the R&S®FSW43 signal and spectrum analyzer, you can analyze the transmitter output in the frequency domain, do FMCW chirp analysis and capture modulated signals.

Fast and accurate EIRP measurements can be done with the R&S®NRP8S power sensor. With the high-precision tilt/ tilt positioner in the R&S®ATS1500C chamber, 3D antenna pattern plots can be captured at high measurement speed.



Example of a radar antenna pattern

OTA FULL VEHICLE TESTING

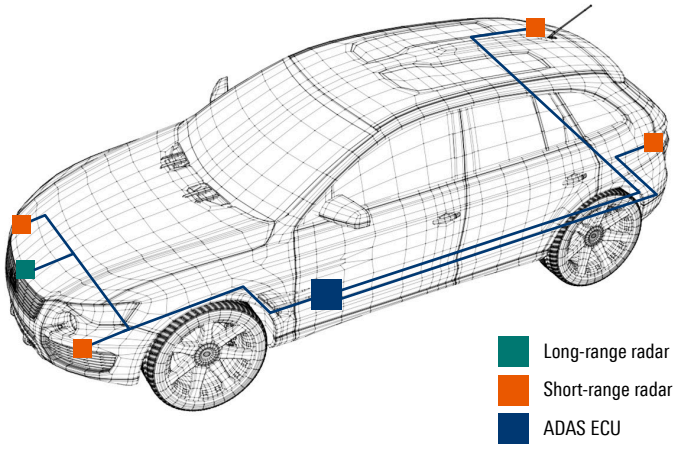
Today's vehicles feature a multitude of antennas for different technologies. Placed at various locations inside and outside the vehicle, these high-performance antennas enable connectivity for features such as satellite navigation (GNSS), Wi-Fi, UWB (remote keyless entry) and cellular services (e.g. C-V2X) among many others.

All of these high-performance antennas require full-vehicle antenna testing, not only to ensure their proper positioning, reduce wiring and save costs but also to ensure optimal radiation patterns and reduce electromagnetic interference (EMI).

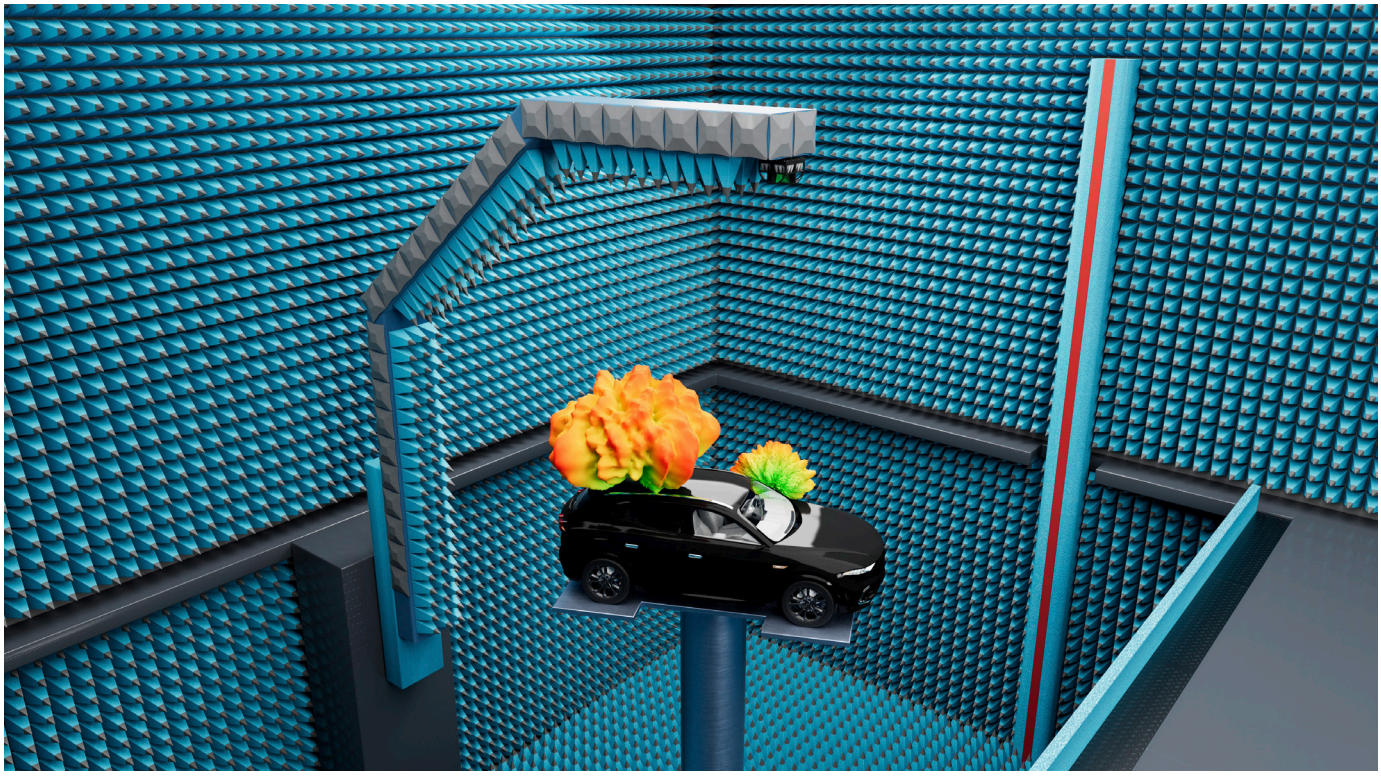
The shape of the vehicle, its surrounding materials, high speed data buses and the RF environment influence the antenna and overall system performance.

Therefore, passive and active antenna transmit and receive characteristics such as directivity, gain, efficiency, EIRP, sensitivity and TRP must be measured over the air in the controlled RF environment of an anechoic chamber. This ensures accuracy, repeatability and compliance to regulatory standards.

Typical radar sensors and electronic control unit (ECU) for advanced driver assistance systems (ADAS) integrated into a vehicle



Fully anechoic OTA antenna test chamber for testing and verifying antenna modules integrated into a vehicle

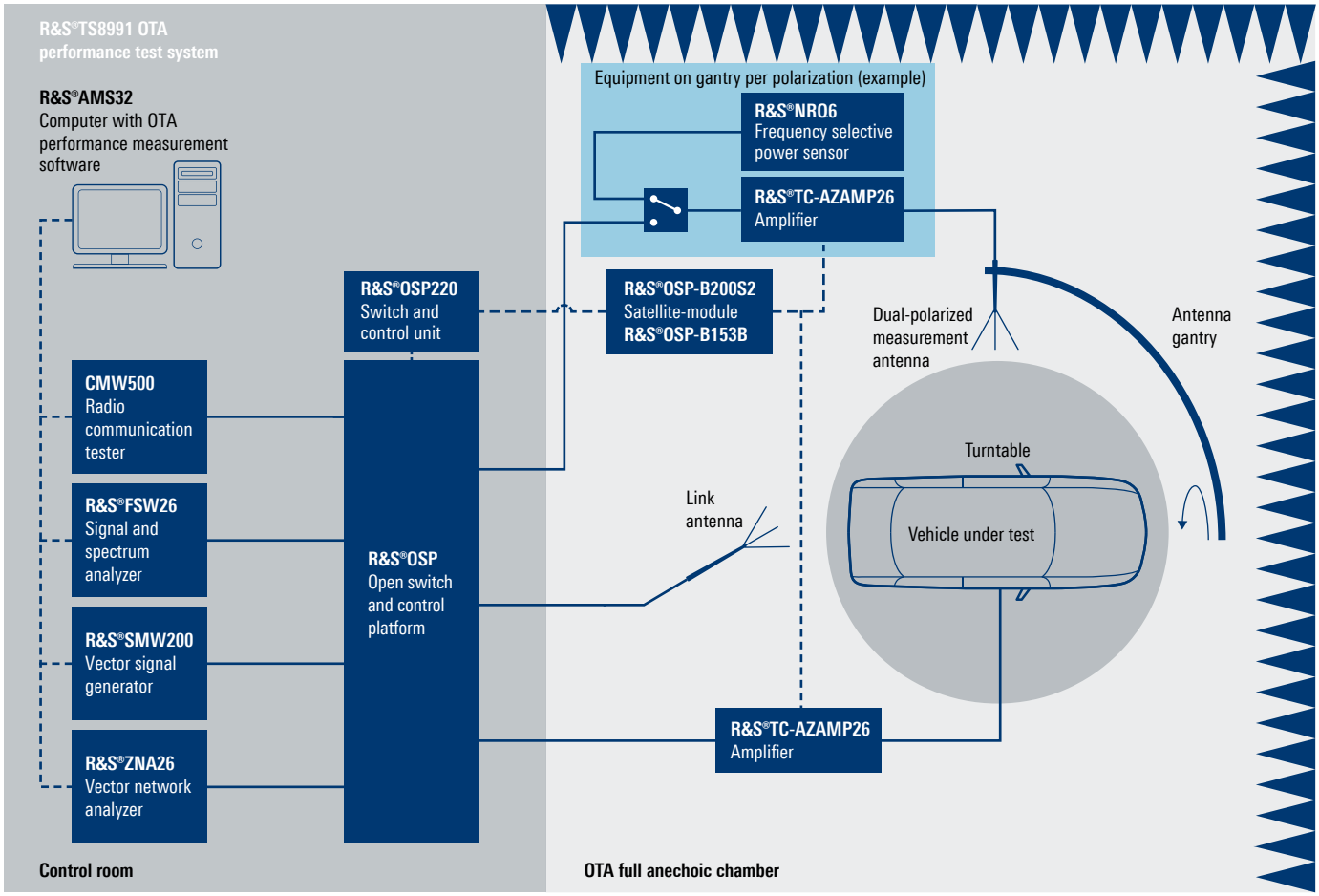


Customized solutions from Rohde&Schwarz for OTA full vehicle testing

Rohde&Schwarz full vehicle OTA antenna test solutions are based on our flexible R&S®TS8991 test system combined with a fully anechoic chamber, a turntable, vehicle lift and a single probe antenna gantry. A single probe test system is used because it delivers higher measurement accuracy, faster calibration times and finer angular resolution than a multiprobe system. It is also much easier to upgrade to higher frequencies, which ensures a truly future-proof and cost-efficient solution. Chamber, turntable and gantry size can vary depending on your specific needs.

The control room next to the chamber houses system racks equipped with typical measurement instruments such as the R&S®ZNA vector network analyzer, R&S®SMW200A vector signal generator, FSW signal and spectrum analyzer and the CMW radio communication tester. Our R&S®AMS32 performance measurement software on a standard PC controls the complete system and acquires a full 3D antenna characterization of the vehicle's antennas. The integrated FIAFTA code will do the near-field to far-field transformation where needed. Parallel to your ongoing measurements, you can visualize the results and create all necessary test reports.

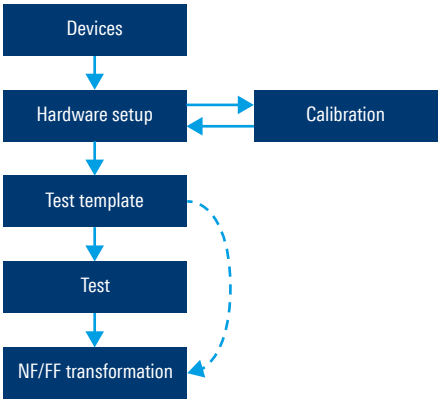
Schematic view of a fully customized R&S®TS8991 OTA performance test system with anechoic chamber, control room and measuring system.

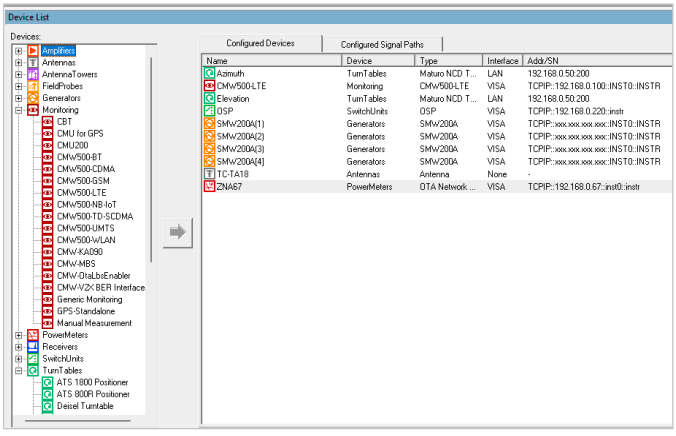


The Rohde&Schwarz presence spans over 70 countries worldwide, ensuring that we deliver customized solutions encompassing design, setup, training and calibration. Our regional specialists in sales and service are dedicated to delivering the system perfectly adapted to your needs and supporting you with fast maintenance and repair services as needed.

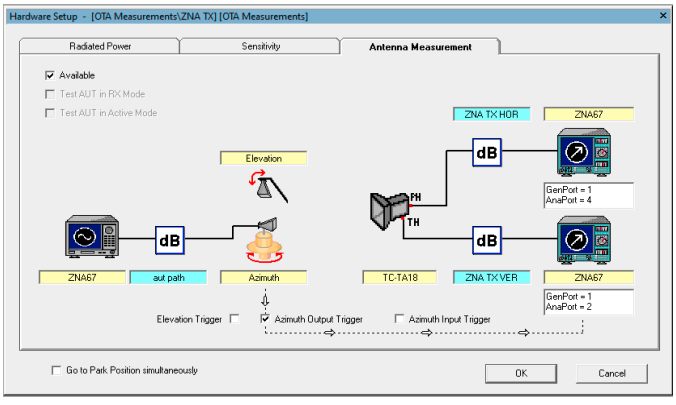
R&S®AMS32 SYSTEM SOFTWARE

Workflow of an OTA measurement





Example of devices controlled by R&S®AMS32



Example hardware setup

Universal system software for all OTA and antenna related measurements

R&S®AMS32 OTA performance measurement software is the universal system software for all the above mentioned OTA systems. It handles the complete workflow (see figure on the left), starting from the control of all Rohde&Schwarz measurement instruments (devices) used in the system. But it also includes positioning systems and other system components. The screenshot on the center-left shows an excerpt of supported devices.

Individual hardware setups (see screenshot bottom left) can be defined for various measurement tasks such as classical VNA based antenna measurements and TX/RX over-the-air UE testing in line with CTIA OTA test plans. Supported technologies range from 2G to 4G as well as Bluetooth®, Wi-Fi, A-GNSS and NB-IoT.

The software also calibrates each individual hardware setup. This includes pathloss data based purely on magnitude values as well as phase-critical channel balance calibrations required for antenna measurements in the near-field followed by a transformation to far-field data.

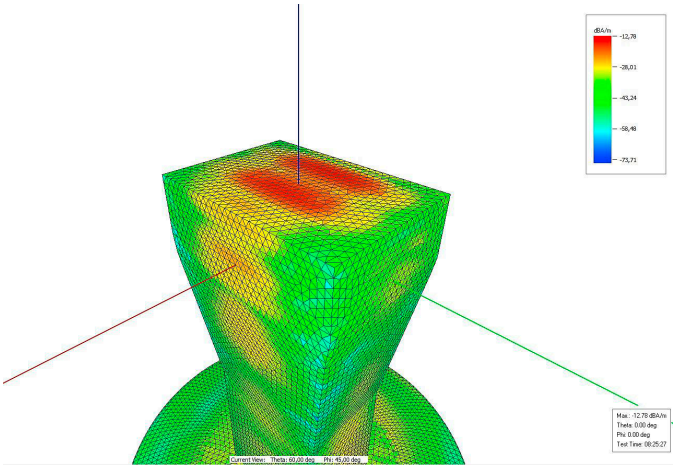
Defined parameters for dedicated measurements are stored in test templates to ensure reproducible results for a series of devices under test. The software also estimates the duration of measurements based on the relevant parameters with a focus on optimizing test time. One way it does this is by using triggered measurements of a continuously moving turntable.

Unique near-field (NF) to far-field (FF) transformation algorithms

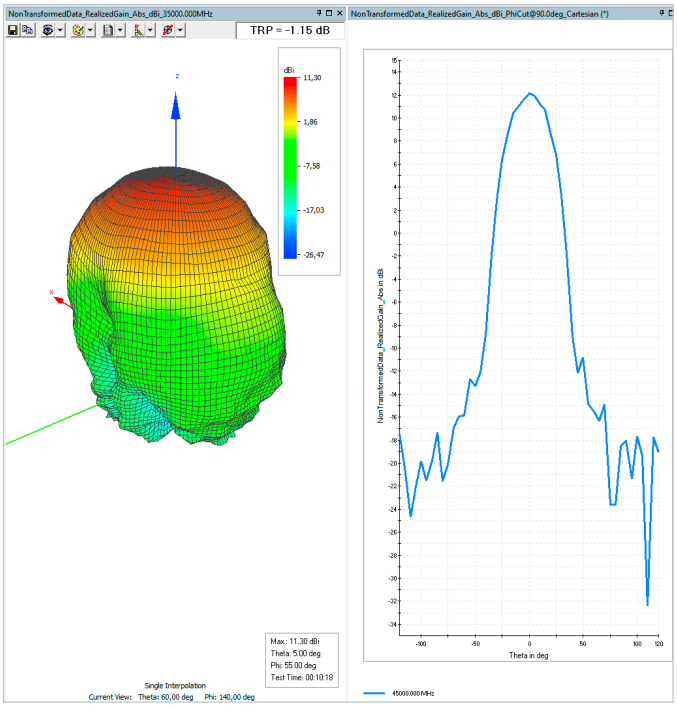
When an antenna aperture size exceeds far-field conditions for a given measurement setup, the measurement can be performed in the radiating near-field to acquire far-field data based on a transformation. To do this, it is necessary to capture magnitude and phase data of two orthogonal polarization planes. This procedure can be performed using R&S®AMS32. The software contains algorithms based on spherical wave expansion (SWE) and on the very powerful fast irregular antenna field transformation algorithm (FIAFTA) developed by the Technical University of Munich, Germany.

Apart from far-field parameters like directivity or realized gain, the software can also calculate and visualize electric and magnetic surface currents on a predefined volume. A typical application for this feature is antenna troubleshooting (see screenshot on the right).

The visualization shows 3D radiation patterns as well as 2D cuts in cartesian or polar coordinate systems. Other post-processing features include 3D rotation, offset correction and phase center calculation. Data can also be exported to external tool formats such as CST Microwave studio or TICRA (.cut).



Surface current visualization on a standard gain horn



3D and 2D radiation pattern visualization

ACCESSORIES

Rohde&Schwarz has a wide range of chambers that
the requirements, many accessories are needed. Feed

Feedthroughs

Feedthroughs are used to run cables into a shielded environment such as an RF shielded box or an OTA chamber to maintain shielding effectiveness for a given environment and prevent RF radiation from leaking into or out of the chamber. Various types of feedthroughs are available for running and supporting infrastructure inside the chamber. Some enable an exchange of RF signals; others are communications feedthroughs for remote control or for the DUT power supply.

The size and shape of most Rohde&Schwarz feedthroughs are standardized and can be reused in the following Rohde&Schwarz chambers and shielded boxes:

- R&S®WPTC wireless performance test chambers R&S®TC-WAPAN wall access panel
- R&S®ATS1000 antenna test system
- R&S®CMQ200 shielding cube
- R&S®CMQ500 shielding cube
- R&S®ATS800R CATR based compact 5G NR mmWave test chamber, model .03
- R&S®ATS1800C 3GPP compliant OTA chamber for 5G NR mmWave signals, model .02
- R&S®ATS1800C 3GPP compliant OTA chamber for 5G NR mmWave signals, model .03
- R&S®ATS1800M multiple angle of arrival extension to R&S®ATS1800C, model .03
- R&S®ATS1500C antenna test chamber for automotive radar sensors
- R&S®TS7124 RF shielded box, model .12
- R&S®TS7124 RF shielded box, model .02

For more information, see the Feedthroughs | For Rohde&Schwarz RF shielded boxes and OTA chambers flyer (PD 3683.8609.32) or www.rohde-schwarz.com

operate in various frequency ranges and test DUTs with diverse interfaces. To meet dthroughs and antennas very important here.

Test antennas and probes

Test antennas connected to the test instruments perform TX and RX measurements in OTA systems and cover a very wide frequency range so that a single antenna can measure at different frequencies.

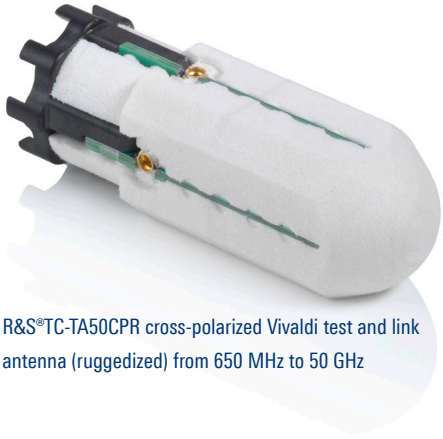
Dual-polarized test antennas are preferable when measuring 3D radiation patterns since they can be used to simultaneously measure both horizontal and vertical field components with a four-port vector network analyzer.

R&S®TS-F24-V3 cross-polarized Vivaldi antenna from 1.7 GHz to 18 GHz

Link/communications antennas

Link/communications antennas establish stable communications links to a DUT. The antennas are usually arranged closely to the DUT. Link/communications antennas are commonly used in base station simulations on the signaling level to guide uplink/downlink signals in a cellular system.

Link/communications antennas should be installed on a rotating positioner together with the DUT. The link antenna and DUT move in sync with the positioner, helping prevent level variations from irregular/scattered radiation patterns with deep nulls.

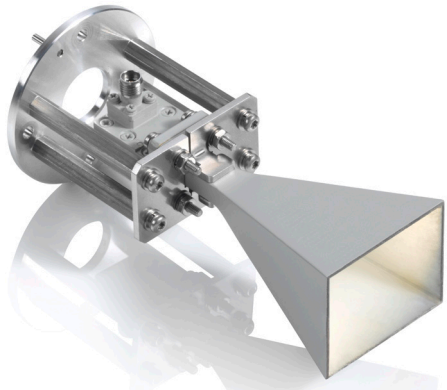


R&S®TC-TA50CPR cross-polarized Vivaldi test and link antenna (ruggedized) from 650 MHz to 50 GHz

Reference or calibration antennas

Calibration antennas are used as the reference to measure the path loss in a test setup. The antennas are installed in place of the DUT to determine the RF path loss along the entire RF chain in the OTA test system.

For more information, see the Antenna overview for Rohde&Schwarz OTA test systems flyer (PD 3608.2136.32) or www.rohde-schwarz.com



R&S®TC-SGH40 standard gain horn from 26.5 GHz to 40 GHz

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