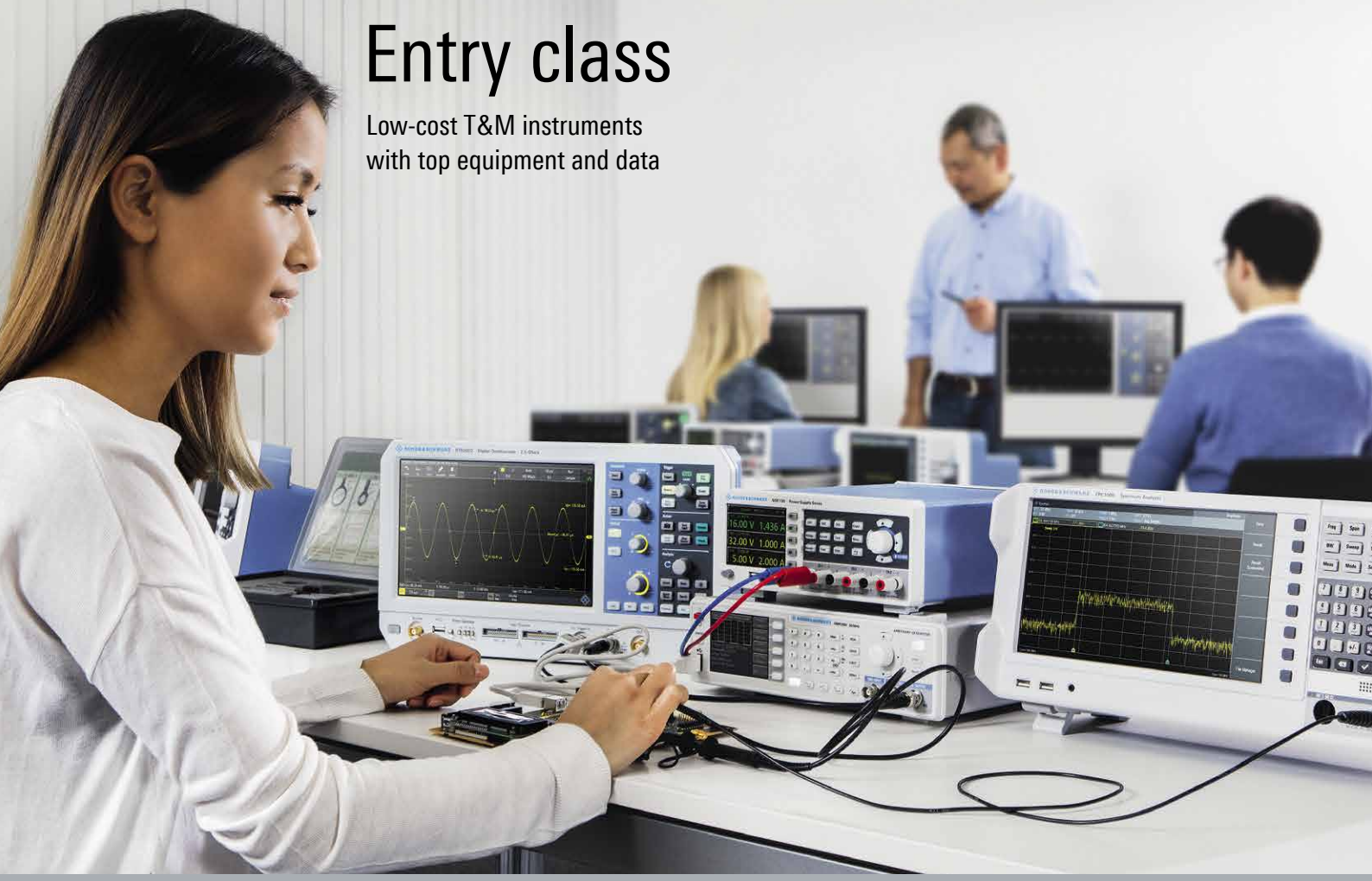
NEWS

217/17

ROHDE&SCHWARZ

Entry class

Low-cost T&M instruments
with top equipment and data



Automotive

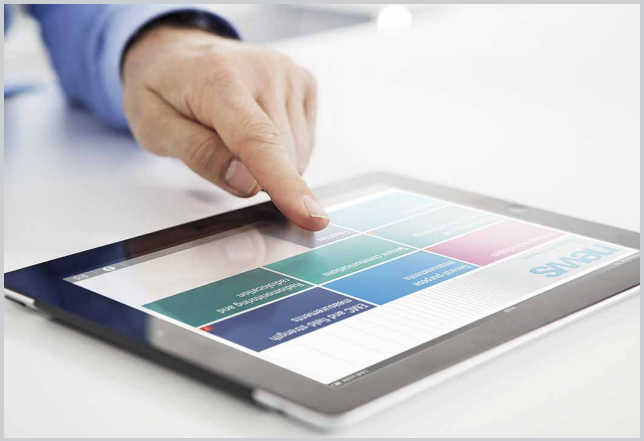
T&M solution for RKE locking systems that use ultrawideband technology

General purpose

Oscilloscope probes for fast signal integrity and DC rail measurements

Cybersecurity

Secure IT solutions protect police forces' mobile devices and workstation PCs



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Besides the texts in the current print edition, all articles published in the last three years, sorted by topic, are accessible in seconds. The content is enriched by videos. Graphical signs mark which new articles have appeared since the app was last opened, guiding you selectively to the innovations.

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NEWS

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Cover feature

At first glance, tradition and innovation may sound like a contradiction in terms. But like many other seemingly mismatched pairs – nature and technology, or time and space, for example – on closer inspection they can exist in perfect harmony. A case in point: Rohde&Schwarz. For more than 80 years, the company has been a forward-looking producer of leading-edge technology. However, it has always honored its cultural assets and remained aware of its roots. This comes quite naturally, without having to perform a balancing act. Fearlessly tackling technical challenges and overcoming them with solutions that are warmly embraced by the market is deeply ingrained in the company's DNA. This time, though, the self-imposed task was somewhat unusual, but no less challenging. The Executive Board presented the developers with a simple demand: "Show the market that Rohde&Schwarz can produce low-cost solutions, too!" After all, for many measurement tasks in everyday laboratory operations, relatively simple instruments will do the job. To appeal to customers, however, the instruments must be positioned within a narrow price range. There were two other requirements: as always, the technical quality must set standards, and the instruments have to be manufactured at a profit in the company's own plants. These plants are located in Germany and the Czech Republic, and not in low-wage countries like those of our competitors. No sooner said than done. The result can be admired in triplicate in this issue. Kicking off a new generation of Value Instruments aimed at establishing Rohde&Schwarz in the entry level class of T&M instruments are an oscilloscope, a spectrum analyzer and a power supply. The groundwork has also been done at the sales end. Many distributors around the world have added the new instruments to their portfolio. Of course, they are also available directly from the manufacturer. To learn what makes these models stand out – apart from the unaccustomed price tag – see the articles starting on page 46.

Overview

NEWS 217/17

Find out what technology is behind the new 802.11ax WLAN standard and how it helps networks handle the increasing density of users, e.g. at airports (page 24).

New probes expand the measurement capabilities of the R&S®RTO and R&S®RTE oscilloscopes (page 32 and page 39).

On-wafer measurements at 300 GHz with MPI probers and the R&S®ZVA network analyzer (page 58).

Pay TV provider Sky Deutschland uses Rohde&Schwarz technology for UHD transmissions (page 66).

Cost-efficient cable and antenna tester for field use

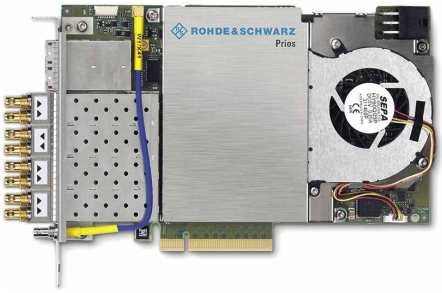
Anyone paying attention in an urban area won't have to wait long to see the next base station or other types of cellular equipment. With so much of this equipment in use, installers and operators alike are searching for efficient and cost-effective tools for installation and maintenance in an effort to keep their infrastructure service costs down. The newly available R&S®Cable Rider ZPH meets all of these T&M needs. The R&S®Cable Rider is a one-port analyzer that offers all of the test functions a service technician needs to check the functioning of an antenna system. The return loss and VSWR measurements identify faulty connections and defective cables, and the distance-to-fault measurement indicates their location. The cable loss measurement and the optional power measurement are used to assess whether sufficient transmit power is available at the antenna. Actual working conditions were considered in order to make these measurements as fast and simple as possible. For example, the analyzer boots up in just 15 seconds and then remains operational for up to nine hours. A measurement wizard automates the test sequences and eliminates human errors. The capacitive touchscreen with gesture control provides a highly usable display of results. Other advantages include best-in-class measurement speed, factory calibration over the entire operating temperature range and optional upgrades via keycodes.

New power meter generation now up to 30 W

Rohde&Schwarz continues the renewal of its range of power sensors with the new R&S®NRP18S-xx high-power three-path diode power sensors for USB operation. Based on the R&S®NRP18S up to 18 GHz, these models have flanged attenuators that make it possible to directly measure power average values of CW and modulated signals up to 2 W, 15 W and 30 W. The new sensors offer improved, market-leading measurement speed, accuracy and sensitivity as well as video bandwidth as compared to the already very good predecessor models. For example, up to 10000 triggered measurements per second are possible in continuous average mode. Other available test modes include burst average, trace, timeslot and time gate, providing an appropriate operating mode for just about every signal waveform. In burst average mode, for example, the sensor automatically detects the start and end of a burst and measures only within this timespan. Like all sensors in the R&S®NRP family, the new high-power models are also extremely contact-friendly. They can be operated directly on the PC, on the R&S®NRP2 display and control unit or on various test instruments.

Test solutions for communications satellites – both on the ground and in orbit

About 1700 active satellites orbit the globe, half of which are commercial communications satellites, and the number is increasing. Because repairs cannot be made in space, development and construction times are long and the investments enormous, meticulous testing is performed during each phase of construction, in particular of the communications payload, in order to eliminate expensive surprises after launch and to ensure that operational performance objectives are met. Tests are performed on the individual components and subsystems as well as the complete communications system, both separately and integrated, in the lab and under real-use conditions (vibration and vacuum testing), and finally fully constructed on board the launch vehicle. Proof of functionality and performance must be supplied, both in orbit and before starting up regular operation; these are also obtained via the appropriate measurements. Rohde&Schwarz has developed a series of model solutions for testing of communications satellites. One unique measurement, for example, is the measurement of group delay and phase linearity on satellites in orbit. Interested? You can find the application notes on www.rohde-schwarz.com under search term 1MA223 for measurements before launch and under search term 1MA263 for measurements on satellites in orbit.



Video board with SDI and video over IP on a single card

The R&S®Prios SDI is a PCIe video card for OEM customers who develop and market their own digital video or digital film products and require an appropriate interface board. The card offers operating modes for simultaneous recording and playback over up to eight independent HD channels or two 4K/UHD channels (each up to 1080p60 or 4K/UHDp60). The necessary SDI interfaces are provided by SFP+ plug-in modules, each with two ports. The card can hold four of these plug-in modules. Their cages can also accept 10G Ethernet network modules, making the R&S®Prios SDI ready to support future video-over-IP standards. The combination of SDI and IP enables applications that link conventional video technology with state-of-the-art IP technology using only a single interface board. For example, multiple SDI cameras can be connected directly to the board. The outstanding performance of the boards makes them especially suited to live applications. The signals can then be sent via a network to centralized recording equipment or to remote editing stations. The support of video over IP in line with SMPTE 2022 is planned for the 2nd quarter of 2017, and additional protocols are also planned. An SDK is available for R&S®Prios SDI product integration that includes drivers and libraries for Windows and Linux along with documentation and sample programs.

R&S®PRISMON brings broadcast monitoring to the cloud

Broadcasters and streaming providers must always keep an eye on the signal quality they bring to their viewers. Poor video quality and major problems like dropped audio must be immediately identified and rectified. This is managed by A/V monitoring systems that decode all conventional signal standards for broadcast and media and that are able to process several programs simultaneously and display them along with their quality information. Until recently these systems used to be designed as dedicated instruments with specialized hardware, but like in so many other fields, the trend is now toward software-only solutions. A major driver behind this development is the rapid evolution in the field of IP-based media transmission protocols. Software implementation is the most economical way for products to keep up with this trend. The new R&S®PRISMON family lets the user decide: those requiring a hardware platform can select from several levels of COTS servers based on power and interface configuration. The R&S®PRISMON software can also be installed on a cloud server, as it is not dependent on broadcast-specific transport streams but rather processes IP-encapsulated data. Analysis packets are available for a variety of applications, including monitoring in playout centers, DVB transmission routes and OTT/streaming services.

Test system for 5G antennas

The future 5G wireless standard will unify a number of technologies, applications and user equipment under one roof in order to cover a wide frequency spectrum. High-performance applications, which require a large bandwidth, are being considered for frequencies into the millimeterwave range. At the same time, existing WAN/WLAN/WPAN/IoT technologies that operate in the RF and lower microwave range should integrate seamlessly into the 5G landscape. As a result test requirements for antennas used in wireless components vary widely. The new R&S®ATS1000 antenna test system is designed to handle this. Whether beamforming, near-field or far-field measurement, base station antennas, 5G user equipment or IoT wearables, during development, production or type testing – the R&S®ATS1000 can be configured to handle any OTA antenna test task between 700 MHz and 90 GHz. It performs passive (amplitude and phase) and active (TRP, EiRP, TIS, EiS, EVM) measurements quickly and accurately. The housing dimensions (e.g. 1.4 m × 1.8 m × 1.0 m [W × H × D]) and interior fittings are variable. The R&S®AMS32 software application provides system control and processes the readings.

Key technology

Remote keyless entry has been a standard feature in even lower-end passenger cars for a while. New models are increasingly equipped with locking systems where proximity is sufficient to enable the car to be started, allowing the key to remain in the driver's pocket. The technology for these wireless systems is also changing. The use of ultrawideband (UWB) technology is on the rise. No matter what technology a manufacturer uses, a new test system can handle them all.

Cars are no longer a technically simple means of transportation consisting of a body, interior, chassis, engine and transmission; those days are long gone. Aside from the fact that electromobility is revolutionizing propulsion, electrical and electronic components that provide comfort and safety already find themselves in every nook and cranny of our cars. For the industry's vision of autonomous driving to become a reality, vehicles must reach beyond their own boundaries and learn how to "see". This will be accomplished through highly-developed sensor technology and constant wireless contact with the car's surroundings, whether with other traffic participants or the infrastructure. This will allow the car to always know what is beyond the next curve or at the next intersection and respond proactively. The result will be a significant increase in road safety.

A challenge with this scenario, however, is data security. The wirelessly networked car offers a potential gateway for hackers. Demo hacks such as the famous "Jeep hack" of 2015 have proven that this danger is not just something plucked out of the air. An insufficiently secured mobile wireless access in a Jeep Grand Cherokee allowed external intervention into elementary vehicle functions such as steering and braking. Short-range wireless services such as Wi-Fi and Bluetooth® open up other paths for attack. While these generally require an "alert" car with an activated infotainment system, another wireless interface is idly waiting to be addressed when the ignition is switched off: the keyless entry system, which is either realized as a remote keyless entry (RKE) solution where the driver triggers a wireless command on the key or, increasingly, as a passive entry/passive start (PEPS) system where it suffices to have the key in your pocket.

Interestingly, the first RKE in a mass-produced vehicle was not in a high-end model, but rather in the 1982 Renault Fuego. But it was only in the early 1990s that this technology made its way into other manufacturers' vehicles. In the first RKE models, a short-range wireless transmitter with a range of five to ten meters sent an unencrypted open or close command to the car's receiver – in North America normally at 315 MHz, in Europe and Asia at 433.92 MHz. The signal reception was acknowledged visually via the indicator lights or acoustically via the horn.

Car thieves could either block a close command with a jammer so that the car remained open or record the control signals and send them again once the vehicle's owner had left. Naturally, this weak point did not remain concealed for long, resulting in the systems being cryptographically enhanced. But even state-of-the-art systems are not immune

Fig. 1: Typical test system configuration. Customized variants are possible.

to break-ins. PEPS systems have already been cracked by setting up a wireless bridge consisting of two transceivers between the car and the remote key; this duped the car into thinking that the key was nearby (relay attack). In other cases, the encryption proved to be insufficient or poorly implemented.

However, it is not just criminal activities that can put conventional RKEs in distress. Sometimes the cause of a failure is not easy to explain. There was a case in North America where a shopping center's flawed RFID system sent a signal into its surroundings that blocked the RKEs of parked vehicles. This misery was likely not eliminated in just five minutes …

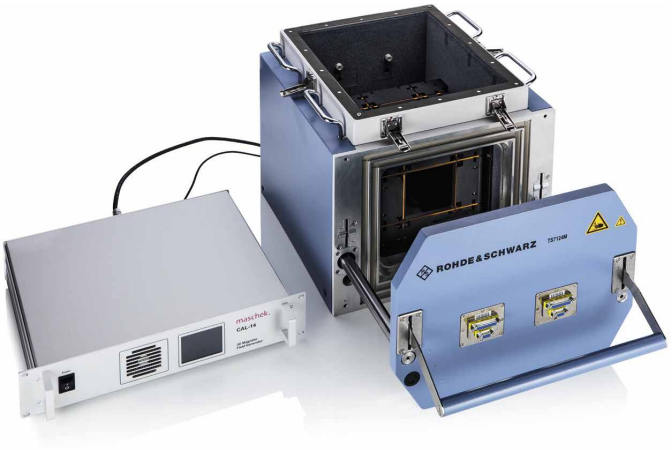


Fig. 3: R&S®TS7124 shielded box with test setup for magnetic field sensors.

UWB solves several problems

Until recently, a mix of wireless technologies was used for RKE and PEPS systems: LF (e.g. 125 kHz) as a beacon signal to wake up the components, UHF (e.g. 433 MHz) for encrypted communications, and a magnetic compass system in the vehicle interior (e.g. 21 kHz) for testing whether the key is inside or outside. Since these systems have proven vulnerable, the trend is toward a solution with a single wireless standard in the UWB frequency range from 3.1 GHz to 10.6 GHz in which various bands have been reserved.

UWB is a general designation for very short, pulsed low-energy signals that use a wide bandwidth of more than 500 MHz. The reciprocal relationship between time and bandwidth is the main reason for selecting this technology, since a wide bandwidth results in short-duration signals. This, in turn, is desirable for several reasons. First of all, for pulse durations in the nanosecond range no reflections are superimposed on the original signal, which guarantees that the signal is unambiguous. Secondly, pulse propagation time and the transmitter distance can be accurately determined, so that the time-consuming magnetic field measurement for the positioning of the key is no longer required. The fact that UWB wireless technology operates with very low transmission power – slightly above the noise floor – extends battery life, prevents jamming of other wireless transmissions and limits the range, which makes it more difficult for hackers to intercept the signal.

As pronounced as the advantages of UWB are, the regulators' specifications with respect to the concrete implementation are just as strict. In order to ensure that there is as little

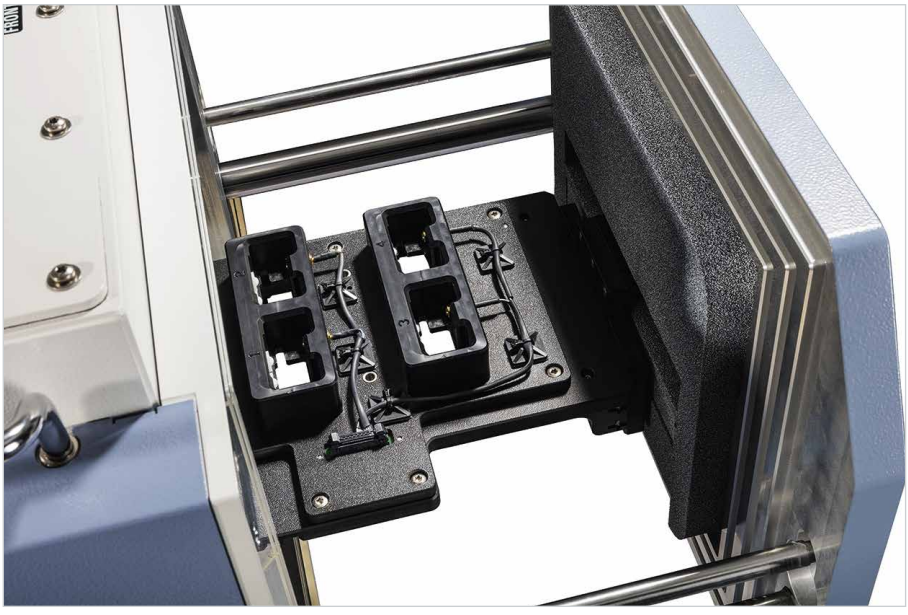


Fig. 2: Test fixture for four DUTs. Fixtures for up to eight DUTs are available.

Schematic setup of the RKE test solution

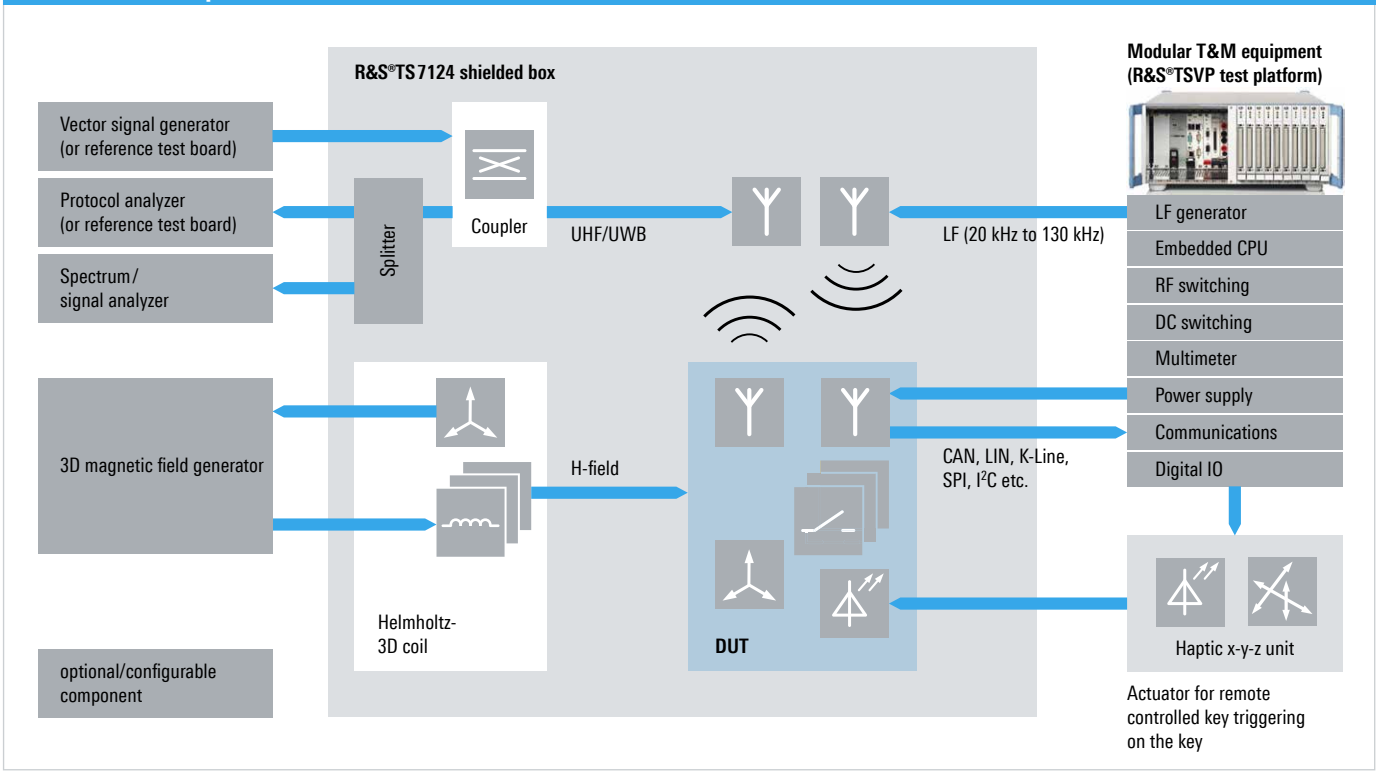


Fig. 4: System setup with different options.

interference with the spectrum as possible, for example, the FCC limits the spectral power density to –43 dBm per MHz of bandwidth (by comparison: mobile devices transmit with up to +30 dBm per MHz). As a result, T&M equipment is required that reliably evaluates a signal that is approximately 1 GHz wide with levels far below –45 dBm.

One solution for all common technologies

Even if UWB is the fashionable technology for future RKE and PEPS systems, there are still many vehicle models on the market with mixed wireless solutions. This means that a component test system should have the flexibility to support all of the technologies used. Rohde&Schwarz has developed such a solution (Fig. 1).

The R&S®TS7124 shielded box functions as a test environment that can be fitted with application-specific test fixtures (Fig. 2) and antenna systems, for example also with a test setup for magnetic field sensors (Helmholtz coil, Fig. 3). The box is available with a manual or pneumatic opening in order to fulfill requirements in the development lab as well as in production.

Spectrum analyzers, for example the production-optimized R&S®FPS, analyze the transmit signal in the frequency and time domain. Here, the occupied bandwidth and the channel and adjacent channel power are of interest. Distance measurements between two UWB DUTs can be realized via programmable signal delays.

The technological "heart" of the system is the R&S®TSVP PXI-based test platform, which accommodates the control computer, power supply as well as the interface (LIN, CAN, I²C, SPI) and test modules (generators, analyzers, multimeters, switching matrices, etc.). Typically, the DUT current drain in the various operating modes is analyzed at the same time as the transmission bursts.

It is either the remote keyless entry or the associated on-board units that are being tested. The respective remote station for the DUT can optionally be integrated into the test setup as a reference test board ("golden device") or simulated using test instruments such as a protocol analyzer and vector signal generator. R&S®Quickstep, the powerful and easy-to-operate test sequencer, handles the design and the workflow control of the test program.

The system can be flexibly configured to customer requirements (Fig. 4) – from an equipped shielded box with the R&S®TSVP PXI system to a big rack solution with dedicated T&M instruments.

Rob Short; Volker Bach

Automated GNSS performance tests for ERA-Glonass modules

Effective January 1, 2017, all newly registered cars, trucks and buses in Russia and the Eurasian Customs Union must be equipped with the ERA-Glonass automatic emergency call system. In an emergency, an in-vehicle module transmits vehicle position data and other information via a cellular link. A new option for the R&S®SMBV100A vector signal generator now delivers standard-compliant, fully automated tests of the GNSS receiver integrated in the module.

In recent years, both the Russian Federation and the European Union have launched initiatives to introduce automatic in-vehicle emergency call systems with the goal of significantly reducing response times to serious traffic accidents. In an emergency, the system automatically places a call to the nearest public safety answering point (PSAP). Users can also make emergency calls manually. In both cases, the system transmits a standardized minimum set of data (MSD) including information such as the number of passengers and time and place of the accident and establishes a voice connection to the PSAP.

In addition to Russia's ERA-Glonass, a European equivalent emergency call system referred to as eCall will soon be available. The two systems are based on the same architecture, have the same core functionalities, and are harmonized and interoperable (Fig. 1). ERA-Glonass, however, does offer additional functions such as SMS transmission of MSDs in case that no data or voice connection can be established with a PSAP.

System architecture

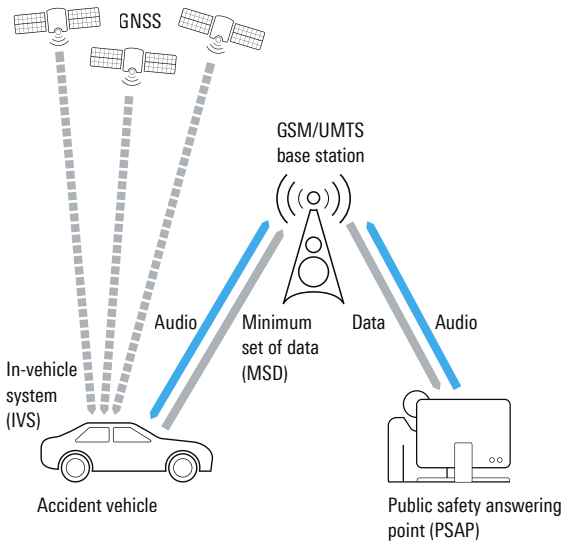


Fig. 1: Architecture of an automated in-vehicle emergency call system. Both ERA-Glonass and eCall are based on this setup.

Certification of ERA-Glonass modules

The in-vehicle system (IVS) is made up of various components including a GNSS receiver to determine the time and place of an accident, a modem with an antenna to send an emergency call, microphones and loudspeakers for voice communications and a push button for manually activating emergency calls. Before an IVS can be used, it must undergo a certification process encompassing diverse standardized tests. The test specifications applicable for ERA-Glonass modules are laid down in the GOST R standards issued by the Federal Technical Regulation and Metrology Agency in Moscow. The tests specified in these standards fall into two main categories, which will be discussed in the following, using a GNSS receiver as an example.

Conformance tests

During these functional tests, a PSAP is simulated and a wireless connection established between the IVS and the PSAP. The information sent from the IVS to the PSAP is decoded and analyzed. A test solution that meets these requirements is already available. The solution is based on an R&S®CMW500 wideband radio communication tester and an R&S®SMBV100A vector signal generator (see NEWS 213/15, page 7) and enables validation and certification of ERA-Glonass modules in line with the GOST R 55530 specification. The tests include evaluation of the GNSS based vehicle position data contained in the MSD. The test in question, however, merely verifies whether position data is present in the MSD. The accuracy of the transmitted position data is determined in separate performance tests.

Performance tests

The GNSS receiver integrated into the ERA-Glonass module evaluates both GPS and Glonass signals to determine the vehicle position. Dedicated GNSS tests and associated pass/fail criteria from the GOST R 55534 and 33471 specifications are used to determine the accuracy of the transmitted position and a number of other performance parameters. The transmitted position must not deviate by more than 15 m from the actual position in 95 % of all cases, and the time to first fix must not exceed 60 s after the GNSS receiver has been switched on. The tests also determine how quickly the GNSS receiver can deliver valid position data following a temporary signal loss (after passing through a tunnel, for example) as well as the receiver's capability to provide position data under difficult reception conditions with very weak satellite signals (e.g. signals blocked by foliage).

T&M requirements

A suitable GNSS simulation environment is required to perform the stipulated tests. Real-world tests are not a viable option since they are difficult to implement, time-consuming, costly and almost impossible to reproduce. The difficulties to reproduce tests are due to navigation satellites being in continuous motion and never presenting the same conditions during two sequential test runs. In addition, certain test requirements (e.g. identical signal strengths for all satellites) are not possible to achieve, and results are distorted by uncontrollable environmental influences and other sources of error such as weather conditions and multipath effects.

These constraints can be avoided by using a GNSS simulator to perform the tests with complete control of all simulation conditions and 100 % reproducibility. However, this approach also involves a number of T&M challenges. For example, the GNSS simulator must be able to generate complex scenarios and allow full control of a multitude of simulation parameters. The large number of tests (GOST R 55534 defines 17 GNSS tests) and the requirement to perform repetitive tests in order to generate statistical information mean that automated tests are needed. And to generate pass/fail information based on diverse criteria, the position data supplied by the receiver must be compared against the simulated target position data. This means that an automated test solution must also be capable of communicating with an ERA-Glonass module and reconfigure it for each new test run in line with the relevant test criteria.

Automated test solution

The R&S®SMBV100A vector signal generator together with the R&S®SMBV-K360 option provides an appropriate solution for automated GNSS tests. The generator is a full-featured GNSS simulator. In addition to GPS and Glonass signals required for ERA-Glonass tests, it also generates Galileo, BeiDou, QZSS and SBAS signals on up to 24 channels. Its versatile and flexible configuration options enable even complex GNSS scenarios to be realized. Both stationary and moving receivers can be easily simulated, as well as ionospheric and tropospheric influences and complex impairments in the receiver's environment (multipath propagation, shadowing,

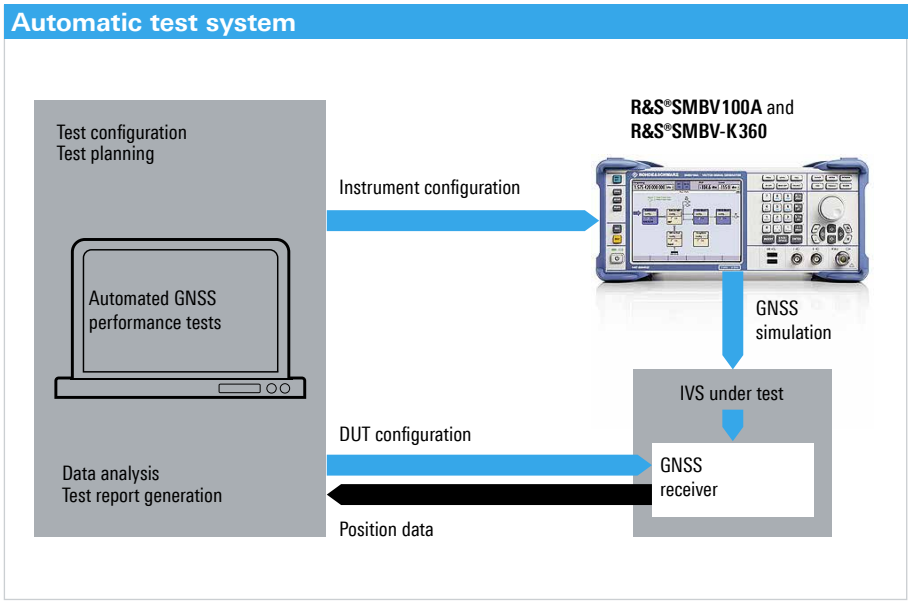


Fig. 2: System components and their functions for carrying out automated GNSS performance tests on ERA-Glonass modules with the R&S®SMBV100A and the R&S®SMBV-K360 option.

antenna characteristics). The R&S®SMBV100A meets all functional requirements for testing ERA-Glonass modules in line with GOST R 55534 and 33471.

Equipped with the new R&S®SMBV-K360 option, the generator can also be expanded to become a fully automated ERA-Glonass performance test system (Figs. 2 and 3). The R&S®CMWrun sequencer software installed on a PC is used for system control. An additional plug-in for R&S®CMWrun provides a list of the tests required by GOST R 55534 and 33471. The tests can be configured individually to create customized test plans. The software configures the signal generator and the ERA-Glonass module and runs the tests correctly and automatically. The system analyzes the data collected from the generator and the IVS and documents it in test reports, which can be used for both validation and certification. The new test solution supports all tests required to certify ERA-Glonass modules within the Eurasian Customs Union.

Benefits

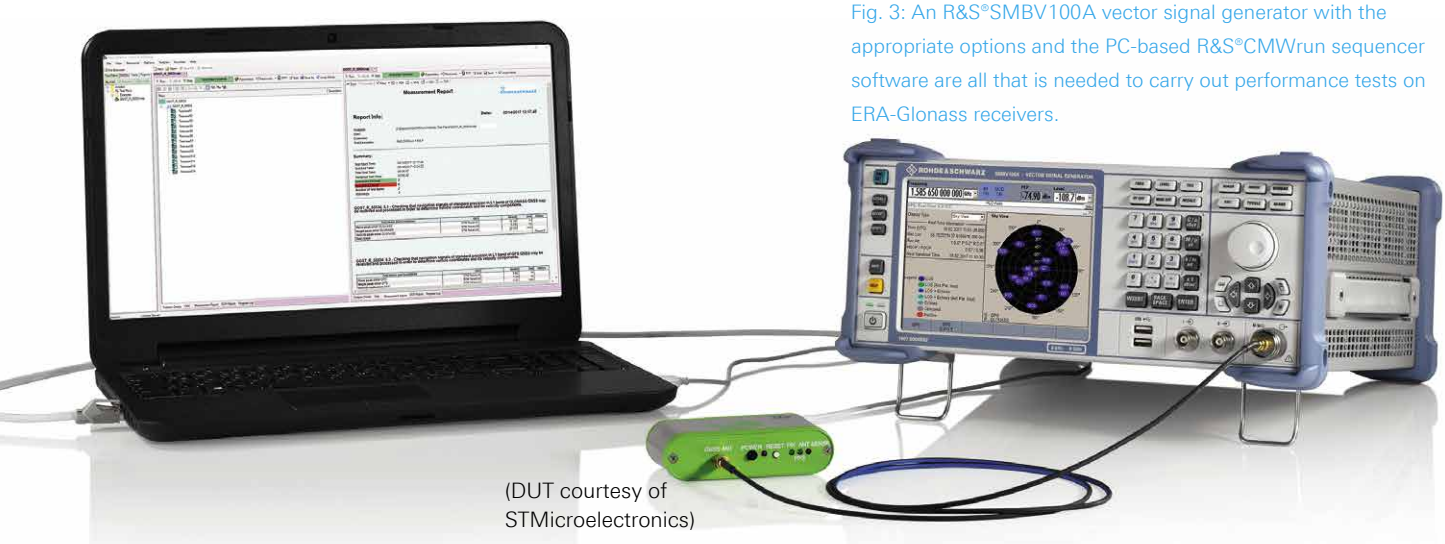
Full test automation makes it possible to efficiently plan, execute and evaluate validation and certification tests. The new test solution provides users with an exceptionally convenient, time-efficient and cost-saving alternative (compared with manual test configuration and analysis) for testing GNSS receivers installed in in-vehicle systems. The tests are fully reproducible, making the system ideal for validation measurements in the runup to official certification. IVS manufacturers and test houses that perform tests for their customers can thus ensure that upcoming certification tests will be completed successfully even before they are carried out. ERA-Glonass certification testing is performed by the Russian Svyaz-Certificate Certification Center. Svyaz-Certificate exclusively uses the R&S®SMBV100A for all official certification tests stipulated by GOST R 55534 and 33471. This provides users with an additional benefit in that the same T&M equipment is used for pretests and validation testing and for official certification.

Customers that already use the Rohde&Schwarz eCall/ERA-Glonass conformance test solution based on the R&S®CMW500 and R&S®SMBV100A enjoy an additional advantage: the R&S®SMBV100A already includes the required GNSS simulator and R&S®CMWrun sequencer software for test automation. All that is needed to perform automated GNSS tests in line with GOST R 55534 and 33471 is the new R&S®SMBV-K360 option and an additional plug-in for R&S®CMWrun.

Summary

Newly registered motor vehicles will in the future have to be equipped with automatic emergency call systems, which must be tested and certified in line with applicable standards. The new R&S®SMBV-K360 option together with the R&S®CMWrun sequencer software enhances the R&S®SMBV100A to become a fully automated GNSS test solution for performance testing of ERA-Glonass modules in line with the GOST R 55534 and 33471 specifications. The new test solution provides users with time- and cost-efficient validation measurements to simplify and accelerate certification.

Dr. Markus Irsigler



(DUT courtesy of STMicroelectronics)

Fig. 3: An R&S®SMBV100A vector signal generator with the appropriate options and the PC-based R&S®CMWrun sequencer software are all that is needed to carry out performance tests on ERA-Glonass receivers.

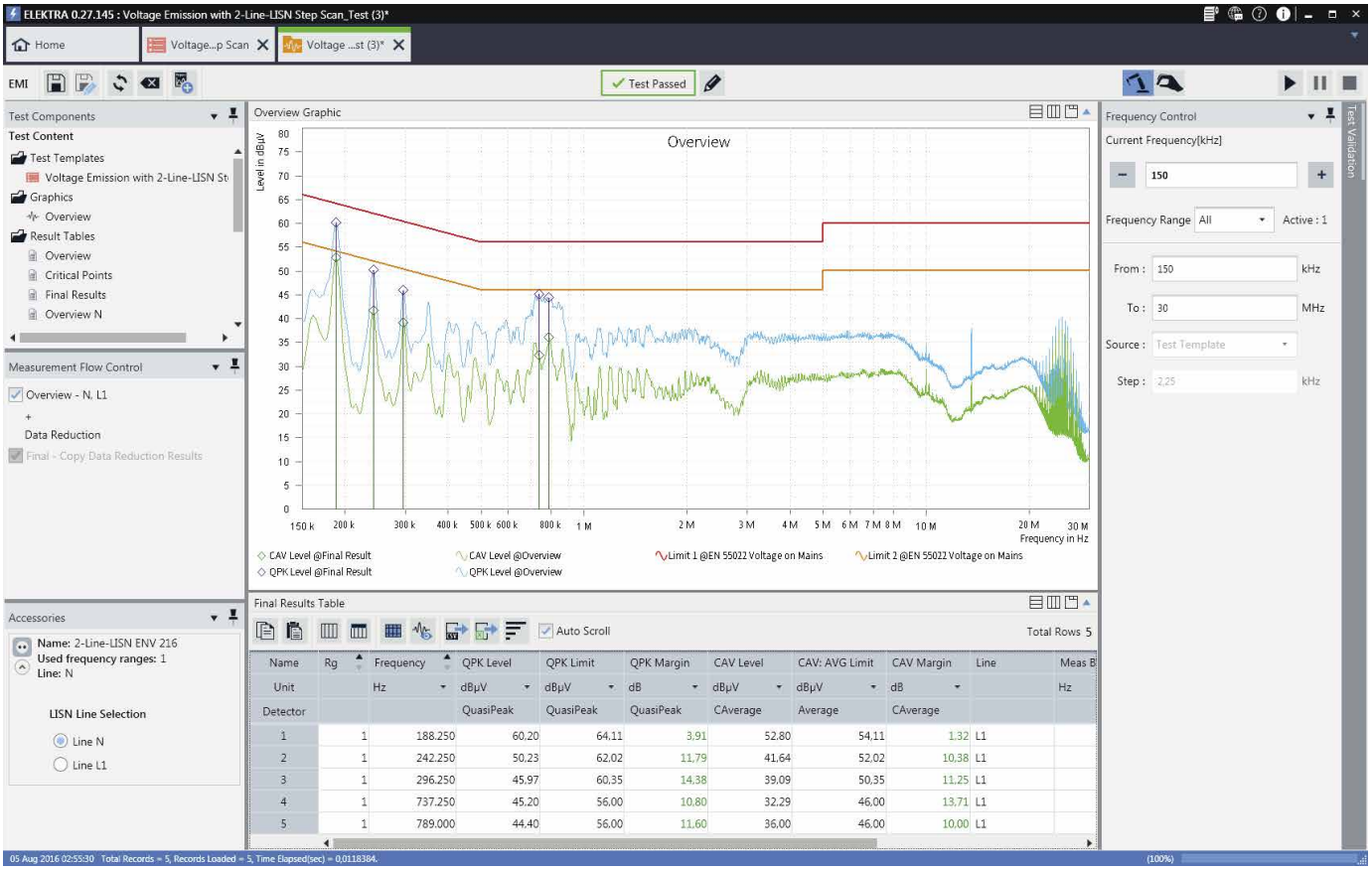
R&S®ELEKTRA: easy-to-use software for measuring electromagnetic interference (EMI)

Every electrical device must pass electromagnetic compatibility (EMC) tests before market approval can be granted. This obstacle is easier to overcome if the device's EMC behavior can be assessed and influenced during the development stage. New EMC test software for Rohde&Schwarz measuring receivers and spectrum analyzers offers valuable support.

Passing EMC tests proving that the device complies with the limits required by law is a prerequisite for market approval of every electrical device. That is why EMI testing is an important aspect of the development process. EMC plays a major role in launching products on time. The ability to assess and influence a product's EMC behavior before final certification is therefore indispensable during product development. The goal is to avoid multiple development cycles and the associated costs, and to lay the groundwork for a smooth certification process.

Under normal circumstances, however, design engineers only occasionally and marginally concern themselves with EMC. It therefore makes sense to provide user-friendly, specialist software for measurements during development, i.e. software that controls the test setup and "knows" all the necessary device setups and workflows. Rohde&Schwarz is now replacing its R&S®ES-SCAN software that was previously available for this purpose with the R&S®ELEKTRA software presented here.

Fig. 1: Result of a voltage emission measurement with a two-line LISN.



R&S®ELEKTRA supports both the measurement of conducted emissions via LISNs (Fig. 1) and of radiated emissions via antennas. The software also offers a further alternative of using gigahertz transverse electromagnetic (GTEM) cells to measure emissions. GTEM cells can be thought of as an expanded coaxial transmission line in which the device under test (DUT) is arranged between an inner conductor (septum) and an outer conductor. The IEC 61000-4-20 standard requires measurements along the x-, y-, and z-axis of the DUT, whereby the device is rotated. An R&S®ELEKTRA algorithm converts the measurement results into a spectrum that corresponds to the spectrum measured in an open area test site (OATS). For DUTs such as battery-operated hand tools, this type of measurement even complies with CISPR 14-1 standards. GTEM cells are often used in the development and precertification of multimedia equipment (CISPR 32).

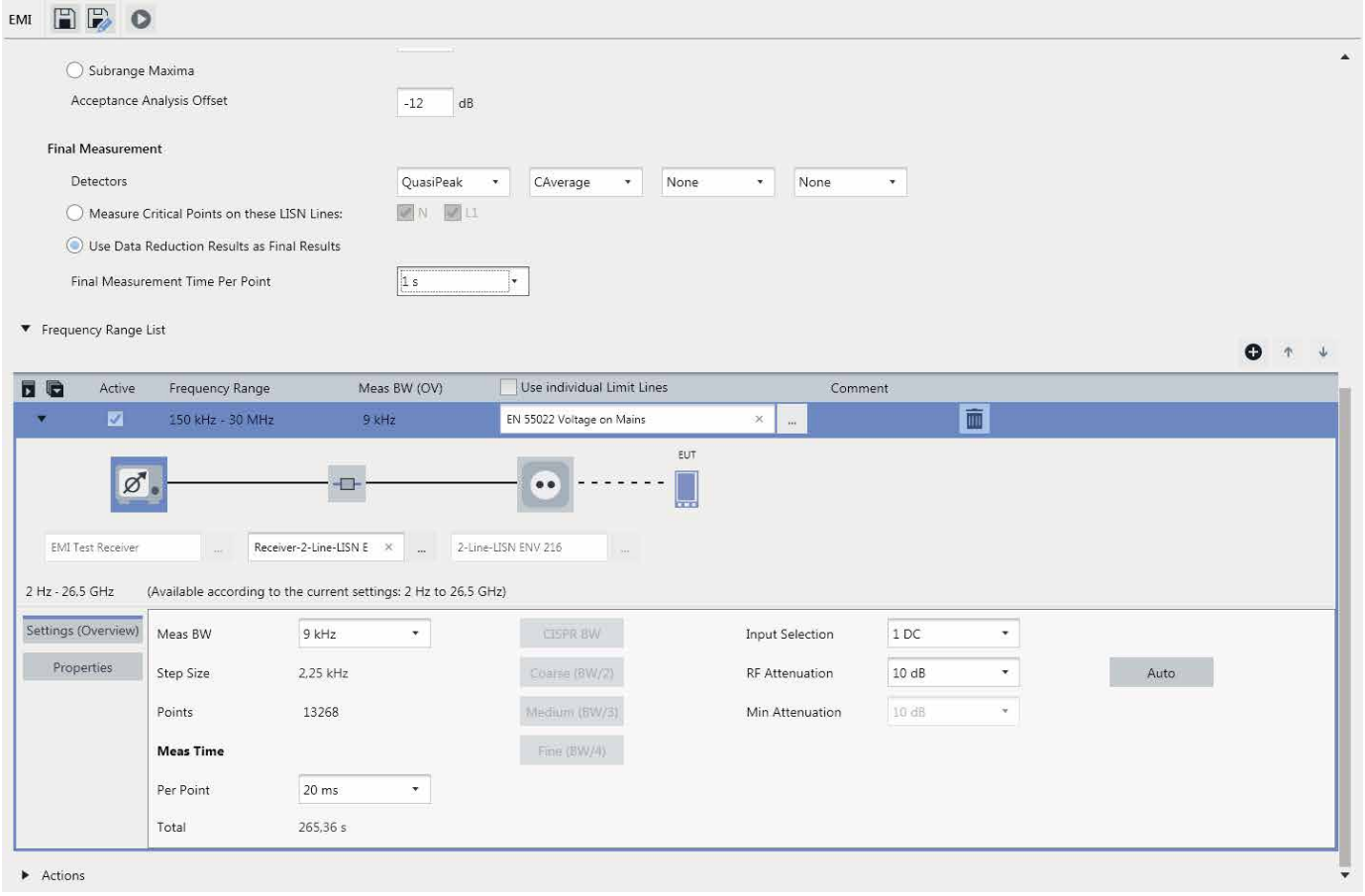
The starting point for each measurement is choosing a standard-specific template. Templates for key commercial and military standards are included. They contain the receiver settings and show the transducer test setup (Fig. 2). Tables containing transducer factors for many antennas, LISNs and other accessories are also included and are factored into the measurement result by the software.

To measure the RF spectrum, R&S®ELEKTRA first loads the template settings into the receiver or spectrum analyzer. If a device supports both operating modes – which all Rohde&Schwarz measuring receivers do – the user decides

Highlights

- Clear, straightforward configuration of the measuring receiver or spectrum analyzer from a PC
- Reliable recording, analysis and documentation of measurement results
- Automated phase selection for LISNs
- Measurements using GTEM cells
- Determination of the highest levels using selectable acceptance limits and selectable subranges
- Editable frequency list for automatic or semi-automatic final measurements
- Saving of measurement results and settings on the control PC, including limit lines and transducer factors
- Flexible report configuration for different layouts
- Can be used with the R&S®ESCI, R&S®ESPI, R&S®ESL, R&S®ESR, R&S®ESU, R&S®ESRP and R&S®ESW EMI test receivers, the R&S®FSL spectrum analyzer and the R&S®FSV and R&S®FSW signal and spectrum analyzers
- Backup wizard for regular data backups

Fig. 2: Configuration of a voltage emission measurement. Measurement settings, frequency range, limit line and accessories are neatly grouped together.



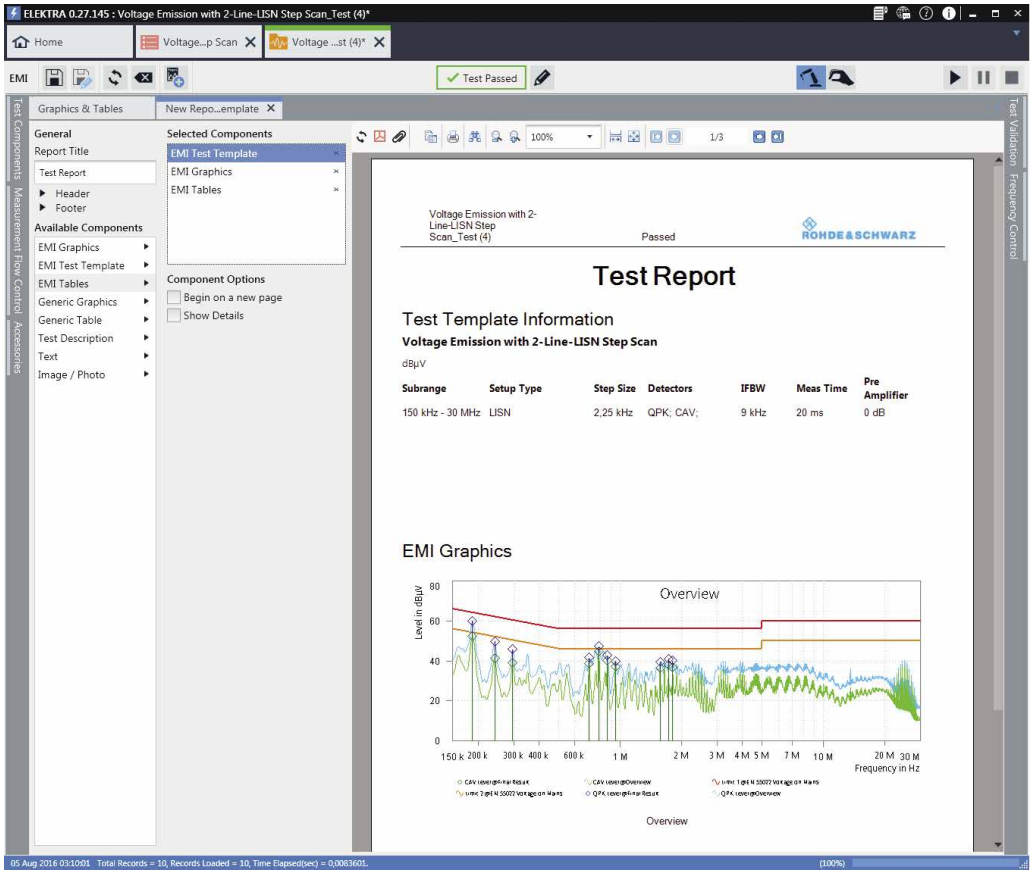


Fig. 3: The test report documents measurement results and settings. Users can add texts and pictures.

which one to use. The software starts, interrupts when required, and ends the test sequence. R&S®ELEKTRA automatically switches phases for conducted emission measurements using multiphase LISNs.

The next step, evaluating the measurement results, takes place either automatically or manually. Marker functions such as marker-to-peak are available for manual analysis. The software also automatically compares the measured spectrum to the limit lines – even in frequency subranges if needed – and finds out-of-limit conditions. A collection of key limit lines for commercial and military standards is included. Customers can of course also define their own limit lines. The frequencies with the highest interference levels in relation to the limit line are saved to the frequency list. This list can be edited to add known interferers or to remove ambient interferers.

When the measurement has been done with a standard-compliant detector, the frequency list will already contain the correct levels. This is the case, for example, when using a receiver with time domain scan that only takes seconds to measure a voltage emission of up to 30 MHz despite the comparatively slow quasi-peak detector. If this turbo method is not available, users typically first use the fast peak detector to perform preliminary measurements. Final measurements with a standard-compliant detector, i.e. either quasi-peak or CISPR-average, are only carried out for the frequencies that have the highest interference levels. R&S®ELEKTRA offers two methods for these final measurements. If a stable interference scenario can be assumed, then a fully automated final measurement is recommended, where the software sets and measures, one after the other, all frequencies determined to be critical in the preliminary measurements. If, on the other hand, fluctuating interferers are expected, the interactive method is ideal, where the user manually sets the receiver to exactly the frequencies that have critical levels at the preliminary measurement points.

Each measurement is documented. All results and the settings used to obtain these results are stored in a database where they remain available for future comparisons or reports. The user selects the desired report components. Free elements, such as texts and pictures of the test setup, can be added to the measurement results and the setup data. The user checks the report with the preview function and then prints it out or saves it in a portable format such as PDF (Fig. 3). To evaluate the results using external software, the user exports the measurement results in a tabular (CSV) or Excel format (xlsx).

Matthias Keller

Connected car, IoT and mobile devices on the security test bench

When it comes to cyberattacks, the focus is usually on devices that communicate with the Internet via fixed networks. Mobile users, however, are at no less risk – a fact that is becoming more critical with the advent of the Internet of Things. A new test solution now covers the network activities of wireless devices, providing important information about security gaps.

The Internet of Things and security

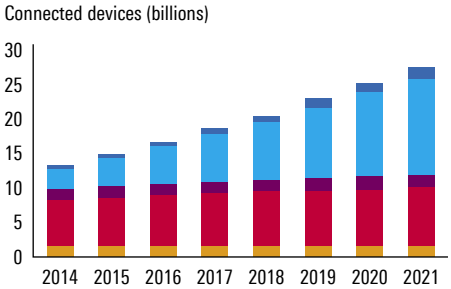
Currently more headline than reality, the Internet of Things (IoT) will soon permeate everyday life through home automation, wearables and connected car technology. It will ultimately have a far greater impact than smartphones do today. An increasing number of devices are being designed with integrated wireless modules in order to exchange (often sensitive) data, transmit measured values and remotely control systems. The number of "things" communicating via the Internet is expected to increase drastically over the coming years, with a major surge predicted after 2020 when 5G provides the necessary network resources (Fig. 1).

The downside of this development is that every wireless device with an IT core becomes a potential target for hackers. The cyber eavesdropping methods recently made public by WikiLeaks have made this threat tangible. Every IoT-connected device represents a potential risk, especially in light of the fact that IoT components are (currently) generally more poorly protected than products originally designed for the IT world. For reasons ranging from price and time pressure to lack of awareness and technical expertise, the security features in many wireless products in which IT plays a secondary or non-existent role (e.g. household appliances) are rudimentary and poorly implemented. Along with absent or weak encryption, open ports (communications channels) and vulnerable firmware, installed apps represent a significant security risk if developers fail to adhere to common IP connection security standards or do not provide regular updates. A single weak point can provide a loophole enabling unauthorized access to one or many devices. A widespread compromised IoT device can create difficulties for network operators and even cause networks to crash.

Companies also at risk

While IoT is still in its infancy, classic wireless communications is omnipresent and extensively used in both professional and personal environments. This becomes problematic for companies when these two spheres intermingle, e.g. when employers follow the "bring your own device" motto and personal mobile devices are used for business purposes.* Unprotected customer and company information poses an imminent risk. Unfortunately, it must be assumed that attackers will attempt to exploit any and all security gaps. Not only operating systems, but the increasing number of apps harbor a security risk. The multitude of helpers found on any well stocked personal mobile phone increase the probability of a poorly programmed or outdated app revealing a security gap. In the worst case, an entire corporate network can be accessed via such a device.

IoT devices – expected growth



	15 billion 2015	28 billion 2021	CAGR* 2015–2021
Cellular IoT	0.4	**1.5**	27 %
Non-cellular IoT	4.2	**14.2**	22 %
PC/laptops/tablets	1.7	**1.8**	1 %
Mobile phones	7.1	**8.6**	3 %
Fixed phones	1.3	**1.4**	0 %

* Compound annual growth rate

* The article on page 70 presents an alternative solution. BizzTrust from Rohde&Schwarz offers a secure solution for mobile devices that are used for business and personal purposes.

Fig. 1: The Internet of Things will soon overtake "classic" Internet use.
(Source: http://blogs-images.forbes.com/louis-columbus/files/2016/07/Internet-of-Things-Forecast.jpg).

Devices become truly susceptible to threats when jailbreaking or rooting manipulates their operating systems and deactivates fundamental security functions. But for attackers, looking for loopholes in allegedly secure original operating systems is a better alternative since there are only two major systems in use worldwide. Fig. 2 shows the percentage of iOS and Android devices in company and government use in selected countries.

New strategies and test methods needed

It must be determined whether a mobile device is at risk and whether the installed apps meet security requirements. The task of the responsible IT team is to verify that any wireless device used in the corporate environment safeguards the confidentiality and integrity of the data it stores and transmits, irrespective of whether it uses WLAN or a cellular connection (it cannot be assumed that malware will behave the same in both environments).

In the past, this task was easier to describe than perform since the communications behavior of the devices could not be readily examined. An analysis of the servers contacted on the Internet, and especially their location, provides essential information about unwanted communications. The server location can be identified using IP geolocation as long as no obfuscation techniques have been used. Any abnormality must be further examined and, if required, the source apps should be banned from devices used within the company. Apps developed specifically for company use, however, must certifiably behave as expected, especially with respect to security.

Security parameters revealed

The R&S®CMW500 wideband radio communication tester can significantly help developers improve the security of IP-based data communications for mobile devices and IoT modules. The new IP connection security analysis reporting module (R&S®CMW-KM052) performs realtime IP data traffic analysis in a controlled test environment (Fig. 3). The R&S®CMW500 also emulates a mobile network or WLAN access point. The data application unit (DAU) is required for security analysis. It provides the DUT with IP addresses and manages the connection with servers on the World Wide Web. The R&S®CMW-KM052 analyzes and logs the security-related parameters of the data traffic. This enables developers to detect and close security gaps early in the design process. It gives IT personnel a tool to determine whether mobile

	Global	France	Germany	Japan	Spain	UK	US	Govt.
iOS	81	50	85	92	33	83	86	82
Android	18	50	14	5	66	16	14	18

Fig 2: Percentage of iOS and Android mobile devices in corporate and government use. (Source: Mobile Security and Risk Review, Second Edition 2016, MobileIron Security Labs).

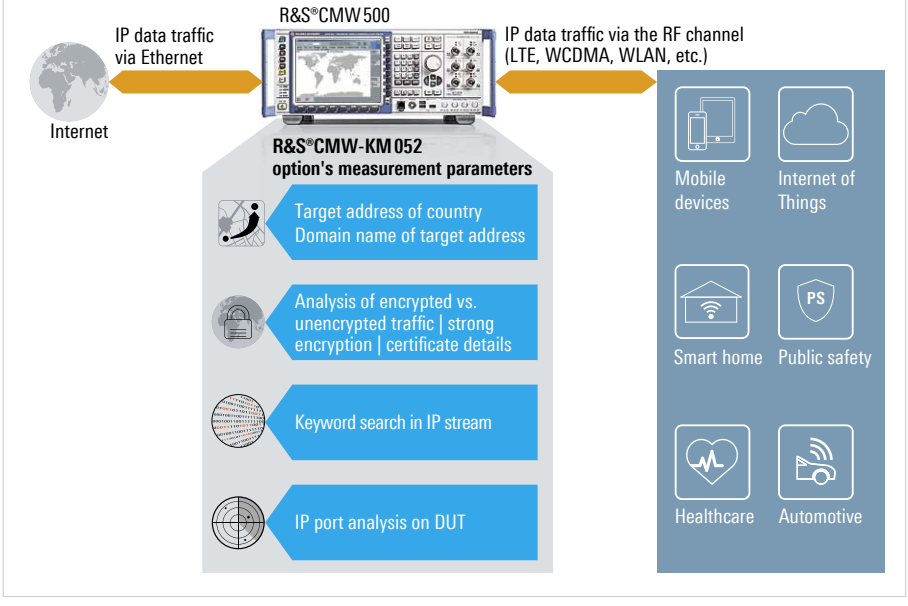
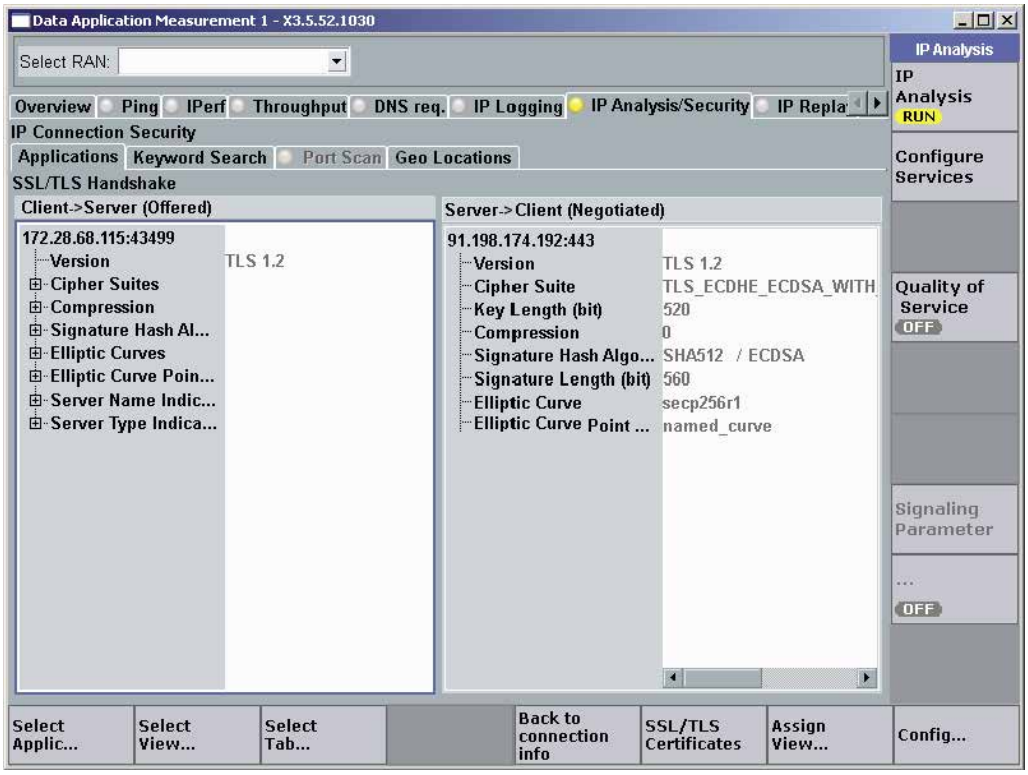


Fig 3: The "path" taken by the data transmitted and received by a connected mobile or IoT device. The R&S®CMW500 manages the data traffic between the wireless product under test and the Internet. Similar to a firewall, it checks for security-relevant content, e.g. whether passwords are transmitted unencrypted.

Fig. 4: The SSL/TLS handshake determines the security of a connection and is comprehensively analyzed.



devices used for business purposes comply with internal security policies.

The analysis software produces real-time statistics of the IP connections and communications protocols used. The software module makes it possible to search for sensitive information in data streams, including for user-specified input such as passwords and device IMSIs. If this information is transmitted unencrypted, the software lists the target address, domain name and, if possible, the source app. The module also analyzes SSL/TLS handshake parameters as well as certificates and country/domain names of the server location.

The SSL/TLS handshake that the client and server use to agree on the cryptographic method is essential for a secure connection and is therefore closely examined (see box on page 22). The R&S®CMW-KM052 displays the cryptographic methods (cipher suites) offered by the client during call setup as well as the cipher suite chosen by the server, including key lengths and other parameters (Fig. 4). The CMW KM052 can even analyze the certificate transmitted by the server.

When analyzing communications behavior, one of the most important things users want to know is where the involved servers are located (country). Geolocation (IP address assignment according to geographic location) makes it possible to determine this information. Since IP domains are unique and registered, localization is successful 95 to 99 percent of the time. Domain names provide additional security-related information. The new analysis option enables users to easily detect suspicious domains and unwanted countries that might present a security problem (Fig. 5).

The port scan function is another important security feature of the software. The client and server of an application talk to one another via ports. Via the operating system, an application offering a service in a network (server) opens a port (an address) that the client can access. This port waits for inquiries in the "listen" state. A port in "listen" state that is unintentionally open to the Internet is a potential gateway for attackers. Malware such as Trojans often open "backdoors" via freely accessible ports (some ports are reserved for certain applications). This is why it is highly recommended to review the open ports in a system from time to time – an easy to implement measure with the R&S®CMW-KM052 option.

No additional software is required on the DUT to use the analysis tool. The tests are independent of its operating system. DUTs with an antenna connector can be connected to the R&S®CMW500 via a cable. DUTs without a connector can be accommodated in an RF shielded box from Rohde&Schwarz and connected to the R&S®CMW500 via an air interface (Fig. 6).

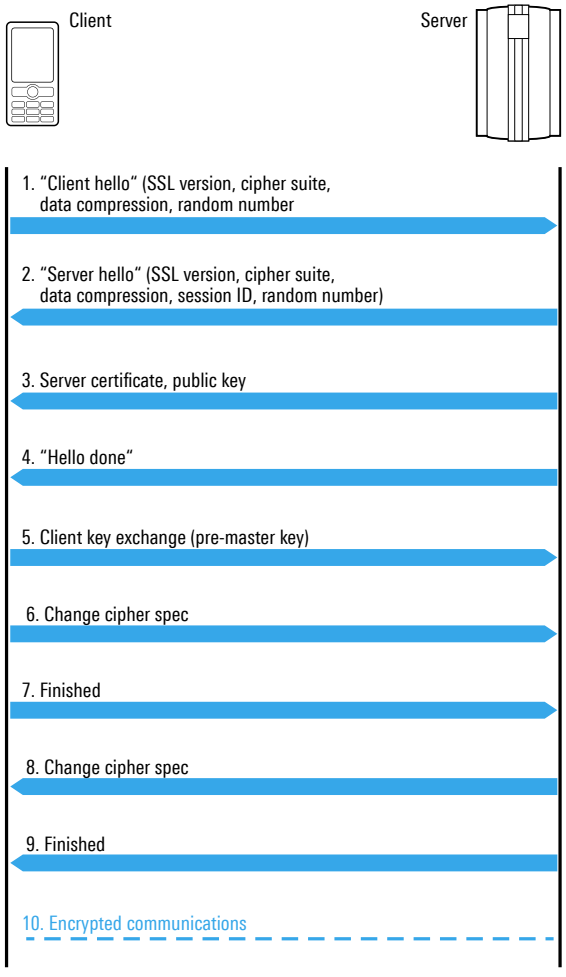
IP connection security

Transport layer security (TLS) – more commonly known as secure sockets layer (SSL) – plays a key role in secure online communications. The last version of the SSL protocol was 3.0. After that, development and standardization continued under the new name TLS, starting with version 1.0.

SSL/TLS defines security levels for communications between clients and servers, verifies the authenticity of the certificates and negotiates session keys. All of this takes place during the SSL handshake at the outset of each connection.

Due to the central importance of strong encryption for secure IP communications (key length recommendations available at www.keylength.com), the R&S®CMW-KM052 software thoroughly examines the SSL handshake. The clearly structured parameter list makes it easy to determine if connections meet security requirements (Fig. 4).

SSL/TLS handshake process



Source: https://publib.boulder.ibm.com/tividd/td/TRM/GC32-1323-00/en_US/HTML/admin231.htm

1. The client sends a "client hello" message that lists the cryptographic capabilities of the client (sorted in client preference order), such as the version of SSL, the cipher suites supported by the client, and the data compression methods supported by the client. The message also contains a 28-byte random number.
2. The server responds with a "server hello" message that contains the cryptographic method (cipher suite) and the data compression method selected by the server, the session ID, and another random number.
   Note: The handshake will fail if the client and server do not support at least one common cipher suite. The server generally chooses the strongest common cipher suite.
3. The server sends its digital certificate, which contains its public key. The client uses other certificates (TrustStore) to authenticate this certificate.
4. The server sends a "server hello done" message and waits for a client response.
5. The client sends a "client key exchange" message containing the pre-master secret that enables the server to generate the master secret for a symmetric cipher suite. The pre-master secret is encrypted using the server's public key and can only be decrypted with this key.
6. The client also generates the master key and sends a "change cipher spec" message to inform the server that the key was changed.
7. The client sends a "finished" message that is encrypted using the master key.
8. The server responds with a "change cipher spec" message …
9. … and also sends a "finished" message.
10. End of the SSL handshake and transmission of encrypted data.

Fig. 5: Certain IP addresses and countries can be unwanted in the data stream. The R&S®CMW-KM052 option shows whether the DUT contacts them.

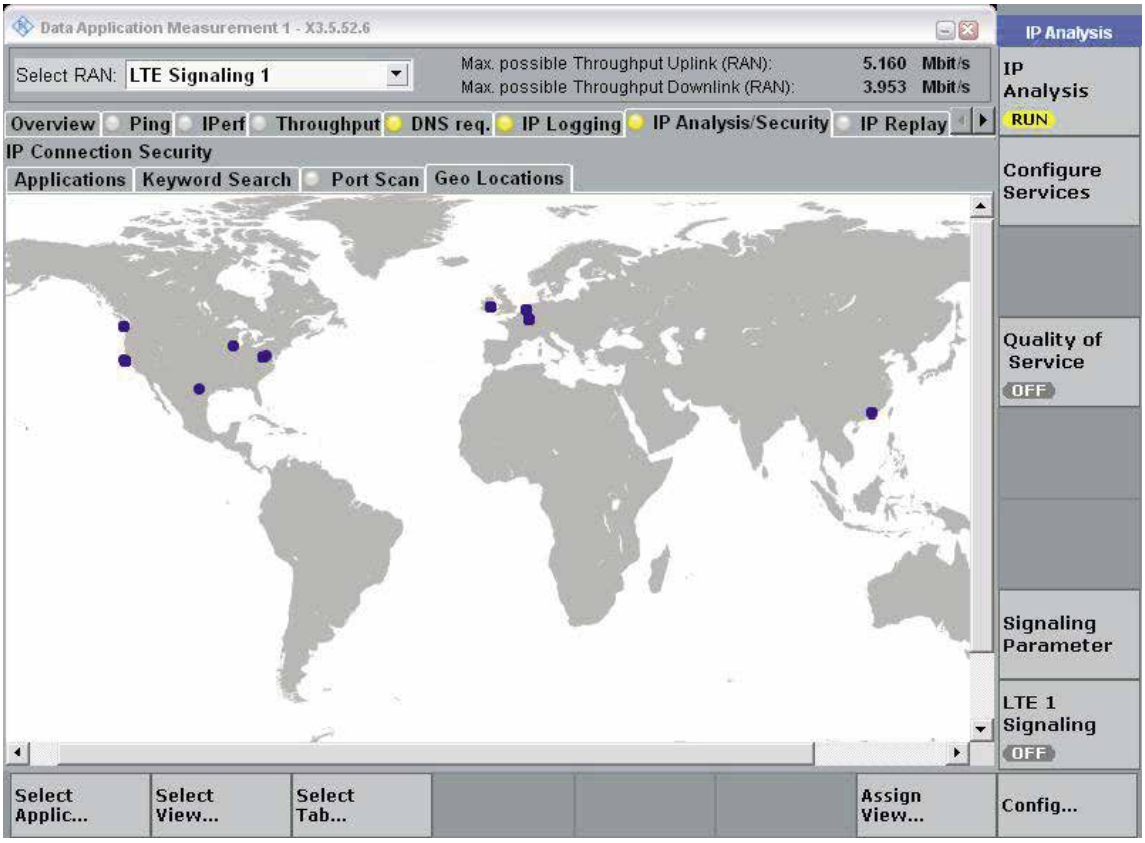


Fig. 6: DUTs without an antenna connector can be placed in an R&S®CMW-Z10 RF shielded box and connected to the R&S®CMW500 over the air.

Summary

Up until now, it was very difficult to analyze data traffic from mobile and IoT devices. Security weak points could go undiscovered for long periods of time. The R&S®CMW500 wideband radio communication tester with the R&S®CMW-KM052 analysis option solves this problem. Users can obtain a detailed overview of security-relevant communications parameters in a freely configurable controlled wireless environment and also determine whether a device behaves differently in WLAN and cellular networks.

Developers can detect security gaps early in the design process. IT teams can analyze the communications behavior of smartphones, tablets and apps used in the corporate environment. Automotive OEMs and network operators can verify that connected car and IoT devices comply with the specified connection security standards.

The test sequence is very simple since the DUT requires no preparation. The R&S®CMW-KM052 option integrates seamlessly into the powerful R&S®CMW500 test suite. A single T&M instrument now enables RF analysis in cellular and non-cellular networks, protocol tests and IP application tests as well as analysis of security-relevant parameters for IP data communications. A truly unique solution.

Christian Hof

WLAN 802.11ax speeds up communications in multi-user scenarios

The upcoming 802.11ax standard introduces new techniques to more efficiently utilize the unlicensed 2.4 GHz and 5 GHz bands. Public WLAN networks will especially benefit from the standard.

Background

The number of WLAN-capable devices has risen drastically in the past few years, and the growth rate is expected to increase. This is because, in addition to laptops, smartphones and tables, an ever greater number of televisions, game consoles, cameras, smart home devices and IoT devices are connecting to WLANs. This will increase the density of users in networks, leading to a noticeable reduction in the data throughput due to packet collisions and shorter "free" time periods during which a subscriber can transmit. WLAN routers (access points, AP) in apartment buildings have the same effect because they are very close to each other and act as interferers.

To alleviate these problems, the IEEE is currently working on a new WLAN standard: 802.11ax. Previous standards (802.11g/n/ac) increased data throughput primarily by enhancing physical parameters such as bandwidth and modulation factor or by introducing new transmission methods such as multiple input multiple output (MIMO). 802.11ax will not introduce any essential changes in this area. Instead, the new standard focuses on making networks more efficient and on better utilizing existing transmission capacities.

802.11ax

The standard is currently in the planning phase and is projected for completion by the end of 2018. The key players in the WLAN market already started developing 802.11ax-capable chipsets in 2016. Although draft version 1.0 of the standard did not receive a majority vote by the IEEE working group in early 2017, the first devices are expected on the market even before the standard receives final approval.

802.11ax aims to increase the performance of intensively used networks, especially those for:

- Airports and train stations
- Local and long-distance public transportation
- Stadiums and concert halls
- Apartment buildings

This article presents the changes that 802.11ax will make to the physical layer (Fig. 1) (for changes to the MAC layer, refer to the draft of the standard [1] and to the specification framework document [2]).

The focus is increasingly on outdoor applications. Outdoor transmission channels exhibit stronger multipath propagation and longer echo times. To prevent intersymbol interference in this scenario, an optional transmission scheme will be introduced in which the guard interval and symbol duration are lengthened by a factor of four while the subcarrier offset is reduced by one fourth, keeping the transmission rate the same but improving resistance to fading. Under optimal conditions, 802.11ax can achieve a maximum data rate of 1200 Mbit/s on a single channel by using the newly introduced 1024QAM modulation and a shorter guard interval. With 8 × 8 MIMO, 9.6 Gbit/s is theoretically possible. Even in its optimal configuration, 802.11ac achieves "only" 6.9 Gbit/s.

OFDMA

The most significant change is the introduction of orthogonal frequency division multiple access (OFDMA) in the uplink and downlink, where multiple users transmit simultaneously and share the available bandwidth of a channel. Previous standards use OFDM and time division multiplexing, i.e. only one user transmits over the full bandwidth.

In the case of OFDMA, each user is allotted a portion of the available spectrum by assigning the user a contiguous subset of subcarriers (minimum 26, maximum 996). This subset of subcarriers is called a resource unit (RU). Both the spectral width of an RU and the modulation mode can vary from subscriber to subscriber. This makes it possible for an access point to satisfy the data rate requirements of each individual user. Unlike the frequency domain's dynamic structure, the

Feature	Benefit
OFDMA in the uplink and downlink	Overhead reduction, channel can be used by multiple users in parallel
Multi-user MIMO (uplink)	Higher throughput in the uplink through space division multiplexing
1024QAM	Higher maximum data rate
Quadruple symbol duration	Robustness for outdoor use
Extended range preamble	Specialized packet format for outdoor applications

Fig. 1: The most important changes in 802.11ax.

time axis has a uniform structure: to prevent interference, the data packets in all RUs have the same length and are transmitted synchronously. Users that have less data to transmit than permitted by the packet length must pad the packet with padding bits.

Fig. 2 shows the possible resource unit configurations for a 20 MHz channel. The smallest RU size of RU 26 allows up to nine users to transmit simultaneously (see the top row in the figure). The maximum bandwidth is 160 MHz, permitting up to 74 simultaneous users.

A single active user is a special scenario in OFDMA in which a resource unit is allocated the entire bandwidth (RU 242 in the figure).

802.11ax operating modes

Previous WLAN standards typically use only one packet type and do not distinguish between the uplink and the downlink. 802.11ax introduces four new, uplink and downlink specific packet types (Fig. 3). Uplink still refers to the transmission from a mobile device (station, STA) to the WLAN router (access point, AP), while a downlink is the transmission from the access point to the station. Every packet type (high-efficiency PLCP protocol data unit, HE-PPDU; physical layer convergence procedure, PLCP) has a different preamble for the signaling information, followed by the payload.

Single-user mode (HE_SU)

This mode is used to communicate with a single user. Uplink and downlink signals use the same packet format. The user is allocated the entire spectrum via a resource unit with the maximum size. This mode eliminates the unavoidable communications overhead found in multi-user mode.

Multi-user downlink (HE_MU)

Packet type HE_MU is used for OFDMA mode in the downlink. The access point transmits the packets for all users simultaneously, the usual 802.11ax case. The preamble contains the HE_SIG_B field, which contains information about the organization of the spectrum into resource units and their allocation to users.

Multi-user uplink (HE_TRIG)

In OFDMA uplink, the stations simultaneously transmit their data packets to the access point when triggered by the access point. To ensure that this process takes place without collisions, it must be defined in advance which RU is allocated to which user, how much data will be transmitted and at what level each user must transmit. This information is essential because signals from the station must arrive at the access point simultaneously and at the same level to prevent any interference. To achieve this, the AP first sends a trigger frame to all users (Fig. 4). This frame contains the configuration parameters, including payload length, bandwidth, RU allocation and modulation mode. Users must start transmitting the uplink PPDUs after a predefined time interval known as short interframe space (SIFS).

Resource units

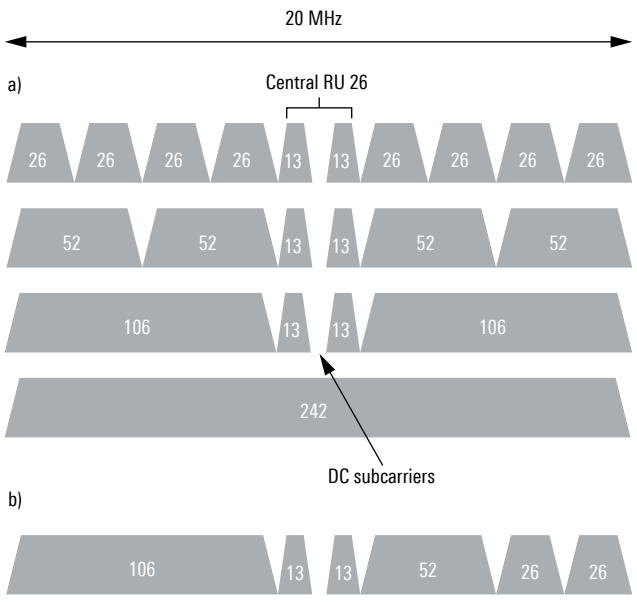


Fig. 2: a) Possible sizes and positions of the resource units for 20 MHz bandwidth.
b) Example of different RU sizes in multi-user downlink mode. The DC subcarriers in the channel center are excluded to prevent interference due to LO leakage.

Transmission modes

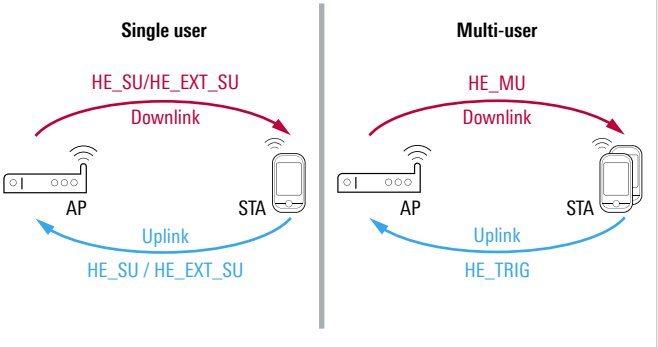


Fig. 3: 802.11ax distinguishes between four different packet formats.

Extended range PPDU (HE_EXT_SU)

This packet type is intended specifically for outdoor use over large distances where a poor signal-to-noise ratio is typical. The bandwidth is limited to 20 MHz, and only the robust BPSK and QPSK modulations are used. Portions of the preamble are transmitted at 3 dB more power to ensure robust channel estimation.

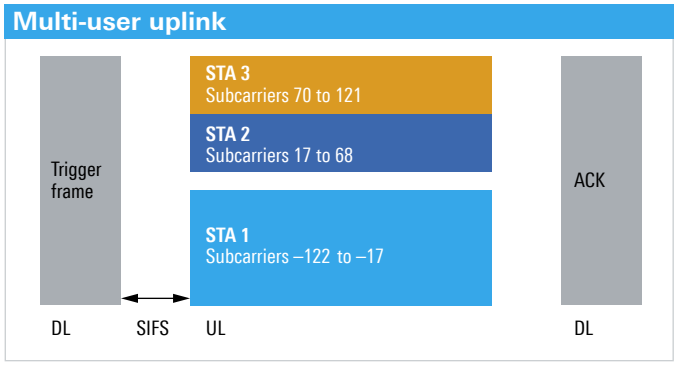


Fig. 4: Multi-user communications in the uplink with three users at a channel bandwidth of 20 MHz.

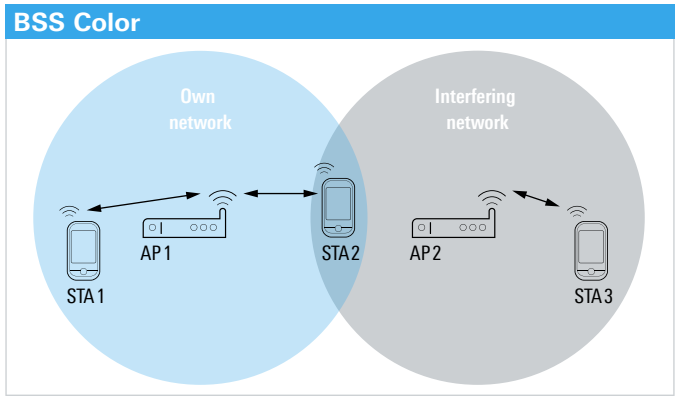


Fig. 5: Scenario showing the benefit of BSS color. STA 2 lies in the coverage area of two networks, but can ignore the external network thanks to BSS color.

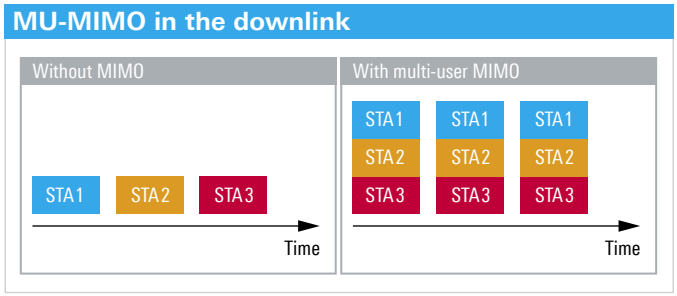


Fig. 6: In 802.11ax, multi-user MIMO supplies up to eight stations simultaneously.

BSS color

A basic service set (BSS) is a network that consists of an access point and the stations associated with it. Each station is assigned to one and only one BSS. Multiple BSS networks can exist in close proximity to one another. Fig. 5 shows a typical scenario often found in apartment buildings. A station (STA 2) not only receives the signals from its own access point (AP 1), but also from the adjacent AP 2. Because AP 1 and AP 2 do not recognize one another, they transmit independently of each other and often simultaneously, leading to packet collisions and interference at STA 2. As a consequence, incorrectly received packets from the local AP must be retransmitted, resulting in an additional load on the network. On the other hand, stations themselves can only transmit when the path is free, i.e. only if no other device (AP or STA) is transmitting. However, STA 2 has the opportunity to do so less often because of the additional signals it receives from AP 2. Both situations can significantly reduce the throughput for the affected station. 802.11ax therefore introduces BSS color to improve the reutilization of frequencies. The 802.11ax preamble assigns a BSS color to each AP so that STA 2 can distinguish between packets from its own BSS (intra-BSS) and those from an adjacent BSS (inter-BSS). As a result, STA 2 can ignore inter-BSS packets up to a certain receive level and can transmit its own packets despite simultaneous activity on AP 2.

Multi-user MIMO

Single-user MIMO was introduced in 802.11n. The intent was to increase the data rate by simultaneously transmitting multiple data streams from the access point to an individual subscriber over multiple antennas. This is done sequentially in the case of multiple subscribers. 802.11ac further improves performance with multi-user MIMO (MU-MIMO, Fig. 6), where multiple users are supplied simultaneously via additional antennas, increasing the effective data rate in the network.

Downlink MU-MIMO uses beamforming (Fig. 7). Antenna array beamforming is designed to direct a beam toward each individual user so that each station receives only the signals intended for it. 802.11ax includes this feature and extends the number of possible parallel data streams from four to eight. It also introduces MU-MIMO in the uplink for the first time. This makes it possible for multiple stations to transmit simultaneously (Fig. 7). However, they do not use beamforming so the signals are jumbled together on the path to the access point. But with its antenna array, the access point is able to separate the overlapping signals and allocate them to the individual users.

TX/RX specifications

The requirements placed on stations' digital and RF components increase further with 802.11ax. The smaller subcarrier offset makes signals more vulnerable to phase noise due to interference from adjacent carriers. As a result, the local oscillator (LO) phase noise must be better than was necessary for 802.11ac. Because the spacing between the constellation points in 1024QAM is smaller than in lower-order constellations, the system noise must also be reduced in order to ensure error-free transmission. This requires a larger signal-to-noise ratio for the D/A and A/D converters. Amplifiers must also operate with minimal distortion.

The standard defines a number of requirements for physical parameters in the transmit (TX) and receive (RX) mode, all of which must be validated using appropriate test equipment. Most of the values have not changed from those defined for 802.11ac. Therefore, only the modified or new requirements are described below.

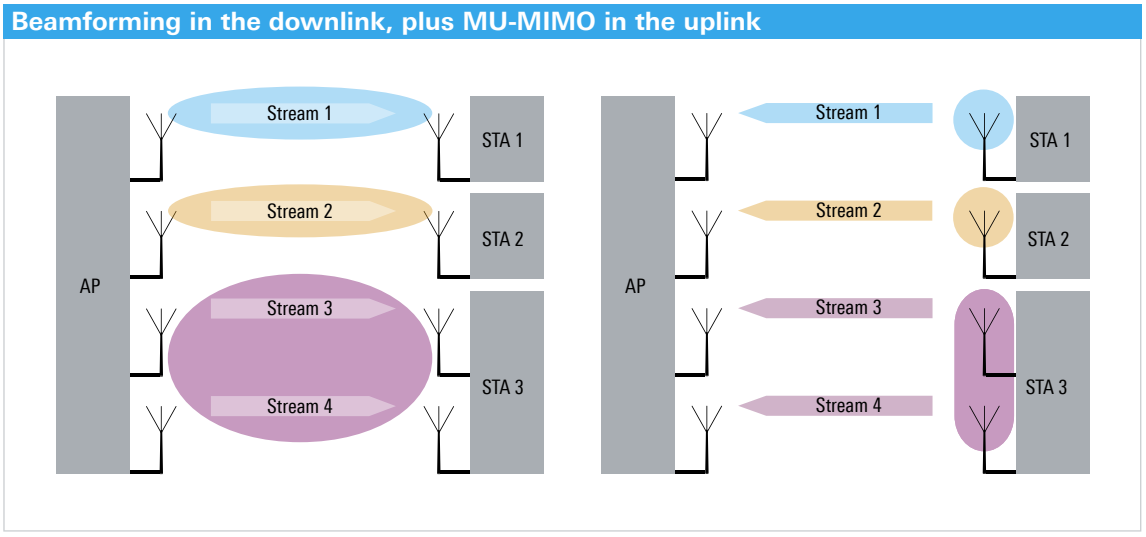


Fig. 7: In the downlink, beamforming ensures targeted station coverage. In the uplink, the data streams can be separated without beamforming.

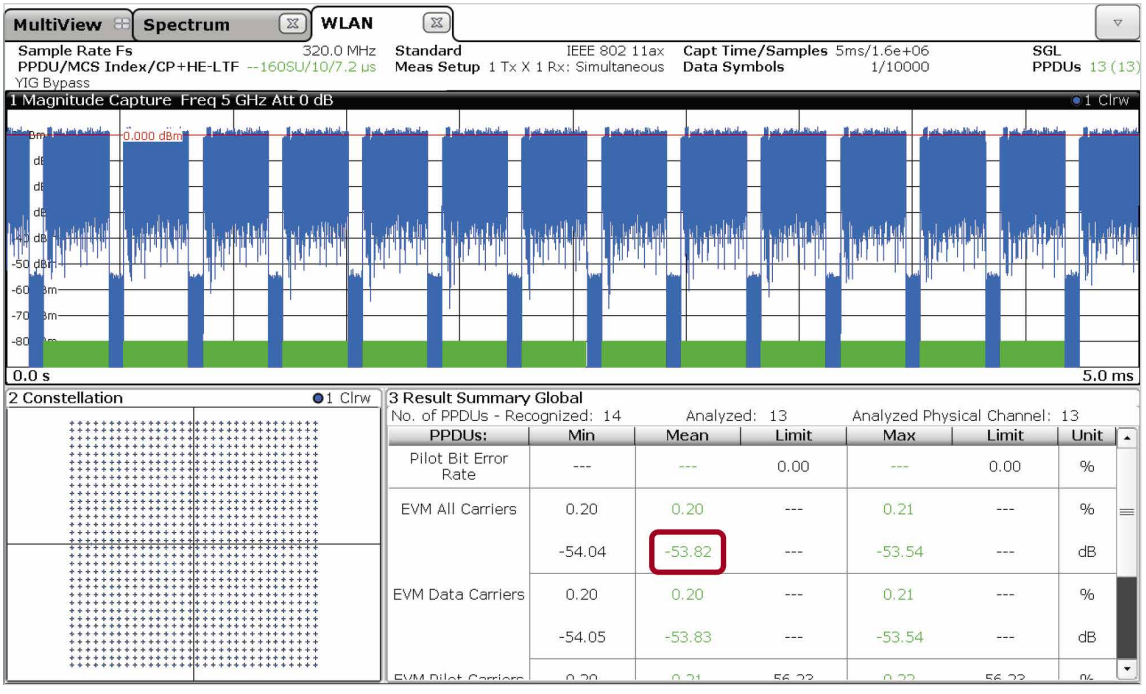


Fig. 8: Modulation analysis of a 160 MHz 802.11ax signal using the R&S®FSW-K91ax option. In the case of a 1024QAM signal, the R&S®FSW achieves an EVM of < –53 dB when transmitting at 5 GHz.

Error vector magnitude (EVM)

Due to the denser constellation, stricter EVM limits apply for 1024QAM. Whereas in 802.11ac a DUT must achieve an EVM of –32 dB or less for 256QAM, the 802.11ax limit for 1024QAM is –35 dB. The T&M equipment requirements increase accordingly. To minimize measurement errors, the intrinsic EVM for the signal analyzer must lie significantly below the specification limits. A reserve of 10 dB is often required, which leads to a measurement error of about 0.5 dB. The R&S®FSW spectrum and signal analyzer with its excellent signal-to-noise ratio achieves an internal EVM of less than –53 dB, reducing the measurement error to 0.07 dB (Fig. 8). In this example, the test signal was generated by the R&S®SMW200A vector signal generator which has a similarly good EVM value.

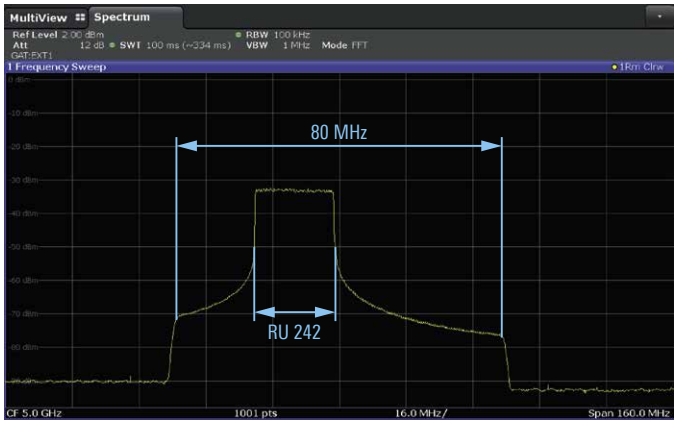


Fig. 9: Spectrum of an 80 MHz uplink signal (HE_TRIG) on an active resource unit with a size of 242 (18.9 MHz).

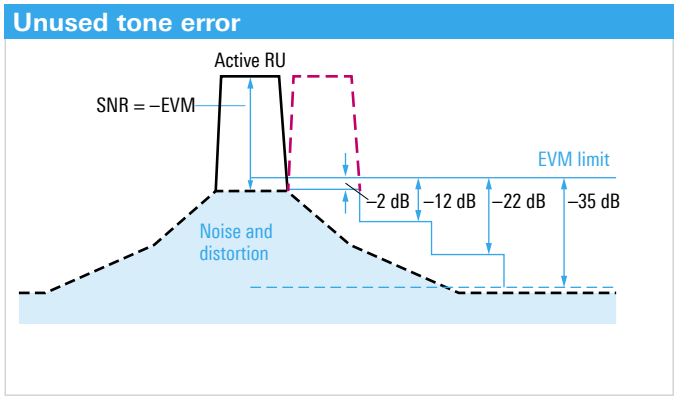


Fig. 10: Unused tone error limit value for RU 26. For other RU sizes, different limits values and step widths apply.

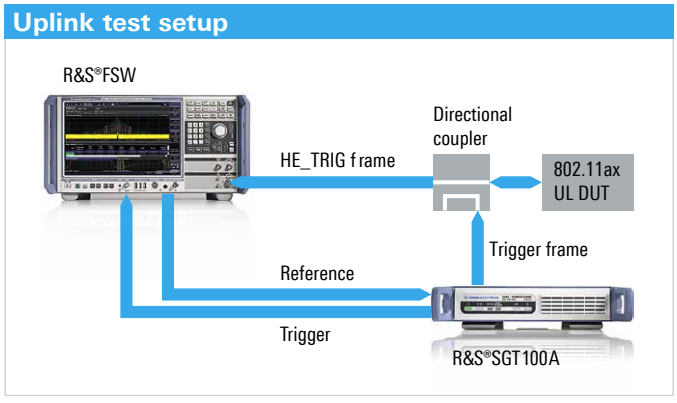


Fig. 11: Setup for measurements on uplink signals.

Uplink requirements (stations)

Unused tone error

In the uplink, each station transmits only on the resource unit assigned to it by the access point (Fig. 9). Spurious emissions into adjacent spectrums, which are of course used by other stations, must be minimized. 802.11ax introduces the unused tone error for this purpose. The power for the subcarriers that remain unused by a station (in RU 26 blocks) is calculated and set proportionate to the power of the active RU, similar to an adjacent channel leakage ratio (ACLR) measurement. The limits the power must maintain are defined relative to the EVM limits of the active RU (Fig. 10). Subcarriers in close proximity to an active RU 26 must lie 2 dB under the EVM limit, for example. For more distant subcarriers, the value is reduced in 10 dB steps down to –35 dB.

Frequency offset and timing offset

To ensure that stations do not interfere with one another when transmitting in parallel, the transmissions must be started virtually simultaneously. Otherwise, a timing offset between the frames will lead to intersymbol interference. In addition, all stations must adjust their transmit frequency to very closely match that of the access point. A frequency offset in one station disrupts the subcarriers of the adjacent stations. Stations synchronize their frequencies using the trigger frame previously received from the access point (Fig. 4).

The 802.11ax standard defines two new measurements for the uplink. First a trigger frame is sent to the DUT, which responds with an HE_TRIG frame (the frames for the uplink and downlink have different names). The relative frequency error (center frequency offset, tolerance ±350 Hz) of the response signal as well as the delay between the end of the trigger frame and the start of the response frame (timing accuracy, tolerance ±0.4 µs) are measured. Fig. 11 shows the test setup. In its role as the access point, the R&S®SGT100A vector signal generator generates the trigger frame and simultaneously starts the measurement by sending a trigger signal to the R&S®FSW. The RF must be extremely precise in order to measure the very small permissible frequency offset. The R&S®SGT100A and R&S®FSW are therefore coupled via the 10 MHz reference.

Receiver tests

Various sensitivity tests must be performed on the receiver. For example, it must be ensured that at low input power (–43 dBm in the case of 1024QAM), only 10 % of the received packets contain faulty bits. 802.11ax extends the 802.11ac test cases to include additional requirements for the new 1024QAM modulation. For these tests, a high-quality reference signal is needed to ensure that the measurement results are not influenced by the signal source. The R&S®SMW200A vector signal generator with the R&S®SMW-K142 WLAN option offers sufficient capacity for this purpose. Fig. 12 shows the settings for a measurement at 5 GHz. The R&S®SMW-K142 option makes it possible to generate both uplink and downlink signals. When combined with multiple R&S®SGT100A instruments and the realtime fading option for the R&S®SMW200A, the setup can also generate MIMO signals with up to eight antennas (Fig. 13).

Dr. Michael Simon

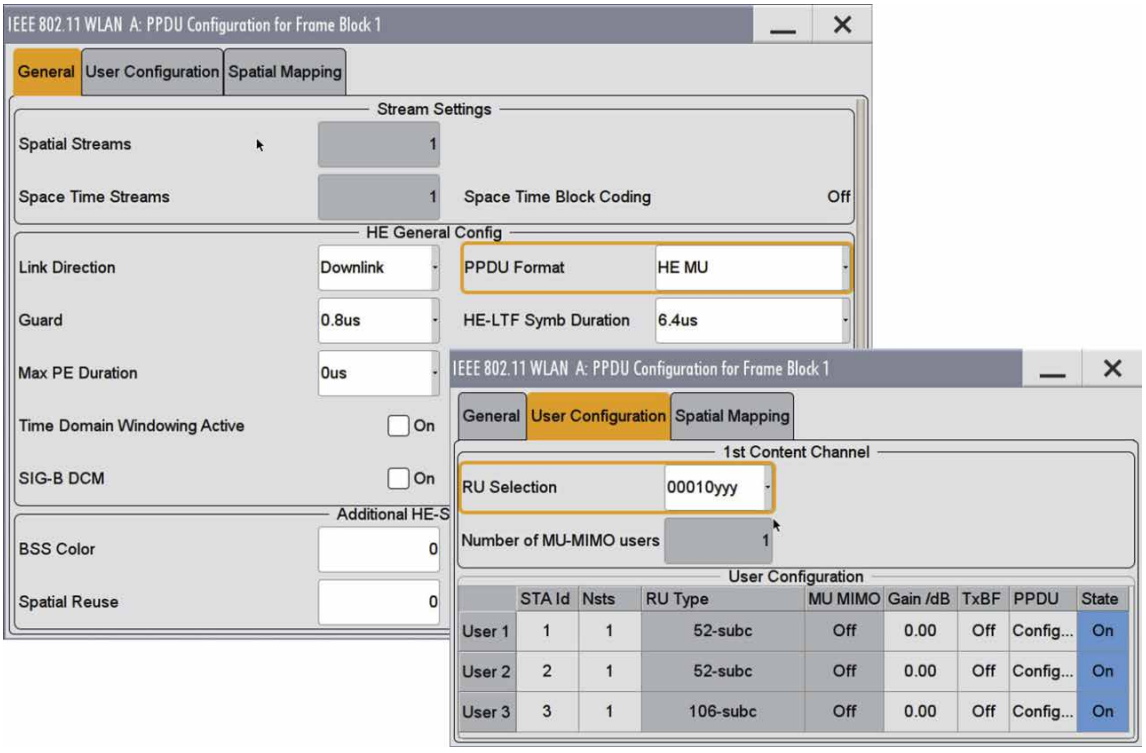


Fig. 12: The R&S®SMW-K142 option's configuration menu for downlink signals (HE_MU).

Fig. 13: Compact MIMO system for creating eight TX or eight RX signals using an R&S®SMW200A vector signal generator and six R&S®SGT100A extension units, optionally with real-time fading simulation.

References

[1] IEEE 802, IEEE P802.11ax/D1.0, 2016

[2] Specification Framework for TGax, May 2016 [Online]. Link: https://mentor.ieee.org/802.11/dcn/15/11-15-0132-17-00ax-spec-framework.docx

[3] L. Ward, "IEEE 802.11ax Technology Introduction," October 2016. [Online]. Link: https://www.rohde-schwarz.com/de/applikationen/application-note_56280-345664.html

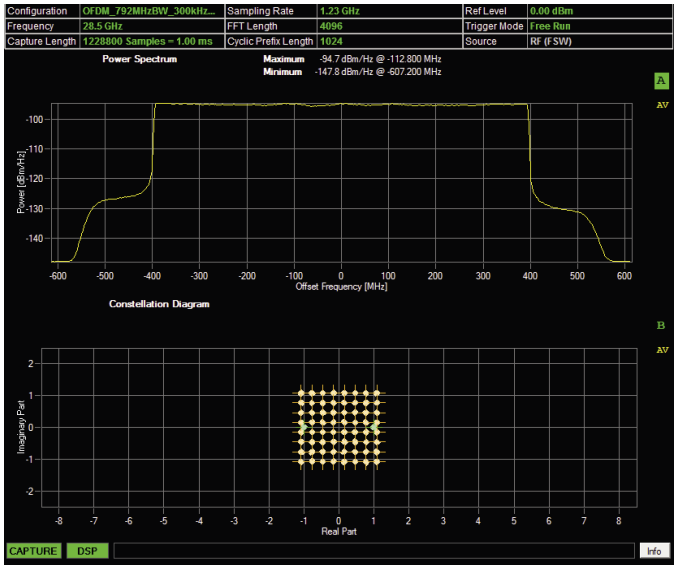
Wideband amplifier measurements for 5G with up to 1.2 GHz analysis bandwidth

The extended analysis bandwidth of 1.2 GHz for the R&S®FSW signal and spectrum analyzer makes it possible to carry out demanding measurements on components for the future 5G cellular standard. Additional measurement options are available to comprehensively characterize amplifiers and analyze OFDM-modulated signals.

To surpass the data rates of the current LTE technology with the future 5G cellular standard, the industry is focusing on frequency bands in the microwave range, including at 28 GHz and 39 GHz. Bundling multiple carriers makes it possible to achieve bandwidths of several hundred megahertz, for example 800 MHz with eight carriers of 100 MHz. 5G component developers, therefore, require a T&M solution to analyze signals of these frequencies and bandwidths.

The new R&S®FSW-B1200 option expands the analysis bandwidth of the R&S®FSW signal and spectrum analyzer to 1.2 GHz. It offers a high dynamic range and low input signal distortion, with a spurious free dynamic range (SFDR) of 65 dBc. These characteristics allow users to precisely determine the signal modulation quality, e.g. by measuring the error vector magnitude (EVM). The EVM generated by the instrument itself must be minimal to ensure reliable measurements on signals with very good EVM. For example, the bandwidth extension and the R&S®FS-K96PC OFDM vector signal analysis software allow the R&S®FSW to measure EVM values in the order of –40 dB with 800 MHz wide signals in the 28 GHz range (Fig. 1). The OFDM analysis software enables users to measure modulation also on non-standardized OFDM signals and offers a high degree of freedom in defining the measurement parameters for the OFDM demodulator. This flexibility provides a tremendous advantage, as the specification of OFDM signals has not yet been finalized in the future 5G cellular standard.

Fig. 1: Analysis of an 800 MHz wide OFDM signal at 28 GHz with the R&S®FSW-B1200 1.2 GHz analysis bandwidth option and the R&S®FS-K96PC OFDM vector signal analysis software. The measured EVM value is better than –40 dB (not displayed).



Digital predistortion compensates for nonlinear effects in amplifiers

Power amplifiers in base stations and smartphones must exhibit a high degree of linearity over a wide frequency range to offer good transmit and receive characteristics. Unwanted nonlinear effects, however, generally occur in the upper power range and diminish signal quality. They manifest themselves as higher EVM values and increased interference in adjacent channels. As a result, only lower orders of modulation and, consequently, lower data rates can be achieved. By characterizing these effects, it is possible to compensate for them using digital predistortion.

The R&S®FSW-K18 amplifier measurements option and its extension, the R&S®FSW-K18D direct DPD measurements option, enable developers to determine the extent to which predistortion can compensate for nonlinear effects in an amplifier design. These options can be used to characterize distortion caused by nonlinear amplitude and/or phase changes relative to the input signal (AM/AM and AM/φM) and compensate for it mathematically by applying various methods. R&S®FSW-K18 initially compares a reference signal from a vector signal generator against the signal amplified by the device under test. The software then calculates a correction polynomial that describes predistortions by way of approximation. The software can also use an equalizer to calculate the frequency response. Analysis bandwidths that are triple, quadruple and quintuple the signal bandwidth are typi-

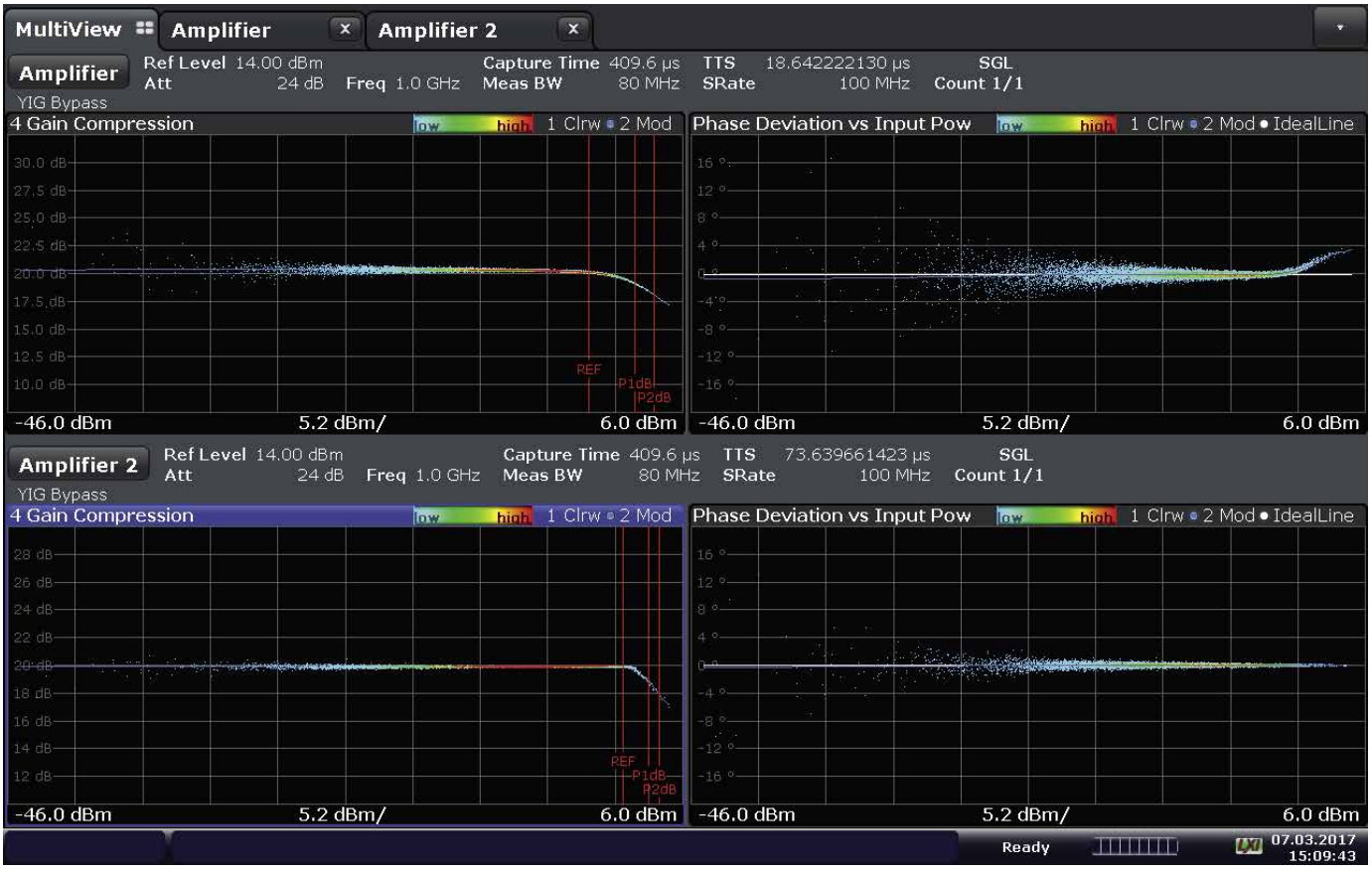


Fig. 2: Diagrams at the top: A signal distorted by an amplifier. The amplifier goes into compression when the power is increased (at approx. 1 dBm). Amplification is no longer linear and the phase is distorted. Diagrams at the bottom: A signal predistorted with correction data from the R&S®FSW. Compression starts at a significantly higher power level. The 1 dB compression point is approx. 1 dB higher, and the phase distortion is corrected perfectly. Correcting memory effects with the R&S®FSW-K18D option also reduces the scattering of test points; the displayed traces are narrower.

cally used to incorporate interference interspersed in adjacent channels. R&S®FSW-K18 sends the calculated amplitude and phase correction values to the R&S®SMW200A vector signal generator. The generator uses these values to predistort a signal, which is applied to the DUT. The R&S®FSW measures and displays the output signal from the DUT (Fig. 2). At this point, the output signal has as little distortion as the amplifier design and correction method will allow.

In addition to nonlinear effects, memory effects in the amplifier produce a frequency response that cannot be corrected using polynomials. In the past, elaborate mathematics such as Volterra series were required to describe this response. The R&S®FSW-K18D extension to the R&S®FSW-K18 amplifier measurements option now simplifies compensation. Instead of approximation through polynomials, R&S®FSW-K18D applies iterative approximation via the individual samples. In this way, the software compensates both nonlinear distortion and frequency response for a predefined signal sequence. The result delivers the best possible reference for predistortion algorithms employed by the user. The 1.2 GHz analysis bandwidth now available in the R&S®FSW makes it possible to characterize amplifiers with a bandwidth up to approx. 1 GHz.

Summary

An analysis bandwidth of 1.2 GHz is now available for the R&S®FSW43 and R&S®FSW50 high-end signal and spectrum analyzers. It can be used across the entire frequency range of the analyzers, making them particularly suitable for measurements in the frequency bands relevant to 5G. The R&S®FSW-K18D direct DPD measurements extension to the R&S®FSW-K18 amplifier measurements option now also makes it possible to compensate for memory effects in amplifiers.

The R&S®FSW now supports 2 GHz with the R&S®FSW-B2000 option for applications requiring more than 1.2 GHz analysis bandwidth. The option uses an R&S®RTO oscilloscope as an external analog-to-digital converter and can be applied with center frequencies from 5.5 GHz.

Martin Schmähling

Modular probe system for measurements up to 9 GHz

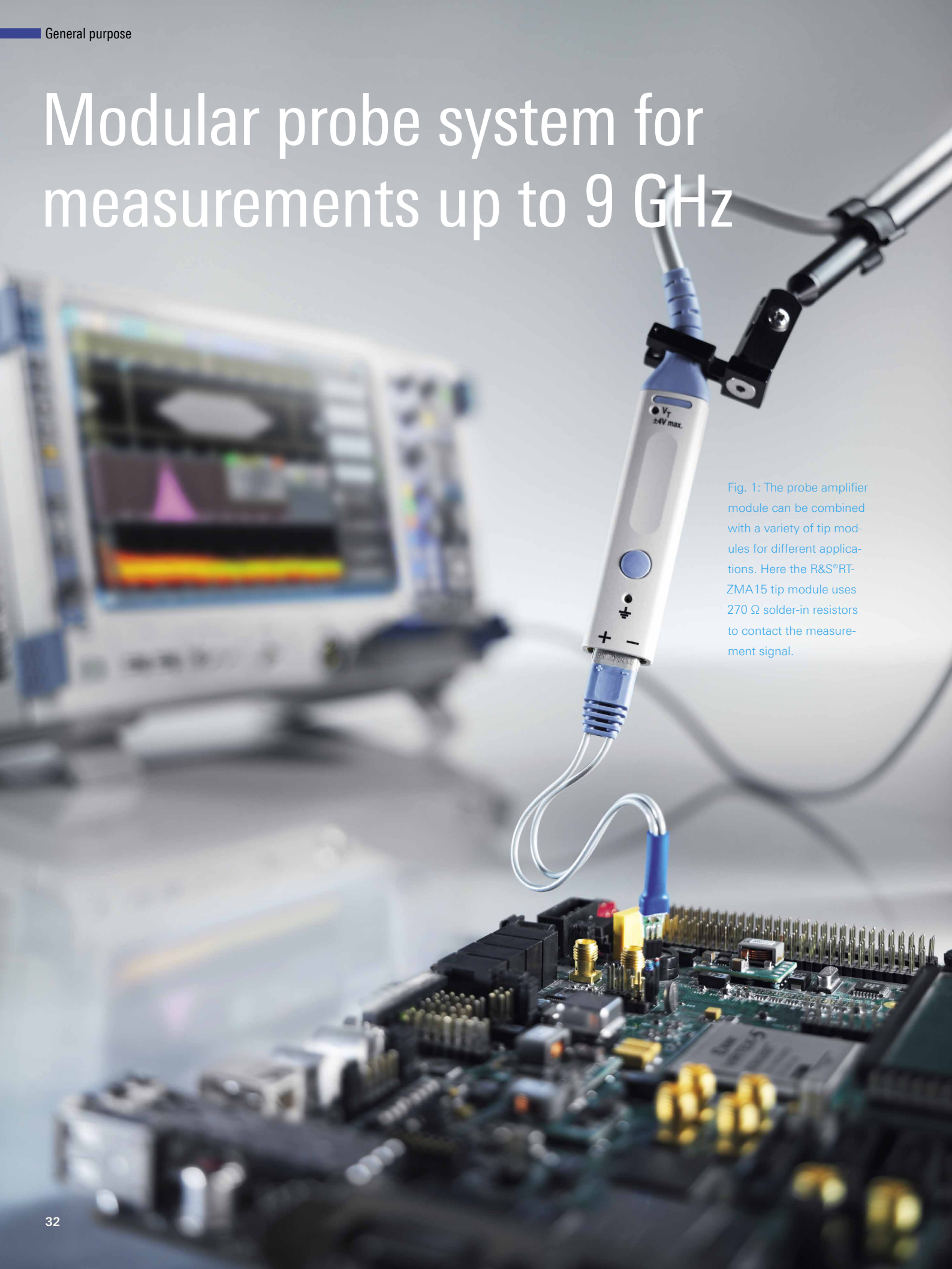


Fig. 1: The probe amplifier module can be combined with a variety of tip modules for different applications. Here the R&S®RT-ZMA15 tip module uses 270 Ω solder-in resistors to contact the measurement signal.

The new modular broadband probe system is designed for precision measurements on high-speed data signals. When switching measurement modes, there is no need to reconnect the DUT.

High-performance probes are needed when measuring high-speed data signals, for example on USB and PCIe interfaces. The probe must have the necessary bandwidth as well as a sufficiently large dynamic range and the input impedance of the probe tip must not load or distort the measurement signal. Versatile contact options and a wide temperature range are also high on the list of requirements.

The new R&S®RT-ZM modular probe system was developed to meet these requirements. Thanks to sophisticated technology, the probes are very versatile yet easy to use, making them ideal for many different applications. The probes consist of an amplifier module (Figs. 1 and 2) plus a tip module to make contact with the DUT. Different tip modules are available for various measurement tasks. A coaxial cable connects the amplifier module to the Rohde&Schwarz probe interface which is plugged into the desired channel on the oscilloscope. The interface provides the necessary supply voltages and simultaneously transmits the analog and digital signals.

Amplifier modules are available for the bandwidths 1.5 GHz/3 GHz/ 6 GHz/9 GHz. An RF ASIC that was developed in-house plus specially adapted components give the module its outstanding RF properties and unique DC characteristics, e.g. a low temperature drift that is unrivaled in the industry. The DC offset compensation in the amplifier module and the ability to perform balanced and unbalanced measurements without reconnecting results in a high degree of versatility and convenience. Further, an integrated analog-to-digital converter for DC voltage measurements allows channel-independent DC measurements in parallel and ensures high precision.

The choice of tip module depends on the specific requirements. The measurement bandwidth and other parameters such as the input impedance, temperature range and contact type need to be taken into account. The R&S®RT-ZM modular probe system offers a wide range of possibilities (Fig. 3).

Designed for challenging requirements

One connection for all measurements

One of the key features of the broadband probes is the MultiMode function in the RF ASIC. It switches between the different measurement modes. Single-ended, differential and common mode measurements can be performed without reconnecting the device. The oscilloscope controls the ASIC's internal switches so that signal components are forwarded to the amplifier in accordance with the selected mode (Fig. 4). This prevents faulty connections and reduces measurement time.

R&S®RT-ZM modular probe system

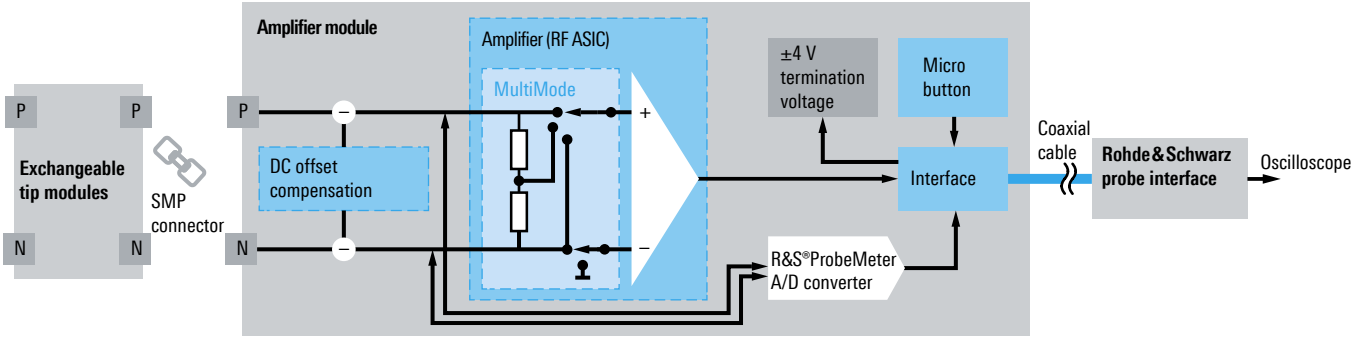


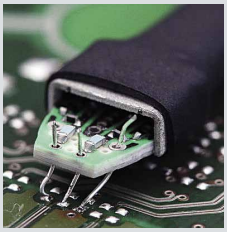
Fig. 2: The amplifier module is available in the bandwidths 1.5 GHz/3 GHz/6 GHz/9 GHz. Exchangeable tip modules are used to contact the DUT.

DC offset compensation

The dynamic range of probes depends on their attenuation factor. The R&S®RT-ZM modular broadband probes offer two choices: 2:1 and 10:1, with a corresponding dynamic range of ±0.5 V and ±2.5 V. Because this dynamic range does not always suffice, DC offset compensation can be used to shift the measurement window between –16 V and +16 V. With this functionality, test signals' DC components can be compensated at the probe tip prior to the differential amplifier in the ASIC. The benefit is clear. Even signals with high DC components can be measured with the full dynamic range and maximum resolution. This capability is also available in MultiMode. There is an appropriate DC offset compensation method for each of the four measurement modes.

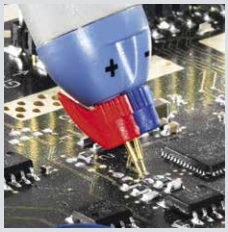
Two typical applications are measuring differential signals with high DC voltage components and measuring the power integrity of DC power rails with superimposed AC components (Fig. 5). For especially challenging measurements on state-of-the-art DC power rails with low operating voltages, Rohde&Schwarz offers a special probe: R&S®RT-ZPR20 (see article on page 39).

Fig. 3: For every application, the right tip module is available for contacting the DUT.



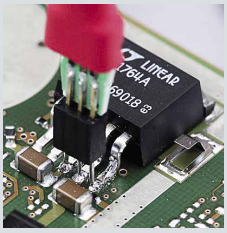
Closely spaced test points; requires minimal input impedance:

R&S®RT-ZMA10: Solder-in tip module with low input capacitance of only 77 fF.



Universal contacting of points with differential signals:

R&S RT-ZMA30: Manual contacting of the DUT with spring-loaded probe tips. The input capacitance is 32 fF.



Fast and flexible contacting for bandwidths up to 6 GHz:

R&S®RT-ZMA12: Contacting via a 1.27 mm pin connector with input capacitance of 279 fF.

Measuring single-ended and differential sources with an impedance of 50 Ω or 100 Ω:

R&S®RT-ZMA40: Contacting via an SMA module that is compatible with 3.5 mm and 2.92 mm connectors. A common mode voltage of ±4 V can also be supplied via the module and used as the reference instead of ground.

Fast and flexible contacting for bandwidths > 6 GHz; low input capacitance:

R&S®RT-ZMA15: 270 Ω solder-in resistors with higher bandwidth and lower input capacitance (109 fF) than the R&S®RT-ZMA12.

Measurements in temperature range from –55 °C to +125 °C:

R&S®RT-ZMA50: The **RT-ZMA11 solder-in module** is separated from the amplifier module by a 1 m cable pair; measurements up to 2.5 GHz in the extended temperature range in a climatic chamber.

Precision voltage measurements, independent of oscilloscope settings

The integrated R&S®ProbeMeter is ideal for quickly and easily determining the operating points and supply voltages – in both single-ended and differential configuration. It uses a separate A/D converter that is integrated into the amplifier module and therefore independent of the oscilloscope settings. The DC components of a measurement signal can be continuously determined in parallel to the oscilloscope measurement. The measurement uncertainty is 0.05 % in a measurement range of ±7 V.

R&S®ProbeButton for oscilloscope control

The function of the micro button on the amplifier module can be configured on the oscilloscope. Various functions are available such as run/stop, auto set, save measurement results and switch measurement mode. These functions simplify oscilloscope operation and prevent other activities from distracting the user.

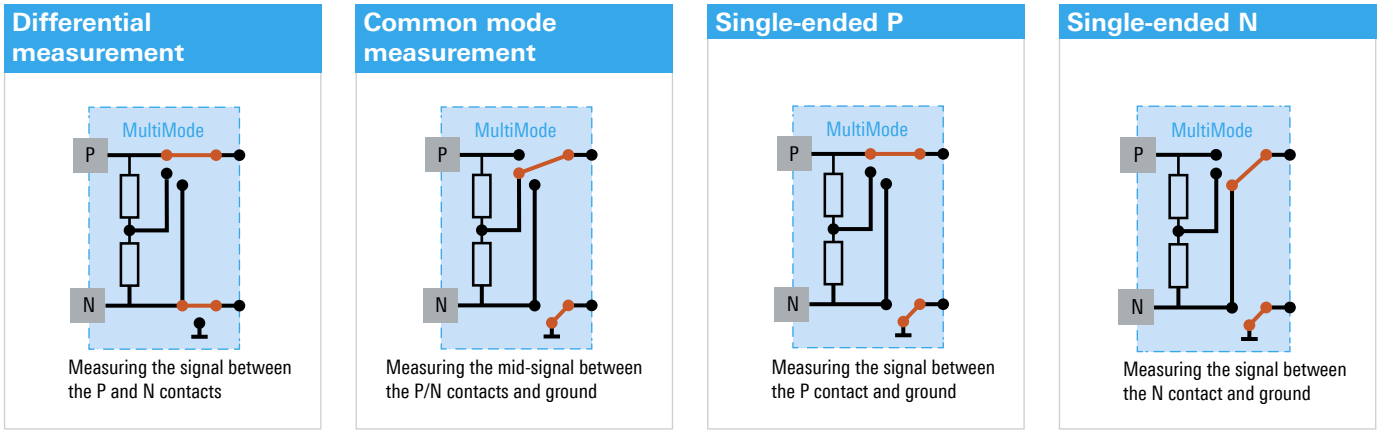


Fig. 4: The MultiMode function controlled by the oscilloscope switches the signals in the RF ASIC in accordance with the selected measurement.

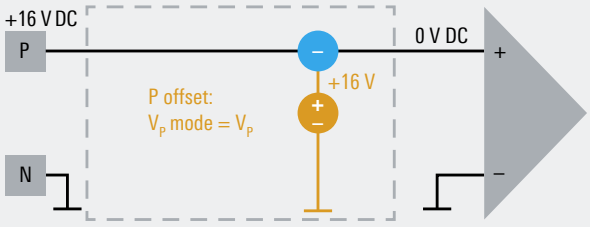
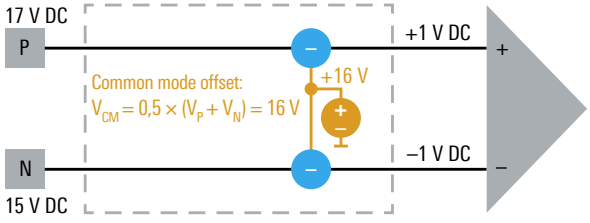
Application	DC offset compensation	Procedure
Power integrity measurements on DC voltages with superimposed AC components		When making measurements on power rails on advanced electronic boards, the focus is on superimposed AC components. These components can be measured with the amplifier's full resolution after compensating for the constant DC component.
Measurement of differential signals with a high DC component		The differential signal of interest has a superimposed common mode voltage. In order to measure just the differential signal information, the common mode voltage between the two measurement points is compensated so that the amplifier is only fed a balanced differential signal.

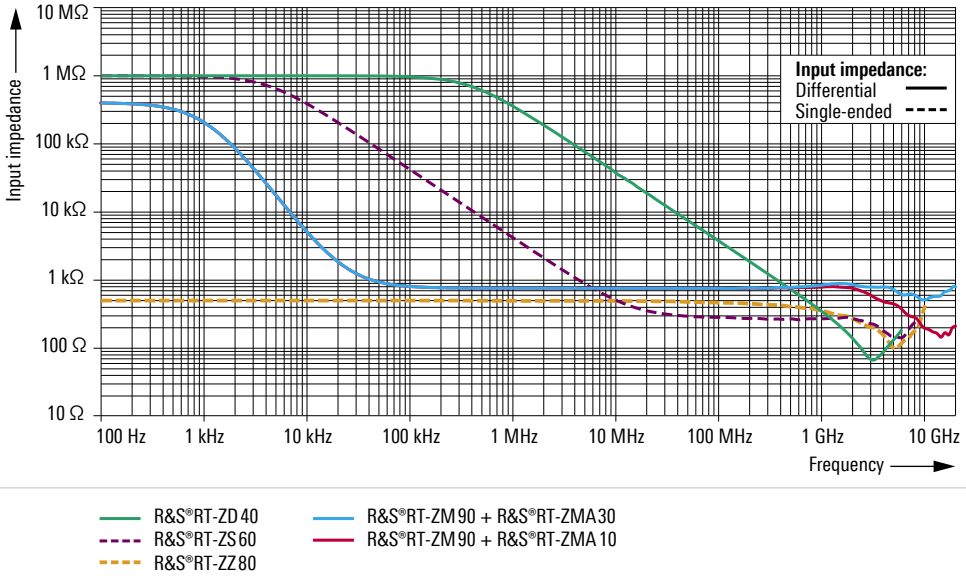
Fig. 5: Typical application examples illustrating the benefits of DC offset compensation.

Comparison of active probes from Rohde&Schwarz: R&S®RT-ZM versus R&S®RT-ZS/R&S®RT-ZD

Probe	Input resistance		Input capacitance	
	SE	DM	SE	DM
R&S®RT-ZS10/10E/20/30	1 MΩ		0.8 pF	
R&S®RT-ZS60	1 MΩ		0.3 pF	
R&S®RT-ZD10/20/30	500 kΩ	1 MΩ	0.8 pF	0.6 pF
R&S®RT-ZD40	500 kΩ	1 MΩ	0.65 pF	0.4 pF
R&S®RT-ZMA10/11	200 kΩ	400 kΩ	96 fF	77 fF
R&S®RT-ZMA12	200 kΩ	400 kΩ	521 fF	279 fF
R&S®RT-ZMA15	200 kΩ	400 kΩ	150 fF	109 fF
R&S®RT-ZMA30	200 kΩ	400 kΩ	52 fF	32 fF

Fig. 6: Comparison of the input impedance of the R&S®RT-ZS/ R&S®RT-ZD probe families and the R&S®ZM modular probes (DM = differential mode, SE = single-ended).

Input impedance versus frequency



R&S®RT-ZD40
R&S®RT-ZS60
R&S®RT-ZZ80
R&S®RT-ZM90 + R&S®RT-ZMA30
R&S®RT-ZM90 + R&S®RT-ZMA10

Fig. 7: Comparison of the input impedance of various probes between 100 Hz and 20 GHz.

Differential input impedance versus frequency

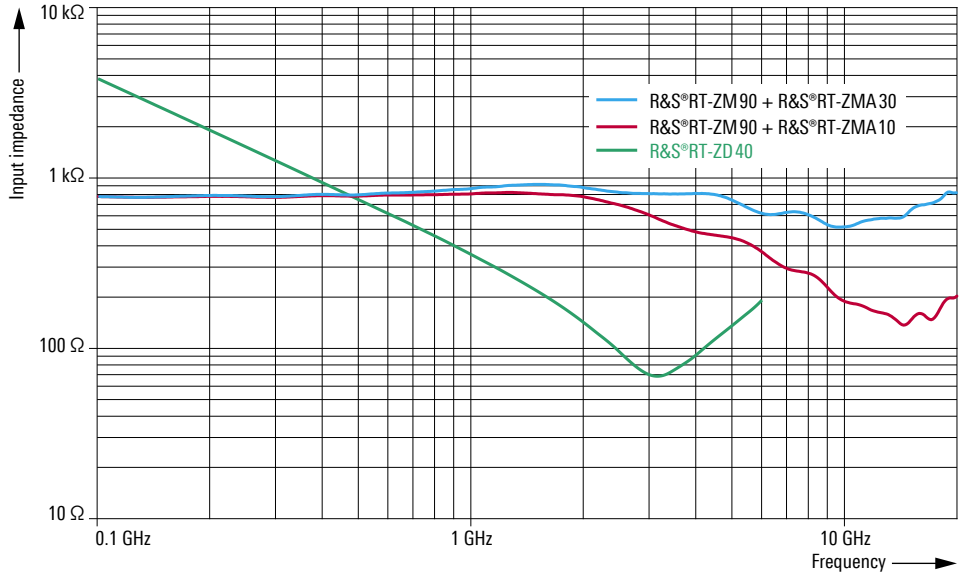


Fig. 8: Comparison of the input impedance of differential probes between 100 MHz and 20 GHz.

Comparison of probe input impedances

An ideal probe has infinitely high input impedance and does not put any load on the signal source. The effective input impedance of real probes is determined primarily by the input resistance and input capacitance. Since they both form a load that draws signal current from the source, they influence the functioning of the circuit as well as the signal to be measured (Fig. 9).

If the input resistance is too low, the signal amplitude will decrease. This results from connecting the resistances in parallel, which distorts the signal to be measured. At higher frequencies, the probe's capacitive load influences the waveform of the signal to be measured. As the frequency increases, the influence on the measurement signal becomes greater.

Active probes generally have higher input impedance than passive probes and therefore do not place as high a load on the measurement signal. Rohde&Schwarz has both types of probes in its portfolio. The company's range of active probes is particularly extensive. In addition to the R&S®RT-ZM modular broadband probe system described here, the company offers R&S®RT-ZS and R&S®RT-ZD probes. They differ from the R&S®RT-ZM mainly in terms of bandwidth and input impedance. Figs. 6 to 8 in the box on page 36 show a comparison of the different probe families.

Impact of input resistance and capacitance

Fig. 9: A probe's input impedance affects the signal source. The left-hand diagram shows the impact of the input resistance, the right-hand diagram the impact of the input capacitance on the measured signal.

Measurement example

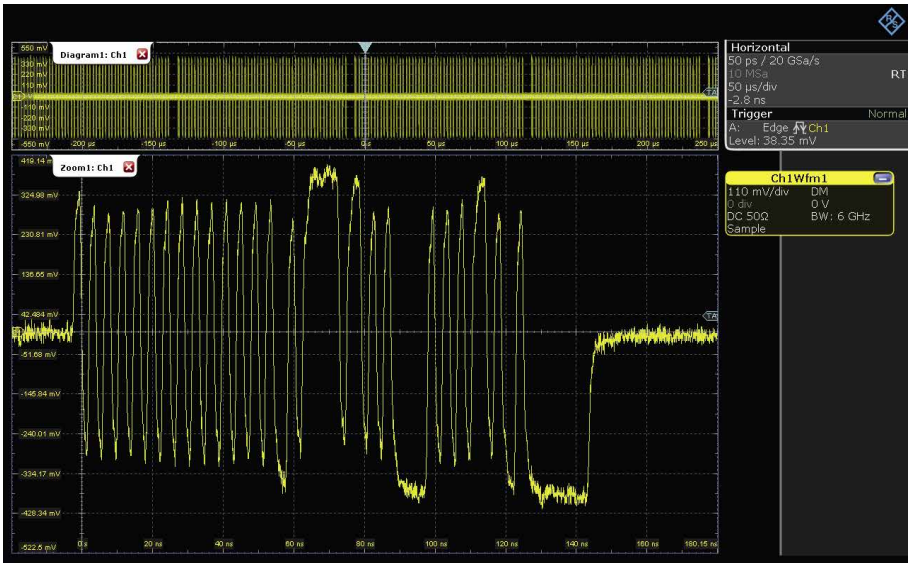
One typical application for the R&S®RT-ZM modular broadband probes is verifying high-speed USB 2.0 signals. In this application, the DUT (e.g. a USB memory module) is contacted via the two data pins D+ and D–. To perform single-ended and common mode measurements in addition to differential measurements, a ground contact is also necessary.

Since the available sensing distance is typically small and in order to minimize the influence on the measurement signal, the R&S®RT-ZMA10 solder-in tip module is recommended. It loads the DUT with less than 77 fF, ensuring a nearly ideal connection. It is important to keep the solder connections as short as possible.

The measurement result in Fig. 10 shows the differential USB signal between the two data pins D+ and D– in idle mode. The probe is set to differential mode (DM).

To now analyze the common mode and single-ended USB signals, the user can simply change the test mode for the R&S®RT-ZM probe on the oscilloscope.

Fig. 10: The USB differential signal. The probe is operated in differential mode (DM).



The DUT does not have to be reconnected (Figs. 11 and 12). The probe's current MultiMode configuration appears in the signal icon as DM, CM, P or N.

For measurements in the extended temperature range from –55 °C to +125 °C, the R&S®RT-ZMA50 extreme temperature kit should be used. It uses two matched cord extension sets to separate the R&S®RT-ZMA11 tip module from the amplifier module so that the DUT can be placed in a climatic chamber.

Summary

The R&S®RT-ZM probes were designed for measurements on broadband signals and are available with 1.5 GHz/3 GHz/6 GHz/9 GHz bandwidth amplifier modules. Thanks to the many different tip modules, they provide the best possible contact with various types of DUTs. With specially developed features such as MultiMode, which allows switching between different measurement modes via the oscilloscope with no need for reconnecting, as well as DC offset compensation in the ±16 V range, the R&S®RT-ZM probes are a universal and easy-to-use solution for measuring high-speed data signals.

Matthias Beer

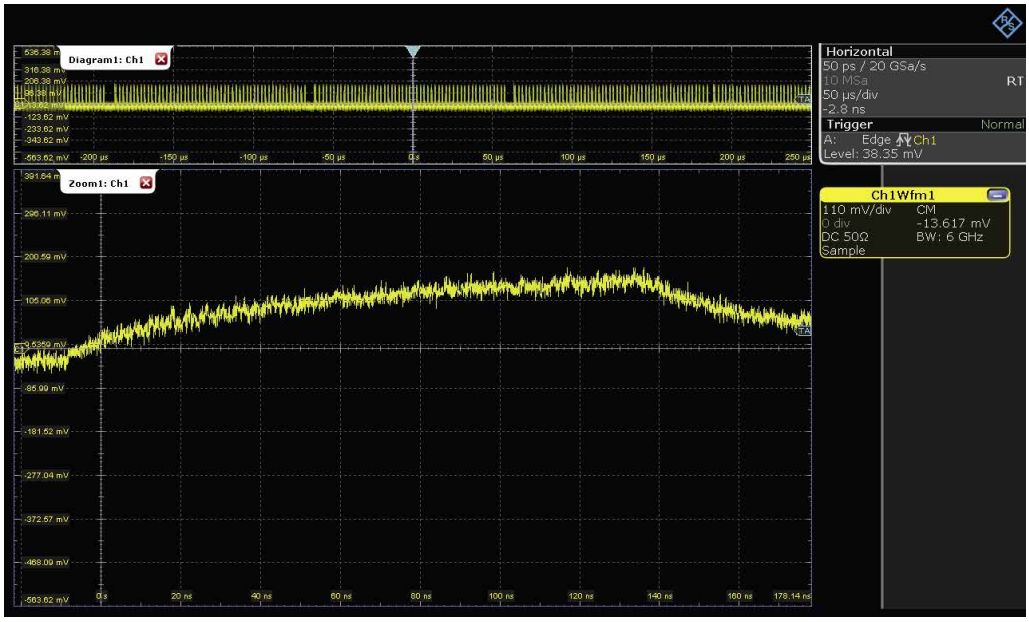


Fig. 11: Measurement of the USB common mode signal. The change to common mode (CM) was made on the oscilloscope. No reconnecting of the DUT was required.

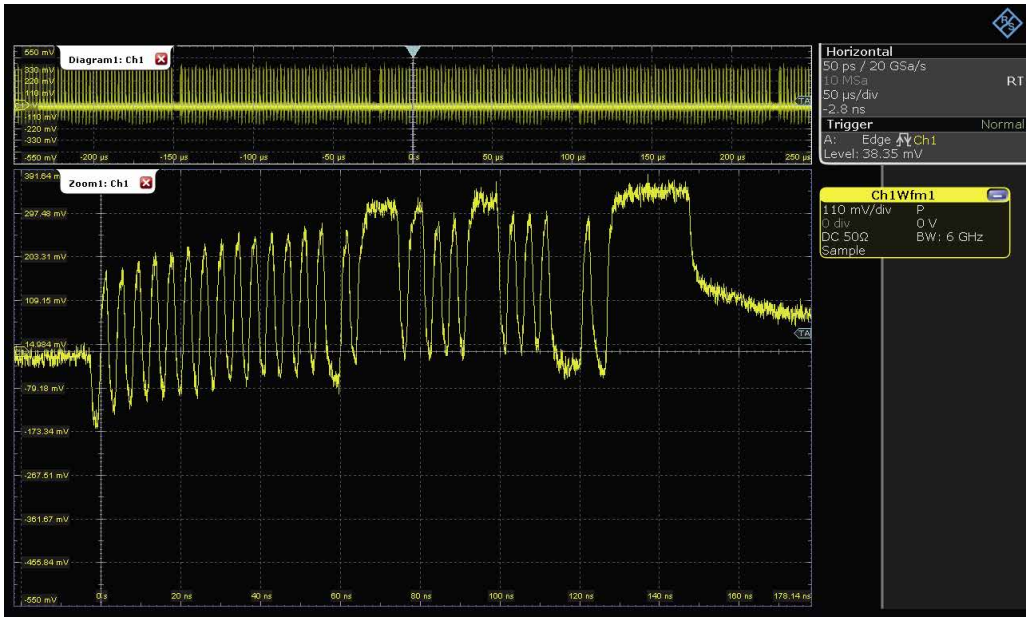


Fig. 12: Once again, no reconnecting was necessary: measurement of the USB single-ended P signal.

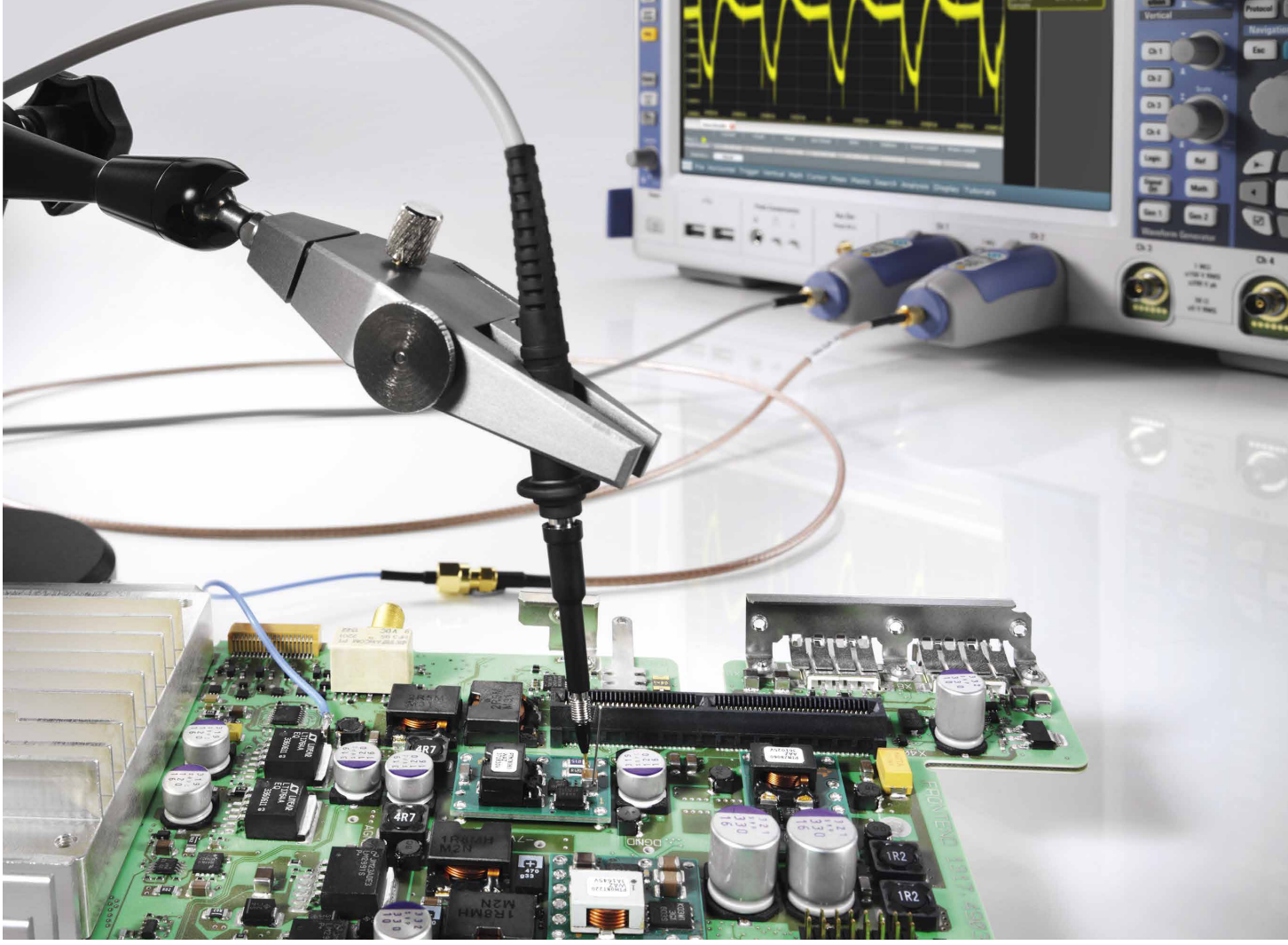


Fig. 1: Two R&S®RT-ZPR20 power rail probes connected to an R&S®RTO oscilloscope. One is connected to the circuit via a solder-in coaxial cable and the second has the browser module for fast overview measurements.

Low-noise probe for accurate power integrity measurements

The quality of the power supply is a key factor in the functionality and performance of electronic circuits. The new R&S®RT-ZPR20 probe makes it possible to perform low-noise, high bandwidth measurements on DC power distribution networks.

In extreme cases, today's advanced electronic designs can contain hundreds of power distribution networks. Each network must be tested to ensure that the pins of ICs are supplied with the necessary DC voltage within defined tolerances and the required level of quality. Oscilloscopes remain the tool of choice for these types of measurements. They can measure not only the DC voltage level, but also its quality. Traditional oscilloscopes and probes have difficulties with these measurements because their measurement accuracy is influenced by factors such as inherent noise and insufficient offset.

Power rail voltages and tolerances required by today's electronic components, such as FPGAs, ASICs and DDR memories (Fig. 3), continue to decrease. While any oscilloscope could make measurements on conventional 5 V rails within the given 10 % measurement tolerance, a 1 V power rail with a tolerance of 2 % corresponds to just 20 mV, a value that lies within the inherent noise of many oscilloscopes and probe systems, making it impossible to accurately measure such small amplitudes.

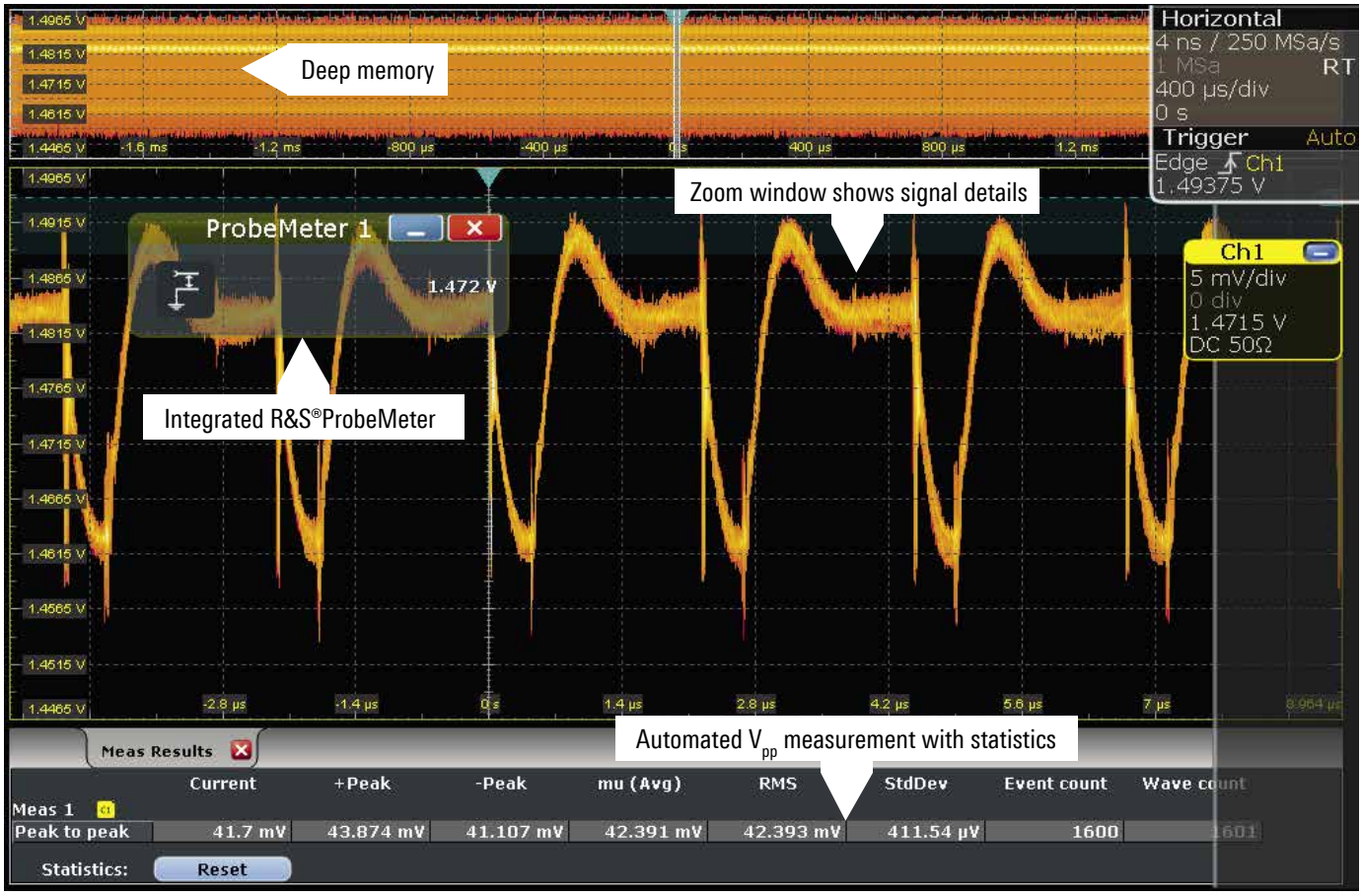


Fig. 2: The R&S®RT-ZPR20 power rail probe with integrated R&S®ProbeMeter outputs the high-resolution signal details to the R&S®RTE and R&S®RTO, including ripple, noise, transients and the power distribution network's exact DC voltage.

Measurement tolerances

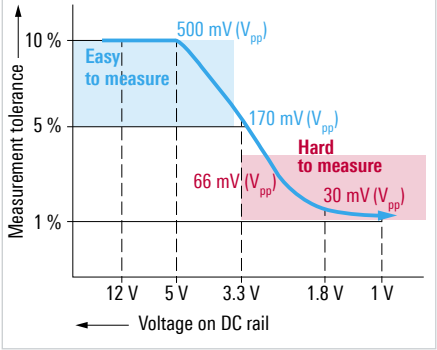


Fig. 3: It is nearly impossible to qualify power distribution networks for sensitive electronic components with traditional probes. The narrow tolerance of < 2 % requires special probes with extremely low inherent noise.

R&S®RT-ZPR20 power rail probe

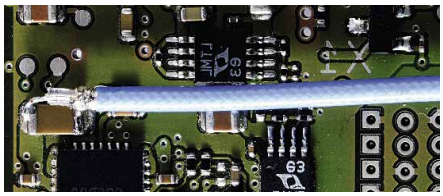
The new R&S®RT-ZPR20 active power rail probe (Figs. 1 and 5) was developed specifically for performing fast, accurate power integrity measurements on R&S®RTO and R&S®RTE oscilloscopes. Unique in the industry, it includes an integrated DC voltmeter, the R&S®ProbeMeter. This feature can be extremely useful for quickly determining how much offset compensation may be required (see below).

Extremely low inherent noise

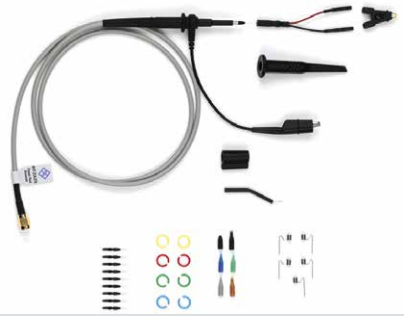
Every oscilloscope frontend and every probe has inherent noise that is added to signals. For small signals, the added noise results in overstated peak-to-peak voltages, which is why it is essential to use oscilloscopes and probes with the lowest possible noise.

The R&S®RT-ZRP20 power rail probe and the R&S®RTO or R&S®RTE oscilloscope have a low RMS noise voltage of only 120 µV at 1 GHz bandwidth and 1 mV/div vertical scaling. The probe's 1:1 attenuation factor circumvents the problem of 10:1 probes, which

Fig. 4: Solder-in pigtail coaxial cable for high bandwidth contacting.



There are two ways to connect the R&S®RT-ZPR20 to power distribution networks. The 350 MHz browser is ideal for quickly measuring multiple power supplies in an electronic design. It connects to the Rohde&Schwarz probe adapter via an SMA connector and includes additional accessories such as a ground spring that minimize ground loops and clips to clip onto components and test points. A reliable high-fidelity connection is required for more precise, low-noise, high bandwidth measurements. In this case, a 50 Ω SMA coaxial cable is usually used to connect the probe. The other end of the cable is soldered to the circuit (Fig. 4).



attenuate the input signal by a factor of ten without decreasing the inherent noise so that this noise appears 10 times as large.

DC offset compensation range of ±60 V

Oscilloscopes typically do not have enough DC offset compensation to directly measure with a high resolution the wide range of power rails in today's electronic devices. This results in two negative factors. First, the user cannot center the signal within the vertical dynamic range and therefore must work with a less sensitive vertical scaling. As a result, only a fraction of the available ADC resolution can be used for the measurement.

Second, noise is a function of the vertical resolution. Measuring with lower vertical resolution means more noise, and peak-to-peak values will be overrepresented.

Some users add blocking capacitors or use the oscilloscope's AC coupling to remove DC offset. This has the disadvantage of not allowing the user to see the true DC value of the rail, and eliminates the ability to see low frequency drift as circuits turn on and off.

The R&S®RT-ZPR20 solves all these problems with its large DC offset compensation range of ±60 V. This allows users to center and expand the voltages on DC rails from an extremely wide variety of standards, so that they can accurately measure and also see any DC drift that might occur (Fig. 2).

For users who exclusively want to make ripple and noise measurements, the probe includes the ability to choose AC coupling. This allows users to move quickly between different DC supplies without having to continually readjust the offset compensation voltage.

2 GHz bandwidth

Finding coupled signals and harmonics on the power rail has been another traditional challenge. With close proximity to clock signals and other types of coupling, power distribution networks are often subjected to high-frequency crosstalk that requires large bandwidths to measure. This lies outside the capabilities of lower-cost 38 MHz passive probes with an attenuation factor of 1:1 often used for power integrity measurements. These probes are suitable only for measuring low-frequency ripple signals and would miss higher frequency transients.

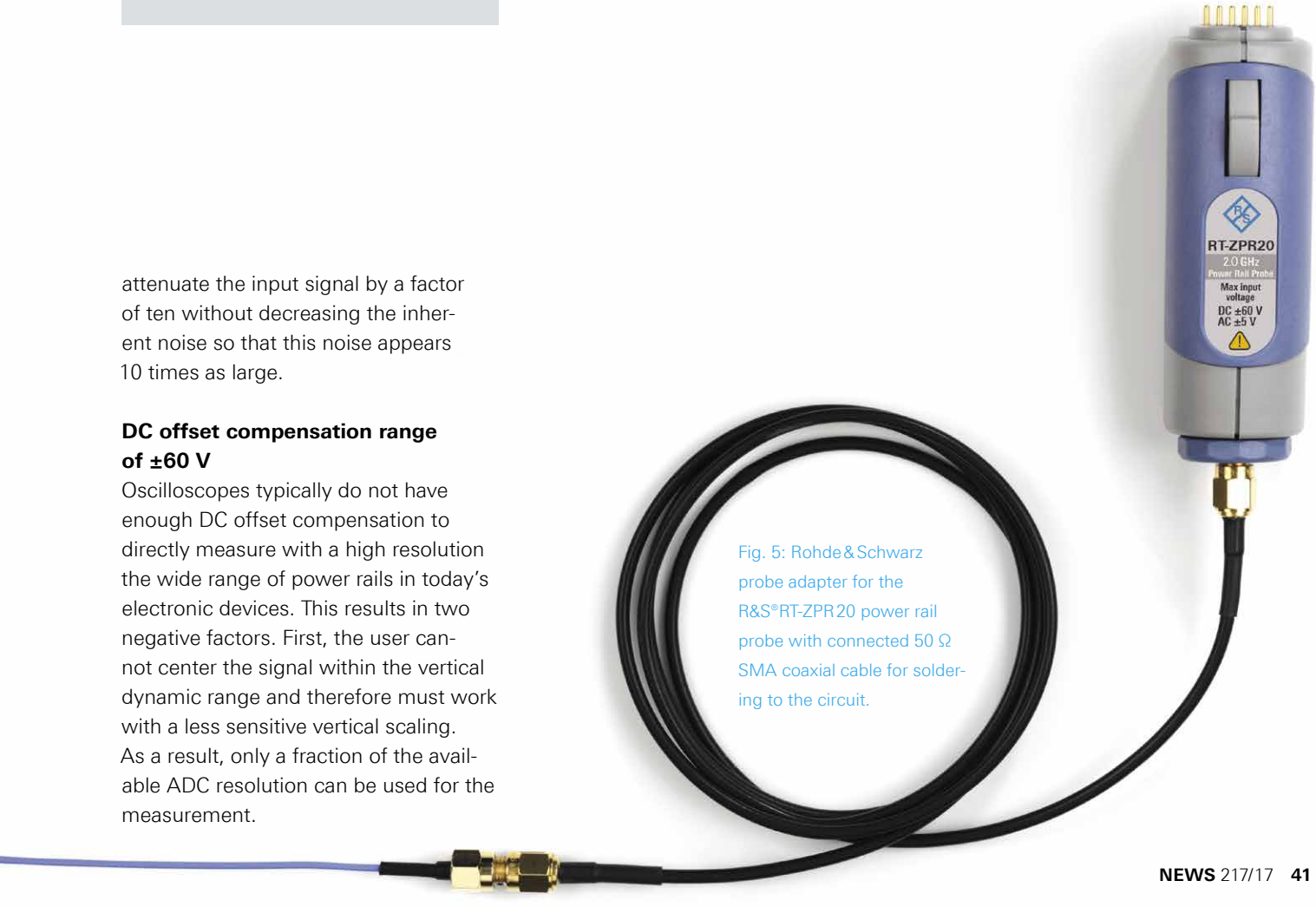


Fig. 5: Rohde&Schwarz probe adapter for the R&S®RT-ZPR20 power rail probe with connected 50 Ω SMA coaxial cable for soldering to the circuit.

Fig. 6: The spectrum analysis function in Rohde&Schwarz oscilloscopes is a powerful tool for identifying unwanted coupled signals in DC power distribution networks. In the example, a coupled 2.4 GHz WLAN signal is clearly visible.

The R&S®RT-ZPR20 has a specified bandwidth of 2 GHz and a typical 3 dB point near 2.4 GHz, which is why, for example, a coupled 2.4 GHz WLAN signal will be visible.

Power integrity measurements often include troubleshooting at slow timebases and fast oscilloscope sample rates. An oscilloscope must have deep memory to be able to measure for the long periods of time required in this situation. The hardware-accelerated FFT measurements in the R&S®RTO and the R&S®RTE provide users with a sufficiently fast spectral display to make their work easier (Fig. 6).

High input impedance

The impact of probe loading on DC rails must be minimized to prevent DC values from changing due to probe loading. Power rails typically have impedances around 1 mΩ. Connecting to a power rail via the 50 Ω path on the oscilloscope, for example, will change the DC value. The R&S®RT-ZPR20 probe's DC input impedance measures 50 kΩ to minimize its impact.

Summary

Today's power integrity measurements with decreased rail voltages and smaller tolerances are a challenge to traditional oscilloscopes and probes. But they are no problem for the new R&S®RT-ZPR20 power rail probe, which was designed specifically for these types of measurements. It is not only low noise with its 1:1 attenuation factor. With its ±60 V offset range, 2 GHz bandwidth, 50 kΩ DC input impedance and integrated DC voltmeter, it offers everything users need to successfully measure today's DC power distribution networks. The probe can be used with R&S®RTE (200 MHz to 2 GHz) and R&S®RTO (600 MHz to 6 GHz) oscilloscopes.

Joel Woodward

Arbitrary waveform and pattern generator module for the R&S®RTO/R&S®RTE oscilloscopes

The integrated generator option eliminates the need for a separate device on the lab bench. The option can be operated and configured directly on the oscilloscope without any additional software. It provides the functionality needed for challenging design and development tasks.

Rohde&Schwarz is the first oscilloscope manufacturer to offer an integrated arbitrary waveform and pattern generator in the laboratory class (Fig. 1). The option (R&S®RTO-B6 or R&S®RTE-B6) has two analog channels and eight digital channels that are controlled and configured on the oscilloscope's touchscreen. The option can generate a variety of control and stimulus signals for DUTs. It also saves space on the lab bench by eliminating the need for a separate generator.

Each of the two analog channels has a bandwidth of up to 100 MHz and can be operated in four different modes: as a function, modulation, sweep or arbitrary waveform generator. The frequency, amplitude and offset can be set. Additive noise can be superimposed on the signals. For differential measurements, the two generator channels can be coupled to generate a differential signal. Thanks to the ability to set the DC offset as well as the amplitude and phase of the two channels, it is easy to generate both ideal and non-ideal signals, e.g. for testing the amplitude and phase balance of differential amplifiers or I/Q mixers. With sampling rates of 500 Msample/s and 14-bit resolution, the analog generator is ideal for complex applications in design and development.

Characterization of components

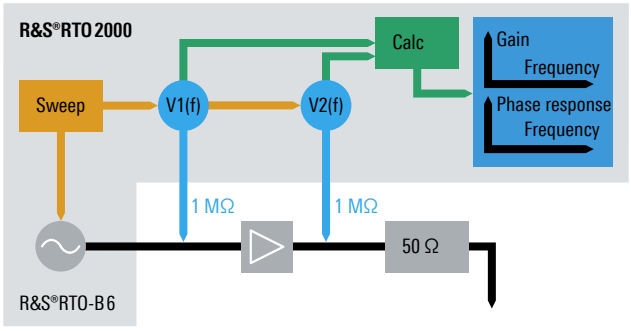


Fig. 2: Block diagram of the setup for using an oscilloscope with an integrated generator to determine the phase response and gain of active and passive components.

Diverse applications

The generator can also be used for applications other than the classic arbitrary waveform and pattern generator applications, for example to characterize active and passive components

Fig. 1: The R&S®RTO-B6 generator module with two analog and eight digital channels.

R&S®RTO-B6	Analog	Digital
Channels	2	8
Bandwidth	100 MHz	up to 40 Mbit
Sampling rate	500 Msample/s	up to 40 Msample/s
Resolution	14 bit	0.1 V (0 V to 5 V)
Operating modes	**Function generator** (sine, square, ramp, DC, pulse, cardinal sine, cardiac, Gauss, Lorentz, exponential rise/fall), **modulation** (AM, FM, FSK), **sweep generator, arbitrary waveform generator**	

by measuring the phase response and gain (Fig. 2). The generator signal is connected to the DUT and the generator frequency is then varied by a configurable step size between the desired start and stop frequencies. At each frequency, the signal at the DUT's input and output is measured. The difference between the measured value pairs is used to determine the gain and phase response. To avoid distortion, the signals are contacted with high-impedance, e.g. with passive probes.

Thanks to its straightforward operation, the integrated generator is also an excellent training tool. For each operating mode, the configuration menu shows a diagram and the

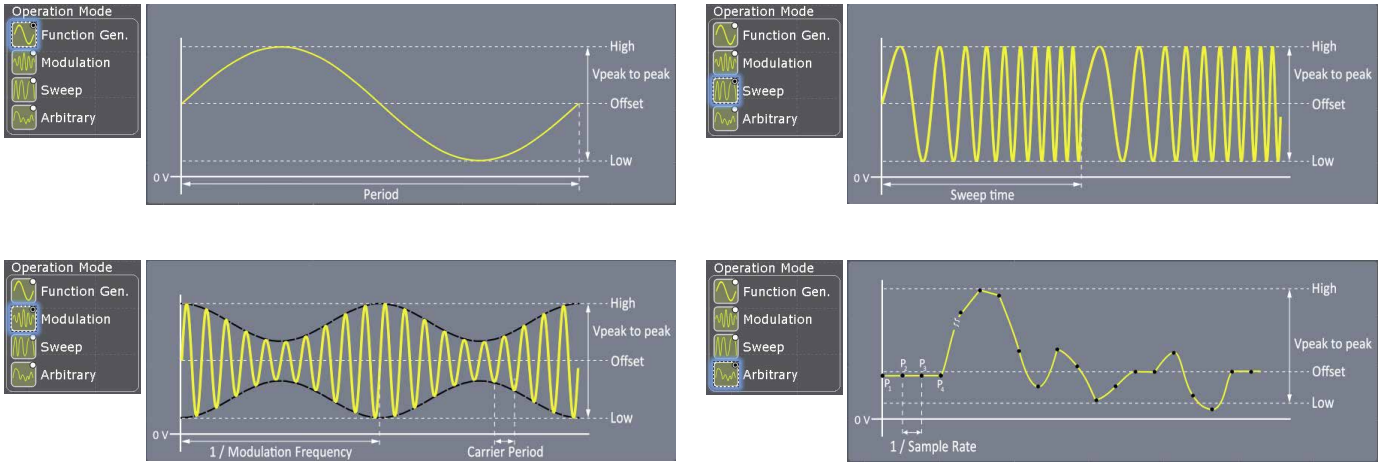
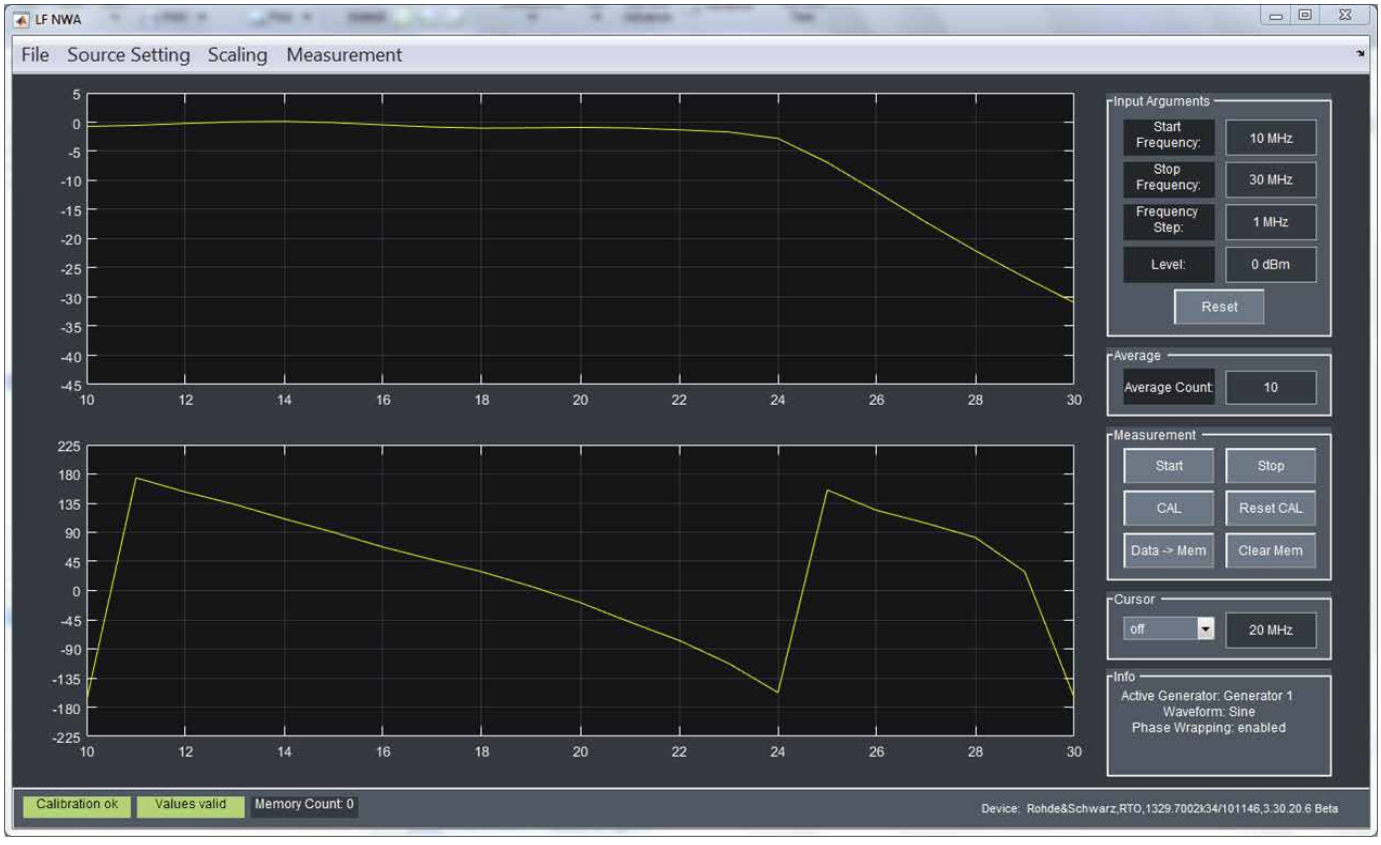


Fig. 3: A useful training tool: configurable signal parameters are explained on the display.

Fig. 4: Example of a MATLAB® program for determining the gain and phase response of a lowpass filter between 10 MHz and 30 MHz. The upper trace shows the attenuation and the lower trace the phase response.



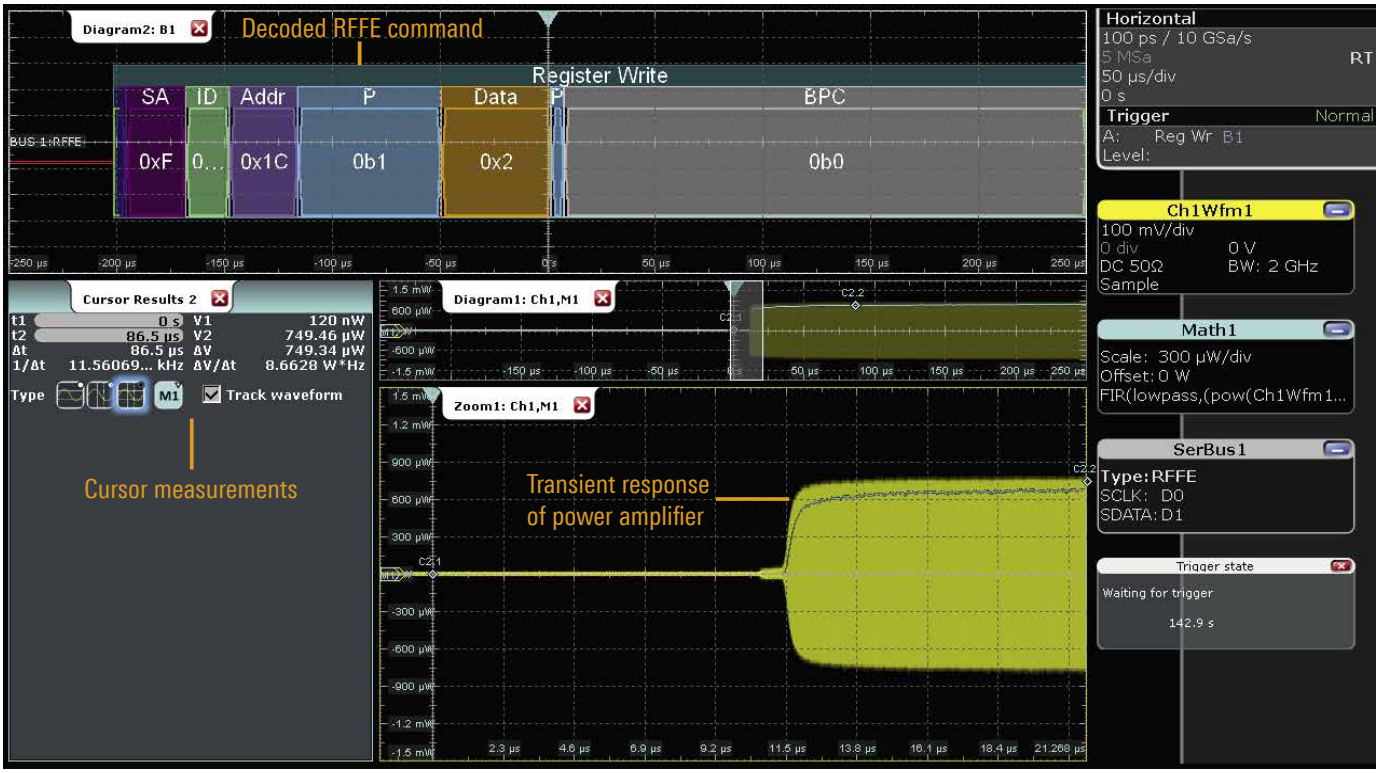


Fig. 5: Measurement of transient time of an RFFE-controlled power amplifier, with markers. The oscilloscope is triggered by the RFFE control signal.

configurable parameters (Fig. 3). Plain comma-separated values (CSV) files from a spreadsheet or MATLAB® can be used to define arbitrary waveform or pattern signals (Fig. 4).

The versatility of this new option can also be seen in the digital pattern generator. It can output customized digital signals on up to eight channels, with a sampling rate up to 40 Msample/s and up to 40 Mbit per channel. This makes it easy to trigger switching operations on DUTs and measure timing relationships. A typical application is measuring the transient response of power amplifiers for smartphones (Figs. 5 and 6). An RF frontend (RFFE) interface is commonly used. The pattern generator can transmit RFFE control signals to the DUT. These are used to configure and control the power amplifier. The oscilloscope measures the output signal and determines the transient time with a timing reference to the transmitted control signal.

Another application for the generator option is in automating compliance tests. The highly automated R&S®ScopeSuite test software can use the integrated arbitrary waveform and pattern generator to generate control signals for Ethernet compliance tests or interferers for 1000BASE-T Ethernet and BroadR-Reach. This simplifies the test setup. Complex measurements can be fully automated and executed without any user interaction. Mistakes are prevented and the entire test runs much faster than in manual operation.

Determination of the transient response

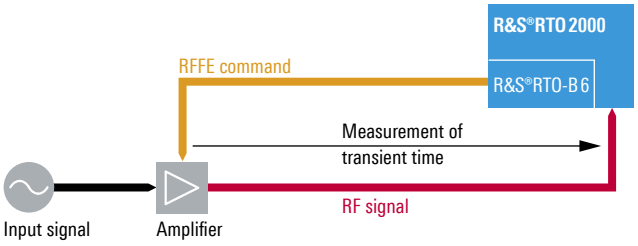


Fig. 6: Block diagram of the setup for measuring the transient time of a power amplifier.

Summary

The arbitrary waveform and pattern generator option extends the functionality of the R&S®RTO and R&S®RTE oscilloscopes. It eliminates the need for an external generator. The fully integrated solution can be operated directly on the oscilloscope without any additional software. Complex test procedures such as compliance tests can be fully automated. The functionality provided by the R&S®RTO-B6/R&S®RTE-B6 option makes it a useful aid during design and development work. Thanks to its straightforward operation and detailed documentation of the signal parameters on the display, it is also an excellent training tool.

Matthias Beer

Program extension

The right tool for every task. Rohde&Schwarz has always represented a T&M treasure trove for anyone doing research and development at the forefront of wireless communications. The solutions described in this issue of NEWS prove that nothing has changed in this tradition. Not everyone works at the very cutting edge of technology, though, and there remain countless more mundane measurement tasks across service, quality assurance, development and education that can be performed perfectly well with equipment that is less sophisticated and less expensive. In the past, customers usually had to look to other manufacturers for these basic test instruments. Rohde&Schwarz is now poised to demonstrate for the entry class what know-how, an innovative spirit and state-of-the-art production methods can deliver for those with smaller budgets. On the following pages, we present the first models in a new generation of Value Instruments. All start at well below EUR 2,000. All come from the same European manufacturing plants as their high-end siblings. And all adhere to the same Rohde&Schwarz principles with regard to brand value and quality: deliver the best performance in their segment at a convincing price/performance ratio. Plus another detail: instruments are typically shipped in their full

configuration from the factory. Special features that not everyone needs lie dormant in reserve in the instrument until they are purchased and then activated via keycode. This makes it very easy for customers to choose the upgrades that precisely meet their needs and their budget, even years later.

But the right combination of price and performance is not enough for products in this purchase class. Customers expect the same uncomplicated and fast ordering and shipping process that they are familiar with from the consumer marketplace. And the same goes for customer support and service requests. The Value program is set up to meet those expectations. The products are available to buy from Rohde&Schwarz as well as from trusted expert distributors who know and serve their local markets best. The product pages at www.rohde-schwarz.com show the available purchase channels for every country.

Other Value products are in the pipeline. NEWS will provide regular reports on these innovations.

Power of Ten


10-bit ADC
10 Msample memory
10" touchscreen
ROHDE&SCHWARZ
RTB2004 · Digital Oscilloscope · 2.5 GSa/s
Undo
Save Setup
Load Setup
Meter
FFT
Demo
Annotation
Delete
Auto
192 MSa/s
Run
Sample
tr: 29.46 µs
tf: 29.88 µs
MeanCyc: 9.28 mV
Vp-: -311.04 mV
RMS-Cyc: 223.10 mV
T: 100.01 µs
f: 10.00 kHz
Vpp: 643.55 mV
C1
C2
C3
100 mV/
C4
D15-8
Gen
Aux Out
Pattern Generator
Probe Comp.
Demo 1
Logic Channels
D15 ... D8
D7 ... D0
Ext. Trigger In
Ch1
Ch2
Ch3
Ch4

10-bit ADC, 10 Msample memory and 10.1" capacitive touchscreen – the new R&S®RTB2000 tops the entry segment with a perfect "10" in three important areas. And that at a starting price of EUR 1,250. The unexpectedly rich feature set qualifies the instruments for innumerable measurement tasks in industry and education.

The R&S®RTB2000 series oscilloscopes set new standards in the entry class. That they are much more than ordinary oscilloscopes is obvious from their impressive functions that include an optional logic and protocol analyzer, signal waveform and pattern generator and digital voltmeter. They also feature dedicated operating modes for spectrum analysis, mask tests and long data acquisitions. They make debugging of all types of electronic systems easy and effective. And all of this comes at an extremely attractive price.

Video

10.1" high-resolution touchscreen with gesture support

The high-resolution, capacitive 10.1" touchscreen makes working with the R&S®RTB2000 a visual experience. That is by no means an unnecessary luxury for users who spend a large amount of time in front of an oscilloscope reading the display. At more than twice the size offered by other oscilloscopes in this class and with a resolution of 1280 × 800 pixels, the screen provides a richly detailed waveform display. Users also want fast and easy operation. The R&S®RTB2000 offers touch gestures for easy scaling, zooming and moving waveforms – familiar features from smartphones. Now even customers with a limited budget can enjoy such convenience features.

The user interface is the result of extensive usability studies. Based on higher-class models, it eases the transition from third-party products. A toolbar provides fast access to frequently used functions and the R&S®SmartGrid function makes optimal use of the screen for waveform display. All axes are labeled for quick recognition of signal characteristics. An annotation tool allows users to make notes directly on the screen or to highlight areas of interest (Fig. 1).

10-bit vertical resolution for visibly more signal details

Oscilloscopes measure voltage over time. The analog-to-digital converter performs a key function in this process. Its characteristics determine how well an instrument can resolve the amplitude of measured signals. For decades, the standard has been an 8-bit ADC with 256 levels. The Rohde&Schwarz 10-bit ADC used in the R&S®RTB2000 offers 1024 levels – four times that of other oscilloscopes in this segment.

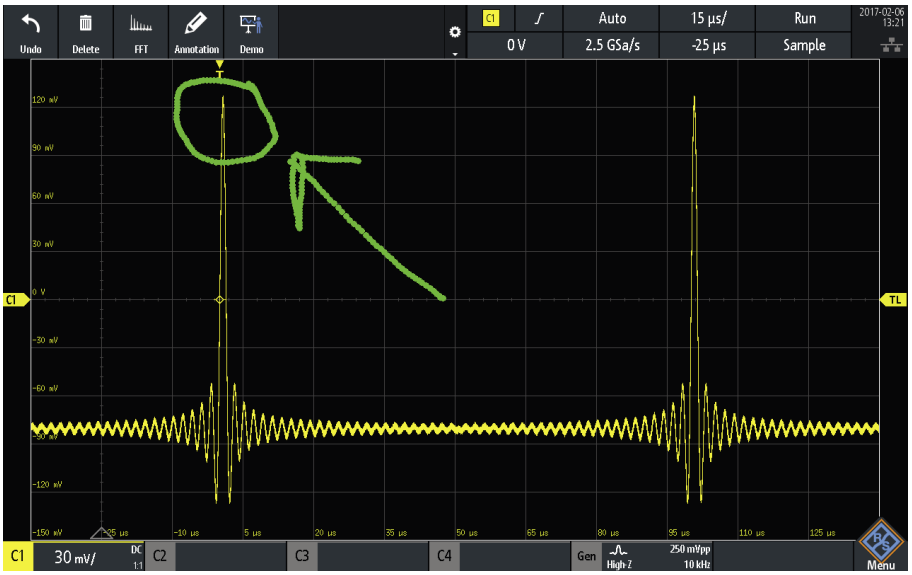


Fig. 1: The R&S®RTB2000 user interface with toolbar and R&S®SmartGrid axis labeling. The annotation tool allows users to draw directly on the screen – convenient for commenting and reports.

Video

The higher resolution permits more precise measurements and helps users detect very small among very large signals. Fig. 2 illustrates the advantage of the higher resolution at the end of an exponentially damped sine function. A large vertical scaling factor is required to fully display the initially high signal level of the sine waveform. The screenshot shows the portion of the time axis in which the amplitude has already dropped sharply. Shown underneath is the same waveform displayed while artificially limiting the ADC to 8 bit. The 10-bit resolution is much richer in details. The display on the R&S®RTB2000 can be improved even more by using averaging and special decimation with lowpass filtering. This significantly higher resolution can be the key to finding a problem within a circuit.

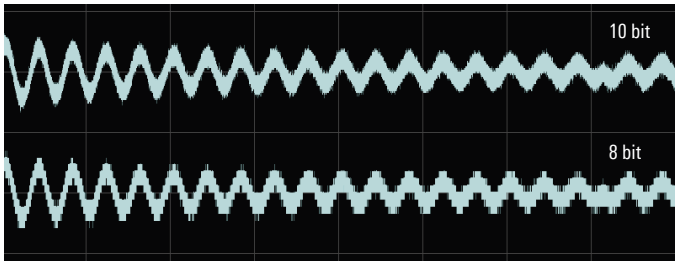


Fig. 2: Signal details of a decaying sine wave. Above is an R&S®RTB2000 oscilloscope with its standard 10-bit resolution. Below is the same signal with the ADC artificially limited to 8 bit.

Video

10 Msample standard memory allows longer acquisitions at full bandwidth

After the bandwidth and the sampling rate, the memory depth is the most important characteristic of an oscilloscope. It is the decisive factor in determining how well an instrument can be used for debugging. At 10 Msample per channel, the R&S®RTB2000 oscilloscope series has the largest acquisition memory in this class – ten times more than other instruments in this segment. In interleaved mode, the memory even increases to 20 Msample per channel. As a result, signal errors and important events are more reliably detected and the high sampling rate is retained even over long data acquisition times.

Long acquisition times are essential for analyzing serial protocols. The standard memory in the R&S®RTB2000 provides sufficient record length for the data telegrams of most buses (Fig. 3). The memory can be optionally expanded to a 160 Msample segmented memory. This mode records only the periods containing signals, such as protocol communications data or signal pulses. For example, protocol-based signals with communications gaps such as I²C or SPI can be captured over several seconds or minutes. Thanks to the variable segment size ranging from 10 ksample to 10 Msample, the 160 Msample memory can be optimally utilized; more than 13000 cohesive individual recordings are possible.

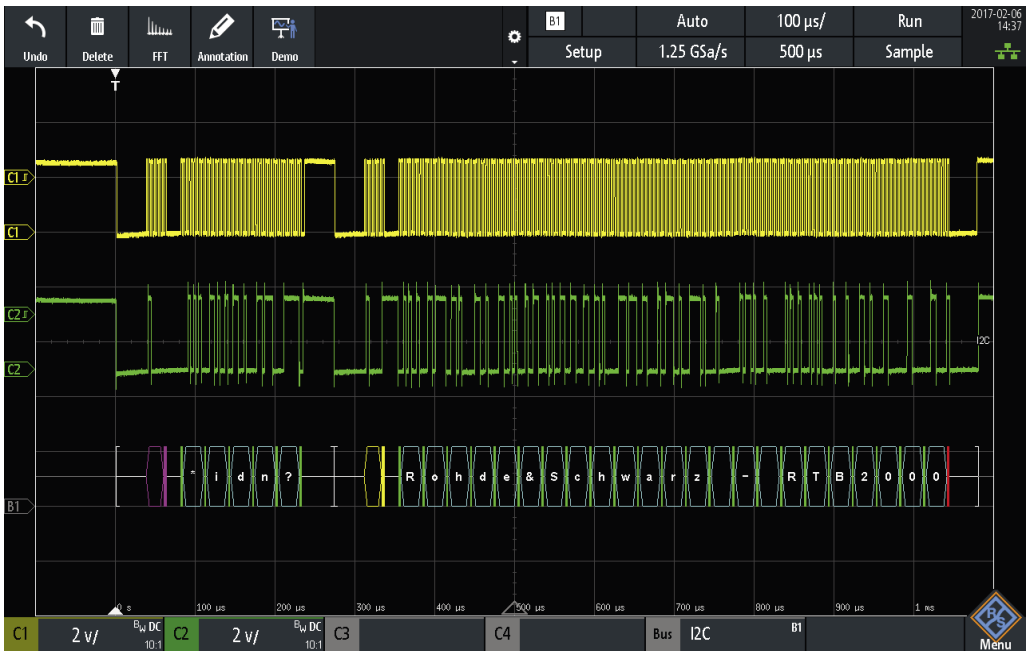


Fig. 3: The deep memory permits the acquisition of long signal sequences. This is especially useful when analyzing data telegrams and serial protocols.

Segmented memory in combination with the protocol trigger and decoding option turns the R&S®RTB2000 into a protocol analyzer capable of handling all the information in analog or digital signal sources.

Grows with your needs

R&S®RTB2000 oscilloscopes can be purchased as 2-channel or 4-channel instruments with bandwidths of 70 MHz, 100 MHz, 200 MHz or 300 MHz. The price of the two-channel, 70 MHz bandwidth model starts at EUR 1,250. License keys are available to unlock upgrades up to 300 MHz bandwidth. The 4-bit pattern generator and the logic analyzer are also enabled using license keys. A secure investment with built-in upgradeability to meet future needs.

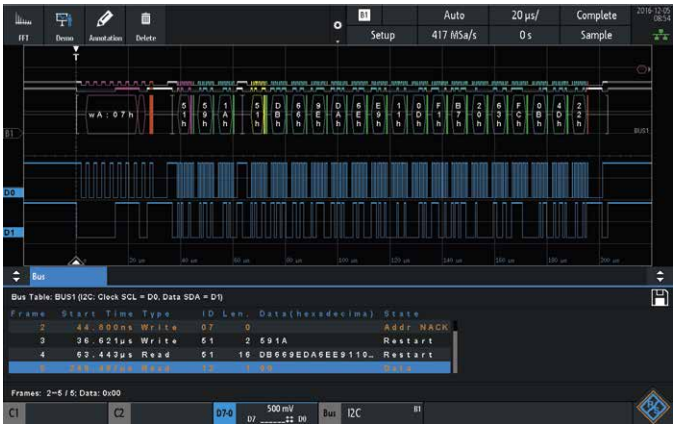
The three perfect 10s described here do not begin to cover all the oscilloscope highlights. Videos on our product webpage show what else users can look forward to. Here's a preview.

Dr. Philipp Weigell

Highlights at a glance

- 10-bit ADC
- 10.1" capacitive touchscreen
- 10 Msample standard memory, 20 Msample interleaved
- 160 Msample segmented memory for more than 13000 recordings
- Frequency range: 70/100/200/300 MHz
- 1 mV/div true vertical resolution
- History mode: analyze previous recordings
- 1.25 Gsample/s, 2.5 Gsample/s interleaved
- Logic and protocol analyzer, signal waveform and pattern generator, digital voltmeter, spectrum analyzer, mask tests
- Education mode to disable automated functionality
- Convenient reporting capabilities
- Localized GUI and online help
- Upgrade options via keycodes
- Web server functionality for instrument access
- Extensive range of probes and accessories

Logic analysis



Protocol analysis

Spectrum analysis

Mask test

Unexpected performance in entry class

The new R&S®FPC1000 spectrum analyzer offers everyone – from expert users to beginners – innovative technology and Rohde&Schwarz quality at a surprising price.

University labs, R&D facilities, production and service shops are often faced with the dilemma of needing precision T&M equipment, but only having a limited budget to work with. For spectrum analysis, the R&S®FPC1000 solves this Gordian knot. It offers RF performance and features previously unavailable in this class – at an affordable price.

Video

Investment protection

R&S®FPC1000 buyers invest only in the features they need. This is because every instrument is delivered with all available hardware and software options, which can only be used after they are enabled with a keycode. Users who only need the 5 kHz to 1 GHz base unit and basic T&M functionality can simply leave the options disabled. Should applications require a higher frequency range, the instrument can be upgraded to 2 GHz or 3 GHz without having to be recalibrated. Other functions can be purchased as needed and used as soon as the keycode is received and entered. The instrument stays in the user's possession and does not have to be shipped to service – a major advantage, especially for instruments that are integrated in racks.

Video

Unexpected RF performance

High sensitivity is one of the key characteristics of a spectrum analyzer, e.g. when measuring very weak signals. The R&S®FPC1000 analyzer's already exceptionally low noise floor of typ. –150 dBm can be further reduced to typ. –165 dBm using the optional preamplifier. The R&S®FPC1000 can measure signals up to +30 dBm (1 W), and even levels up to 2 W do not harm it. Most entry-level instruments can only measure up to +20 dBm (100 mW) at the most. The combination of low noise floor and high maximum input power results in an exceptionally large level measurement range.

The R&S®FPC1000 also excels in other areas. The quality of RF measurements strongly depends on suitable resolution bandwidth settings. Finer resolution bandwidth means more spectral details. The R&S®FPC1000 is the only entry-level spectrum analyzer with resolution bandwidth settings down to 1 Hz (Fig. 1).

Large, high-resolution display

Large, high-resolution displays are a key factor when buying a PC, tablet or smartphone. This also applies to T&M instruments, which is why the R&S®FPC1000 was designed with a high-resolution, 1366 × 768 pixel, 10.1" display. It far exceeds the 640 × 480 pixel VGA resolution – the previous standard among entry-level analyzers – and its visibly larger display area provides a level of detail and clarity previously unavailable in this price class.

Fig. 1: The R&S®FPC1000 sensitivity with the optional preamplifier is typ. –165 dBm at a resolution bandwidth of 1 Hz.

Video

Measure over there, control from here

Another unique feature of the R&S®FPC1000 is the integrated Wi-Fi module that eliminates the need for connection accessories. All instrument functions can be remotely controlled via Wi-Fi – as well as via LAN or USB. The R&S®FPC1000 comes with two free software tools, the R&S®InstrumentView PC software (Fig. 2) and the R&S®MobileView app for iOS and Android devices (Fig. 3).

R&S®InstrumentView is much more than just a convenient way to remotely operate a single instrument. It also includes the special LabDisplay feature, which enables instructors to set up a wireless lab in just minutes. They can then simultaneously monitor and control an entire classroom of instruments, and manage and assist students with their measurements (Fig. 2 and title page). The tool is also helpful in industrial applications, for instance to remotely monitor a distributed network of T&M instruments.

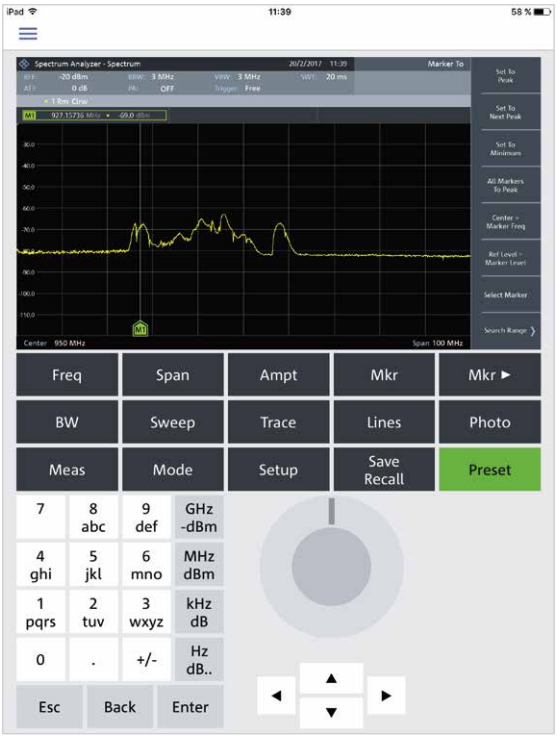


Fig. 3: The R&S®MobileView app for iOS and Android devices remotely controls the R&S®FPC1000.

Fig. 2: The LabView function in the R&S®InstrumentView remote control software is used to manage multiple R&S®FPC1000 spectrum analyzers in a Wi-Fi network.

Conversely, the ability for many users to access a single instrument opens up fascinating opportunities. Students from around the world can access a centrally located instrument via the Internet. The virtual classroom is open for business.

Other features

The R&S®FPC1000 offers many other T&M functions for sophisticated applications, including receiver mode, modulation analysis of AM, FM and ASK/SK signals, and measurement of allocated bandwidths and channel power. See our product page on the Internet for detailed information.

Stefan Stahuber

Highlights at a glance

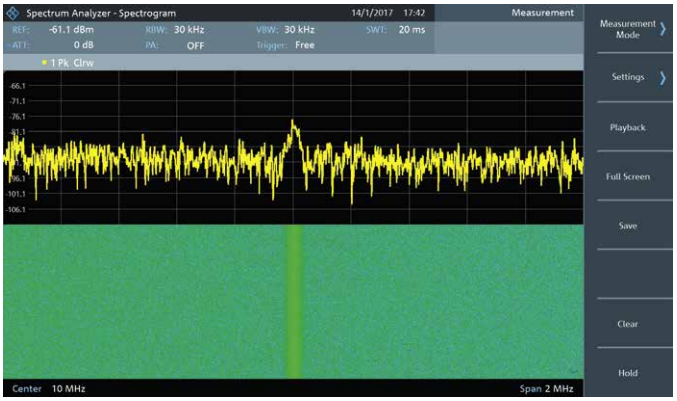
- 10.1" display (1366 × 768 pixel)
- Frequency range: 5 kHz to 1 GHz, upgradeable to 2 GHz or 3 GHz via keycode
- Resolution bandwidths starting at 1 Hz
- Low noise floor of typ. –150 dBm, typ. –165 dBm with optional preamplifier
- High max. input power of +30 dBm (1 W)
- Upgrade options via keycodes:
  - Receiver mode for EMI measurements
  - Preamplifier for even higher sensitivity
  - Modulation analysis
  - Advanced measurement options, including channel power, occupied bandwidth, spectrogram
  - Wi-Fi support
- Free remote control software for PCs and iOS/Android devices
- Set up a networked lab or virtual classroom in minutes

FM trace

Channel power

Up to six markers

Spectrogram



Power supplies for everyday use: robust, high-performance and affordable

The two new R&S®NGE100 power supplies provide a number of useful extra features not typically found in this class – all at an attractive price.

The two-channel R&S®NGE102 and the three-channel R&S®NGE103 (Fig. 1) deliver up to 33.6 W of output power per channel, for a maximum output power of 66 W and 100 W, respectively. The power supplies are easy and intuitive to use. All basic functions are accessible on the front panel. A rotary knob is used to set the voltage, current and the limits for the various protection functions. The operating conditions are clearly visible at all times on the large, color-coded display. Green digits indicate constant voltage mode and red digits indicate constant current mode. Yellow digits represent inactive channels. In setting mode, values are displayed in blue.

R&S®NGE100 – what makes it so special

Rohde&Schwarz offers a variety of power supplies in every price and performance class (Fig. 2). The R&S®NGE100 series belongs to the basic class, but it offers extra functions not typically found in this class.

Galvanically separated outputs

Each channel in the R&S®NGE100 is completely separated from the other channels. They are all short-circuit-proof and have no connection to chassis ground. This makes it easy to interconnect the outputs in many different ways. For example, two channels can be used to supply ±12 V (Fig. 3). If both channels are switched to tracking mode, the rotary knob can be used to simultaneously increase the voltage on the device under test in both channels, e.g. from ±12 V to ±15 V.

Parallel and serial operation of the outputs

All channels are electrically identical. Unlike many other power supplies on the market, there are no "auxiliary channels" with lower voltage and current values. Each channel can deliver up to 32 V and up to 3 A for a maximum output power of 33.6 W. If higher voltage or current is needed, multiple channels can be combined (Fig. 4).

Fig. 1: R&S®NGE100 power supplies offer high efficiency in combination with low ripple. The power supplies have many convenience functions that are rarely seen in this class.

Power supply classes

Basic power supplies
- Affordable, quiet and stable
- For manual and simple remote control operation
- Used in education, on the bench and in system racks

Shown here: R&S®NGE100 power supply

Performance power supplies
- When speed, accuracy and advanced programming features are key factors
- Features such as protection functions, fast programming times and downloadable V and I sequences
- Used in labs and ATE applications

Shown here: R&S®HMP2030 programmable three-channel power supply

Specialty power supplies
- Unique capabilities such as
  - Emulating the unique characteristics of a battery
  - Electronic loads to accurately sink current and dissipate power in a controlled manner
- Used in labs and ATE applications

Shown here: R&S®HM8143 three-channel arbitrary power supply

Fig. 2: For practically every application in development and production, Rohde&Schwarz has an extensive line of power supplies (some typical examples are shown here). The new R&S®NGE100 series belongs to the basic class.

Protection functions

The new power supplies are also exceptional in terms of the protection functions they provide. For each channel, users can set maximum values for the voltage, current or power. If a set limit is exceeded, the affected channel is automatically switched off and a warning message is shown on the display. The FuseLink function conveniently monitors overcurrent situations in multiple channels and automatically switches them off if necessary. The Fuse Delay setting lets users adjust the triggering behavior of the electronic fuse protection so that short current spikes are ignored.

Remote control

The power supplies come with a USB interface to allow users to remotely control all instrument functions from an external PC. For LAN or WLAN operation, there is an Ethernet interface option as well as a wireless LAN remote control option. Both options are activated by keycode. The R&S®NGE100 (as well as other equipment) can be integrated into a network and operated via a browser. For example, an instructor can control all student instruments in a classroom.

Klaus Schiffner

Balanced voltage supply

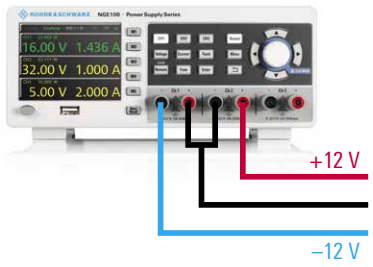


Fig. 3: Interconnected outputs, e.g. for a balanced voltage supply.

Parallel and serial operation through V/I tracking

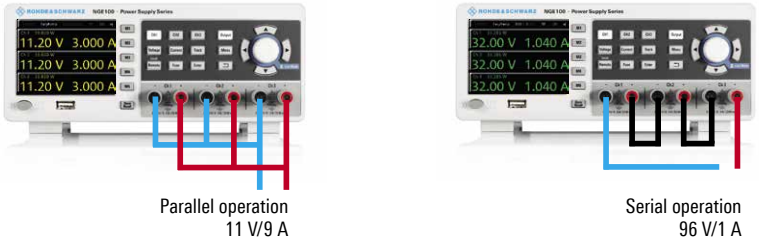


Fig. 4: Multiple R&S®NGE100 channels can be combined to provide higher voltage or current.

All-in-one solution for on-wafer characterization of millimeterwave components

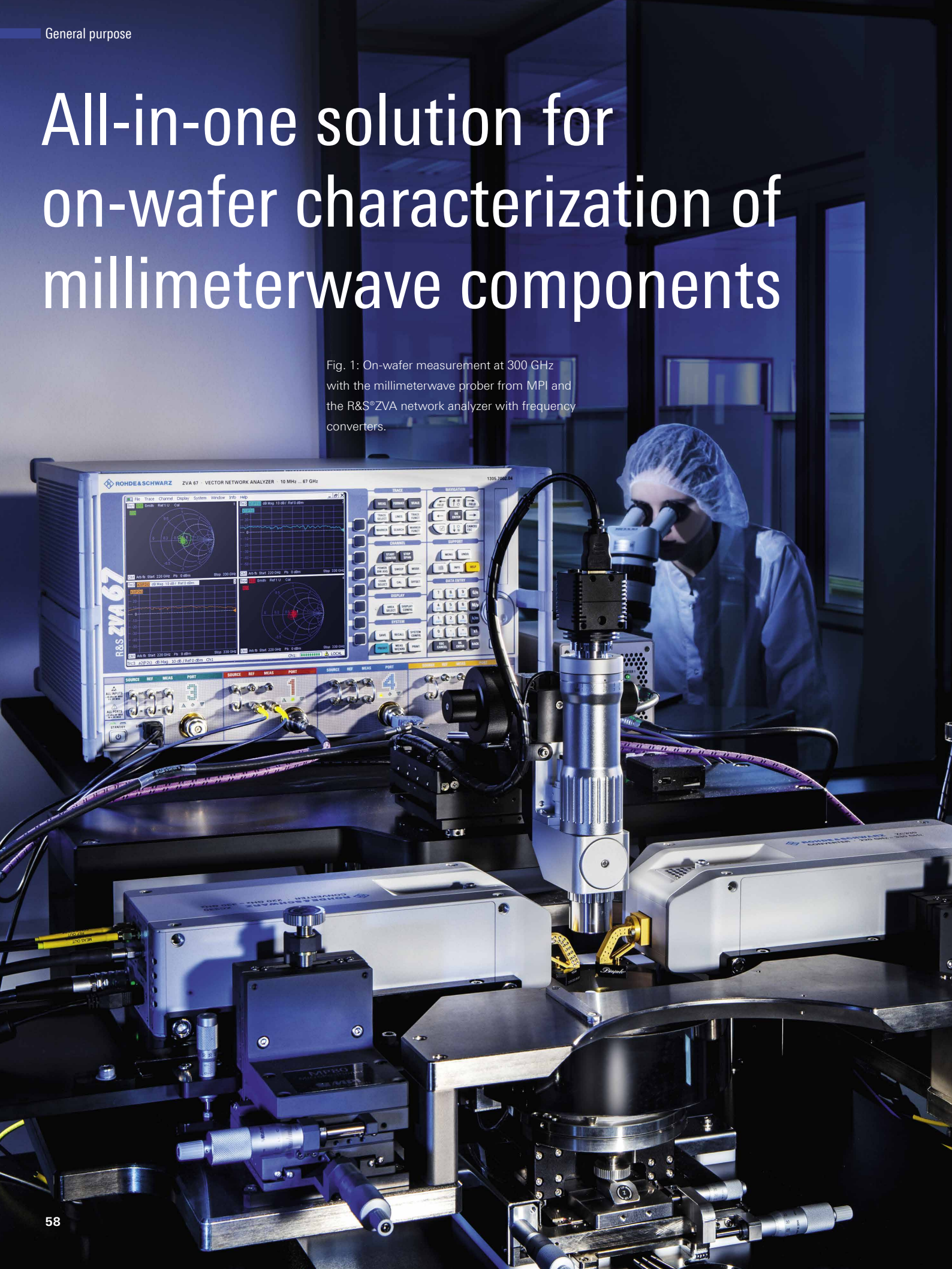


Fig. 1: On-wafer measurement at 300 GHz with the millimeterwave prober from MPI and the R&S®ZVA network analyzer with frequency converters.

Due to the increasing integration of components, testing them via coaxial ports is less frequently an option, since many of them no longer have coaxial ports. Instead, components are characterized directly on the wafer, a task requiring both a network analyzer and a probe station. An all-in-one solution of this type is now available from Rohde&Schwarz.

On-wafer test solutions in cooperation with MPI Corporation

For a number of years, Rohde&Schwarz has collaborated with the MPI Corporation in Taiwan (www.mpi-corporation.com) to offer turnkey solutions for measurements on semiconductor components in the RF and millimeterwave range. This partnership is now being intensified and extended to provide test stations at various sites in Asia, Europe and the USA where interested parties can perform trial measurements before purchasing a solution.

MPI probers feature an exceptionally high level of mechanical stability and a sophisticated design for easy operation and a good reproducibility of measurement results (Fig. 1).

The Rohde&Schwarz R&S®ZVA network analyzer has the dynamic range and stability required for demanding on-wafer measurements. For millimeterwave applications in the automotive, 5G and aerospace and defense fields, converters extend the frequency range of the base unit to various frequency bands up to 500 GHz (Fig. 2). Reproducible measurement results depend on the converters' thermal stability, especially for manual calibrations where the individual calibration steps are performed at a different time than the measurement.

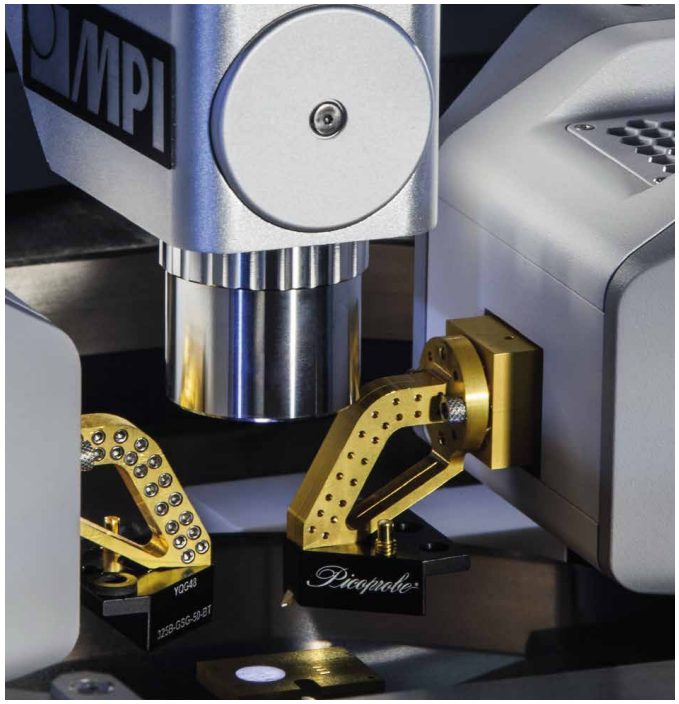


Fig. 3: The probes for wafer contacting are screwed directly onto the converters – a solution that makes designs with waveguide feedthroughs obsolete.

Fig. 2: Frequency converter with waveguide output positioned low. This minimizes the distance to the wafer on the chuck.

Optimized for millimeterwave measurements

In other prober systems on the market, the distance between the converter outputs and the wafer under test can be quite large, with long waveguide bends in them. This can result in mechanical instability and degradation of the RF characteristics, e.g. directivity at the test port at frequencies above 220 GHz. With MPI probers, the wafer chuck and the converters are at the same level. The converters can be placed just a few centimeters from the chip under test so that the mechanically stable probes can be mounted directly on the converter (Figs. 2 and 3). They can be exchanged quickly because they are screwed onto a metal plate that simply slides onto the manipulator from the side and is secured with a dovetail connector. The setup is changed in no time for measurements in a different frequency band.

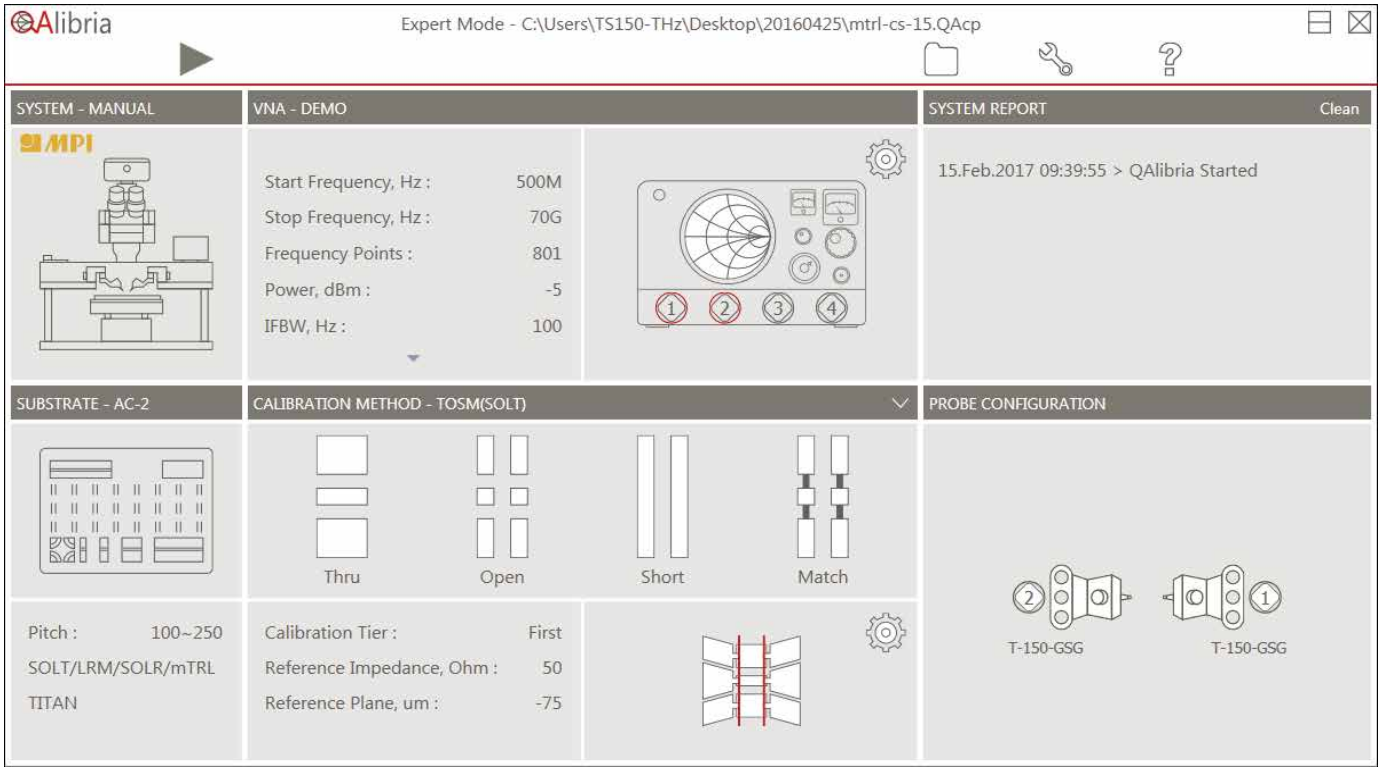


Fig. 4: QAlibria® multitouch calibration software.

With the QAlibria® calibration software from MPI, on-wafer measurements are quickly configured and performed (Fig. 4). Its intuitive multitouch user interface (a touchscreen mounted on the station comes with the system) sets the test parameters on the network analyzer, configures probes and the calibration substrate and selects the appropriate calibration method. Besides conventional methods, the software also offers as a special feature the NIST multiline TRL, which makes it possible to perform on-wafer calibrations based on the accuracy requirements from metrology institutes.

Try before you buy

Any test system consisting of a network analyzer and probe station is technologically complex, especially those used for frequencies in the millimeterwave range. Customers can test the MPI/Rohde&Schwarz solution at various sites in Asia (China and Taiwan), Europe (Germany and Russia) and the USA (Texas and California) in order to ensure that their T&M requirements are met before making an investment. Trial measurements on DUTs allow customers to assess the system operation as well as the quality of measurement results. Depending on the site, manual (Fig. 5), semi-automatic or fully automatic probers are available. Interested? Contact your local Rohde&Schwarz representative for more information.

Andreas Henkel

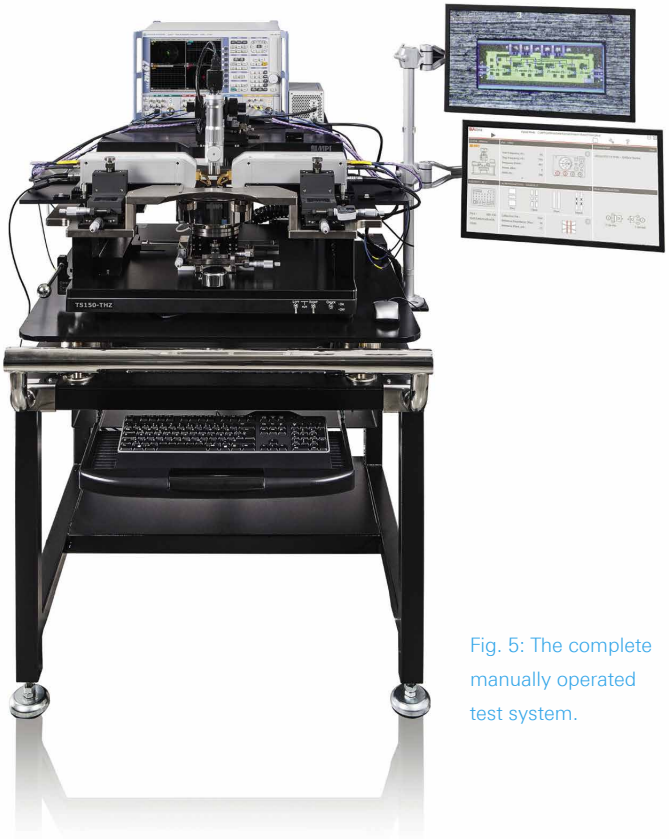


Fig. 5: The complete manually operated test system.

R&S®BBA130: the chameleon among broadband amplifiers

The R&S®BBA130 is the world's first amplifier whose transmission characteristics can be changed to match the application, even during operation.

Amplifier requirements

RF power amplifiers must fulfill a wide variety of requirements based on the application. For example, amplifiers for mobile base stations have different characteristics than those used for broadcast or radar applications – and each of the amplifiers is optimized for its specific purpose and cannot be modified.

However, for development, manufacturing and quality assurance tests on RF components such as filters, switches and amplifier modules, it should be possible to adjust the characteristics of RF power amplifiers to the respective test scenario, since they are influenced by multiple parameters:

Envelope of the input signal

The envelope determines whether the amplifier must retain power reserves for the signal peaks. A distinction is made between signals with a:

- Constant envelope
  e.g. CW signals or FM-, PM- and PSK-modulated signals
- Slowly varying envelope
  e.g. AM or two-tone signals
- Very rapidly varying amplitude
  single and multicarrier signals with high-quality phase and/or amplitude modulation, e.g. OFDM signals with a high crest factor

Time-domain behavior of the input signal

Faithful amplification of an input signal (continuous or pulsed) requires a suitable amplifier bias point.

Transmission characteristics of the amplifier itself

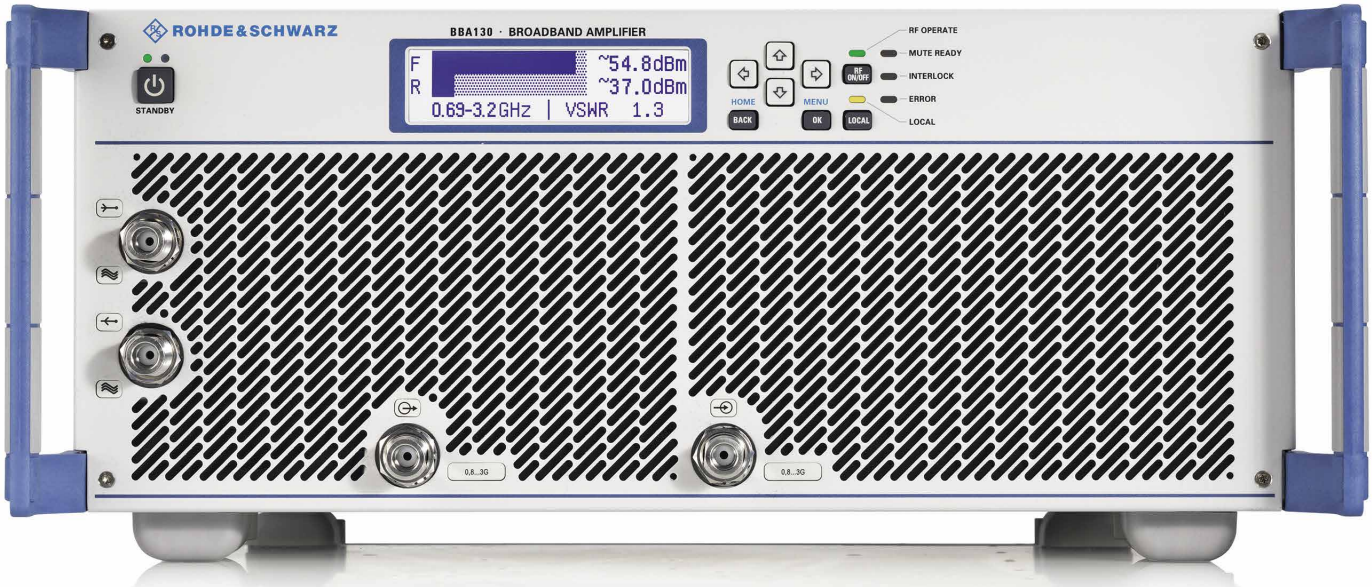
These characteristics affect the amplifier's linearity, harmonics and intermodulation products and are an indication of whether the amplifier can be operated to its saturation point for the test. Depending on the application, an amplifier must either faithfully amplify the input signal with high spectral purity or the focus is on high output power and the time behavior and spectrum of the output signal are of secondary importance.

Impedance matching of DUT to amplifier output

The impedance matching of the DUT determines the amplifier's power reduction behavior and influences the design of the amplifier circuit. In practice, a distinction is made between:

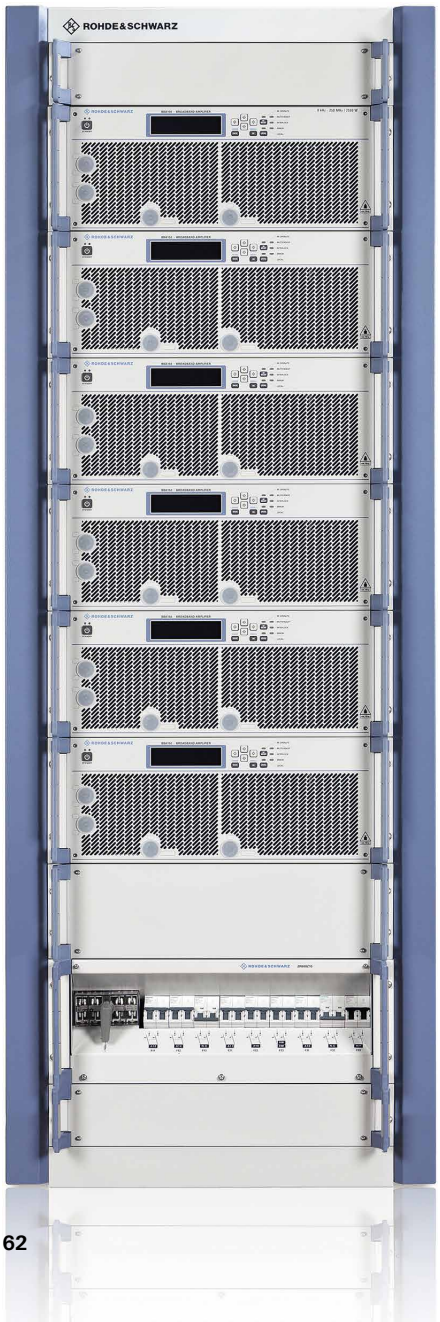
- Applications with good impedance matching (insignificant deviation from 50 Ω)
  The amplifier is allowed to reduce power to protect itself if the imped-

Fig. 1: R&S®BBA130 power amplifiers allow users to adjust (while the amplifier in operation) the transistor operating class between Class A and Class AB as well as to choose between maximum output power or higher mismatch tolerance at the output.



Test	Amplifier requirements
▮ Intermodulation tests, e.g. PIM tests ▮ Multitone tests ▮ Peak-to-average ratio tests	A highly linear amplifier is required so that the DUT is supplied with a spectrally pure input signal. DUTs are typically well matched. If a mismatch occurs, the DUT must be defective and the amplifier is allowed to reduce its power or switch off entirely to protect itself.
▮ Destructive tests ▮ Ruggedness tests ▮ Burn-in	High output power is needed; spectral purity and faithful amplification of the input signal are secondary. The DUT is normally well matched. If a mismatch occurs, the DUT must be defective and the amplifier is allowed to reduce its power or switch off entirely to protect itself.
▮ Tests with pulsed signals	The amplifier must faithfully amplify the input signal.
▮ Scientific applications ▮ EMC tests	The test setups or antennas connected to the amplifier during EMC testing are often poorly matched and therefore require an amplifier that is tolerant against mismatch and that is slow to reduce or switch off power. The requirements for spectral purity and the faithful replication of the input signal differ depending on the application.

Fig. 2: Requirements placed on RF power amplifiers for various tests.



ance matching deteriorates due to a defect in the DUT.

- Applications with poor impedance matching (in extreme cases, short circuit or open circuit)
  The amplifier should continue to produce RF power and not reduce power or switch itself off.

Flexible amplifiers are not only needed for the parameters listed above. They are also needed for the various tests performed as part of development, manufacturing and quality assurance of RF components. Fig. 2 lists some of these tests and the requirements that have to be met for each test.

R&S®BBA130 – one amplifier for many requirements

The R&S®BBA130 amplifiers (Figs. 1 and 3) are the first amplifiers that allow the user to configure the transmission characteristics to meet a specific application. The family covers three frequency ranges: 80 MHz to 1.0 GHz, 0.69 GHz to 3.2 GHz and 2.5 GHz to 6.0 GHz at output power levels from 22 W to 4200 W. Two powerful control parameters allow users to optimize the output signal: a continuously variable bias point between Class A and Class AB and a choice between maximum output power and higher mismatch tolerance. It is possible to change the setting of both parameters during operation directly on the amplifier, for instance if the signal waveform changes or if different requirements are placed on the output signal during testing. This can be done manually on the amplifier, via the browser interface or via remote control commands.

Fig. 3: Example configuration: The R&S®BBA130-BC1500D1200 amplifier system in a 35 HU 19" rack contains power amplifiers for 80 MHz to 1 GHz (1500 W) and 690 MHz to 3.2 GHz (1200 W), input switch, output switch and sample port switch.

With just one amplifier, it is now possible to measure if a DUT is within specifications (a test that requires a highly linear amplifier) and determine its load limit (only the output power counts here).

Continuously adjustable bias point

Being able to continuously vary the bias point affects the characteristics of the output signal. A bias point in Class A has very good linearity, resulting in pure output signals – ideal for generating clean CW signals. A Class AB bias point enables precise amplification of pulsed signals and improves efficiency (Fig. 4).

Maximum output power versus higher mismatch tolerance

The R&S®BBA130 allows users to choose between high maximum output power with good impedance matching (maximum VSWR approx. 2:1) and higher mismatch tolerance with a subsequent reduction in power (VSWR starting at about 6:1) (Fig. 5). Impedance matching at the amplifier output is typically good during design and product validation tests. Good matching is ensured with DUTs developed for a 50 Ω system or when a circulator is inserted between the amplifier and the DUT. The amplifier power margin is then fully used. Mismatch can only be the result of a defective DUT or circulator. In this case, the amplifier can reduce its power to protect itself since the test has to be stopped.

For EMC applications involving poorly matched antennas or for DUT measurements with an input impedance that deviates significantly from 50 Ω, the amplifier must continue to produce the desired output power for as long as possible and therefore cannot reduce its power to protect itself (unless there is a very large mismatch).

Amplification of a 2 ms pulse

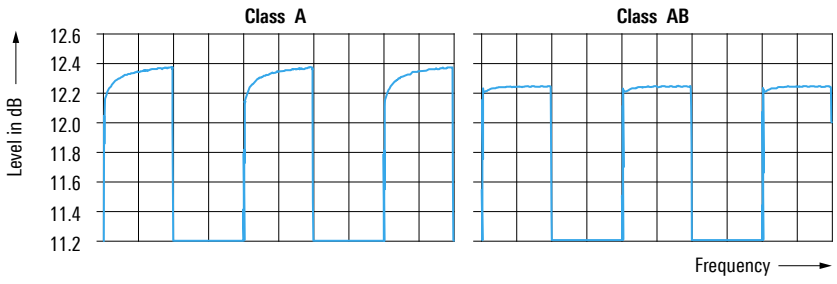


Fig. 4: Left: During the pulse, the power increases by 0.2 dB to 0.3 dB because the power transistor's junction temperature drops when RF is applied, thereby increasing the amplification. Right: The power change during the pulse is less than 0.05 dB because the junction temperature barely changes in AB mode.

R&S®BBA130 D300 power settings

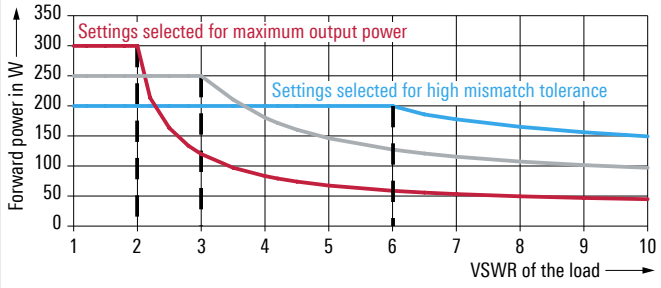


Fig. 5: Example of impact of settings on the R&S®BBA130 D300.

Compact, modular design

The design of the R&S®BBA130 broadband amplifier is optimized for the greatest flexibility and a small footprint. Due to its lightweight design with a special aluminum-copper heat sink, the instrument weighs only half as much as conventional amplifiers in the same power class. An RF output power of up to 750 W below 1 GHz and up to 300 W above 1 GHz in just four height units means excellent power density. The amplifier family allows the setup of highly integrated systems based on 19" rack units (Fig. 3). The frequency and power of these rack units can be flexibly configured.

Twin-band and dual-band amplifier in only four height units

A 4 HU desktop unit can accommodate amplifiers for two frequency ranges in a twin-band or dual-band configuration. A twin-band configuration consist of two amplifiers that operate in parallel, both with the same frequency band. This configuration is ideal for two-tone measurements and for applications that require the same test setup for multiple tests in a small space. A dual-band configuration contains two amplifiers for different frequency bands, and only one of these amplifiers is active at any given time. This configuration covers the frequency ranges from 80 MHz to 3.2 GHz and from 690 MHz to 6 GHz. The optional switches for this option are integrated into the housing.

Summary

R&S®BBA130 amplifiers are the first in the world to allow users to change the transmission characteristics during operation to match the specific application. Now only one amplifier is needed to optimally handle different test scenarios. Output powers of 22 W to 4200 W are available in the frequency range from 80 MHz to 6 GHz. The compact, modular design permits flexible dual-band and twin-band configurations. Because the frequency and power can be upgraded, the R&S®BBA130 offers users investment security and the flexibility to upgrade the system to meet new requirements at a later date.

Michael Hempel; Dr. Wolfram Titze

Faster than ever: measurement of very low-level spurious emissions

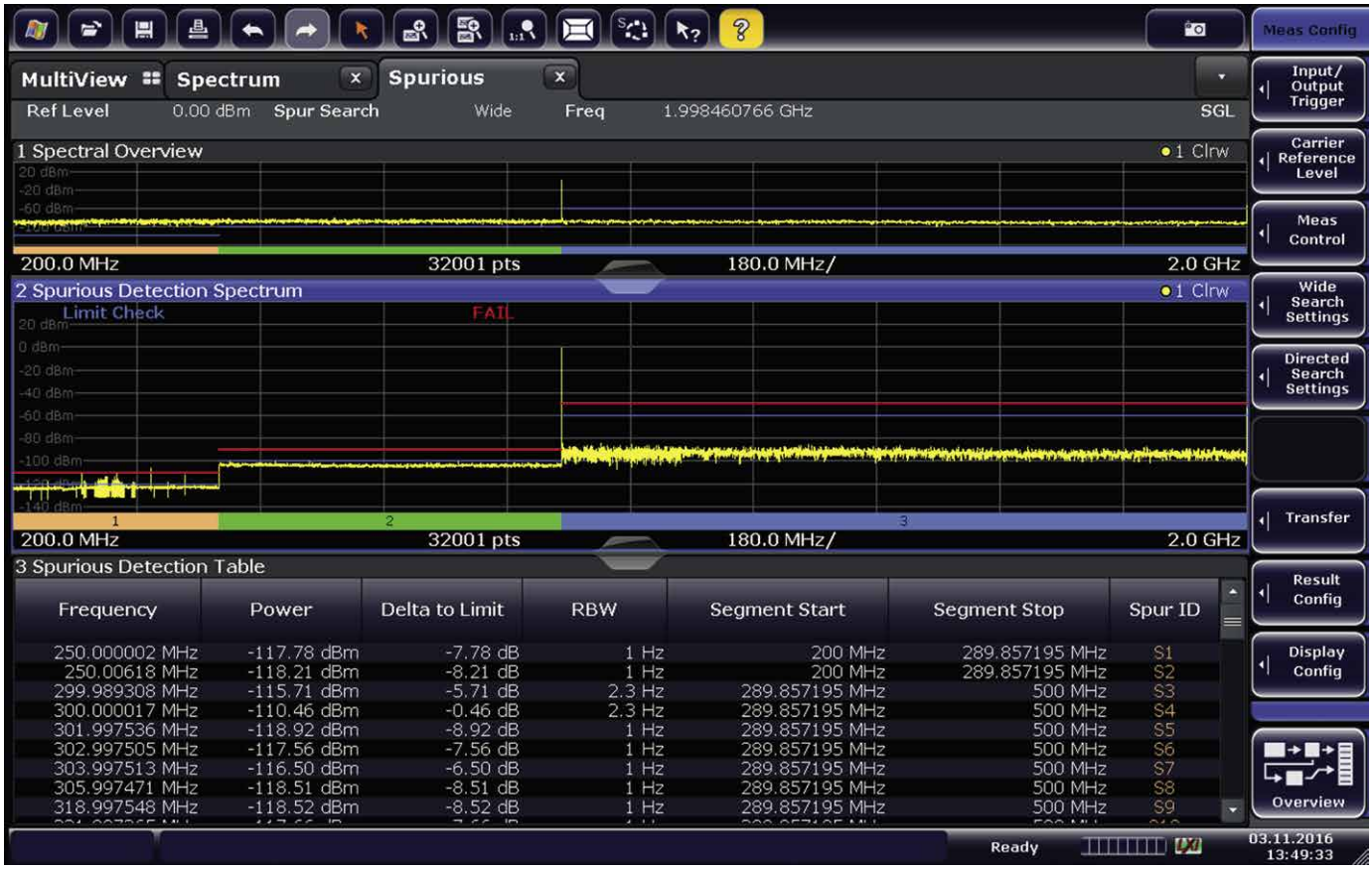
With a new option, the R&S®FSW signal and spectrum analyzer makes spurious searches easier and up to 50 times faster than traditional spurious search methods.

Spurious emissions lie outside the permitted signal bandwidth; they can be caused by harmonics, parasitic emissions, intermodulation and frequency conversion products. Spurious emissions decrease system performance, can impair other modules within a system and interfere with transmitters working in other frequency bands.

Searching for spurious emissions with spectrum analyzers is an essential measurement in the design, verification and production of RF and microwave devices. Manufacturers of all kinds of RF and microwave transmitters such as radars and satellite up/downconverters need to ensure that the spurious emissions of their products are within the specified limits.

Some transmitters, especially in aerospace and defense applications, need to fulfill very stringent spurious emissions limits. This implies searching for very low-level spurs within wide frequency ranges. To make the measurements with low noise floor and high sensitivity, a very low resolution bandwidth (RBW), sometimes of only a few Hz, is required. Moreover, the location of the spurs in the spectrum is often not known beforehand, i.e. a very large frequency range has to be measured. This significantly increases the measurement time: even with very fast FFT spectrum analyzers, a spur search may take several hours or even days.

Fig. 1: R&S®FSW-K50 spurious measurements application screen: the Spectral Overview shows the reference sweep to calculate the necessary RBW. The Spurious Detection Spectrum section shows where limits were violated. The Spurious Detection Table lists the detected spurs along with the frequency, power level and RBW used for the measurement.



RBW/noise (span 1 GHz)	Competitor's high-end spectrum analyzer (fast sweep mode)	R&S®FSW (FFT sweep)	R&S®FSW (with R&S®FSW-K50)
1 Hz/–140 dBm	9700 s	12 246 s	200 s
2 Hz/–138 dBm	2840 s	3088 s	84 s
3 Hz/–135 dBm	1470 s	1384 s	35 s
5 Hz/–132 dBm	660 s	507 s	12 s
10 Hz/–130 dBm	308 s	132 s	7 s
20 Hz/–128 dBm	126 s	36 s	6 s
30 Hz/–125 dBm	51 s	17 s	5 s
50 Hz/–122 dBm	42 s	7.1 s	4 s
100 Hz/–120 dBm	23 s	4.1 s	3 s

Fig. 2: The R&S®FSW-K50 option for the R&S®FSW finds spurs 10 to 50 times faster than a high-end analyzer from the competition.

Smart measurements using optimized RBWs

With the new R&S®FSW-K50 spurious measurements option for the R&S®FSW signal and spectrum analyzer, spurious measurements become much faster, especially when searching for low-level spurs, and are easier to configure. The only settings you need to make are the frequency ranges and the maximum allowed spurious level; you no longer need to set the RBW for each frequency range.

The application performs a fast reference sweep to estimate the noise floor and calculate the necessary RBW at each frequency range. Then it determines whether each detected signal peak is a real spur, a noise artifact or internally generated interference (residual spurs), and summarizes the results in the spurious detection table (Fig. 1). This table lists all signals that exceed the detection threshold, and are really a spur.

The algorithm within the R&S®FSW-K50 option is smart enough to set the RBW as low as necessary to recognize the real spurs at the required frequency ranges but not unnecessarily low in those frequency ranges where no potential spurs have been found. As a result, spur searches are up to 50 times faster than with traditional spur search methods, when wide frequency ranges and stringent spur detection limits are applied (Fig. 2).

Directed search at predefined frequencies

If the spur frequencies are known beforehand, for example harmonic frequencies, the R&S®FSW-K50 option also allows a directed spur search at predefined discrete frequencies with a small span around each frequency. Because the span is smaller, the directed search saves measurement time and, if you use a larger signal-to-noise ratio, it can provide more precise results.

The two search methods can also be combined. After a wide search, a mouse click transfers the frequencies where spurs have been detected into a directed search for more detailed analysis.

Summary

The new R&S®FSW-K50 spurious measurements option automates and speeds up the spurious search, especially when looking at very low-level spurs. The user only needs to enter the frequency range and the desired spur detection level. The option calculates and applies the optimum RBW at each frequency. Very narrow RBWs will be used only in those frequencies where needed. With this option, spurious searches are up to 50 times faster than using traditional search methods.

Laura Sanchez

Soccer now even clearer at Sky Deutschland

Two additional UHD channels have gone on air using Rohde&Schwarz technology. In addition to Hollywood blockbusters (on demand), pay TV provider Sky Deutschland now also broadcasts selected UEFA Champions League and German national league (Bundesliga) matches live in UHD. Rohde&Schwarz products are used throughout the entire production chain – from ingest and storage to playout and the headend. Rohde&Schwarz and system integrator Qvest Media planned and implemented the project.

Production chain

Fig. 2 outlines the UHD transmission chain. The live signal that is fed in via video routers is processed by an R&S®VENICE 4K video server and saved as a native UHD file to the video server and also to a central R&S®SpycerBox Ultra. From there, Sky's playout control system copies it directly to the SSD memory of two additional R&S®VENICE 4K servers responsible for playout. One of these two servers runs as an active standby to ensure maximum operational reliability. The R&S®VENICE units convert the signal to HD in realtime during ingest and playout to support the HD infrastructure that is still the standard used by studios and viewers alike. The R&S®CLIPSTER mastering station is an additional system component. It is used to convert the interoperable mastering format (IMF) data mainly received from international distributors to the Sky proprietary format. Like the R&S®VENICE 4K systems, R&S®CLIPSTER directly accesses the central storage of R&S®SpycerBox Ultra TL.

Fig. 1: As the use of UHD-ready TV sets becomes more widespread, this format also becomes interesting for content providers.

© Sky / sampics

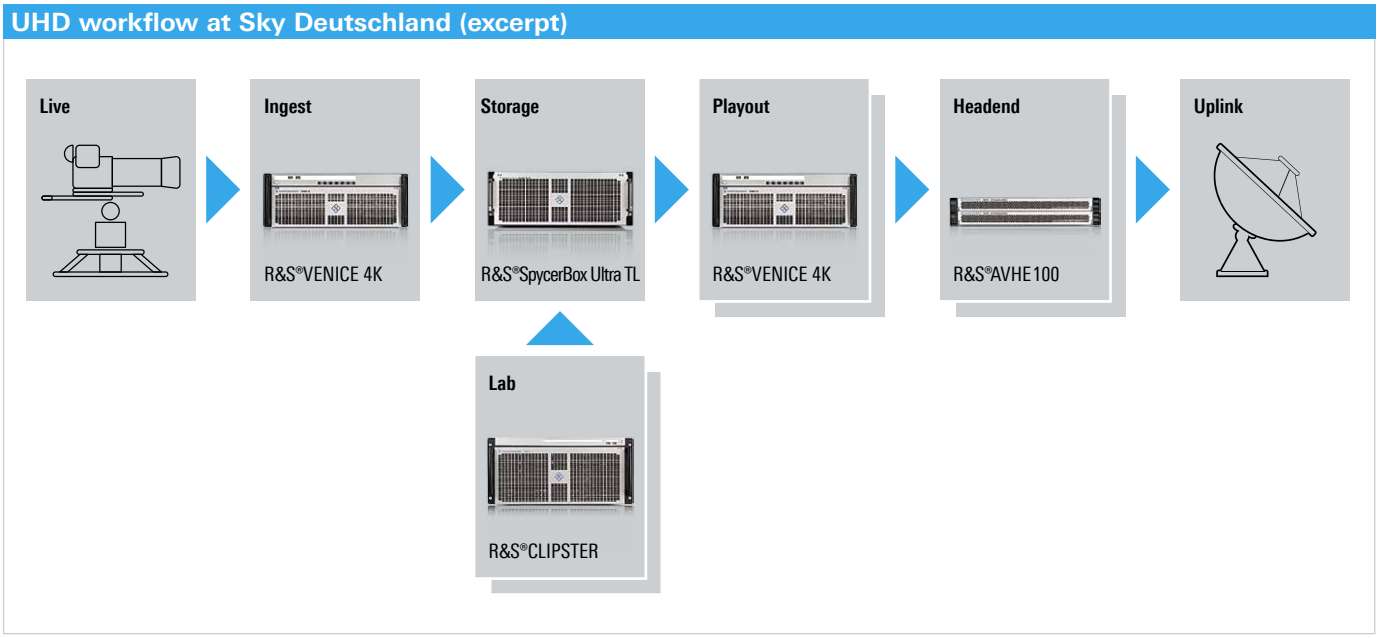


Fig. 2: Sky Deutschland's entire UHD signal processing chain is equipped with Rohde&Schwarz components.

Encoding and multiplexing

Within the Sky Deutschland system, the uncompressed UHD video signal from the R&S®VENICE 4K playout servers is transferred at a rate of 12 Gbit/s to the R&S®AVHE100 headend, which prepares the data for the satellite uplink. Transmission takes place via four 3 Gbit/s SDI lines (3G-SDI) that are still common in studio equipment. Each line transports the image signal of one HD quadrant (1080p50) of the UHD image. The R&S®AVHE100 recombines the quadrants into UHD images (3840 × 2160) and feeds them to the video encoding process. In the future, the data of the currently separate four lines will be transmitted over high-performance IP networks at up to 12 Gbit/s (SMPTE 2022-5/6 or AIMS).

Broadcasting of UHD programs via the currently active satellites (DVB-S2) requires stronger data compression than for HD material. That is why only the high efficiency video codec (HEVC, H.265) has been standardized as a compression format for distribution to consumer electronics devices. The quality-critical process of compressing 12 Gbit/s to approximately 20 Mbit/s as well as coding of the audio data and many other necessary processing steps have to take place in realtime.

In anticipation of future virtualized process chains, the R&S®AVHE100 already relies fully on purely software-based processing modules that run on standard hardware. The HEVC encoder used is an integrated solution from the Fraunhofer Heinrich Hertz Institute (HHI) in Berlin, Germany. This encoder surpassed the competition in terms of quality in extensive benchmark tests. The consistent use of software modules on the R&S®AVHE100 makes it possible to flexibly respond to future customer requirements.

For secure 24/7 operation, Sky Deutschland also decided on 1+1 system redundancy for the headend in this project to prevent broadcast interruptions due to failures or servicing. R&S®CrossFlowIP technology ensures that the upstream satellite uplink is provided with a valid signal at all times.

Reception

Owners of a UHD receiver and a Sky subscription have been able to access the two additional channels, Sky Sport Bundesliga UHD and Sky Sport UHD, since mid-October 2016.

Benjamin Rauch

Physical layer tests on DVB-S2/DVB-S2X components

The DVB-S2X extension of DVB-S2 does more than prepare the DVB-S transmission system for the UHD era. It also makes the system attractive for other applications. The R&S®SMW200A vector signal generator now has a new software option to generate signals in line with both standards.

DVB-S2 is the standard currently used by millions of viewers to receive satellite HDTV channels. Even some UHD channels are already being broadcast via DVB-S2. Although UHD compression (H.265) is better than the H.264 standard currently in use, it still generates a larger data volume. Satellites will be pushed to capacity as more and more content providers jump on the UHD bandwagon. Modifying a transponder's channel spacing is no simple task. The frequencies are already occupied, the number of TV channels should not be reduced and backward compatibility with the existing receiver landscape must be guaranteed. This leaves only one option: more efficient use of the spectrum. Adopted in 2014, the new DVB-S2X standard does just this and is already supported by some consumer devices. DVB-S2X prepares the standard for higher data rates and opens a range of options for highly flexible channel use. The standard offers over 100 different modulation and FEC combinations (including constellations up to 256APSK), employs steep-edge filters to reduce channel spacing (the channels will be somewhat wider) and, similar to carrier aggregation in LTE, enables the distribution of transport streams to multiple channels (channel bonding), even across transponders.

DVB-S2 and DVB-S2X are optimized specifically for satellite data transmissions. It therefore makes sense to use the standard to transmit more than video broadcasts. Highly diverse

Fig. 1: The R&S®SMW200A has a new software option to generate signals for physical layer testing on DVB-S2/DVB-S2X components and receivers.

transport streams from a broad range of customers can travel in parallel through a transponder. This allows satellite operators to leverage hosted bandwidth (leased transmission capacity) to optimize their transponder capacity and recoup investments sooner. It is essential for there to be no mutual signal interference. This can and must be ensured by performing RF tests on the components used.

The R&S®SMW200A is the right platform for these tests (Fig. 1). With output frequencies up to 40 GHz, it supports all common satellite communications frequency bands. For wideband applications, the R&S®SMW200A features a fully aligned internal baseband module with a signal bandwidth of up to 2 GHz offering a flat frequency response.

The new R&S®SMW-K116 software option for generating DVB-S2/DVB-S2X signals (Fig. 2) now enables testing of DVB-S2/DVB-S2X components and receivers on the physical layer. The generator's internal realtime coder makes it possible to achieve data rates of up to 600 Msymbol/s. Even 1200 Msymbol/s is feasible if the signal is calculated externally with the R&S®WinIQSIM2 software and loaded into the generator's ARB memory. Although this is far beyond what is required for TV broadcasting, it could be necessary for other types of payloads supporting wideband signals with high data rates.

To test an amplifier for a satellite that supports DVB-S2X, for example, a single channel does not suffice, a sum signal from multiple signals is needed. In TV broadcasting, these signals are usually numerous, adjacent and of equal width. Various bandwidths can arise when used for other purposes. Neither is a major challenge for the R&S®SMW200A, because multicarrier signal generation can be used to combine multiple DVB-S2/DVB-S2X signals (each individually parametrized) into a sum signal with a bandwidth of up to 2 GHz (Fig. 3).

For receiver testing, users can implement their own transport stream (TS) files or use generic continuous (GC)/generic packetized (GP) data. The R&S®SMW200A takes care of the subsequent coding and signal generation in line with the DVB standard. The data initially undergoes data stream adaptation to prepare the packetized or continuous data streams for the subsequent processing steps. The output is scrambled and error protection is applied in the channel coder. The pilot signals are added prior to modulation. All relevant functions and parameters can be varied, activated or deactivated. This flexibility makes it possible to verify individual layers and function blocks within the receiver.

Markus Lörner

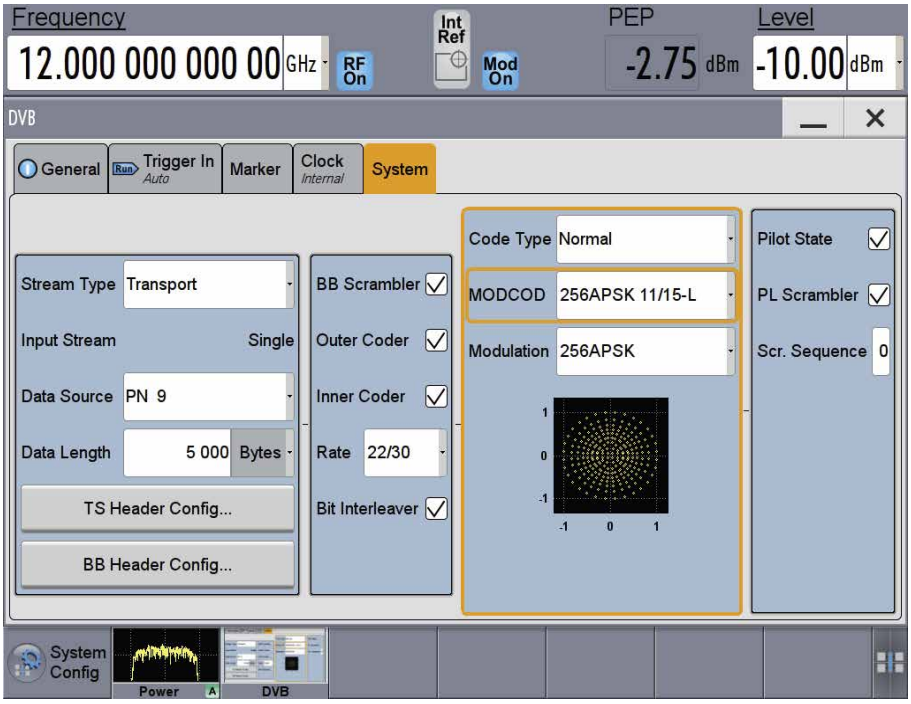
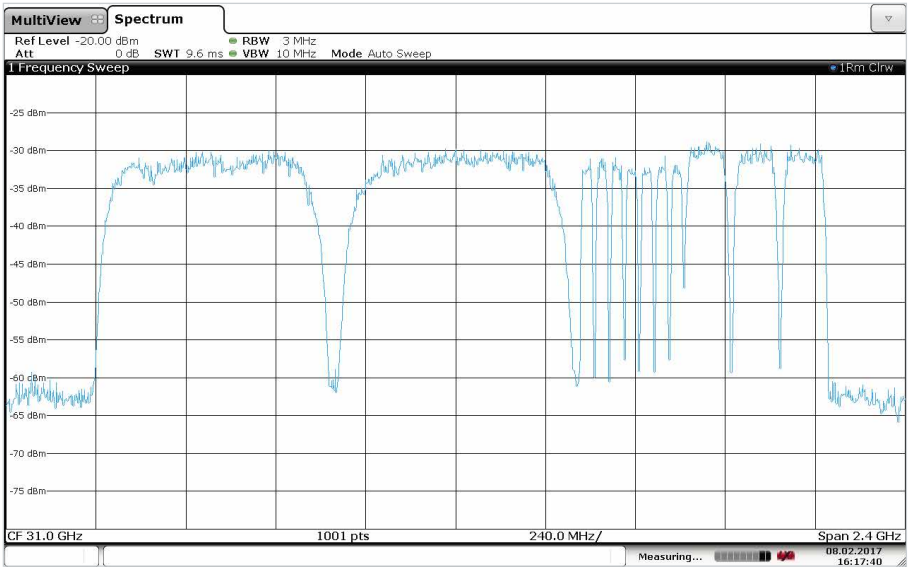


Fig. 2: User interface for DVB-S2X.

Fig. 3: A 2 GHz sum signal for a load test with different payloads in line with DVB-S2.



Playing it safe – high-tech IT for police

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The police forces protecting the German states of Lower Saxony and Baden-Württemberg rely on security concepts from Rohde&Schwarz Cybersecurity to protect their mobile devices and workstation PCs against cyberattacks.

Mobile devices are becoming more attractive targets for cybercriminals due to their proliferation and the valuable data they can hold. The police are aware of this danger and have responded accordingly: instead of pulling up needed information on a smartphone or tablet while out on patrol, it is usually obtained through voice communications via an operations center. Why? Security mechanisms on conventional mobile devices do not sufficiently protect sensitive data against massive attacks, such as zero-day exploits and advanced persistent threats.

Radio inquiries have many disadvantages

Radio inquiries via an operations center are time-consuming for patrol officers and often lack the necessary accuracy. For example, a description has to be provided for any photographs. These calls also pose a security risk for the officer, who must move away from the suspect to place a phone call without disruption.

But there is a different, more up-to-date way. Since August 2016, 500 special tablets from Rohde&Schwarz Cybersecurity have been in use in Lower Saxony. These BizzTrust tablets give police officers secure access to the data on the police server from anywhere. Officer Dennis Karp from the Misburg police station, part of the Hanover police department, has this to say about the advantages of the new tablets: "When I use BizzTrust instead of calling the operations center, I see a photo directly on the tablet and can compare it against the person in front of me. That's a huge time savings. Not to mention that BizzTrust also reduces the number of mistakes." Another advantage: with BizzTrust, police officers can compare the personal details while they are near the suspect, giving them added safety.

Security by separating business from personal

BizzTrust tablets, which are based on commercially available Android models from Sony, are protected by a hardened security kernel with especially strong security mechanisms. They provide additional protection by separating the device into an open domain and a restricted domain, allowing users to run apps from public app stores risk-free alongside official business apps. Fig. 1 shows the BizzTrust GUI.

The separation between business and personal also permits secure access to emails, contacts, calendar, intranet and Internet. In the business domain, the connection is set up via a secure virtual private network (VPN) tunnel. Access to external websites is provided via the centralized authority firewall, which can filter out dangerous content. As a result, users in the Lower Saxony police force have access to all of the applications they need in their day-to-day work.

Enormous time savings

BizzTrust is especially useful when speed is of the essence. Officer Thomas Focke describes the following scenario: "We were performing a routine motor vehicle check. I had the impression that the driver was under the influence of intoxicants. While checking the driver's personal details with BizzTrust, I was able to see that the driver had previously been arrested for drug possession. I was able to act immediately."

For now, use of BizzTrust has been optional for officers in Lower Saxony. The BizzTrust tablets have been extremely well received, in part because the system is very easy to use. Officers find the exact same applications that they use on their computers in the office. "No training is needed for BizzTrust," explains Inspector Steve Schuchardt, who oversees system integration. "But every device is assigned to a mentor who gives a brief introduction and then remains available for questions and problems. We think it's important to keep a direct line open to support – we feel that it provides a high level of acceptance among users."

Fig. 1: BizzTrust is based on commercially available Sony Android devices. A special app on smartphones also allows encrypted phone calls.

The tablets save officers an enormous amount of time. Formerly, they had to take notes by hand and then type them up in the office in the evening, but now they can enter and upload their notes while on patrol. All of the forms they need are available on the device, and tedious after-hours paperwork is a thing of the past.

Two tablets are currently in use at each of the stations, but the plan is for every officer to have their own, personalized tablet in the future. The police force in Lower Saxony is also planning its own app store that will facilitate the distribution and updating of service apps.

Stronger protections in the office as well

To provide protection during web searches, the Baden-Württemberg police previously used only a few, isolated workstations. The law enforcement authority had also designed its own Linux-based access technology. This isolated web access was not an ideal solution. The problem? "The browser's performance was sub-par, and there was nothing we could do to improve it," says Heiner Thierjung, from the Police Technology, Logistics and Service Presidium. "There were also constant bandwidth problems, poor print processing and no upload function. While we were fully protected in the real world, we were nearly incapacitated and without cover online." A search for a replacement solution led to "Browser in the Box".

Convenient, fully functional security

The police force was looking for an IT security solution that would provide unrestricted, user-friendly and reliable Internet access with the greatest possible protection. The solution had to be capable of supporting 5000 users simultaneously and also be deployable in both urban and rural areas.

Police IT planners initially considered a remote controlled browser system (ReCoBS). The security architecture of these types of systems ensures the desired level of protection. "But it quickly became clear that a centralized browser system in a separate DMZ-based terminal server farm would overwhelm the available technical resources," says Sebastian Sieburg from the Baden-Württemberg IT State Authority (BITBW). "In addition, our data volume is so high that bandwidth would be severely limited."

An escape-proof prison: Browser in the Box

Browser in the Box (Fig. 2) creates a virtual machine with a limited operating system and an encapsulated web browser (either Chrome or Firefox) on the workstation computer. This browser has access only to the virtual hardware. Malware such as viruses, Trojans and the like remains encapsulated in this environment and cannot infiltrate the local PC or the network.

Browser in the Box – developed on behalf of the German Federal Office for Information Security (BSI) for federal authorities in Germany – is easily integrated into workaday life at police stations and is also easy to operate, even for users with little technical experience. When malicious code corrupts the browser, the virtual browser environment simply restarts. Data is exchanged with other applications via a buffer directory where downloaded files are temporarily stored while they are being scanned for malware.

Security by design

Both BizzTrust and Browser in the Box are based on the technological "security by design" approach, where data security is integrated already during development into products intended for use by laypersons. The advantage? Instead of reacting to attacks – which is what antivirus programs do – these types of solutions proactively repel attacks, i.e. right from the start, they prevent unauthorized access to security-relevant apps and data.

IT security is a must for authorities and companies, but even private users have every reason to be careful on the web, and Rohde&Schwarz Cybersecurity can help them. The Browser in the Box security environment can be downloaded from the cybersecurity.rohde-schwarz.com website and used free of charge.

Esther Ecke

Fig. 2: No training, no learning curve: Browser in the Box is available with either Chrome or Firefox.

Stake in LANCOM Systems

Rohde&Schwarz is a new strategic shareholder in LANCOM Systems, one of the leading German manufacturers of network infrastructure solutions for business customers and the public sector. LANCOM founder and managing director Ralf Koenzen, co-managing partner Stefan Herrlich and founding partner Carl-Thomas Epping will retain their shares. The two companies have complementary business models and portfolios in the area of secure networks. The shareholders are committed to the common objective of developing LANCOM Systems into the leading European provider of LAN, WAN and WLAN infrastructures. The entry into the market for cloud-based network management, combined with software-defined networking/software-defined WAN (SDN/SD-WAN) technologies, will play a key role. Since being established in 2002, LANCOM Systems has achieved an above-average annual growth of 14 % (CAGR).

Rohde & Schwarz Cybersecurity acquires DenyAll

Rohde&Schwarz Cybersecurity has acquired the French web application security specialist DenyAll, with locations in Paris and Montpellier. With this acquisition, Rohde&Schwarz Cybersecurity has expanded its portfolio of network and endpoint security and security management solutions, as well as its sales and marketing presence. DenyAll's vulnerability management, web applications firewall and access management solutions are the basis for secure business processes in the context of the digital transformation. Rohde&Schwarz will now be able to provide innovative and trusted single-source cybersecurity solutions to even more customers.

NB-IoT base station tests with Rohde&Schwarz equipment

The Chinese provider of IT and telecommunications solutions Huawei and the world's largest mobile operator China Mobile have completed the first tests for narrowband IoT (NB-IoT) in line with Release 13 Cat-NB1. This involved using the R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer. 3GPP developed the narrowband IoT standard to meet demand for services and applications with low power consumption. The cellular air interface has been fully adapted to the conditions of M2M communications. In October 2016, Huawei, China Mobile and Rohde&Schwarz successfully completed the first tests with respect to interface characteristics and RF performance on the relevant base stations. The results were completely compliant with the 3GPP TS 36.141 specification. The next step was to use fading scenarios to carry out receiver performance tests. The measurement solution for base stations is the first that can generate as well as analyze signals for NB-IoT.

Head Quarter chooses Rohde&Schwarz

Since October 2016, the new version 6 of the R&S®CLIPSTER mastering system from Rohde&Schwarz has been in operation at Head Quarter, a post production company based in Cologne and Berlin. The company is planning to use R&S®CLIPSTER for the creation of DCP, IMF and HDR files, including subtitles for cinema productions and for film exploitation. The versatility of the tool allows HDR workflows for Dolby Vision (cinema and home), HDR10 and hybrid log gamma (HLG). The new color processing engine of R&S®CLIPSTER performs this task. This enables Head Quarter to meet customers' increasing demand for HDR content.

New technology center inaugurated

At the Rohde&Schwarz company campus in Munich's "Werksviertel" district, employees moved into a new research and development building, which replaced the older building formerly located in the same spot. Rohde&Schwarz invested around EUR 38 million in its new technology center, which offers around 13500 square meters of floor space on six floors. The building mainly offers developer stations and has an open-space layout able to accommodate about 600 employees. It is another building block for the restructuring of the company premises into a modern corporate campus.

The new technology center replaces some older structures that were torn down at the beginning of 2015.

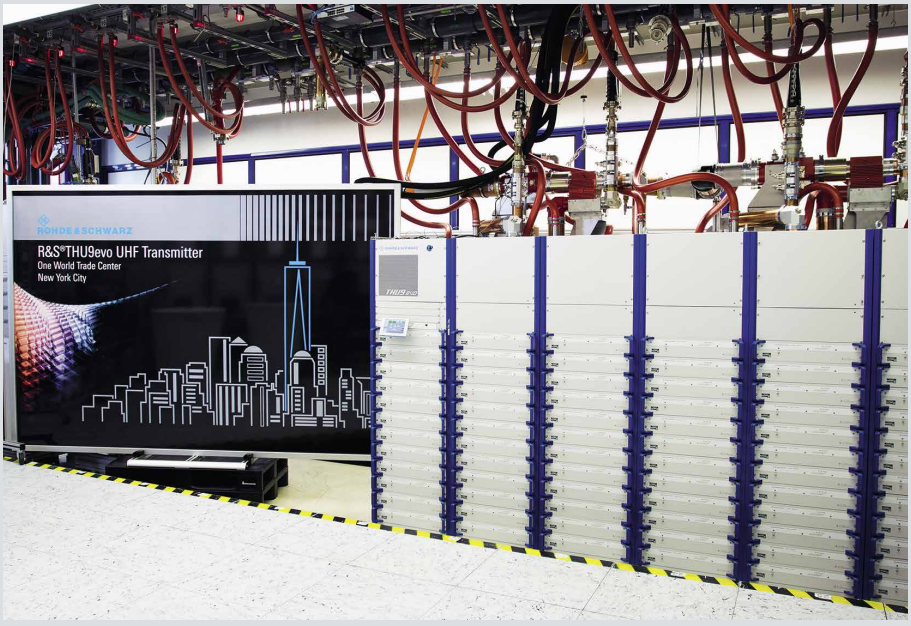
Big delivery for the Philippine Coast Guard

The Philippine Coast Guard equipped its new fleet with Rohde&Schwarz technology.

The Philippine Coast Guard contracted Rohde&Schwarz with equipping its ten new multipurpose ships with radio and radio-monitoring systems. The ships are used for legal enforcement, combating piracy, search and rescue operations and similar missions. Systems from Rohde&Schwarz are used to improve reconnaissance, tracking and communications capabilities. R&S®M3SR Series 4400 and Series 4100 radios are used for secure voice and data communications. R&S®Postman III handles the automatic transmission of messages. In addition, R&S®DDF205 direction finders were included in the scope of delivery.

The most powerful transmitter comes from Teisnach

The R&S®THU9evo UHF transmitter made at the Rohde&Schwarz plant in Teisnach is not only the most powerful transmitter in the company's history – its 106 kW output makes it the most powerful solid-state transmitter ever built. It will be installed on the new One World Trade Center in New York City to provide the population with terrestrial TV. In November 2016, the transmitter system set off on its journey across the Atlantic.



The prestige project is based on the liquid-cooled R&S®THU9evo UHF high-power transmitter.

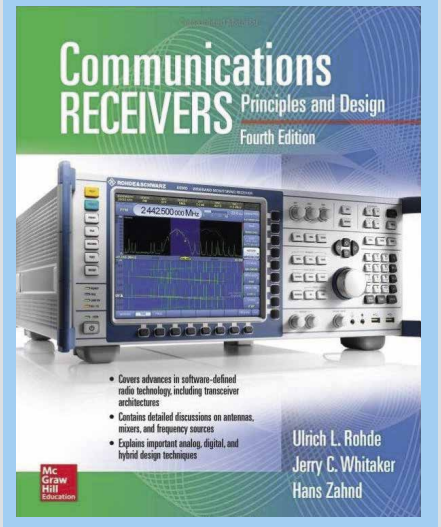
UK air traffic control provider modernizes ATC infrastructure with Rohde&Schwarz

The UK air traffic control provider NATS picked the R&S®VCS-4G IP-based voice communications system from Rohde&Schwarz. It will be used as the second voice system for the UK's aviation radiocommunications. Within the framework of the SESAR program, NATS will modernize its entire air traffic management infrastructure over the next few years. The program is playing a key role in establishing a standardized European airspace. As part of this modernization, ATC communications will be converted from TDM-based systems to voice over IP (VoIP). The R&S®VCS-4G offers impressive reliability, innovation and flexibility. The order includes the delivery, installation and servicing of 450 controller working positions, up to 1700 radios and various ground-ground resources.

Tim Bullock (left), Director Supply Chain Management at NATS, and Bosco Novak, Executive Vice President Secure Communications Division at Rohde&Schwarz, shaking hands after signing the contract. Rohde&Schwarz President and CEO Christian Leicher (front right) was also present.

New edition of the book *Communications Receivers*

First published in the early 1980s, the book is considered a standard work and was recently published in a new updated version. Prof. Dr.-Ing. habil. Dr. h.c. mult. Ulrich L. Rohde and his co-authors explain in their eleven-chapter, nearly 700-page book every detailed aspect of building receivers and the design principles of the components inside them. The latest developments, such as the rapid evolution of software-defined receivers, are addressed along with a view toward coming challenges against the backdrop of 5G mobile radio and the emergent IoT landscape. Professional radio and radiomonitoring experts as well as advanced students and dedicated radio amateurs will benefit from studying the book. The work is published by McGraw-Hill Education.



Rohde & Schwarz protects air show against drones

Rohde & Schwarz tested its R&S®ARDRONIS radiomonitoring solution at the AirPower 2016 air show in Austria. The system was responsible for safeguarding the show against hazards from commercial remote controlled drones, which pose a safety risk in both air traffic and at major events. At air shows like AirPower, any disruption of the closely timed take-offs and landings can pose a danger to event participants and spectators alike. R&S®ARDRONIS enables the detection of drone control signals as well as downlink signals early on, making it possible for drones to be located and even prevented from entering critical airspace sectors. The solution monitors the signals in the relevant frequency bands and maintains an extensive library of signal profiles to classify, identify and even disrupt the drones if necessary.

The R&S®ARDRONIS-I quickly and reliably detects the remote control of a commercial drone within a 1 km radius.

Winner of the GTI Award yet again

At the Mobile World Congress 2017, Rohde & Schwarz received the Innovative Technical Product Award of GTI Summit for the fourth time in a row. Rohde & Schwarz was awarded the prize for its user experience test solution, which consists of the R&S®CMW500 and R&S®TS8980 test platform – the first test solution for high-power user equipment (HPUE). GTI awards the trophy each year at the mobile communications trade show in Barcelona, recognizing companies that have shown outstanding achievements in the area of TD-LTE.

GTI awards the trophy each year at the MWC mobile communications trade show in Barcelona.

Rohde & Schwarz is once again official supporter of Berlinale

Rohde & Schwarz has provided technical support at the Berlinale for the fifth time in a row now. Behind the scenes, the company's solutions ensured flawless video quality. Three R&S®CLIPSTER mastering stations, one R&S®VENICE ingest and playout platform and the R&S®SpycerBox Cell storage solution were integrated in the digital workflow. R&S®VENICE was responsible for preparing the various input media for further processing. The incredible speed of the R&S®CLIPSTER mastering station made it possible to generate all digital cinema packages (DCPs) in time for the opening of the festival. About 1100 films in total were shown at the Berlinale, including the European Film Market screenings.

Trusted solutions from a single source.

SecurITy made in Germany

From compact IT security products for SMEs to scalable enterprise solutions, Rohde&Schwarz Cybersecurity provides:

- **Secure and transparent networks**
- **Secure web applications**
- **Tap-proof communications**
- **Endpoint security and trusted management**

Our award-winning solutions protect companies, critical infrastructures and public institutions against espionage and cyberattacks. Developed according to the "security by design" principle, they prevent complex cyberattacks proactively, rather than reactively.

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