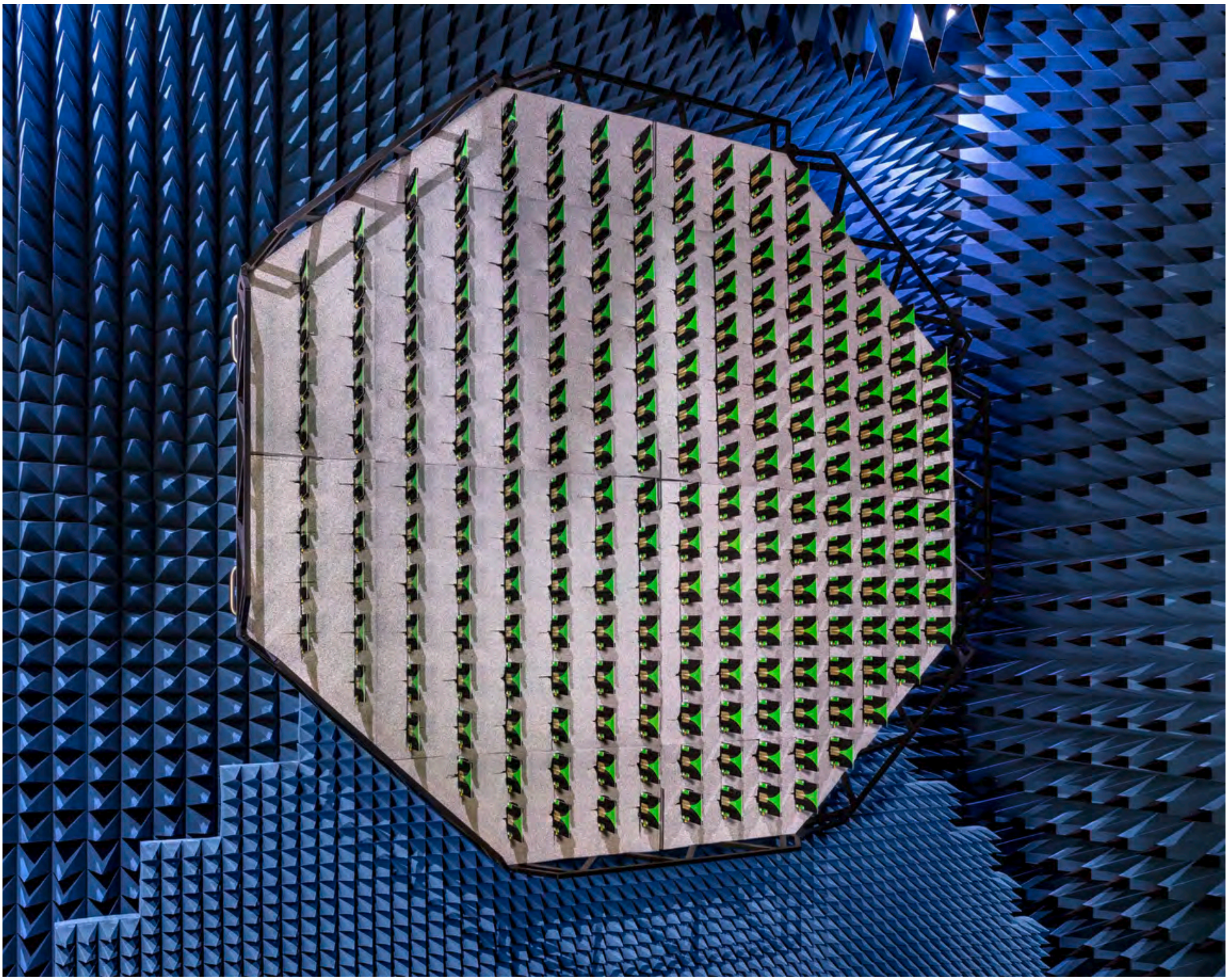
Плосковолновой генератор для испытательных систем PWC200



AT A GLANCE

The R&S®PWC200 plane wave converter is a unique design for 5G massive MIMO base station testing solutions in R&D, quality assurance and production as well as conformance testing over the air (OTA). It is based on a bidirectional array of 156 wideband Vivaldi antennas placed in the radiating near field (NF) of the device under test (DUT). The phased antenna array can form planar waves inside a specified quiet zone encompassing the 5G massive MIMO base station DUT for real-time radiated power and transceiver measurements (EVM, ACLR, SEM, etc.).

5G FR1 OTA testing

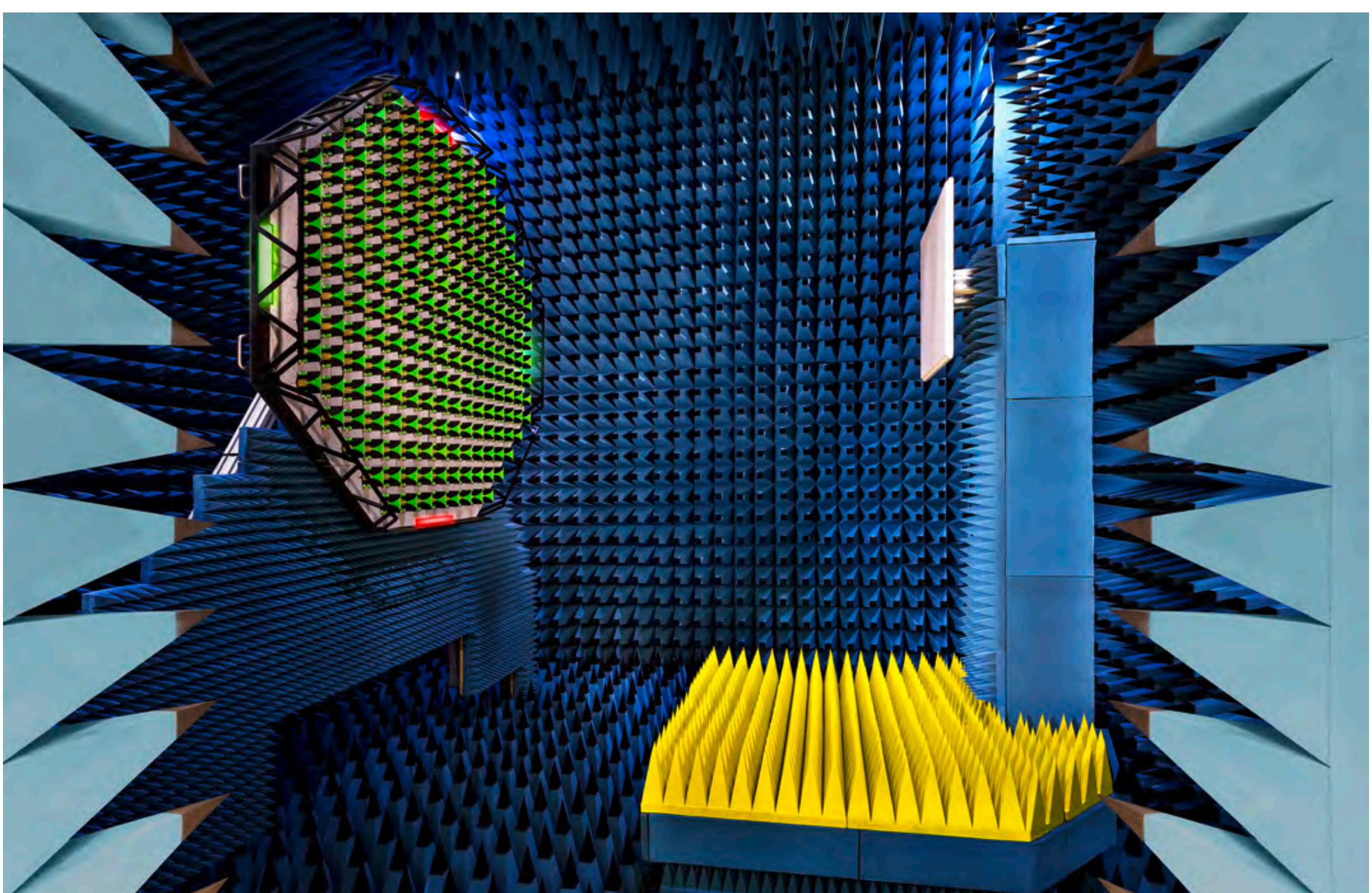
The first 5G deployments were in the FR1 frequency range. Up until recently, cable connections were used for TX and RX base station measurements. However, for 5G, a new generation of base stations will use massive antenna arrays to achieve both higher capacity and higher energy efficiency. Each antenna will contain an RF transceiver with amplifiers, switches, downconverters, upconverters, etc. This new base station architecture with over 64 RF ports requires a novel OTA measurement paradigm to measure traditional antenna parameters.

Base station measurements with far-field (FF) characterization

The key application of the R&S®PWC200 is to measure large DUTs, including base stations, passive antennas and antenna arrays. The active antenna array enables bidirectional conversion of arbitrary RF signals from a single coaxial mode into a plane wave, and vice versa. This conversion allows FF characterization of the DUT at an NF distance. These innovative field synthesis concepts implemented in the R&S®PWC200 are protected by patents[1].

1) Protected by a patent family including the patents US9606158 and US10573974.

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



KEY FACTS

- Phased antenna array to form plane waves within an adjustable quiet zone (e.g. 1 m diameter)
- No near-field to far-field transformation required
- Requires four times less space than CATR based systems
- Built-in self-test features
- For R&D and production testing
- Ideal for 5G massive MIMO base station testing solutions
  - Research and development
  - Quality assurance
  - Production testing
  - Conformance testing
  - OTA testing of large DUTs

BENEFITS

Small test setup footprint thanks to innovative design
▶ page 4

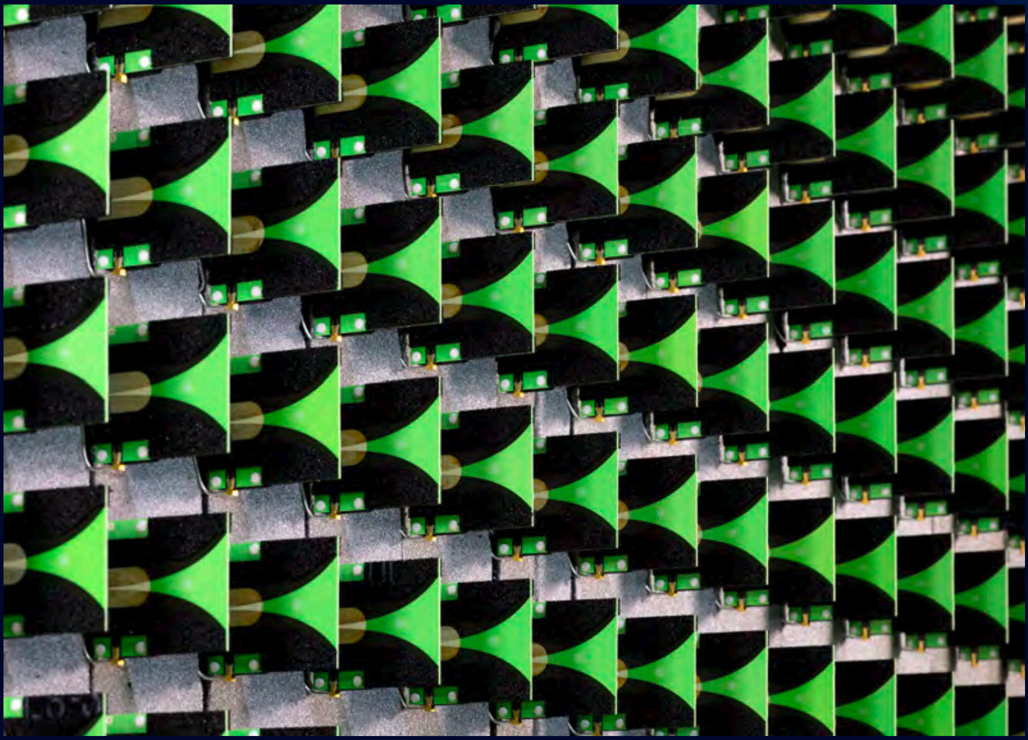
Reliable performance verification
▶ page 5

Powerful system software for easy handling
▶ page 6

Scalable test setups
▶ page 7

Straightforward realization of measurement sequences
▶ page 8

Detail of the R&S®PWC200



SMALL TEST SETUP FOOTPRINT THANKS TO INNOVATIVE DESIGN

has developed a broad portfolio for OTA testing, with solutions based on compact antenna test range (CATR) technology that feature a reflective mirror to provide far-field conditions in a near-field range. The unique R&S®PWC200 has opened up new application areas and use cases. Based on plane wave synthesis (PWS) technology, the converter offers exclusive advantages.

Design of the R&S®PWC200

The patented Vivaldi antennas of the R&S®PWC200 are placed in the DUT's radiating near field. Each antenna includes a phase shifter and attenuator path, allowing arbitrary synthesis of the electromagnetic field directly in front of the array in the spherical quiet zone enclosing the DUT. All signal paths are combined to a single port that can be connected to T&M equipment such as an oscilloscope, power meter, vector network analyzer, signal generator or signal analyzer.

The R&S®PWC200 is a highly linear field transducer with very low intermodulation products, even for the very high radiating power densities expected to be generated by high-power 5G base stations. An R&S®OSP120 open switch and control platform controls the settings of phase shifters and attenuators for each set of measured frequencies and can automate various self-test and monitoring functions.

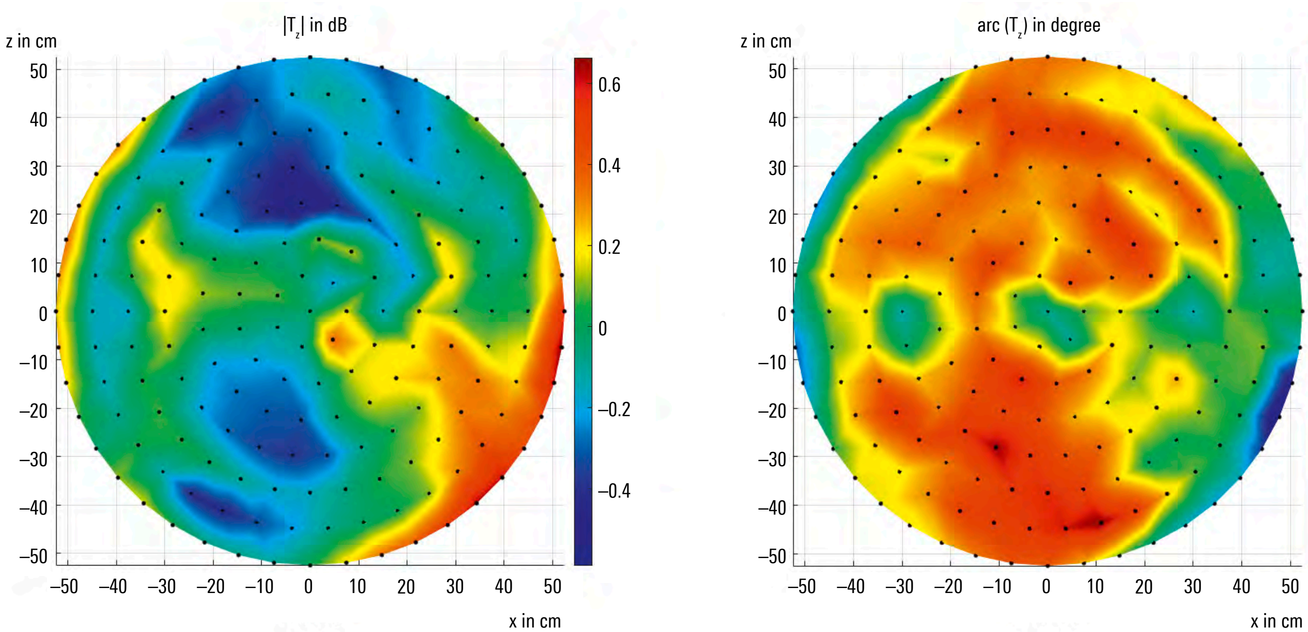
With a height of 1.72 m, the R&S®PWC200 generates a 3D spherical quiet zone at a test distance of 1.5 m. This results in an extremely compact test system design for both R&D and production setups. In comparison, CATR based solutions, which are commonly used for far-field measurements, include a larger reflector and require at least four times more space to install the anechoic chamber.

Motionless near-field scanning

The R&S®PWC200 is also capable of motionless near-field scanning of DUT radiation over a planar observation surface. Featuring very fast electronic switching, the R&S®PWC200 antennas can be used as calibrated field probes, supported by the R&S®PWC-K80 option.

R&S®PWC200 radiated field distribution

Magnitude (left) and phase (right) of the R&S®PWC200 radiated field (or transfer) distribution at 3600 MHz in low-power (LP) mode within a quiet zone of 1.00 m

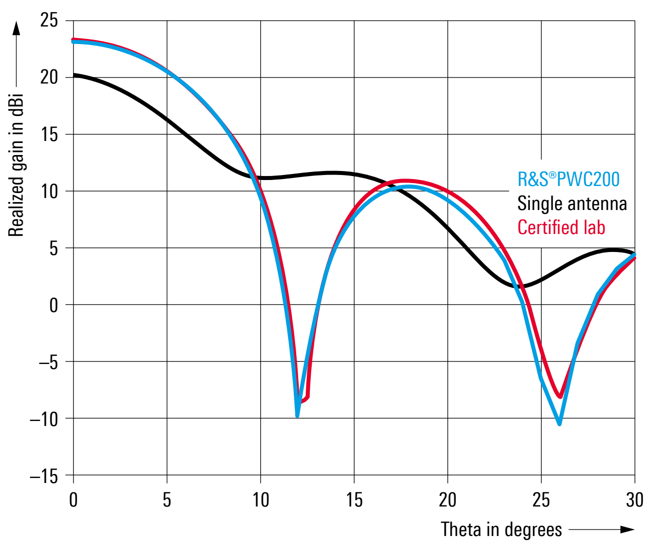


RELIABLE PERFORMANCE VERIFICATION

Verification of the theory and simulation results has consistently shown excellent correlation of radiated power measurements performed with the R&S®PWC200 to reference measurements carried out by a certified laboratory.

First, a high-gain passive antenna array with dimensions of 60 cm × 60 cm was measured in a certified antenna chamber to provide far-field results. The DUT dimensions correspond to a far-field distance of around 12 m at 2.4 GHz.

Radiated power measurement verification

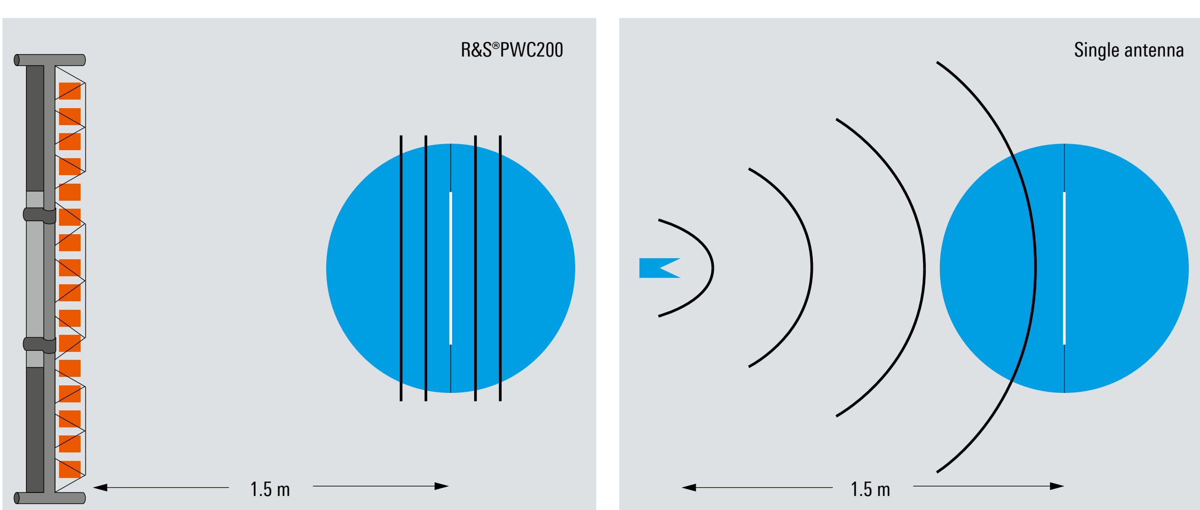


The verification of the antenna gain with the R&S®PWC200 was performed in the DUT's radiated near field at a distance of 1.5 m. The realized gain, sidelobe level and location of nulls show excellent agreement.

Second, the R&S®PWC200 was replaced by a single Vivaldi measurement antenna in the same test setup, creating spherical waves. As expected, the test results show the effect of insufficient far-field distance for the given reference DUT. Especially nulls of the radiation pattern cannot be determined correctly.

Many test campaigns have been conducted with base station manufactures and a test house with massive MIMO BS samples. The results showed an excellent correlation of both the radiation pattern and equivalent isotropically radiated power (EIRP) transmit power, compared to measurements within a CATR.

Phase fronts of electric field radiated by R&S®PWC200 compared to single test antenna



POWERFUL SYSTEM SOFTWARE FOR EASY HANDLING

The R&S®PWC200 system software is complemented by the R&S®AMS32 performance measurement software. Together they offer versatile calibration and measurement functions.

R&S®PWC200 system software

The R&S®PWC200 system software enables the solution's hardware to be configured to suit your measurement task. 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 DUT.

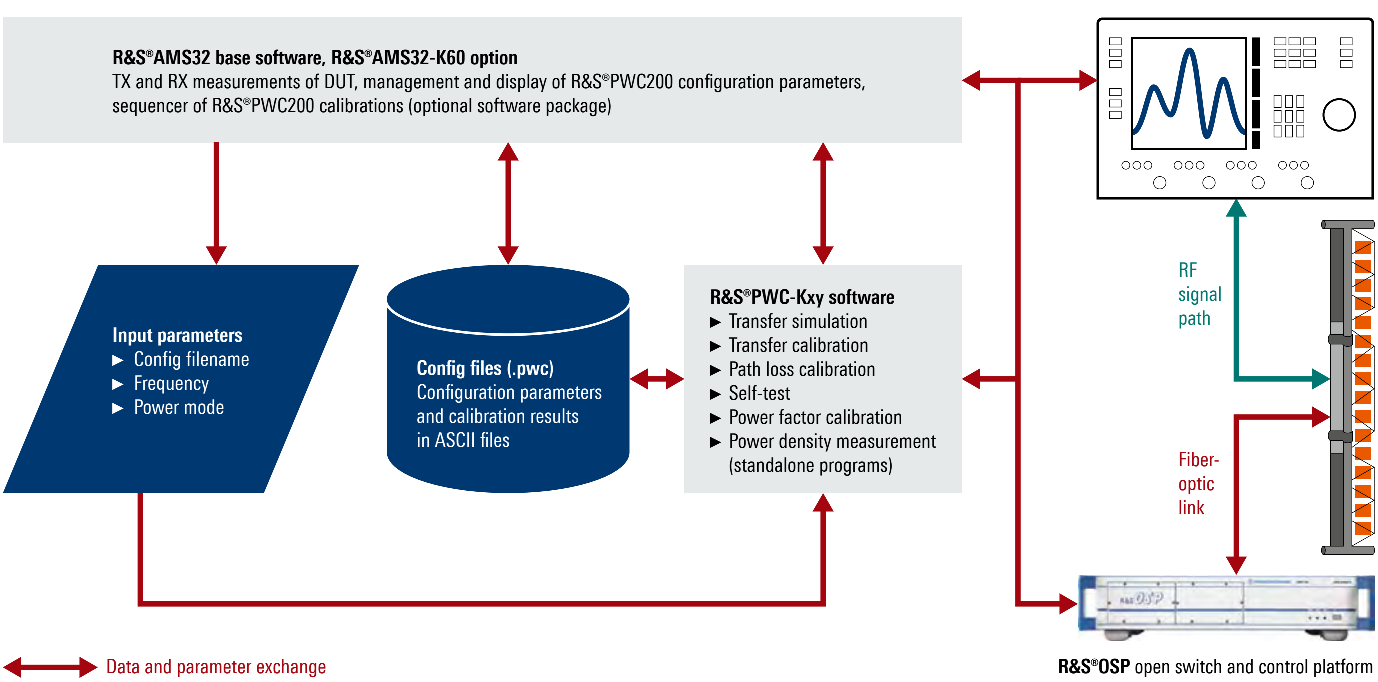
R&S®AMS32 performance measurement software

The powerful R&S®AMS32 performance measurement software can automate radiated characterization of your DUT using the R&S®PWC200 as a programmable measurement antenna. The R&S®AMS32 software controls the test instruments, defines the test setup, generates test templates and creates a clearly structured result documentation.

The test templates can be easily configured for various test parameter settings such as frequency range, measurement bandwidth, pattern step size and more.

2D or 3D measurements can be acquired quickly with hardware triggered measurements provided by the positioner for the base station – both for network analyzers and vector signal analyzers.

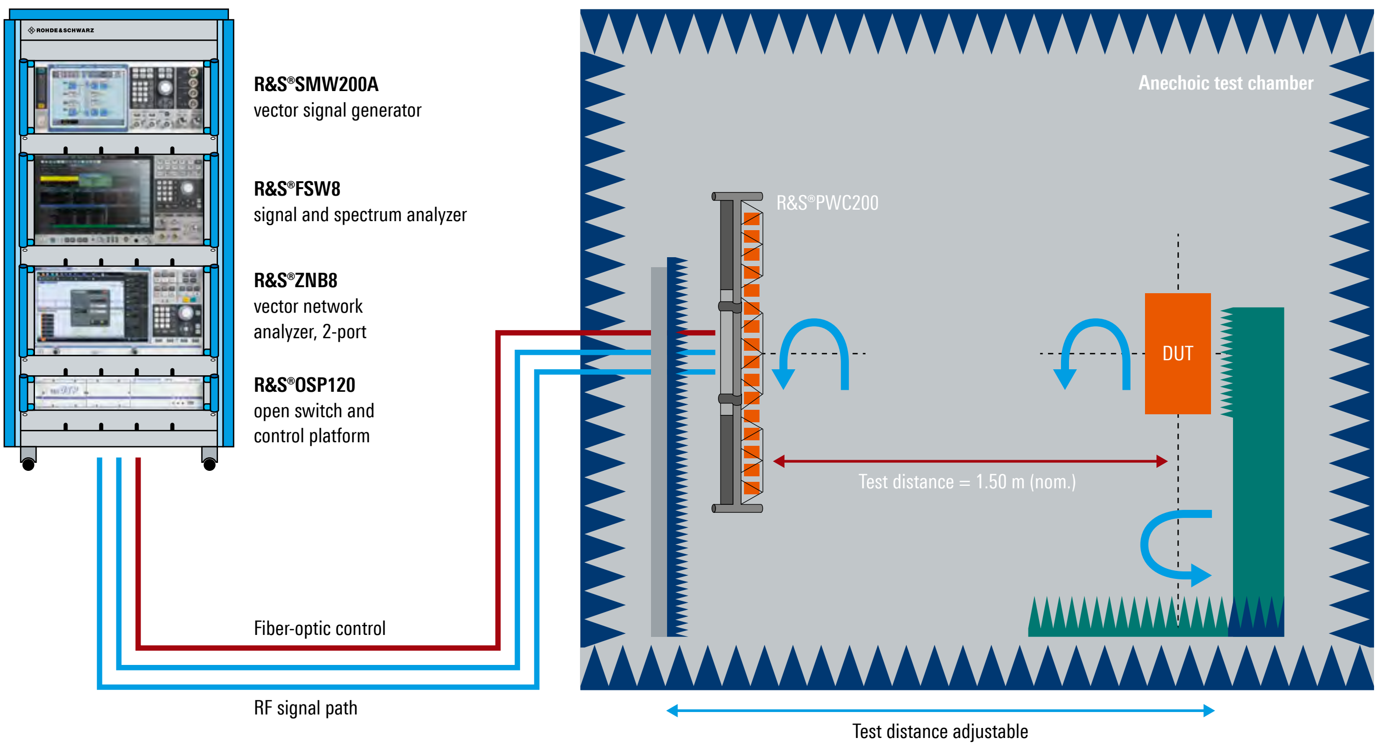
R&S®PWC200 system software architecture



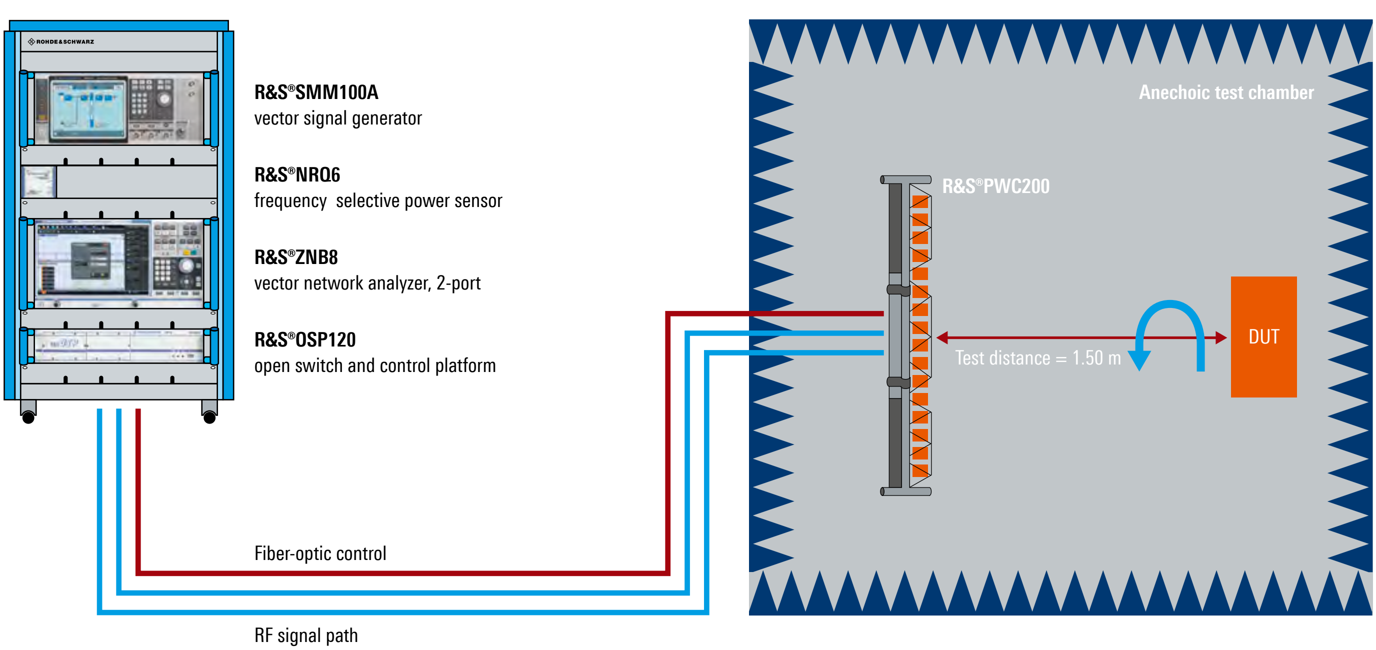
SCALABLE TEST SETUPS

R&S®PWC200 test setups can be easily tailored to dedicated applications.

TEST SETUP FOR R&D MEASUREMENTS WITH A 3D POSITIONER



TEST SETUP FOR PRODUCTION MEASUREMENTS



STRAIGHTFORWARD REALIZATION OF MEASUREMENT SEQUENCES

Various software tools simplify the creation of test campaigns for base station measurements. The different software options build on each other. They all have the same transparent data set that defines key parameters such as the frequency range or quiet zone size.

Accurate plane wave synthesis

A plane wave calibration campaign starts with defining and optimizing the required quiet zone (QZ) configuration of the R&S®PWC200 using the R&S®PWC-K10 simulation software application. In the next step, static settings of the attenuators and phase shifter of the R&S®PWC200 are found using the R&S®PWC-K50 transfer calibration application. Basic parameters such as test distance, QZ diameter, frequency and low-power/high-power mode are user-defined. The R&S®PWC-K70 self-test program enables optional verification of the unimpaired state of the R&S®PWC200. Additionally, you can use self-test results to monitor the RF integrity of your R&S®PWC200 antenna and compensate potential RF drifts.

The R&S®PWC-K80 power factor calibration and power density measurement software applications enable the planar distribution of the power density radiated by your DUT to be measured and incident on a set of antenna elements in the antenna array of the R&S®PWC200. This allows the R&S®PWC200 to quickly characterize the radiation of your DUT at near-field distance with an absolute power density.

The software creates a transparent data set for each execution of a PWC application. This file provides details on the iterative steps during execution.

Fast, motionless near-field scanning

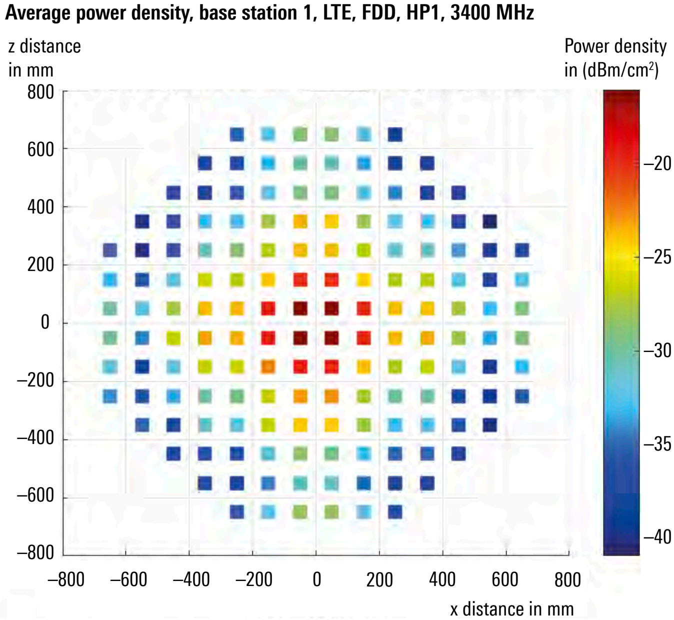
Production test setups are designed with a fixed adaptation of the base station and without 3D positioners. Once the phase calibration has been performed for various frequency bands, verification will ensure a zero-defect production process.

Together with the R&S®PWC-K80 software option, the 156 Vivaldi antennas serve as a power density scanner. The radiated power of a perpendicular beam will be sequentially scanned with each R&S®PWC200 antenna element.

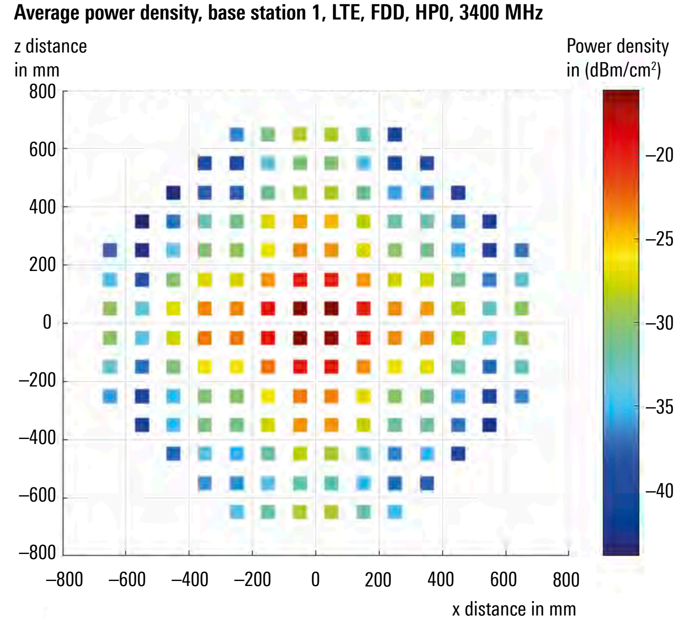
From the measurement results, the R&S®PWC-K80 generates a numerical output and 2D graphical illustration of this power density distribution. The beam tilting functionality of the BS can be verified in small angular ranges of around ±20°, depending on the test distance.

Power density measurement of a perpendicular radiated beam in FDD mode

Average power density, base station 1, LTE, FDD, HP1, 3400 MHz



Average power density, base station 1, LTE, FDD, HP0, 3400 MHz



Software modules

The software options of the R&S®PWC200 provide versatile tools for field simulation, calibration, self-test and base station measurements

Designation	Description
R&S®AMS32-K60	Base software for handling R&S®PWC200 settings and measurements in R&S®AMS32
R&S®PWC-K10	► Determination of complex weighting for the R&S®PWC200 antenna array ► Simulation of requested target field in quiet zone (frequency, test distance, quiet zone diameter) ► Output (graphical and numerical) of achieved target vector field in quiet zone
R&S®PWC-K20	Frequency extension for the R&S®PWC200, 1.7 GHz to 5.0 GHz
R&S®PWC-K50	► Determination of actual phase shifter/attenuator settings for the R&S®PWC200 antenna array ► Determination of path loss ► Output (graphical and numerical) of the calibrated vector field in a quiet zone
R&S®PWC-K51	► Discretization compensation for the R&S®PWC200 antenna array ► Enhanced accuracy of the calibrated vector field
R&S®PWC-K70	► Self-test and verification for the R&S®PWC200 antenna array ► Required for RF drift compensation of the R&S®PWC200
R&S®PWC-K80	► Enables linear high-power measurements ► Calibration of the R&S®PWC200 as a planar near-field scanner ► Planar scanning of the power density radiated by the DUT

Approved for 3GPP conformance testing

The R&S®PWC200 is also suitable for conformance testing, since TR 37.843 and TR 37.941, the main 3GPP standards for base station conformance tests have been extended to include alternative PWS based setups.

As a commercial realization of PWS technology, the R&S®PWC200 can achieve far-field testing conditions in a quiet zone that are comparable to CATR based solutions.

Since it enables direct measurements of far-field BS performance in a controlled anechoic test chamber environment, the R&S®PWC200 can be seen as an alternative solution to CATR.

The commercial testing laboratory Verkotan Oy had been validated by the Finnish Accreditation Service (FINAS) for the first 3GPP TS 38.141-2 test cases using the R&S®PWC200.

Test case overview of 3GPP TS 38.141-2 base station conformance testing, part 2: radiated conformance testing

Section	Test case	R&S®PWC200 applicability
Transmitter tests		
6.2	Radiated transmit power	•
6.3	OTA base station output power	•
6.4.3	OTA total power dynamic range	•
6.5.1	OTA transmitter OFF power	–
6.5.2	OTA transmitter transient period	–
6.6.2	OTA frequency error	•
6.6.3	OTA modulation quality	•
6.6.4	OTA time alignment error	•
6.7.2	OTA occupied bandwidth	•
6.7.3	OTA adjacent channel leakage power ratio (ACLR)	•
Receiver tests		
7.2	OTA sensitivity	•
7.3	OTA reference sensitivity level	•
7.4	OTA dynamic range	•
7.5.1	OTA adjacent channel selectivity	•
7.5.2	OTA in-band blocking (general)	•
7.5.2	OTA in-band blocking (narrowband)	•
7.8	OTA receiver intermodulation	•
7.9	OTA in-channel selectivity	•

R&S®PWC200 MEASUREMENTS

Parameter	Base station type	Measurement/evaluation
Gain, directivity, efficiency, vector radiation pattern, cross-polarization	passive	specific passive antenna features
Transmitter characteristics		
Radiation pattern	active	3D pattern and 2D cuts, directivity, sidelobes and nulls, half-power beamwidth
EIRP, TRP	active	TX test, equivalent isotropic radiated power, power density
EVM	active	modulation quality, error vector magnitude
ACLR	active	transmit linearity test
SEM, OBUE	active	spectrum emission mask, operating band unwanted emissions
Receiver characteristics		
EIS pattern, TRS	active	3D pattern and 2D cuts of equivalent isotropic sensitivity; total radiated sensitivity
OTA dynamic range, ACS, blocking and ICS, intermodulation	active	BS sensitivity in the presence of interfering signals, adjacent channel selectivity (ACS), in-channel selectivity (ICS)
Throughput, BER	active	performance test

SPECIFICATIONS IN BRIEF

Specifications in brief		
Frequency range	basic	2.3 GHz to 3.8 GHz
	extended	1.7 GHz to 5.0 GHz
Quiet zone size	variable, spherical, depends on test distance	up to 1.35 m in diameter
Polarization		single linear
Incident power density	average	< 17 dBm/cm² (or more in overrange mode)
Third-order intermodulation distortion	two-tone, total power density < 17 dBm/cm²	< –77 dBc (meas.)
RF connector		2 × N(f)
Control connector		fiber optic
Dimensions	W × H × D	172 cm × 172 cm × 28 cm (67.7 in × 67.7 in × 11.0 in)
Weight		approx. 80 kg (176 lb)