NEWS

215/16

ROHDE&SCHWARZ

Clean compliance

Only approved devices are allowed to emit radiation. All others must be spectrally discreet. A new EMI test receiver checks compliance with limit values in record time.

General purpose

Latest generation of power sensors communicates via USB and LAN

General purpose

Realistic simulation of radar echoes and complex radar scenarios

Radiomonitoring / radiolocation

New functions turn monitoring receiver into a system-in-a-box

The NEWS app

The R&S®News app for iPad, Android tablets and Amazon Kindle devices can be downloaded free of charge from the respective provider's app store. The app's language can be set internally to English, German, French or Spanish.

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.

You can find the app in the respective app stores, under the key words R&S News or Rohde&Schwarz.

NEWS

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Cover feature

At the dawn of the 20th century, when Marconi undertook his groundbreaking experiments with the first transmitters, he did not have to worry about any adverse effects on the radio spectrum because he had it exclusively to himself. The veritable chaos that his spark-gap transmitters produced in the spectrum went unnoticed. Only with the increasing proliferation of radio and broadcasting did it become clear that mandatory regulations were needed to prevent mutual interference. In the International Radiotelegraph Convention of Washington, signed in 1927, 76 nationes reached an agreement on appropriate statutes. The agreement included not only a detailed plan for the allocation of frequencies, but even back then it required that the radio equipment used by the signatory states comply with the spectral purity and efficiency provisions, to the extent technically feasible. In principle, nothing in the convention has changed, only that the number of emitting products has reached a breathtaking scale that makes strict regulation more necessary than ever before. For the first time, receivers are also regulated by the new radio equipment directive (RED) that is now in effect (page 20). An even larger number of electronic products should not produce emissions at all, but without constructive countermeasures, would undoubtedly do so. EMC measurements can indicate whether these countermeasures were effective. And although measurement regulations are becoming stricter and constantly being expanded, testing needs to be faster and faster to keep costs low. That's where a test receiver like the R&S®ESW comes in. It does more than ensure that washing machines, which for some years have had to be examined for radiated emissions in line with the CISPR 14-1 standard, will receive their test seal faster. Its unprecedented measurement speed is a major advantage when testing DUTs such as automotive window lifters that are active only for seconds. Why is it worth switching to the new EMI flagship for test houses and development labs? Find out on page 48.

Overview
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Wireless technologies

General purpose

Versatile tester for installing and servicing DME and TACAN systems (page 26).

All-in-one test instrument for multidomain applications: the new R&S®RTO2000 oscilloscope (page 42).

New power sensors offer impressive connectivity, precision and speed (page 22).

Vector signal generators produce realistic radar scenarios (pages 28 and 33).

General purpose

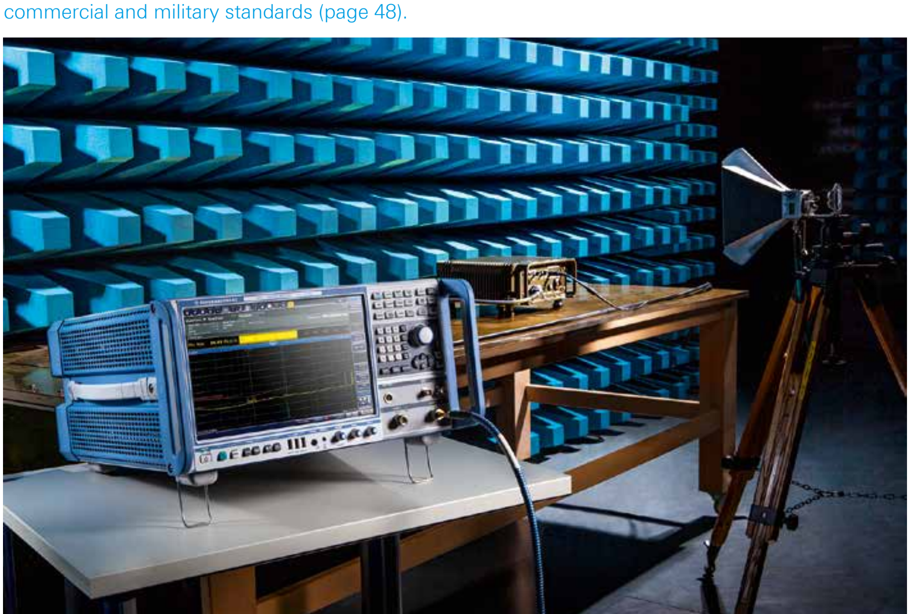
Radiomonitoring / radiolocation

Miscellaneous

EMC / Field strength

Users appreciate the R&S®ESMD as a powerful radiomonitoring tool for stationary or mobile use. New options give it even greater versatility (page 56).

A new EMI test receiver with outstanding performance fulfills all requirements of the relevant commercial and military standards (page 48).

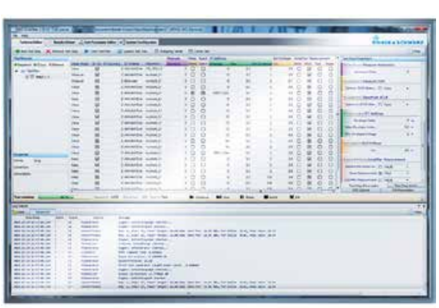


Modular PXI test solution for automotive electronic control units

Modern vehicles feature an entire armada of networked electronic control units (ECU) that manage a diverse range of subsystems and communicate with the on-board computer. The modules are expected to be 100 % reliable – a restriction reflected in the testing requirements. A major manufacturer was searching for a flexible production test station for its universal programmable compact control units and decided in favor of a solution based on the R&S®CompactTSVP system platform. Some of the key factors that influenced this decision were the broad range of available power switch modules, the built-in test and calibration options and the comprehensive application support and training provided by Rohde&Schwarz. The station thoroughly tests all ECU functions, checking their voltage values, current drain, frequencies and impedance under various load conditions. Contact is made via CAN, Ethernet, analog and digital inputs/outputs, frequency inputs and also via pulse width modulation (PWM) outputs for actuators. Other interfaces can be integrated if required for a specific DUT. Interested parties can request a PF5000-CCU demo system with an adapted sample CCU and test software for evaluation.

Automated testing of professional radios during servicing

Organizations that have to maintain large operational inventories of professional radios (predominantly militaries) generally have service centers with organizational or O-level maintenance. This means following an established service plan to restore or verify the operability of radios through activities such as replacing the battery and balancing oscillators. The new R&S®URTS226X test set was designed with such service centers in mind. Based on the large R&S®UCS test and calibration systems that Rohde&Schwarz uses in its own manufacturing process, the R&S®URTS226X offers full software compatibility with these systems. It can be used to automate testing of R&S®SDTR, R&S®M3xR, R&S®Series4200 and R&S®Series2000 radios and future models. Test procedures for third-party products can be integrated upon request. The T&M core of the system that comes in an IP65 protected aluminum case is the R&S®CMA180 radio test set. The modular software provides test procedures of various depth, which can be combined by dragging and dropping them to create test sequences that are different from the predefined sequences. This makes it easy to adapt the tests to a customer's testing philosophy. Test results are clearly documented. A statistics tool is provided for in-depth, database-aided analysis of test results.



Conveniently define, run and evaluate test sequences

In the past, developers had to use test management programs from other manufacturers to implement automated test systems with Rohde&Schwarz instruments. These programs were generally poorly suited for RF testing and required significant adaptation. The new R&S®QuickStep text executive software solves this problem. R&S®QuickStep combines a universal high-speed test sequencer with run times approaching those of native C++ test routines and a graphical user interface for defining, parameterizing, running and evaluating tests. Test procedures are mapped in flow charts for clear modeling and maximum parallelization of test tasks. The software's current library of test functions for analyzers, generators and power supplies will be expanded to include other device classes in the future. Users can use Microsoft Visual Studio to comfortably develop additional test functions based on automatically generated source code templates. These are currently in C++ but will be available in C# and script languages in the future. In-depth software development expertise is not required. A results browser allows users to evaluate measurements by analyzing runtime protocols and viewing test results in tables, diagrams and statistics.

Wideband test and measurement I: vector modulation with record bandwidth

Developers of state-of-the-art radar systems and communications products for 5G and IEEE 802.11ad need T&M instruments with tremendous modulation bandwidth, such as the R&S®SMW200A vector signal generator with the new R&S®SMW-B9 2 GHz option. No other vector signal generator on the market offers a fully calibrated wideband solution up to 40 GHz in a single device. The option can be installed twice to make it possible to generate two independent wideband signals of any modulation type up to 20 GHz with a single instrument. A&D users can cover the entire K and K_a bands with the 40 GHz version and generate radar pulses with minimum period and rise time as well as wideband FMCW signals for high range resolution. The R&S®SMW-K114 5G air interface candidates option offers software support for developers working on potential 5G mobile network access technologies. Signal forms such as FBMC, UFMC, GFDM and f-OFDM can be generated directly from the instrument's menu. The R&S®SMW-K141 option enables developers of IEEE 802.11ad technology to provide the signals they need with symbol rates of 1.76 Gsample/s in single-carrier mode.

Wideband test and measurement II: analyze signals up to 40 GHz and 160 MHz bandwidth

The mid-range R&S®FSV signal and spectrum analyzer has demonstrated its value as a universal instrument in labs and T&M systems for many years. It delivers sufficient performance for a broad range of applications, seldom leaving users wishing for a higher-range tool. When dealing with state-of-the-art communications technology, however, the demands on T&M equipment performance are so great that they can only be met by high-end analyzers – or the new R&S®FSVA. It is based on the R&S®FSV and looks and operates just like it. The only difference is a new frontend with improved RF characteristics. Data such as a phase noise value of typ. –117 dBc (1 Hz, 1 GHz, 10 kHz offset) and a sensitivity with preamplifier of typ. –166 dBm (1 Hz, < 7 GHz) proves its quality and ensures highly cost-effective phase noise measurements. The R&S®FSVA has a high dynamic range (up to an upper frequency limit of 40 GHz with the top model). And thanks to the bridgeable narrowband YIG oscillator, it can demodulate signals with up to 160 MHz bandwidth. Manufacturers of wireless base stations and developers of satellite and relay technology and tactical radio systems for the A&D sector benefit from the high-quality characteristics of the R&S®FSVA.

A giant among low-power transmitters

If you were to give a TV broadcast network operator free reign to design an ideal low-power transmitter, the specification would most likely include the following features. It would have to have practically unbreakable, maintenance-free hardware that could be repaired quickly and effortlessly in-house in the unlikely event of a problem. It would have to consume much less energy than a conventional transmitter. Depending on its class, it would need to have low power and be small in size, yet have a broad range of features such as an uninterruptible power supply, signal measurement technology, transport stream feed via IP and satellite, component redundancy and much more. This optimal transmitter is now on the market: the R&S®TLU9. Building on our experience with thousands of installed predecessor R&S®SLx8000 transmitters and the R&S®Tx9 generation of high-power transmitters, we have completely revisited and redesigned low power. Numerous innovations have been implemented, including direct RF synthesis via FPGA and TxDAC, which eliminates the need for an I/Q modulator and removes it as a possible point of failure. Seven output power levels ranging from 5 W to 200 W in 1 HU or 2 HU housing (display unit separate) are available.

In the realm of the world machine

Fig. 1: The ATLAS detector in the Large Hadron Collider, where proton-proton collisions are registered.

CERN near Geneva is the world's largest and most well-known research facility for particle physics. Its 27 km long underground accelerator ring is fully covered by a mobile network that is monitored by a Rohde&Schwarz system.

Founded in 1954, CERN is now financed and run by its 21 European member states. CERN is the world's largest particle physics research facility, occupying an area in Switzerland and France that covers many square kilometers, although the facility is now considered to be extraterritorial per UNESCO resolution. The most impressive part of the facility, however, is hidden about 100 meters below the surface. That's where the Large Hadron Collider (LHC) accelerator ring is located. With a circumference of almost 27 kilometers and enormous detectors, it is considered to be the largest and most complex machine in the world (Figs. 1 and 2). The issues that are experimentally investigated here touch on fundamental questions on how the world works (hence the popular image of the world machine). CERN researchers answered one such question in 2012 when they were able to prove the Higgs boson. Postulated 50 years ago, Higgs boson is an important building block in the standard model for elementary particle physics. The CERN findings resulted in its namesake, the elderly Peter Higgs, being awarded a Nobel Prize the following year. Other particles are still waiting to be discovered, such as the predicted supersymmetrical counterparts

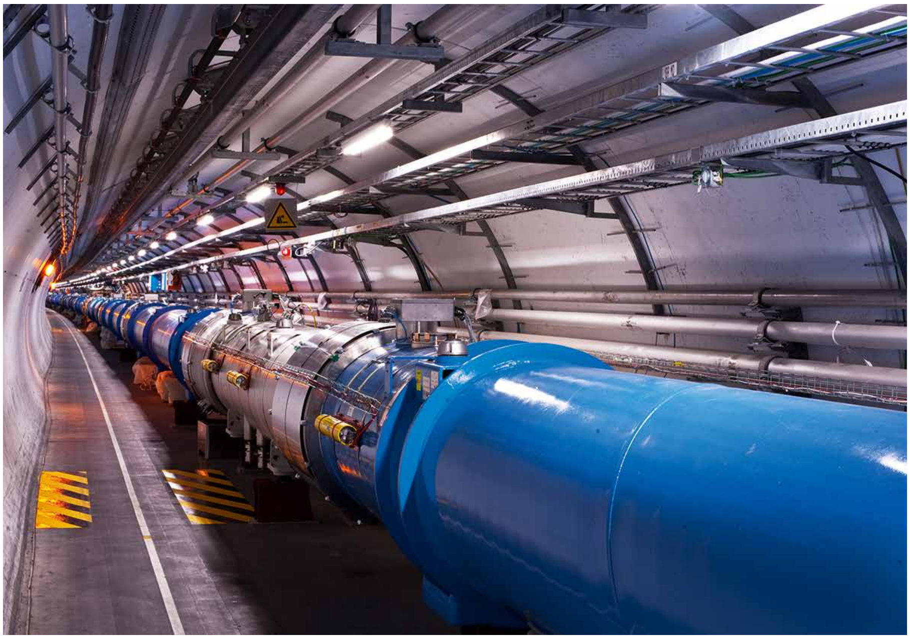


Fig. 2: Either protons or lead ions run through the LHC ring. Their collisions are triggered and recorded by different detectors.

of known elementary particles. Considered to be a possible manifestation of dark matter, these particles are being sought by researchers around the world.

If ever a research institute were destined to bring light into the dark corners of fundamental physics, it is CERN. With the LHC, CERN expects to achieve previously unattainable energy levels of up to 14 tera-electronvolts (TeV, 13 TeV have been achieved to date), which corresponds to protons colliding at a speed of 99.9999991 % of the speed of light. This can be expressed even more vividly as an equivalent temperature of 1.6×10^{17} K, an inferno that, based on the time scale proposed by currently accepted cosmological theory, existed about one billionth of a second after the Big Bang.

Overcoming the high relativistic inertia of particles near the speed of light and forcing them into the 27 km circular path of the LHC ring (the distance is defined by the tunnel that was previously dug for the LHC predecessor LEP) requires the strongest electromagnets that can be built using state-of-the-art technology. Or viewed from the other perspective: The energy levels that the accelerator can achieve are determined by the strength of the magnets. The magnets must be cooled to just above absolute zero, at which point superconductivity occurs. At CERN, this involves several thousand tons of liquid nitrogen and helium and takes several weeks, starting at room temperature. Magnets cooled in this manner conduct currents of up to 12 000 A. High energy and cryogenic temperature – this is a combination that practically screams danger. A general alarm is triggered if anything goes wrong. Accessibility, and therefore mobile communications, is critical to safety in the ring. Everyday work is made easier when the many scientific and engineering employees have access to state-of-the-art communications equipment wherever they are in the huge facility. This is why CERN maintains multiple communications systems. Most recently, the older TETRA/TETRAPOL trunked radio network was enhanced with a modern 2G/3G/4G system installed by the Swiss network provider Swisscom. Several above-ground base stations, dozens of RF access points and 60 km of leaky feeders throughout the tunnels and caverns ensure full coverage, connecting CERN employees with each other and with the outside world. But no infrastructure is immune to malfunctions, which is why round-the-clock monitoring of the network status is a priority at CERN. And CERN would not be CERN if it outsourced the technical details. It prefers to monitor network performance and uncover areas needing improvement itself. An international tender for the monitoring equipment was issued – and awarded to Rohde & Schwarz.

QualiPoc Remote Control solves the monitoring problem

The core of the monitoring system is the QualiPoc Remote Control probe from Rohde & Schwarz subsidiary SwissQual (Fig. 3). The small box contains a commercially available, software-modified smartphone that regularly checks the transmission quality of voice, data, video streams and messaging based on dozens of performance criteria and stores comprehensive quality data records. These records are sent via SMS or FTP to the CERN monitoring center, where an operator uses the NetQual suite from SwissQual to process and analyze the data (Fig. 4). The center also remotely manages the probes and keeps the software up to date. Full monitoring coverage is ensured by 60 sensors distributed throughout CERN. The system is designed for maintenance-free, 24/7 continuous operation. The probes are current buffered and restart automatically to resolve any blockages.

The use of commercially available smartphones as T&M sensors has several advantages. The quality of mobile networks is increasingly analyzed based on the user's subjective quality of experience (QoE) with the various applications and services (quality of service, QoS) (see article on page 16). Because this experience is gained using standard mobile devices, it makes sense to use these same devices for testing and use the data available in the device to objectivize the user experience. Smartphones are also cost-efficient and always come with the very latest innovations available on the market. Should the CERN network need new features or even a 5G upgrade, service technicians can replace the test phones in the QualiPoc probes with the latest model and update the test software – a standard part of product sustaining engineering. In other words, CERN does not have to worry about keeping up with mobile communications technology.

Volker Bach

For research, CERN will also use oscilloscopes from Rohde & Schwarz in the future (see page 62).

Fig. 3: The compact QualiPoc Remote Control probes from SwissQual can be placed anywhere that mobile networks need to be monitored. Only a power connection is required.

Layout of the CERN mobile network monitoring system

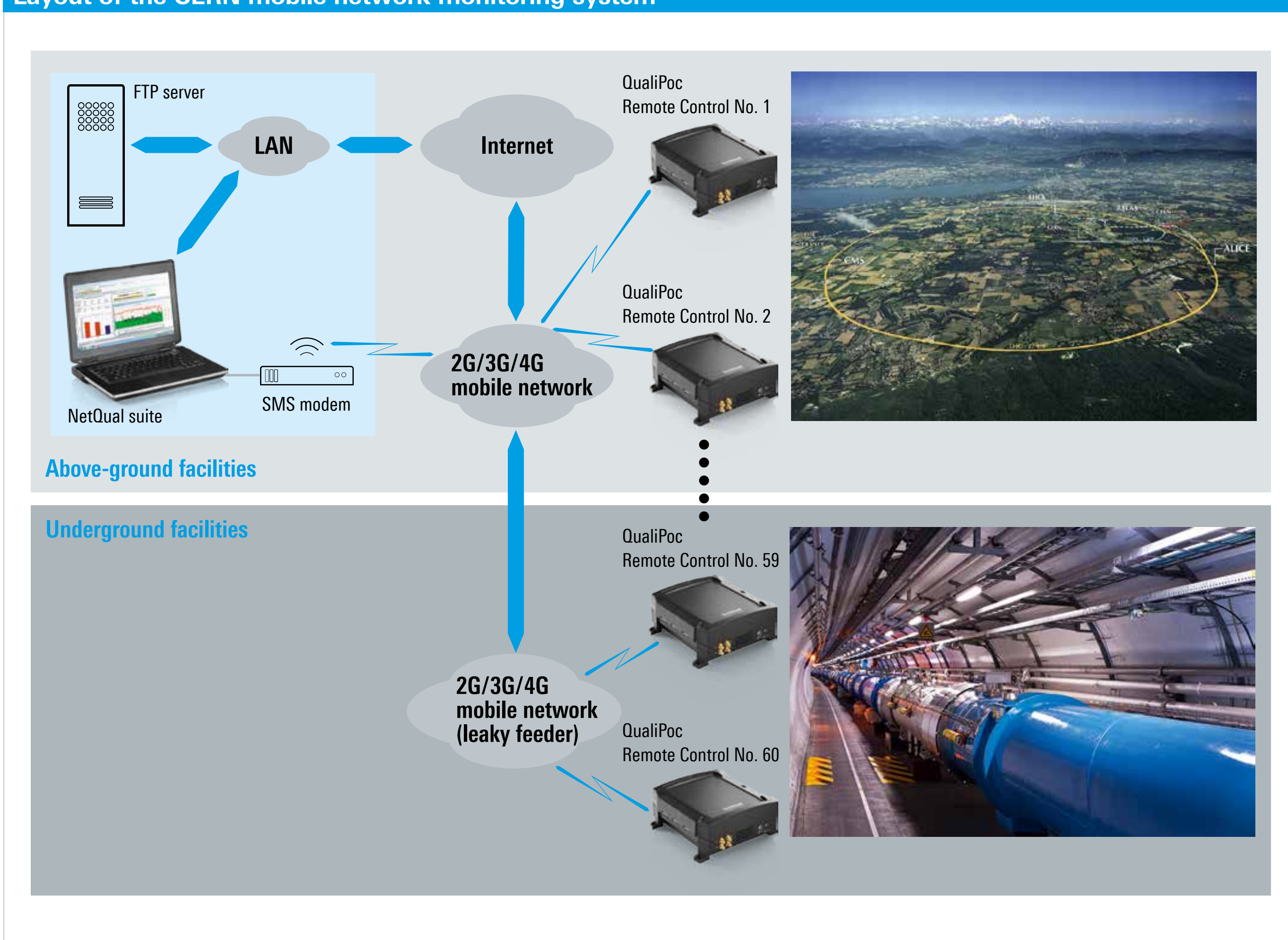


Fig. 4: The QualiPoc system both monitors the CERN mobile network and uses it to transmit its readings and remote maintenance commands.

Triangular relationship

A characteristic feature of mobile communications is that subscribers operate in a network of base stations used to process all communications. Future mobile devices will additionally be able to exchange data without an intermediate base station if they are in close proximity to each other. A tester for this scenario must be able to simulate not only a base station but also a mobile device with corresponding functionality – a case for the R&S®CMW 500.

With the advent of device-to-device functionality (D2D) in Release 12 of the 3GPP specification, proximity services (ProSe) are possible for the first time in the history of cellular mobile communications. ProSe is based on a direct data transfer between two UEs. The use of such services has to be authorized, i.e. covered by the subscriber's cell phone contract. Once this is in place, the need for the base station is eliminated and under certain circumstances the devices can be used like walkie-talkies. The motivation for D2D is twofold. The first is an emergency or major disaster situation. If the mobile network is unavailable due to a power failure or if the rescuees or rescuers do not have network coverage, for instance in a cellar, self-sufficient mobile devices are exceptionally helpful. The second application scenario relates to local broadcast services, namely unidirectional data transfer.

To be able to handle D2D, the mobile device (UE) must have the new LTE D2D interface, which is called a sidelink. The UE is expected to be able to communicate over distances up to 500 m over the sidelink. D2D as per Release 12 can be implemented in two different forms: sidelink direct discovery (for broadcast) and sidelink direct communication (for groupcast). Both are possible in FDD as well as TDD networks and use the resources for the UL LTE Uu interface, which are allocated to the sidelink for this purpose. Direct communication is reserved for safety-related applications (see below for more detail), but the direct discovery feature is also open to commercial applications. In documentation from technology suppliers and network operators, this feature is referred to as LTE Direct (Qualcomm) and LTE Radar (T-Mobile).

No ProSe usage without authorization

Irrespective of whether the user would like to use the direct discovery or direct communication service, the UE first determines if it is authorized. If the UE has network coverage, this is usually done via a network request. The UE uses existing DNS lookup procedures to find the responsible server (ProSe function) at the contracting company. If there is no network coverage, a UE can be pre-provisioned for ProSe services by having ProSe authorization stored on the SIM card or in the UE file system. Rohde & Schwarz offers the R&S®CMW-Z6 SIM card option to test this capability.

Direct discovery – efficient messaging with network support

Sidelink direct discovery is an extremely efficient method for broadcasting locally relevant information to other nearby receivers. For example, retail businesses can use this feature to advertise special promotions. The announcing UE periodically transmits the ProSe application code (PAC), a short 184-bit data telegram, over the sidelink air interface (see Fig. 1). The monitoring UE forwards the PAC to the network ProSe function, where it serves as an access key to the actual XML-based user information (ProSe ID). The ProSe function delivers this previously uploaded ProSe ID to the monitoring UE over the mobile network.

An announcing UE's ProSe application first requests a PAC, such as: "mcc123.mnc456.ProSeApp.Theatre.Tickets.Sales. Available.2", and forwards it together with the broadcast information to the provider. If the provider gives a green light (which depends on the current network load and other criteria), the mobile network operator (MNO) responds to the request by issuing a PAC that is intended for broadcasting.

The specific design of the whole process in actual networks has not yet been finalized. One of the open questions is how to ensure that the message reaches every LTE subscriber,

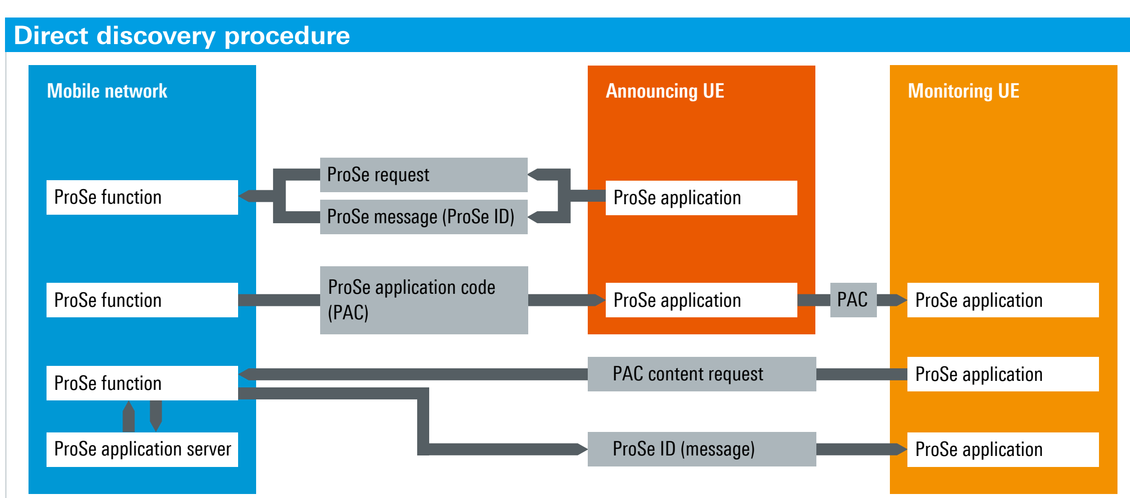


Fig. 1: Direct discovery means that a UE uses the network to broadcast locally relevant information to nearby receivers.

even when the transmitter and receiver are operating on different frequencies or are registered with different providers. 3GPP does not specify how two MNOs allow access to each other's ProSe function. The technical principles, however, are established in Release 12 so that the basic process can be simulated. The R&S®CMW500 with the Release 12 option can simulate this process.

Comprehensive ProSe tests with the R&S®CMW500

Fig. 2 shows the network and UE components involved in direct discovery. Fig. 3 illustrates this in greater detail from the perspective of the R&S®CMW500 with a connected UE. The tester has to provide measurement functions for the sidelink interface (PC5) and also be able to simulate the data traffic with the ProSe function via the logical PC3 interface (XML over http, routed via the LTE Uu air interface). The UE under test functions alternately as a direct discovery transmitter (announcing UE) and receiver (monitoring UE). The medium level API (MLAPI) for the R&S®CMW500 includes a DLL implementation of the network's ProSe function so that the ProSe protocol can be tested. UE development often takes place in teams working in parallel. These teams are dedicated either to the RAT or to the core network-related layers and interfaces. Since each team assumes that the other team's functionality will work, the direct discovery implementation on the R&S®CMW500 offers the possibility of circumventing the PC3 interface and carrying out tests even without implemented ProSe protocols by using test loop mode D in line with 3GPP TS 36.509.

According to the 3GPP specification, a UE that supports direct discovery must be able to receive up to 50 messages per channel (assuming a 20 MHz cell) within a single transmission time interval (TTI, 1 ms). To test this capability, the R&S®CMW500 generates up to 50 sidelink UEs in a specified frequency band. In addition (although this is not a firm requirement), a UE should also be able to monitor frequency bands of other local LTE networks in order to receive messages transmitted there. This situation is also covered by the R&S®CMW500. Two active sidelinks, each capable of receiving up to 50 messages per TTI, are set up in parallel on different frequencies.

Direct communication – modern IP communications for public safety and security

Public safety and security organizations have special communications requirements. In the past, they generally relied on customized (trunked) radiocommunications systems such as TETRA. The capability of commercially deployed technologies like LTE leave such systems far behind when it comes to performance. LTE direct communication solves the need for such features. It extends network communications by adding groupcast and push-to-talk direct mode functions that are typical of trunked radio systems. Voice, photos and high-resolution videos (which are not possible using traditional trunked radio systems with their low data rates) can easily be sent to members of a group. Each UE can be a member of any number of groups. Reserving radio resources and the security mechanisms for direct communication are described in detail in Rohde&Schwarz white papers [1, 2].

Direct discovery: network and UE components

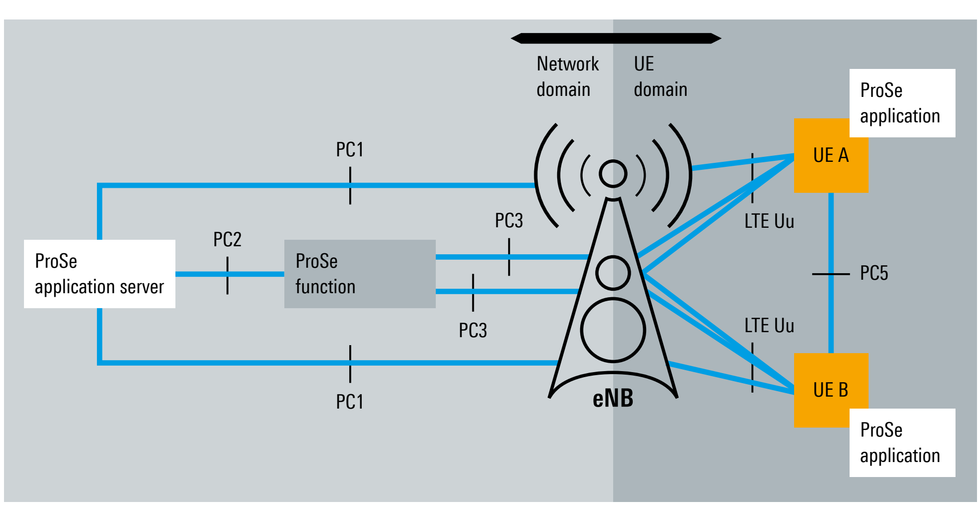


Fig. 2: Network resources and interfaces involved in ProSe.

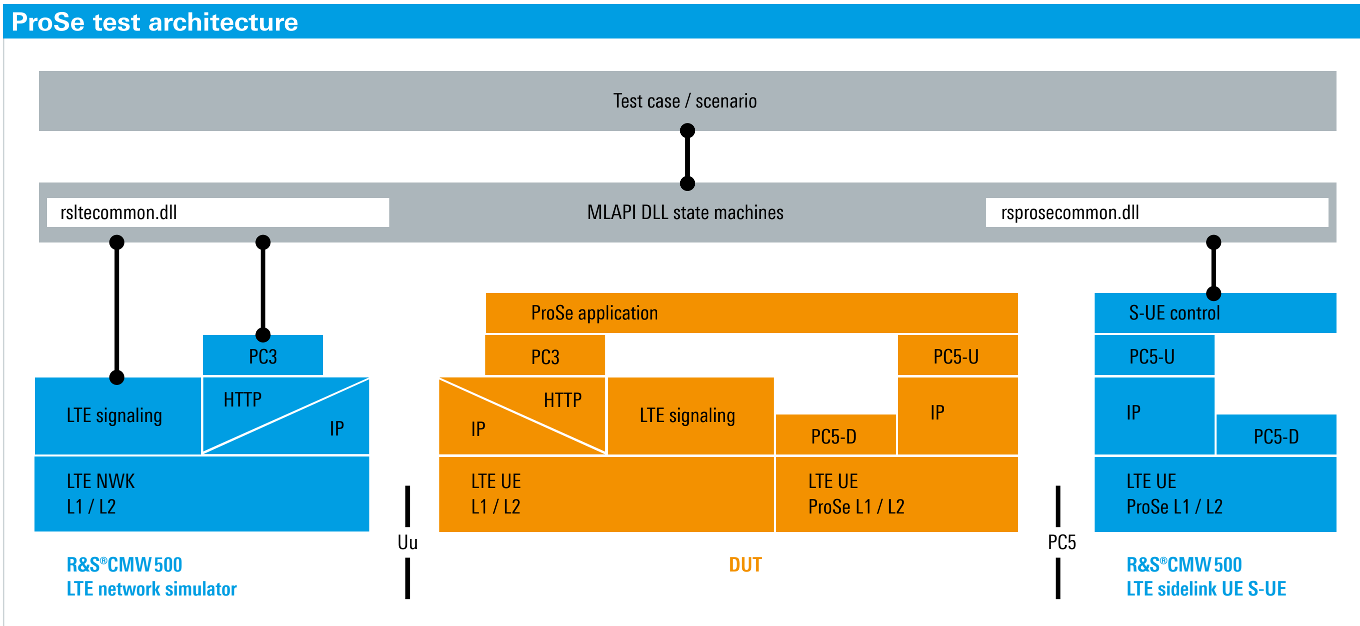


Fig. 3: Test architecture for ProSe tests, consisting of the R&S®CMW500 (blue) and the mobile device (DUT).

Since direct communication is especially important when there is a network outage, a solution had to be found for the problem of compensating for the absence of a common timebase, which is critical for synchronizing UEs. The problem was resolved by ensuring that each UE wishing to transmit that does not find a time reference declares itself as the synchronization master. It then transmits all necessary information that is usually contained in the master information block, such as the system bandwidth and duplex mode (direct synchronization). The sidelink UE simulated by the R&S®CMW500 implements all the functions needed to test the DUT in both roles, both as the synchronization master and as a receiver that needs to synchronize with the master.

Direct synchronization can also be used to extend network coverage. If required, a direct communication enabled UE (though direct synchronization is not restricted to direct communication) at the edge of network coverage can be prompted by the network to take on the role of synchronization master for the UEs in its vicinity. A typical application scenario might be an emergency situation in which the emergency personnel needs to penetrate a building where there is no network reception.

Outlook

The definition of the D2D air interface is far from finalized with 3GPP Release 12. Release 13, for example, will add functionality to turn a UE into a relay node for UEs that are out of coverage. This feature will enable UEs to use direct discovery even when they are not in direct contact with a base station. In addition, a service called mission critical push to talk is being defined. This service will encompass both public safety and commercial applications. Other D2D application areas will include vehicle-to-vehicle communications, although these will only be addressed in future standardization efforts since they require much lower latencies than are currently possible with LTE. For all existing and foreseeable D2D services, the R&S®CMW500 is the tester of choice – for RF, protocol or application testing.

Dr. William Powell

References
[1] White paper "LTE-Advanced (3GPP Rel. 12) Technology Introduction" (search term 1MA252 at www.rohde-schwarz.com).
[2] White paper "Device to Device Communication" by Rohde&Schwarz (search term 1MA264 at www.rohde-schwarz.com).

Measuring user experience under lab conditions

User equipment (UE) test specifications published by standardization forums focus on characteristics that ensure error-free operation on the network. While testing of subjective criteria such as sound and picture quality is not mandatory, these are key factors for success on the market. An award-winning[1)] test solution from Rohde & Schwarz now makes it possible to measure these features as well.

What matters is the user experience

Anyone purchasing a cell phone can safely assume that any commercially available model will perform as intended. This is ensured through a comprehensive test program that every device must pass before market introduction. However, when it comes to assessing how a device stands up to everyday use and where its strengths and weaknesses lie, potential customers rely on consumer portals and magazines. These assessments increasingly govern the quality discussion, with emphasis on keywords such as user experience, quality of experience (QoE) and quality of service (QoS). However, the user experience is not solely a product of the UE characteristics, but rather results from the interaction between the network, the UE hardware and firmware and the software applications, i.e. apps. This is why all market participants – including network operators, UE manufacturers and app developers – are interested in test solutions that enable the objective measurement of subjective assessment criteria. Walk and drive test products for QoE measurements in real networks, such as those offered by Rohde & Schwarz, lack the necessary reproducibility, and they take the local network characteristics (the analysis of which is their primary purpose) as a given. This makes them unsuitable for the applications described here. In order to achieve fast and reproducible results during development, what is needed instead is a lab solution where all parameters affecting quality, especially with respect to the network, are configurable. This need is filled by the tried and true R&S®CMW500 wireless tester, which serves as the basis of a small test system controlled by the R&S®CMWrun test sequencer software application.

The test system

The R&S®CMW500 can emulate two wireless systems simultaneously and analyze all conceivable data traffic criteria between the network and the UE. Internal data handling is taken care of by a data application unit (DAU) that includes the IP multimedia system (IMS) that is also key to voice transmission in LTE. An audio board provides the voice codecs specific to each standard. Specialized instruments are integrated for measuring audio and video quality as well as power consumption, including the R&S®UPV audio analyzer, the R&S®VTE video analyzer (both of which are capable of objective quality measurements[2)]) and the R&S®NGMO2 dual-channel analyzer/power supply. R&S®CMWrun is a test automation software application for remotely controlling R&S®CMW based test systems and processing their results. The individual, ready-to-use test steps are stored in a library and then combined on the user interface into application-specific test plans. Available tests include the carrier acceptance tests that large network operators require for UEs in their networks. Fig. 1 shows the test setup.

Audio – a compulsory exercise …

In the days of GSM, a cell phone was primarily a telephone. On an LTE smartphone, however, voice is just one of many services; one that even has to be added by means of IMS. This is because LTE was optimized for data services, not for analog applications (see NEWS 214, page 18). However, telephony remains such an essential component of cell phone usage that good audio quality is taken for granted by users and should therefore not be neglected by manufacturers. In fact, new broadband codecs make it possible to pamper users with a voice quality that will seem a revelation in comparison to fixed network telephony with its bandwidth-limited 3.4 kHz. However, achieving this quality with VoLTE requires that the parameters relevant for digital realtime systems, such as path quality (radio conditions), packet loss, packet delay, jitter strength, jitter distribution and latency, remain within permissible limits. It is also necessary to test interaction with users who connect via non-IP-based technologies such as GSM, WCDMA or CDMA2000®.

1) See Newsgrams on page 63.
2) Although this term has become commonplace in the literature, it is misleading because it actually means the opposite. The goal is to simulate the human physiology of perception for computerized analysis, i.e. to objectivize it.

The R&S®CMWrun software provides all of the measurement functions required to assess audio and voice quality for all conventional standards. Only a few mouse clicks are needed to set up customized test campaigns that include all signaling and radio parameters and conditions that can affect audio quality and its subjective perception. The ITU-T test algorithms PESQ and POLQA are used in the audio analyzer to capture subjective perception. These algorithms digitally compare the test signal to a reference signal and assesses the difference in terms of perception. The following signaling settings can be made: establishment of a voice or video call via the IMS server, RoHC, SPS, TTI bundling, dedicated bearer and QoS, IPv4/IPv6, delay, jitter, packet loss and fading profile.

Video tests – gaining in importance in the multimedia age

Videos are currently responsible for approximately 50 % of the data volume in cellular networks. The Ericsson Mobility Report calculates that this will increase to 70 % by 2021. Given these numbers, it is understandable that the cellular industry works to optimize its infrastructure and UEs for this application. Running the necessary tests on R&S®CMWrun does not require deep understanding of video because the software configures all settings. The network is emulated by the R&S®CMW500 and includes an HTTP streaming server (DASH). The transmission channel can be influenced with IP impairments and fading scenarios. All access technologies that support E2E video streaming can be incorporated into the tests, i.e. LTE (FDD/TDD), WCDMA/HSPA, (E)GPRS and WLAN. The tests can be performed in two different ways:

- Via an A/V interface (HDMI™/MHL/Miracast) using the R&S®VTE video tester
  The video signal is supplied to the DUT either via a wired connection (HDMI™/MHL) or via a wireless connection using an adapter box (Miracast). The R&S®VTE uses its reference image based quality analysis functions (SNR/SSIM/MOS) to analyze the decoded signal.
- Visually via a barcode reader with appropriately prepared video material
  R&S®CMWrun permits this test method even without a connected video tester. Instead, the R&S®CMW-Z17 high-speed barcode reader is used. It is connected via USB to the control PC running the R&S®CMWrun software. The DASH server in the R&S®CMW500 delivers a prepared video whose individual frames contain sequentially numbered barcodes. The barcode reader scans the codes from the UE display and sends them to the PC for evaluation. Missing

User experience test scenario

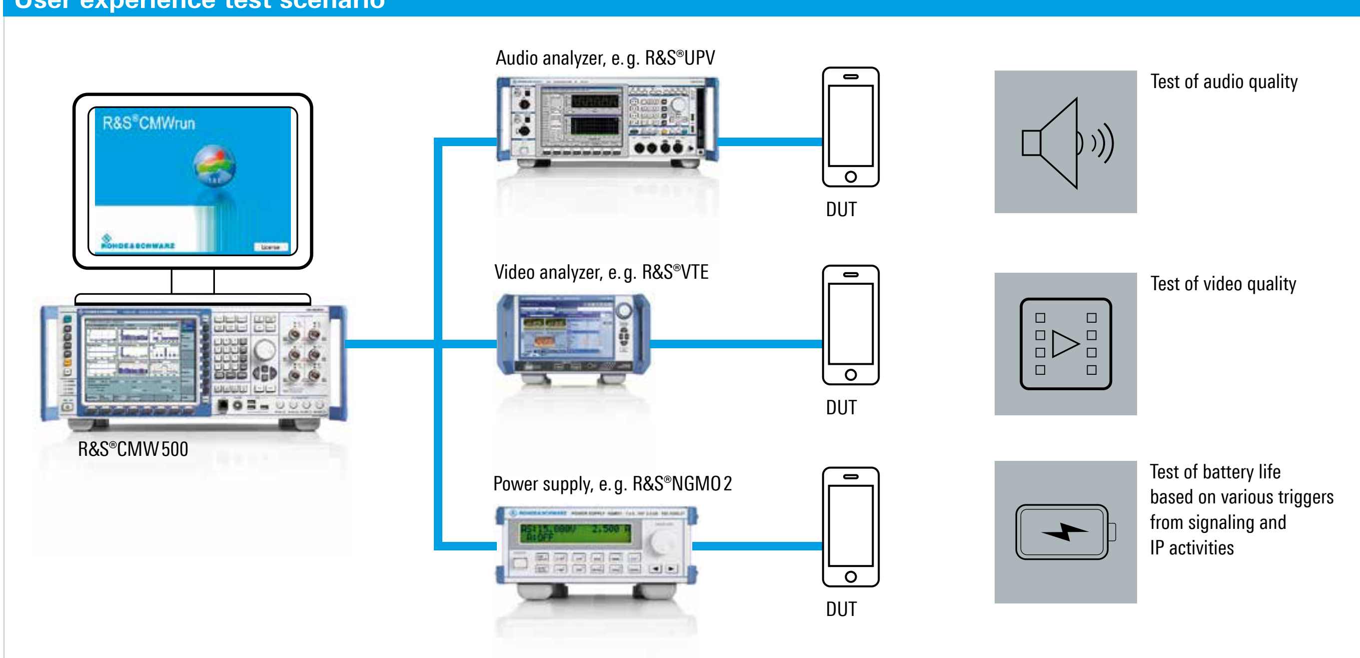


Fig. 1: Test setup for quality of experience measurements under lab conditions.

frames, delayed frames or out-of-sequence frames can be reliably detected. This setup can also be used to test bit rate adjustments made by the DASH server under changing channel conditions. This option includes barcoded videos.

Battery life – a key quality feature

Everyone who has forgotten to plug in their cell phone at night knows the aggravation of waking to a dead battery. Many apps run in the background without the user's knowledge, increasing power requirements. Power-saving mechanisms, such as discontinuous reception (DRX) in LTE, manage device resources fairly efficiently by ensuring that only the components currently needed remain in a waiting state. But to sustainably reduce power consumption, every device function and every app must be individually monitored. The R&S®CMW-KT051 option for R&S®CMWrun provides the means to test this. In the test setup, the R&S®NGMO2 power supply replaces the integrated battery. R&S®CMWrun precisely logs the power consumption in the form of a continuous measurement trace (Fig. 2). However, this log only becomes truly useful when combined with overlaid event markers that make it possible to correlate power consumption with device-internal activities. This can include trigger events at the signaling level, e.g. establishment of a VoLTE call, or processes at the IP level that the IP analysis option makes

Fully automated battery life tests, IP throughput tests, as well as IP analysis with R&S®CMWrun

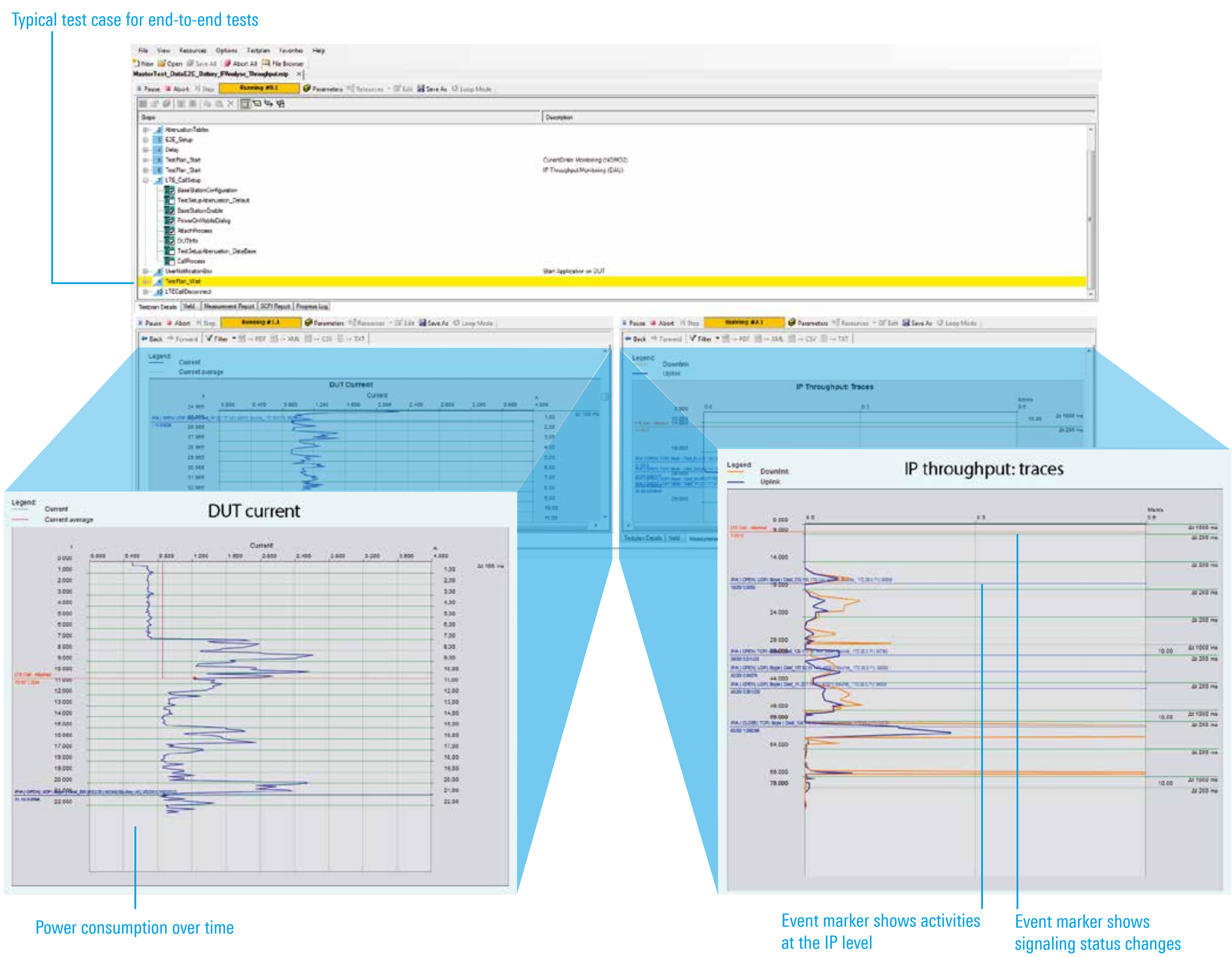


Fig. 2: Event markers can be used to correlate the power consumption with device-internal processes at the signaling or IP level.

accessible to users. By integrating the R&S®UPV audio analyzer into the setup, the power consumption can be correlated with the audio quality, which is measured with DRX switched on and off. Another very telling correlation results from combining power consumption and IP throughput measurements. The IP throughput is recorded in a second measurement trace over time (also with overlaid event markers) that is time-synchronized with the power consumption measurement. The measurement results provide an estimation of the operating time with a charged battery under various (IP) load conditions. On Android mobile devices, the R&S®CMWrun app with its iPerf and FTP functions supports the automation of these measurements.

Summary

Audio and video quality, battery life and throughput performance are key criteria for the success of products such as smartphones, apps, IoT modules and car-to-car modules. With a setup consisting of the R&S®CMW500 and T&M instruments for audio, video and power consumption, these criteria (which can be summarized as quality of experience) can be tested flexibly, comprehensively and without additional programming effort. The solution permits development engineers to monitor factors affecting QoE during every phase of the development process. It allows network operators to determine under lab conditions whether UEs provide the QoE they require for their networks. App developers can monitor the QoE of their creations on a variety of UEs without having to rely on a real network.

The table below summarizes the measurement options.

Fernando Schmitt; Volker Bach

Measuring user experience for all standards with the R&S®CMW500 / R&S®CMWrun

	Features / conditions	Measurement results
Throughput tests		
	▪ Upload / download ▪ iPerf / FTP / UDP ▪ Browsing / streaming ▪ IP impairments and fading	▪ Throughput monitoring over time ▪ IP events over time (IP analysis) ▪ Throughput versus modulation coding method ▪ BLER versus modulation coding method
Audio performance		
	▪ End-to-end voice quality ▪ VoLTE / circuit-switched ▪ Handovers, incl. SRVCC ▪ IP impairments and fading ▪ Voice / loopback call	▪ Voice quality / performance (MOS: POLQA / PESQ) ▪ Audio delay (ms) ▪ Acoustic measurements
Video analysis		
	▪ Streaming (HTTP streaming server / DASH) ▪ Video call, incl. ViLTE ▪ IP impairments and fading	▪ Wired (HDMI™ / MHL interface) ▪ Via optical interface (embedded barcode) ▪ Lost frames, frame delays, request for repeated frames ▪ Pixel errors ▪ Subjective quality assessment (SNR / SSIM / MOS)
Battery life test		
	▪ With voice, video, data ▪ With defined profiles ▪ With signaling and IP event markers	▪ Power consumption (mW) ▪ Current drain (mA) ▪ Estimated battery life (h)
Coexistence tests		
	▪ WLAN RX desensitization ▪ LTE RX desensitization	▪ Desensitization by distance of aggressor (dB) ▪ Desensitization by UL power of aggressor (dB)

RED – new radio equipment directive for Europe

The new radio equipment directive (RED) is effective from mid-June onward. The directive also covers radio receivers; they will have to meet minimum performance requirements in terms of sensitivity and selectivity.

Radio transmissions only with permission

Whoever wants to transmit or receive radio signals in Europe must comply with the relevant European directives governing the approval of radio equipment. These directives are developed in close cooperation between the European Commission as a body taking an active part in political decision-making, the European Electronic Communications Committee (ECC) within the European Conference of Postal and Telecommunications Administrations (CEPT), both of them guardians of the ever more valuable frequency resources, as well as the European Telecommunications Standards Institute (ETSI, Fig. 1). In addition to general requirements relating, for example, to the protection of health and safety or environmental compatibility, the directives also contain fundamental technical requirements. All radio equipment must fulfill what is referred to as "essential requirements" in the applicable directives, during normal operation and under the operating conditions specified by the manufacturer (ambient temperature, humidity, etc.). Evidence of compliance must be furnished by the radio equipment manufacturer or operator as a prerequisite for obtaining approval for operating the equipment and putting it on the market. To this end, the manufacturer or operator must submit a test report that has been issued by a certified test laboratory using validated measuring equipment, for example from Rohde & Schwarz. Technical details on the diverse radio applications and frequency bands falling under the directives are specified in the "harmonized standards" developed by ETSI, along with possible test methods to demonstrate compliance. Harmonized standards become effective as European standards (EN) following a thorough examination by the regulatory bodies. Fig. 2 presents important examples of these standards. The currently applicable European standards are listed in the Official Journal of the European Union. An overview can be found on the ETSI website (www.etsi.org).

The new directive also covers receivers

According to the Official Journal of the European Union L 153/62 of May 22, 2014, the previous directive RTTED 1999/5/EC, better known as R&TTE, has been replaced by the new radio equipment directive RED 2014/53/EU published on April 16, 2014. Replacement took effect on June 13, 2016, with an additional transition period of one year, subject to approval by the national legislative and regulatory bodies.

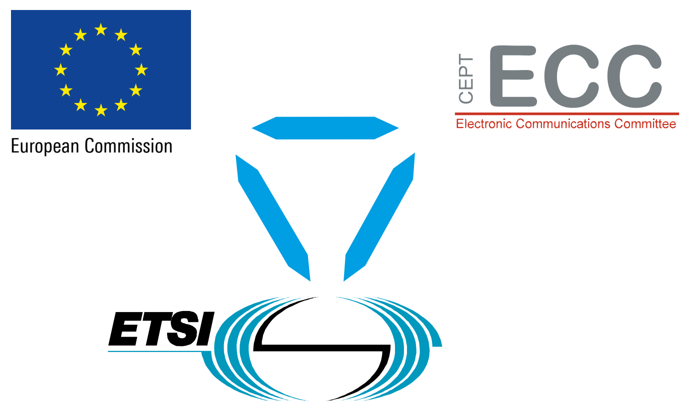


Fig. 1: Regulatory bodies governing radio operation in Europe.

Technical aspects are essentially covered by Article 3.2, both in the previous and the new directive. In the previous directive, this article stipulated that a radio should only use the allowed frequency bands while avoiding interference with other bands. To fulfill these requirements, the transmitter section of a radio had to meet specified technical standards. Radio receiver sections and mere radio receivers (RX-only products) had always been exempt from the regulation.

The new RED adds an inconspicuous but crucial requirement to Article 3.2. Radios must make efficient use of the available spectrum. This is a consequence of the growing economic importance of radio resources. The directive now explicitly covers the receiver sections of radio equipment as well as mere radio receivers, and requires that they achieve a minimum level of performance in terms of sensitivity and selectivity, which must be demonstrated by appropriate measurements.

ETSI Recommendation EG 201 399 lists the typical radio transmitter and receiver parameters to be tested. Fig. 3 shows a selection of these parameters.

Summary

The new European radio equipment directive raises the demands on radio equipment of all types, calling for higher spectral efficiency. This means that from mid-2016, radio receivers will also have to meet regulatory minimum performance requirements, and consequently will have to be tested. Rohde & Schwarz offers all the necessary T&M equipment, both as lab instruments and as fully automatic, complete turnkey solutions tailored to provide the tests for a given regulatory scenario.

Heinz Mellein

Referenzen

[1] DIRECTIVE 1999/5/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, Official Journal of the European Union L 91/10 of April 7, 1999.

[2] DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, Official Journal of the European Union L 153/62 of May 22, 2015.

European standard	Equipment and frequency ranges covered by the standard	Test solution
EN 302 571	Intelligent transport systems (ITS), e.g. modules for car-to-car communications 5855 MHz to 5925 MHz	R&S®TS-ITS100 RF conformance test system
EN 300 328	Wideband transmission systems, e.g. WLAN modules 2400 MHz to 2483.5 MHz (ISM band)	R&S®TS8997 regulatory test system for wireless devices
EN 301 893	5 GHz high performance RLAN, e.g. WLAN modules 5.15 GHz to 5.35 GHz and 5.47 GHz to 5.725 GHz	R&S®TS8997 regulatory test system for wireless devices
EN 301 908-13	IMT cellular networks, e.g. LTE user equipment E-UTRA frequency bands 1, 3, 7, 8, 20, 33, 34, 38, 40, 42, 43	R&S®TS8980 RF test system family
EN 303 340	Digital terrestrial TV broadcast receivers; harmonized standard covering the essential requirements of article 3.2 of Directive 2014/53/EU	R&S®BTC broadcast test center


R&S®TS8980


R&S®TS-ITS100


R&S®TS8997


R&S®BTC

Fig. 2: Important examples of radio standards defining the technical details for compliance with the RED.

Fig. 3: Essential requirements on radio transmitters and receivers in accordance with ETSI EG 201399, and the associated parameters.

Transmitters

(in line with previous (R&TTE) and new (RED) directive)

- Frequency accuracy and stability
- Transmit power
- Adjacent-channel power
- Spurious emissions
- Intermodulation attenuation
- Transient behavior
- Modulation accuracy
- Duty cycle

Receivers

(in line with new directive (RED))

- Dynamic range and sensitivity
- Co-channel rejection
- Adjacent-channel selectivity
- Spurious response rejection
- Intermodulation response rejection
- Blocking / desensitization
- Spurious emissions
- Multipath sensitivity

These next generation power sensors are extremely contact-friendly. They can be operated via the optional R&S®NRP2 base unit as well as via their USB port on a PC or on various Rohde & Schwarz measuring instruments. All models offer a version with LAN port.

Power boost

Highest measurement accuracy, speed and dynamic range have always been the distinguishing features of Rohde & Schwarz power meters. But now a new generation shows that it can get even better.

The next generation of R&S®NRPxxX power sensors pushes performance to the limits of what is currently feasible. And the practical aspects were not forgotten. Now each sensor is also available as a model with a LAN port – ideal when some distance is required between the DUT and the user. The sensors only have to be connected to a power over Ethernet (PoE) switch or a PoE-capable network. Another unique feature: Rohde & Schwarz also offers 40 GHz and 50 GHz models, making the T&M expert the only manufacturer in the world to offer fast multipath diode power sensors for the K_a and Q bands that are quickly gaining in significance in satellite communications.

Depending on the model, the sensors measure frequencies up to 110 GHz (the range is constantly being expanded). The following models are currently available:

- R&S®NRPxx**S** three-path diode power sensors (10 MHz to 50 GHz)
- R&S®NRPxx**T** thermal power sensors (DC to 110 GHz)
- R&S®NRPxx**A** power sensors for EMC applications (8 kHz to 18 GHz)
- Special power sensors for use in a thermal vacuum (see box on page 25).

Models with LAN port have an additional "N" in the type designation, e.g. R&S®NRPxx**SN**. The product brochure contains a detailed overview of this comprehensive program and the different power classes.

Contact-friendly via USB and LAN

Like their predecessors, the new sensors are self-contained, calibrated power meters. There is a base unit for display and operation, however the sensors can also be operated via a PC as well as via other Rohde & Schwarz measuring instruments thanks to their USB interface (Fig. 1).

Contact-friendly sensors

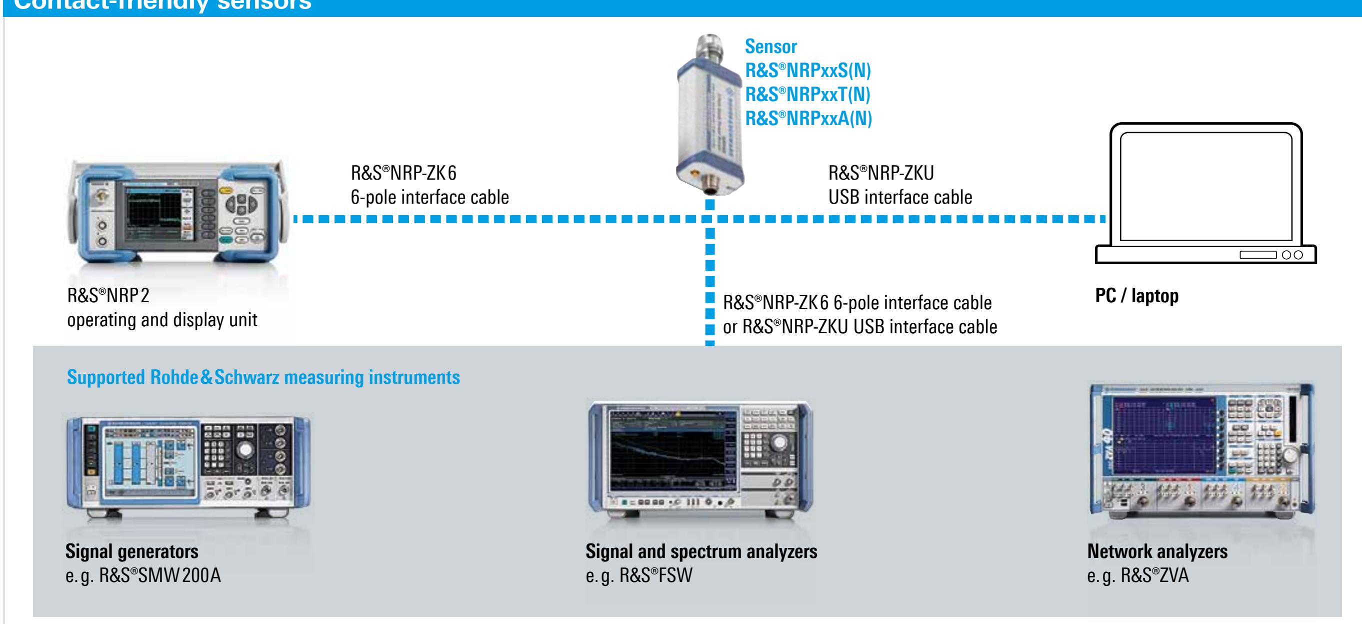


Fig. 1: The various ways to operate the power sensors. All models can be supplied with a LAN port. The interface cables have screw terminals to connect to the sensor and are available in lengths up to 5 m.

The LAN-capable models are easy to operate via any common web browser because their integrated web server provides all available measurement functions on a well-organized user interface. No additional software is required (Fig. 2).

Three-path diode power sensors: all-rounders with a high dynamic range

This sensor type is quite versatile because it measures power independent of the signal bandwidth and modulation type. Highlights includes its dynamic range of 93 dB with a lower measurement limit of –70 dBm and its measurement speed of up to 50,000 measurements/s. These sensors currently cover the frequency range from 10 MHz to 50 GHz, making them ideal for measuring wireless signals such as LTE and LTE-A as well as for applications in the K_a and Q bands, for example.

Thanks to the improved three-path diode technology, the lower measurement limit was lowered from the previous –67 dBm to –70 dBm. This 3 dB reduction in the noise component not only means that even lower powers can be measured, it also increases the measurement speed by a factor of four.

Thermal sensors: maximum precision and highest frequencies

Thermal power sensors are used when highest measurement accuracy is required, e.g. in calibration labs. With a lower measurement limit of –35 dBm, the R&S®NRPxxT(N) models have the widest dynamic range (55 dB) for this sensor type available on the market. Because thermal sensors measure power independent of the bandwidth, they can be used for wideband signal sources such as photodetectors and photoreceivers for the 100 Gbit Ethernet up to 110 GHz.

The top model covers the frequency range from DC to 110 GHz. This range makes it possible to perform interruption-free level calibration of a network analyzer (e.g. the R&S®ZVA110) on the 1 mm test port.

While measurement accuracy is paramount for thermal sensors, measurement speed also plays an important role. That's why the thermal test cell of the new sensors has been optimized so that its temperature very quickly follows changes in the applied power. The new sensors measure up to three times faster than comparable solutions on the market – without compromising accuracy.

Fig. 2: The integrated web server in the LAN-capable power sensors provides a well-organized display of all functions and results in a common web browser.

Out-of-this-world good: TVAC-compatible power sensor up to 33 GHz

In the satellite industry, components, subsystems and even entire satellites must be qualified under realistic operating conditions, i. e. for use in a thermal vacuum (TVAC). This increasingly requires highly accurate power measurements directly on the DUT, i. e. in a TVAC chamber. Therefore, the power sensor not only has to function in a high vacuum, it also must be able to withstand wide temperature fluctuations. And it must not pollute its environment through outgassing.

The **new R&S®NRP33SN-V sensor** was developed just for these conditions. All components are baked in a vacuum chamber during the production process so that subsequent outgassing is minimized. Venting holes in the housing equalize the pressure between the inside of the sensor and the environment. The power sensor covers the common satellite communications frequency range up to 33 GHz and enables fast, highly accurate power measurements over a dynamic range of 93 dB, independent of signal bandwidth and modulation type. The power sensors can be controlled and monitored from outside the chamber via the integrated LAN port.

Special sensors for EMC applications

Power sensors for EMC applications not only have to determine the average power, they also have to measure frequencies down to 8 kHz – both quickly and at low power levels. These sensors also use improved three-path technology and therefore benefit from the extended dynamic range and the resulting increase in measurement speed at low levels.

Summary

The R&S®NRPxxX(N) sensor generation features improved specifications and expands the scope of applications by offering new types and connectivity options. The portfolio includes highly precise thermal sensors up to 110 GHz as well as extremely fast, high dynamic range, three-path diode power sensors up to 50 GHz such as are required for directional and satellite radio. Special models take into account the special requirements of EMC measurements and when operating in a thermal vacuum. The unique combination of USB and LAN interfaces on a single sensor, such as offered by the N models, opens up new application areas when a great distance between sensor and user has to be bridged.

The portfolio is being continually expanded.

Michael Kaltenbach

Efficient performance check for DME and TACAN ground stations

The new, versatile R&S®EDST300 TACAN / DME station tester is ideal for installing and servicing DME and TACAN systems. As a specialist system for ground measurements, it complements the R&S®EDS300 model that is mainly used for flight inspection.

Efficient planning of flight routes and corridors as well as accurate navigation are prerequisites for smooth procedures in the increasingly dense global air traffic. Even if the introduction of performance based navigation (PBN) makes global navigation satellite systems (GNSS) more important for en-route navigation in the future, terrestrial systems such as DME and TACAN remain essential and will continue to be enhanced. Rohde & Schwarz has developed the modular R&S®EDST300 TACAN / DME station tester for continuous monitoring and servicing of DME and TACAN stations (Fig. 1).

The R&S®EDST-B2 interrogator option with an adjustable output power of –80 dBm to +30 dBm is available for receiver measurements. An optional battery and a special test antenna make the analyzer fit for field measurements. Its flat menu structure and task-specific measurements displayed on the easy-to-read (even in sunlight) 6.5" TFT color screen ensure optimal user-friendliness no matter where it is used. All results can be retrieved via the remote control interfaces or be stored on a USB data logger.

Regular maintenance of DME and TACAN ground stations

The R&S®EDST300 provides high-precision stimulus and analysis functions for terrestrial pulsed navigation signals in the 960 MHz to 1215 MHz frequency range. It determines essential system parameters such as peak power, main delay and reply efficiency. It analyzes the identifier and efficiently and accurately performs the conducted tests required for DME and TACAN systems in line with the relevant civil and military standards (e. g. on-channel sensitivity and decoder rejection).

Fig. 1: The compact R&S®EDST300 controls all measurements necessary for the maintenance and servicing of DME and TACAN stations and is suitable for conducted and radiated signals.

The R&S®EDST300 can also be used for numerous in-depth analyses. In addition to special tests such as interrogation loading, reply delay variation and adjacent channel measurements, it also offers time domain analysis (R&S®EDST-K2 option) with automated determination of pulse rise and decay times, pulse duration and pulse spacing, eliminating the need for an external oscilloscope.

Measurement of conducted signals for servicing TACAN systems

Equipped with the R&S®EDST-K1 option, the R&S®EDST300 analyzes the performance of TACAN systems. In addition to the measurements that are identical to those for DME systems, it is possible to analyze, for example TACAN bursts (MRB and ARB) using a directional coupler to determine their pulse repetition rate, pulse count and pulse spacing (Fig. 2).

Everything you need for field measurements

The integrated battery (R&S®EDST-B3 option) ensures autonomy in the field. Charged using the standard power supply, the battery supplies the analyzer with enough power for up to two and a half hours of operation.

Thanks to its low noise figure, the R&S®EDST300 offers an excellent input sensitivity of –100 dBm (RF input 2). This allows highly accurate measurements even at large distances from the TACAN/DME ground station. The R&S®EDST-Z1 test antenna is used to perform extremely accurate field measurements on TACAN systems, for example modulation depth, modulation frequency and phase relationships of the 15 Hz and 135 Hz signal components, and also the TACAN bearing. The test antenna's excellent front-to-back ratio suppresses unwanted reflections. The antenna can be used to determine the range accuracy and many other system parameters of both TACAN and DME systems under realistic conditions in the field, including signal strength in space, pulse spacing and reply efficiency.

Klaus Theißen

Special characteristics of the R&S®EDST300

- High-precision TX/RX measurements on DME and TACAN systems (in line with ICAO Doc. 8071, ICAO Annex 10, STANAG 5034 and MIL-STD-291C)
- Dynamic range of 110 dB and precise peak power measurement
- Precise measurement of characteristic TACAN/DME parameters (main delay uncertainty < 50 ns, bearing uncertainty < 0.2°)
- Detailed, automated time domain analysis
- Compact design with internal battery
- LAN interface for remote controlling all functions and outputting measurement data
- Weight: 7.3 kg; high mechanical stability
- USB port for easy data export and software updates

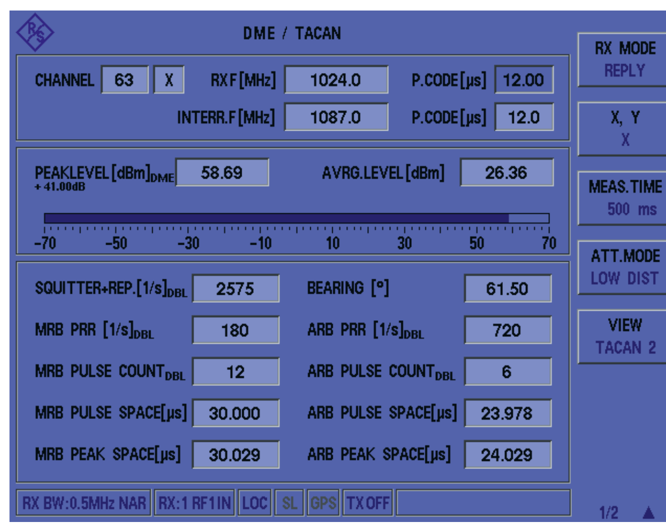


Fig. 2: Analysis of MRB and ARB.

The most important abbreviations

ARB	auxiliary reference burst
DME	distance measurement equipment: distance measurement method in aviation
ICAO	International Civil Aviation Organization: international authority that defines civil navigation standards
MRB	main reference burst
TACAN	tactical air navigation: military DME variant that additionally allows azimuth direction finding

Navigation radars must be able to safely recognize other ships in the area despite the numerous disruptive echoes caused by high seas. The new testing solution from Rohde & Schwarz allows users to simulate radar echoes, including ship echoes, during development.

Radar echoes from a generator – innovative testing solution for the lab and service

A new software option simulates realistic radar echoes that can be used to comprehensively test radar systems. All that is needed is a signal generator and a spectrum analyzer.

Radars: proven reliability a must

Radars, similar to optical systems, provide images of the surroundings. They use electromagnetic signals to illuminate their surroundings and then generate an image of the environment from the echoes returned by reflecting objects. Unlike optical systems, radars can also produce a situational image in the dark or where visibility is poor. Radars consist of several subsystems, including a transmitter, receiver and the radar processor, which calculates the situational image from the data received. The radar is set in the appropriate operating mode for the specific task and the radar processor sets the required parameters, such as the pulse duration and pulse repetition rate.

One of the typical requirements for navigation radars is to reliably detect the signal echo reflected by another ship from among the numerous disruptive echoes caused by waves, even in heavy seas. Since radar images are essential for navigation and reconnaissance, the systems must be extremely reliable. Ensuring reliability often requires extensive field tests in addition to standard laboratory tests (see box) – and these have to be repeated in every operating mode. Navigation radars, for example, have two separate modes for detecting close and faraway objects. All these tests take time and tie up resources, which is why manufacturers and operators always strive to minimize the effort involved.

Simulation software reduces testing effort

The R&S®SMW-K78 radar echo generation software option for the R&S®SMW200A vector signal generator enables users to artificially generate radar echoes. The R&S®FSW signal and spectrum analyzer is also needed as a radar receiver. This solution makes field tests largely unnecessary. The option can generate radar signal echoes in a realistic manner and provides all the prerequisites for conducted and over-the-air (OTA) tests. The generator controls the spectrum analyzer and configures it so that both devices appear to the user as a single system that is operated via the generator.

For pure receiver tests, the R&S®SMW200A can be used as an echo generator even without the spectrum analyzer. It generates the transmit signals in the digital baseband, e.g. using the R&S®Pulse Sequencer software (see article on page 33).

Realistic simulation of radar echoes

The R&S®SMW200A generates radar echoes of static and moving objects at user-configurable ranges. It automatically sets the delay, the Doppler frequency and the RF output level for each object. For moving objects, the generator constantly updates the delay and the output level of the echo signal. This means, for instance, that the signal level of the echo of an object that is radially

Typical test scenario at sea

For certification tests, maritime radars are mounted on a ship and put into operation. The ship operates in a defined sea area in which objects with defined backscatter properties and backscatter power (mainly buoys) are placed. These are arranged so that it is possible to determine the most important radar properties such as the range resolution and the azimuth resolution.

The range resolution of a radar is its ability to recognize that two objects positioned behind each other at the same azimuth angle to the radar are separate objects. The radar under test transmits a pulsed signal and receives the echo signals from the two test buoys (Fig. 1). The difference in the delay times of both echoes is a measure for the geometric spacing of the two objects. If the system can separate the two echo signals from each other, the two objects will be displayed on the radar screen. If the range resolution is too low, only one object will be seen on the screen.

Determination of the azimuth resolution is similar. In this case, a check is made to see if the system can distinguish between two objects that are positioned at the same range, but at different azimuth angles to the direction the ship is traveling. This ability is mainly determined by the antenna characteristic.

Radar testing at sea

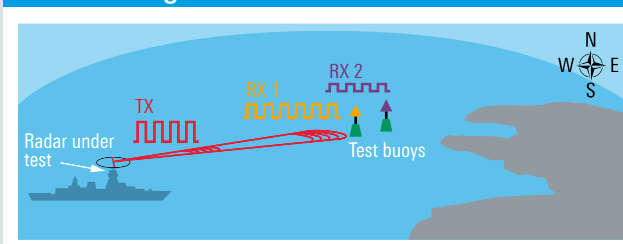


Fig. 1: Test scenario for determining the range resolution of a radar.

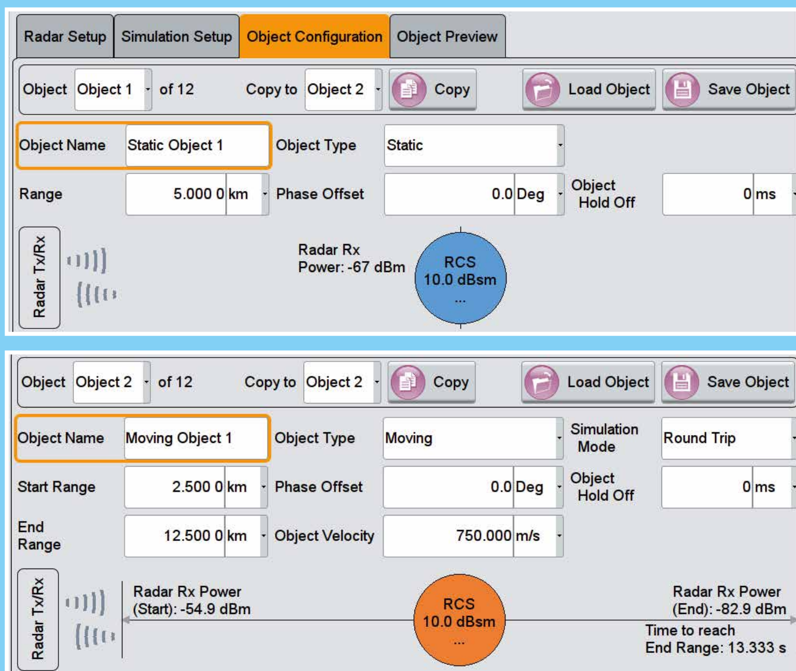
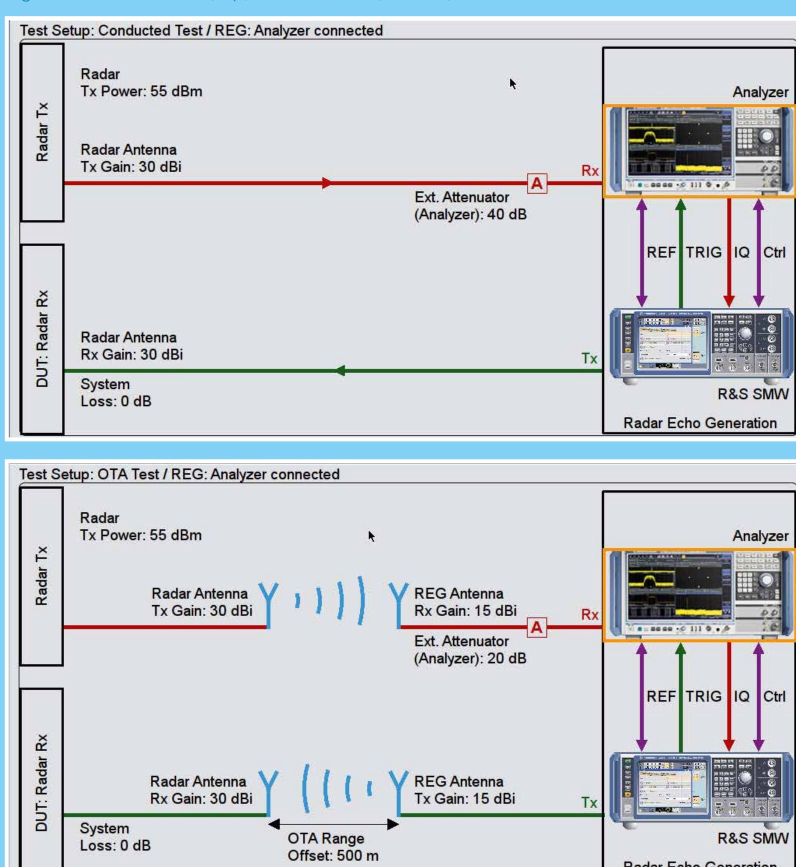


Fig. 2: Configuration of a static (top) and a moving object (bottom) on the R&S®SMW200A vector signal generator.

Fig. 3: Conducted test (top) and OTA test (bottom).



approaching the radar increases after each update. The algorithm is based on the radar equation and the propagation loss in free space. The generator can simultaneously produce up to a total of 24 static and moving objects.

The top section of Fig. 2 shows the menu for defining the objects used to create the echo signal. Static objects are assigned a specific range. Their size can be defined via the radar cross section (RCS). The R&S®SMW-K78 option models the point objects with a constant RCS, which is often called "Swerling 0" after the underlying RCS statistic.

For moving objects, the velocity and the start and end range to the radar can be specified (Fig. 2, bottom). The objects can be assigned a movement pattern, e.g. a one-way path from the start to the end location or continuous movement between the start and end location. Superposition of echoes can easily be simulated by mixing static and moving objects.

Handles many different test cases

Radar engineers have to cope with numerous test cases and types. Typical system tests include confirming fixed target suppression performance for moving target indicator (MTI) radars and testing the minimum threshold for detecting an object. For a test system to be able to test whether a radar system can detect small objects near a large object, it must have a sufficiently large spurious-free dynamic range. By generating multiple echoes and several objects with different velocities, it can be demonstrated how well radars can simultaneously track, resolve and display these objects. Standard test approaches such as using optical delay lines only partially solve these issues. They are often not flexible, generally need intensive maintenance and also require other measuring equipment to perform all the tests. Thanks to its excellent RF characteristics and versatility, the R&S®SMW200A vector generator equipped with the R&S®SMW-K78 option can be used to perform a variety of tests – without a lot of equipment.

Conducted tests and OTA tests

For conducted tests, the radar signal is fed to the R&S®FSW via a cable. It is then downconverted, digitized in real-time and fed to the R&S®SMW200A (Fig. 3, top). The generator uses this signal to generate echo signals that are indistinguishable from real echoes. For OTA tests, the signals are received and transmitted by antennas that are connected to the input port of the analyzer and to the output port of the generator (Fig. 3, bottom).

Conducted tests

Conducted tests are ideal for development and final testing before radars are permanently installed on a platform. They significantly reduce the overall effort since tests that would only be possible fairly late, such as certification runs for navigation radar, can be carried out during development.

The software offers the option of manually configuring the radar receive level or using the radar equation to automatically calculate it based on the radar scenario. Fig. 4 shows all parameters (except the object properties and center frequency) that must be set in order to use the radar equation to automatically calculate the signal power level at the receiver.

OTA tests

If radars are already in operation and installed on a ship, for instance, then the effort to set up tests in the lab is excessively high. In such cases, functional tests have to be performed at sea. However, these take time and during this time the ship cannot be used. The Rohde & Schwarz solution makes it possible to perform comprehensive tests during normal port layovers. The setup consists of the R&S®FSW and R&S®SMW200A with antennas at the RF inputs and outputs (Fig. 5). The generator and the analyzer are installed in a stationary test system that receives the radar signals via a test antenna with known properties and returns the echoes to the radar under test. This test setup (Fig. 5) can be completely configured on the R&S®SMW200A if all relevant transmission path parameters are known (e.g. radar and test setup antenna gains and radar transmit power).

For this test case as well, it is possible to manually configure the radar receive level or use the radar equation

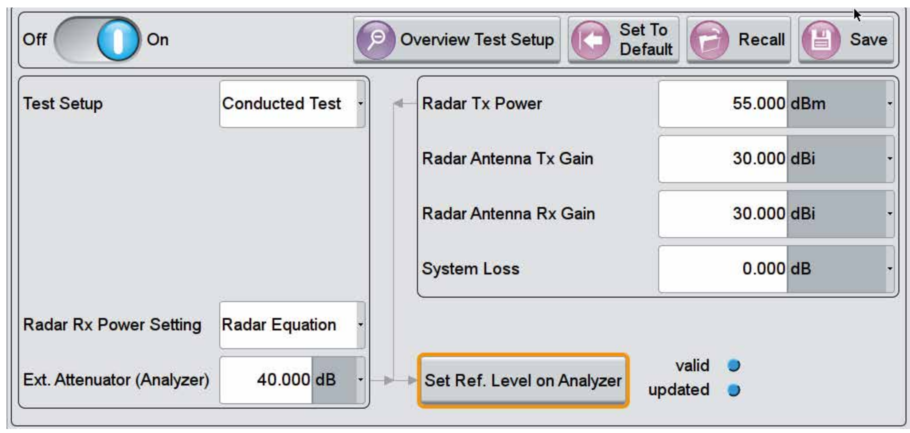


Fig. 4: Required parameters for configuring conducted tests.

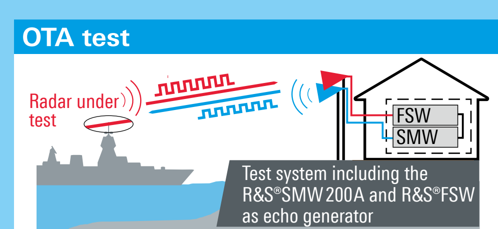
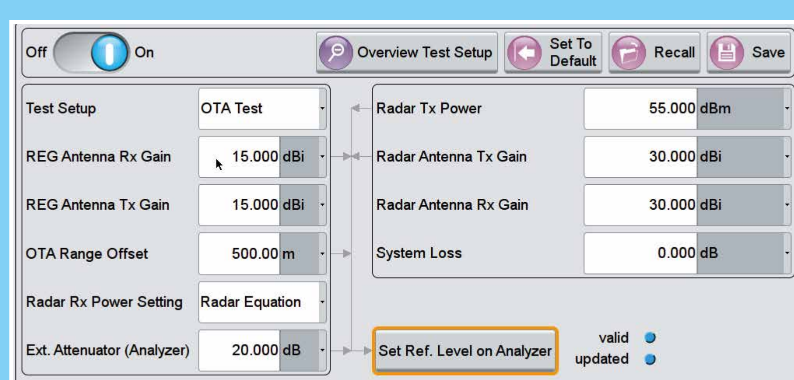


Fig. 5: Basic test setup of an OTA test on a radar (right). Below is the menu for the required settings.



to automatically calculate it based on the radar scenario. The required RF output power at the generator is automatically determined from the configured parameters so that the right echo level reaches the input of the radar receiver.

Example of a test scenario

A typical test scenario consists of two objects. Such scenarios can be easily simulated in the lab with the R&S®SMW200A. The parameters can be changed for variants. The top section of Fig. 6 shows a preview in the range/velocity view displaying the overall result of all configured reflecting object parameters. Object 2 (orange) is stationary at a range of 3.75 km from the radar. Object 1 (blue) moves a few kilometers away from the radar at a velocity of 750 m/s and returns. Before the tests are carried out, the user can check whether the scenario is properly configured.

The bottom section of Fig. 6 shows the level of the echo signal versus time calculated by the R&S®SMW200A. Echo 2 (caused by object 2) has a constant level and a constant time delay to the transmission pulses. Both the level of echo 1 (caused by object 1) as well as the time delay to the transmission pulses vary based on the range.

Summary

The new R&S®SMW-K78 option for radar echo generation saves time when testing prototypes in development as well as when servicing operational radar systems. The R&S®SMW200A signal generator together with the R&S®FSW signal and spectrum analyzer make it possible to perform conclusive radar tests that previously could only be made in time-consuming field tests after development was complete. The user does not have to invest in special solutions and the cost of lab equipment is reduced since the spectrum analyzer and vector signal generator are already on hand and can also be used for other measuring tasks.

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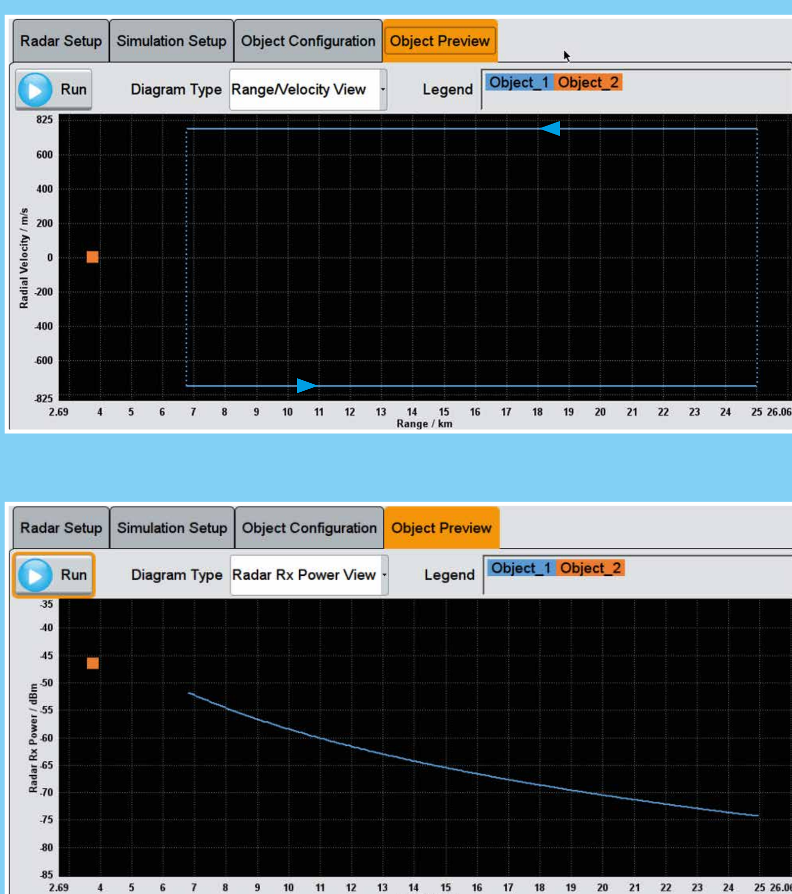
Fig. 6: Live preview of the configured scenario containing a static and a moving object (top). Bottom: Calculated echo signal level versus time.



Realistic simulation of radar pulses and complex radar scenarios

Development lab work often requires time-consuming implementation of customized test solutions. Any automation will noticeably increase productivity. That is exactly what the R&S®Pulse Sequencer software in combination with a vector signal generator does for development and testing of radar components and receivers.

Pulsed signals are required for a number of tests in radar engineering – for components such as amplifiers or entire devices such as receivers. Since there are no standardized test specifications, test engineers have had to invest a lot of time in programming all the signals. The R&S®Pulse Sequencer software minimizes this effort. Users can subject DUTs to realistic signal scenarios and make optimizations as needed.

Scenarios for all requirements

The R&S®Pulse Sequencer software includes numerous preconfigured scenarios. The user only has to set scenario-specific parameters:

- Simple pulse sequences made up of pulse groups with complex single pulses and the associated deterministic interpulse modulation
- 2D and 3D scenarios in which the generated signal is not only a result of single pulses with defined amplitude and interpulse modulation, but also of effects caused by rotating transmit and receive antennas and their polarization as well as the position of the transmitter and receiver in three-dimensional space.

I/Q signals and measured antenna patterns can also be used by importing them into the software.

The 3D visualization and realtime preview of configured signals makes it easier for the user to quickly become familiar with the software and make full use of its performance range. After configuration, the signals are automatically transmitted to a vector signal generator, where they are replayed.

Definition of single pulses and sequences

Depending on the application, the envelope and possibly the modulation on pulse (MOP) of pulses must be defined and their sequence specified. In the simplest case, the sequence consists of the pulse and a pulse pause. The R&S®Pulse Sequencer software can define all details of the pulses and embed them in a sequence, e.g. via the pulse repetition rate. The tree structure shown in Fig. 1 shows all the simulation components that can be used to set up a scenario.

All essential pulse parameters are defined in the Pulse menu (Fig. 2, top): edges and pulse width as well as all other envelope characteristics such as overshoot, pulse droop and ripple. Numerous modulation types such as linear frequency modulation (chirp), amplitude, frequency, phase and vector modulation are predefined. This comprehensive set can be expanded as needed via the software's open plug-in interface. The interface can also be used to add customer-specific interpulse modulation, for example.

The preconfigured single pulses can be embedded in a sequence. The user only has to define what should happen from pulse to pulse. Interpulse modulation is used to define such sequences for testing during development or for

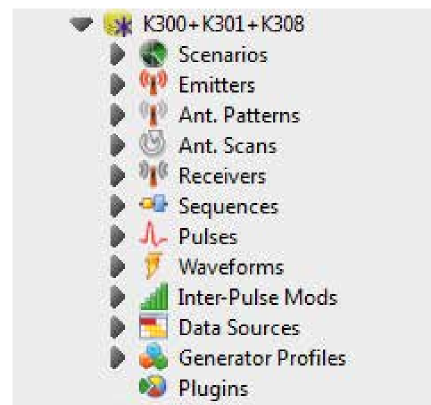


Fig. 1: Tree with simulation components

Testing the channel change function of WLAN routers

Some weather radars operate in the 5 GHz band, which WLAN devices are also allowed to use. To ensure that a WLAN router does not interfere with the weather radar, the router must use dynamic frequency selection (DFS) to automatically change channels when it receives such radar pulses. Regulatory authorities have defined numerous radar profiles that must be used to test all WLAN stations.

A special DFS version of the R&S®Pulse Sequencer software (R&S®SMx-K350) is available. This version comes with radar profiles that comply with international standards. Used together with a vector signal generator, it can perform all required tests – a convenient plug & play solution that also supports report generation for analyzing the test results.

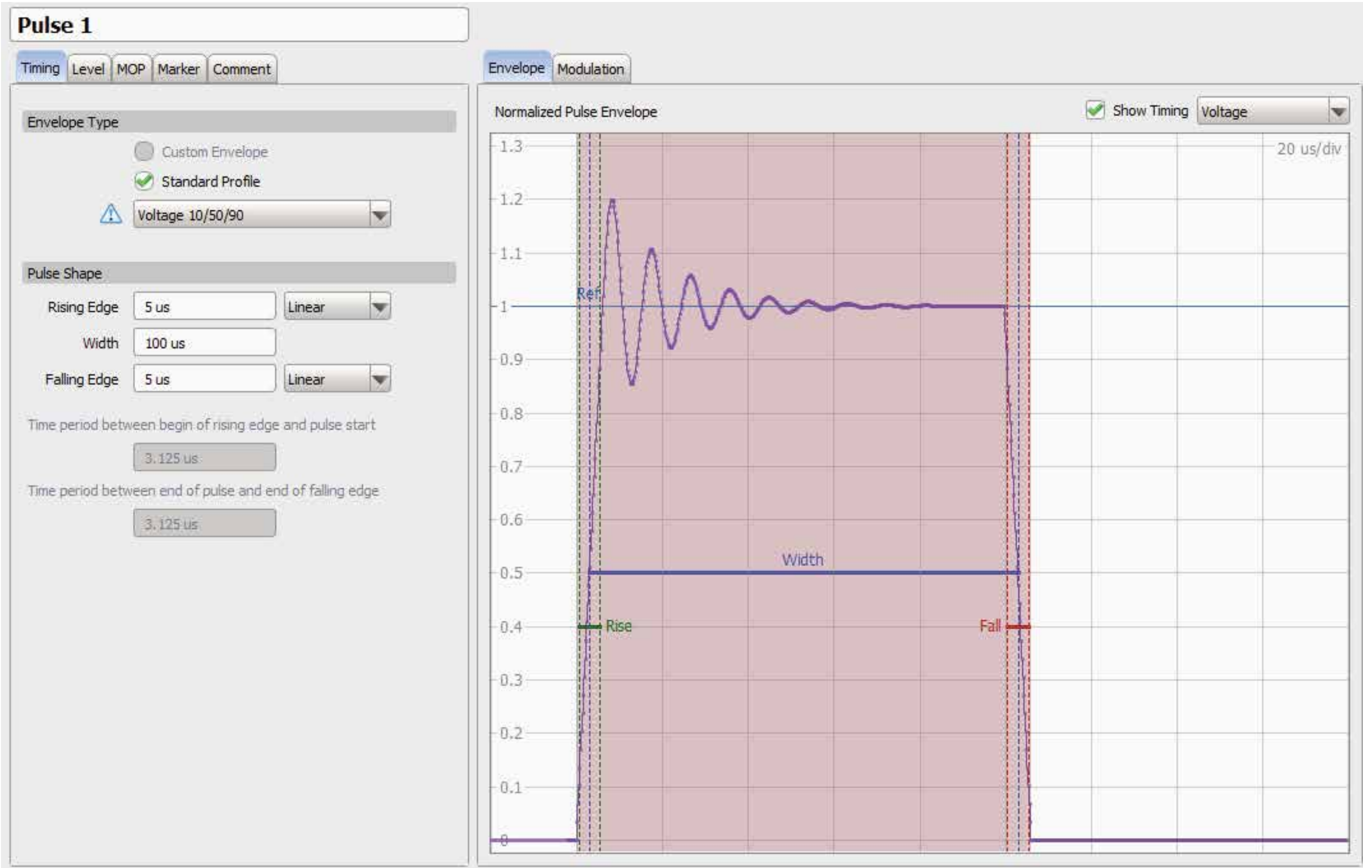
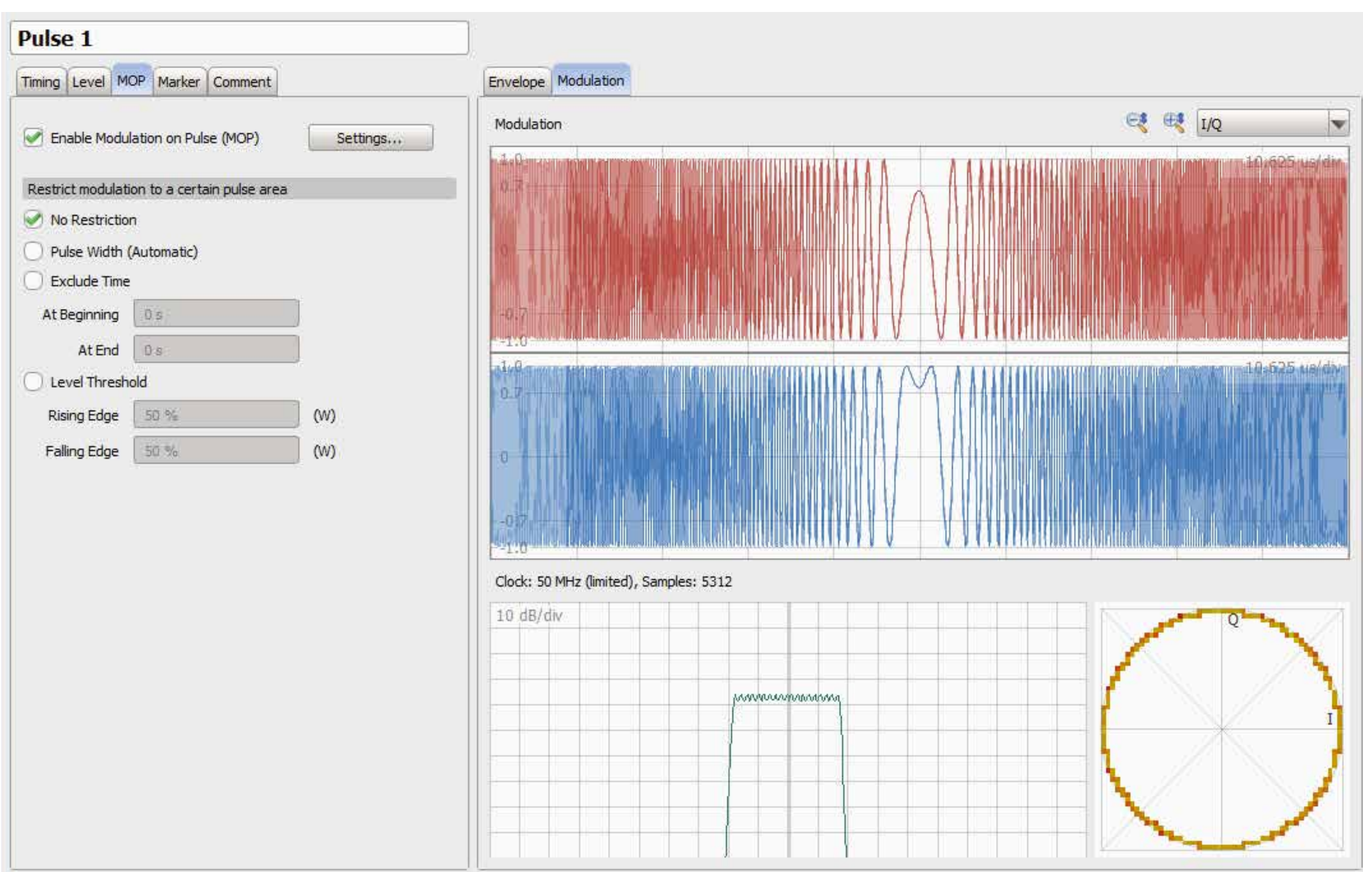


Fig. 2: Top: menu for defining a single pulse with a preview of the envelopes, here with overshoot. Bottom: linear frequency modulation settings with a preview of the baseband signal and spectrum.



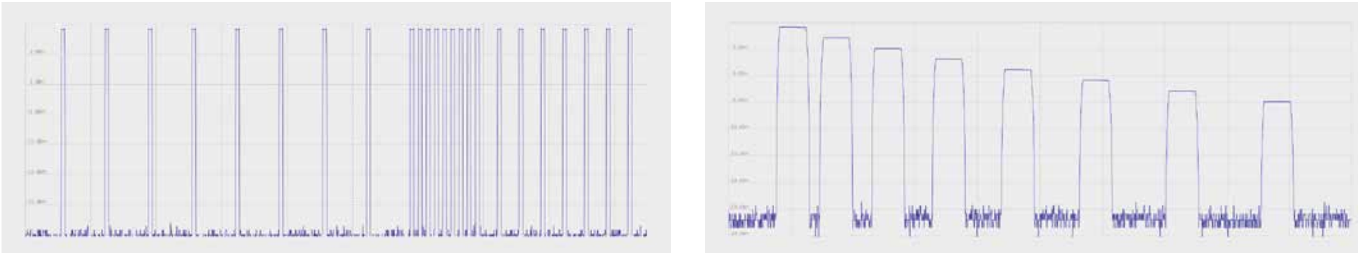


Fig. 3: Left: interpulse modulation with three bursts. The pulse pause changes from burst to burst. Right: interpulse modulation can vary several parameters simultaneously, e.g. pulse pauses and pulse peak power.

verification of receivers or systems. In the simplest case, the user only has to define a pulse pause. The pulse pause, frequency hops, pulse levels, etc. can be modified from pulse to pulse according to definable rules.

The pulse repetition rate plays a major role for radars. Radars must operate with low pulse repetition rates so that their detection range is large enough to detect distant objects. However, high rates are required to measure the often high speed of detected objects. In order to reconcile these and other requirements, radars use a number of operating modes that are selected based on the detection task.

Fig. 3 (left) shows an example with three bursts of eight pulses each. The pulse repetition rate changes from low, to high, to an average value in the last burst. The interpulse modulation can affect several pulse parameters simultaneously, e.g. it can increase the pause from pulse to pulse while simultaneously reducing the level by 2.5 dB (Fig. 3, right).

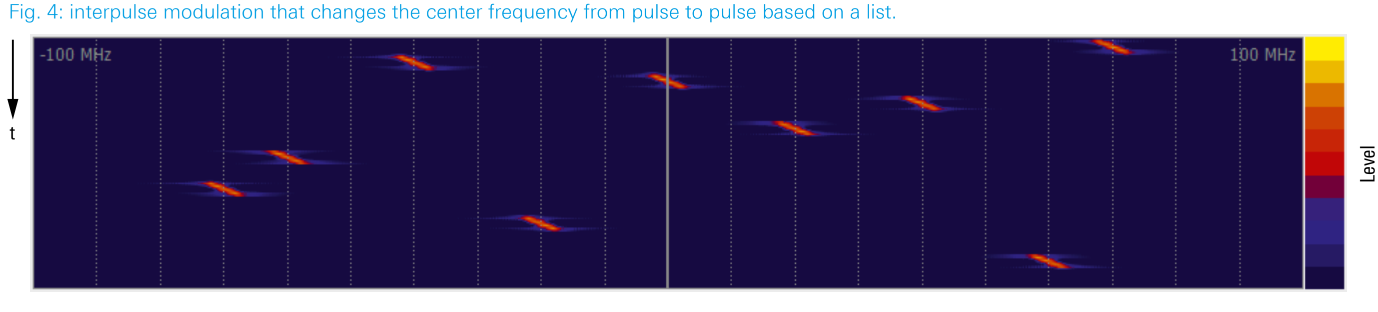
Frequency agile radars use hopping with a changing center frequency to make them more resistant to jamming and being detected. This frequency agility can be simulated via interpulse modulation of the offset frequency. Fig. 4 shows a generated, linear frequency-modulated signal that changes its center frequency from pulse to pulse.

Receiver tests with realistic signal waveforms

In order to test receivers under realistic conditions, all influence quantities have to be taken into consideration. This includes not only pulse parameters, modulation formats and interpulse modulation, which describe the actual signal, but also system-specific influences. Radars are usually equipped with rotating antennas to transmit and / or receive signals directionally, for example. Receivers for monitoring the electromagnetic spectrum can be connected to moving or static, stationary antennas. A signal from a specific direction often only briefly reaches the receiver. The absolute receive level depends on the transmit power, the gain of the transmit and receive antennas as well as the frequency-dependent free-space loss. Additional losses occur when the transmit and receive antennas have a different polarization or when the antennas are not aligned exactly to each other. In addition, transmitters and receivers in three-dimensional space can have different elevations above sea level and different attitudes, which are defined by roll, pitch and yaw angles. The received power is reduced when the boresight directions of the transmit and receive antennas are not directly facing each other due to different attitude angles.

In order to simulate these kinds of complex scenarios, the R&S®Pulse Sequencer software includes a simulator in which all the above-mentioned

Fig. 4: interpulse modulation that changes the center frequency from pulse to pulse based on a list.



effects as well as the transmit signal can be configured. Numerous predefined simulation components such as antenna patterns and scan types are included in the software. Complex patterns of phased array antennas are quickly calculated when the user enters the spatial distribution of the individual radiator elements and the desired sidelobe suppression. All antenna patterns can be assigned a polarization. It is even possible to define unwanted rear leakage. The configured antenna patterns are visualized in a 3D view, including the angle offset to the normal position and the polarization (Fig. 5).

The R&S®Pulse Sequencer software automatically calculates the time-dependent receive level according to the defined scenario. The level no longer has to be manually determined, a time-consuming process. Lab results can easily be correlated with the results of real field tests.

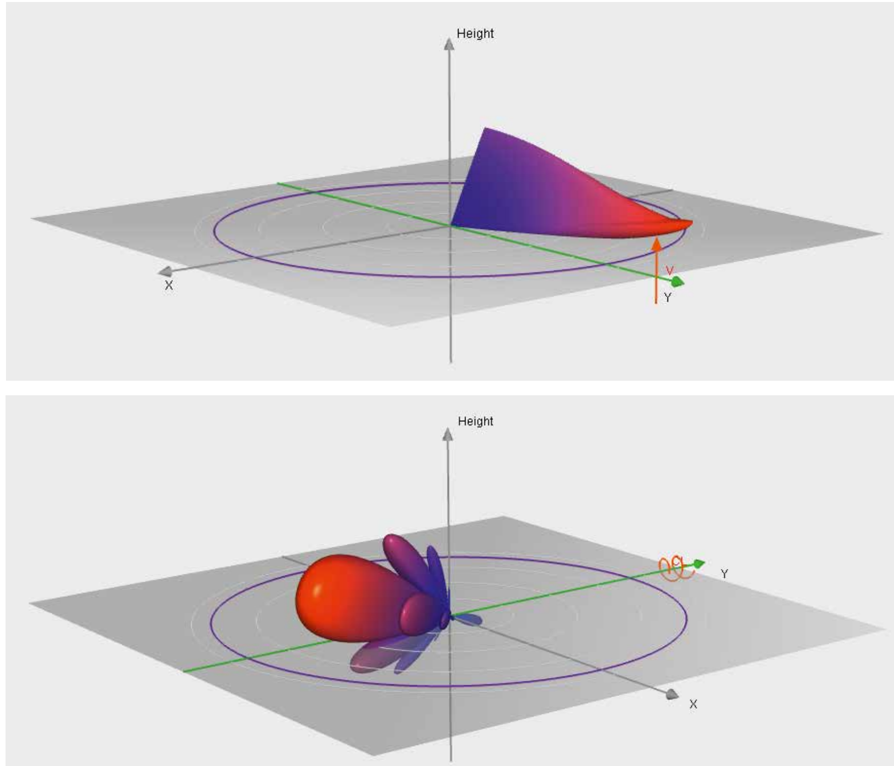


Fig. 5: Top: antenna pattern with vertical polarization. Bottom: with mainlobe, sidelobes and rear leakage.

Complex 3D scenarios

The R&S®Pulse Sequencer software can also be used to simulate complex 3D scenarios for receiver tests as shown in Fig. 6. Fig. 7 shows the receiver (red) at the center of the coordinate system. Its antenna, which has a defined pattern, uses raster scanning to scan a specific solid sector. The transmitter (blue) has a circularly rotating antenna that also has a defined antenna pattern. The level at the receive antenna port changes due to the raster-like search movements of the receive antenna. The software can simulate the time-dependent influences of either the transmit and receive antenna alone and also the combination of all effects, including the impact of position and polarization losses on the absolute receive level (Fig. 8). It can be clearly seen in the bottom figure that the transmit signal is weighted with influence of the receiver's scanning antenna. The absolute level at the output of the receive antenna is now determined based on the free-space loss, antenna gains and transmit power, and

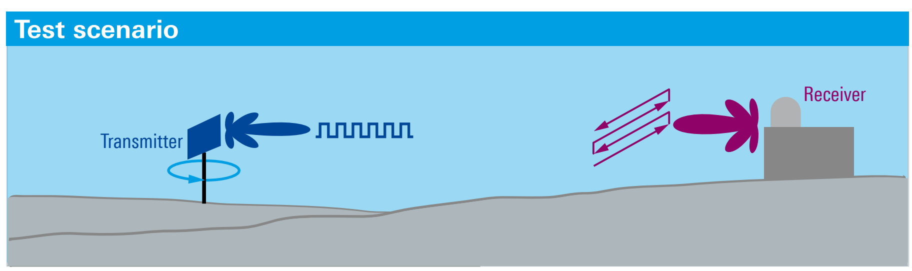


Fig. 6: Challenging receiver and transmitter test scenario

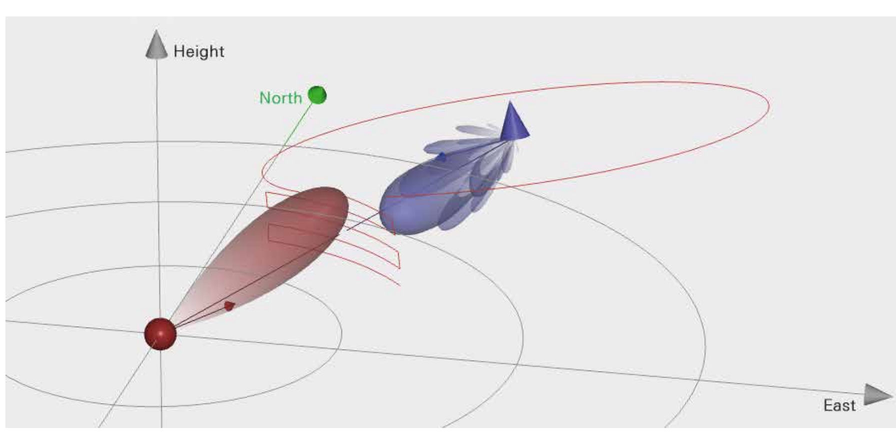


Fig. 7: Transmitter (blue) with vertically rotating antenna and receiver (red) whose antenna uses raster scanning to scan a solid sector.

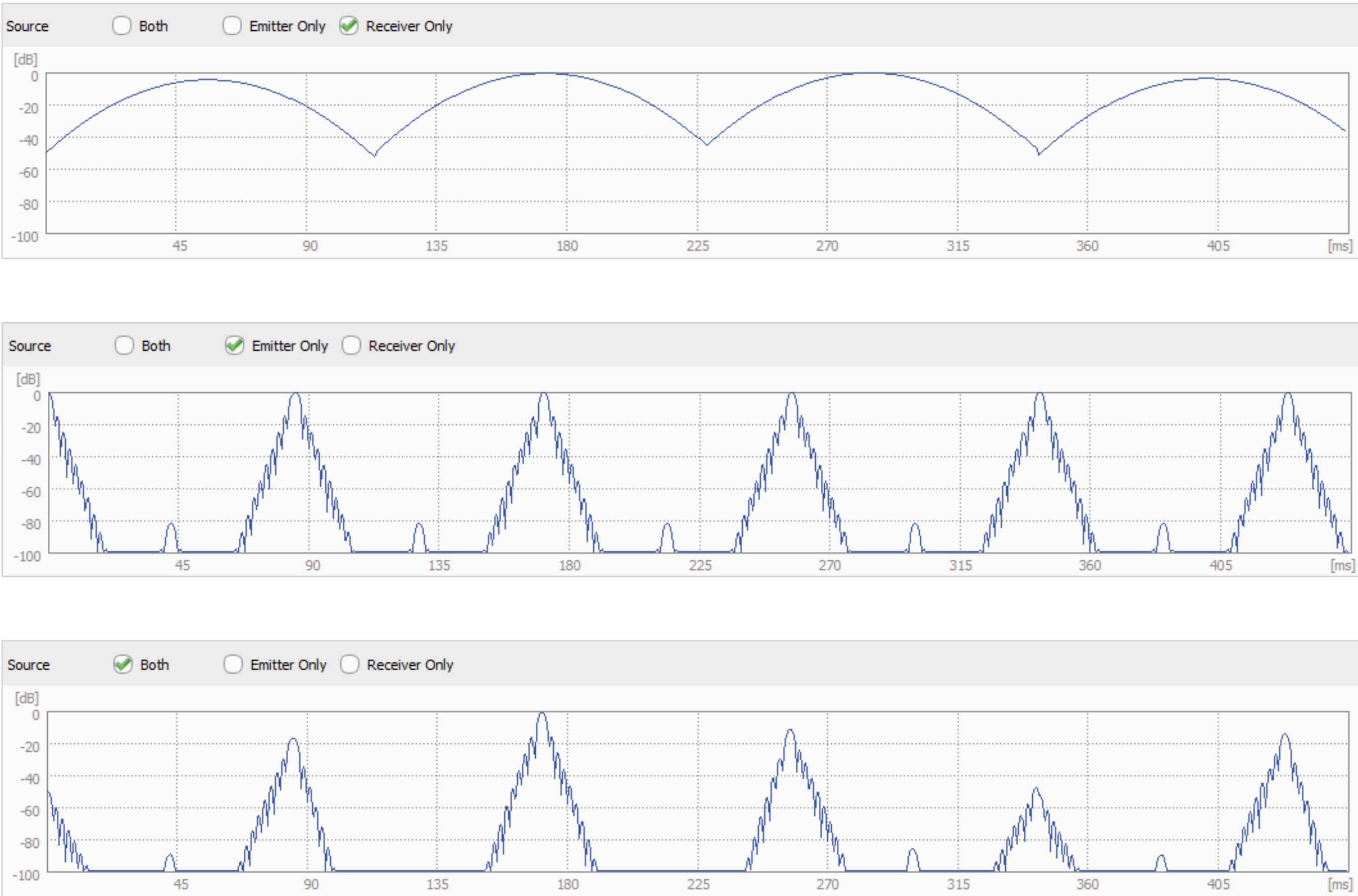
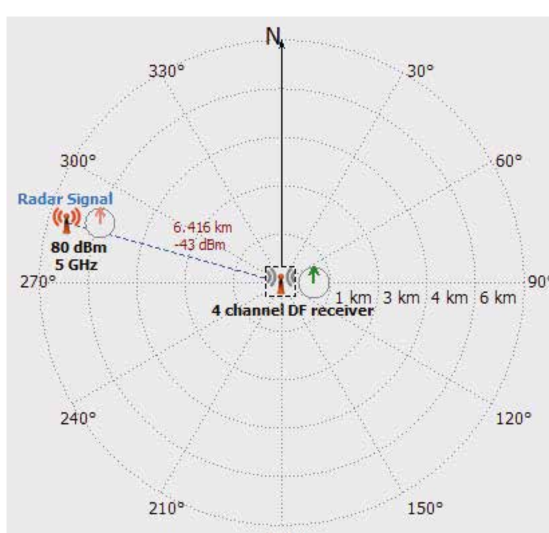


Fig. 8: Top: receive level fluctuation due to the movement of the receive antenna. Center: contribution of transmitter antenna rotation to the time-dependent receive level. Bottom: total of all contributions to the time-dependent receive level, including position and polarization losses.

calculated automatically using the normalized level curve shown in the bottom figure. Once everything has been set as desired, the signal is transmitted to a vector signal generator and replayed there. This makes it possible to test whether or not the receiver can clearly recognize and classify a transmitter's signal.

Testing multichannel receivers

Receivers with multiple channels are used in direction finders to determine the angle of arrival of a signal. When testing these kinds of receivers, the R&S®Pulse Sequencer software offers the option of positioning a transmitter that transmits a defined signal in a polar coordinate system (Fig. 9, left). The user can position the individual antennas of the receiver's antenna configuration as desired (Fig. 9, right). All parameters used to simulate a single-channel receiver antenna are also available here.



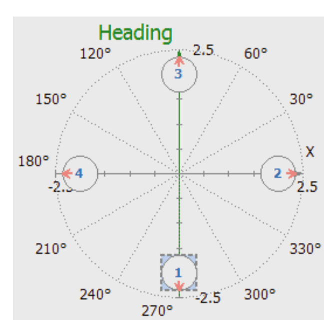


Fig. 9: Left: scenario with transmitter and multichannel receiver. Right: determination of the position of the receiver's individual antennas.

The software automatically calculates the correct receive signal for each of the multichannel receiver's inputs, taking into account all configured parameters. A diagram helps the user assign the calculated signals to the RF outputs of the vector signal generators and shows the cabling required for the test setup (Fig. 10).

An R&S®SMW200A vector signal generator with two paths is ideal because all receiver channels must be simulated simultaneously. For testing receivers with four channels, a four-channel test setup can be configured by adding two R&S®SGS100A and two R&S®SGU100A generators (Fig. 11).

Summary

The new R&S®Pulse Sequencer software, together with appropriate software options and vector signal generators, is a powerful signal simulator for numerous aerospace and defense applications. Applications range from simple test cases for component testing to complex test cases that simulate real-world 3D scenarios for testing single or multichannel receivers. The software is available for all Rohde & Schwarz vector signal generators, which cover the frequency range up to 40 GHz. Thanks to the modular, flexible concept, the number of channels can be selected based on the application.

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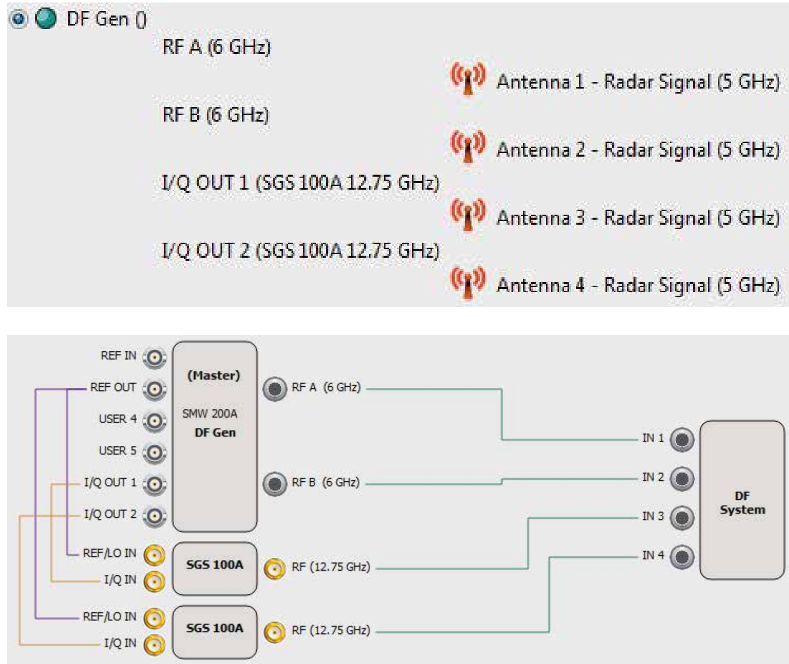


Fig. 10: Top: assignment of four signals to the RF paths of the R&S®SMW200A vector signal generator that has been upgraded to a four-channel setup by adding two R&S®SGS100A generators. Bottom: the required cabling.

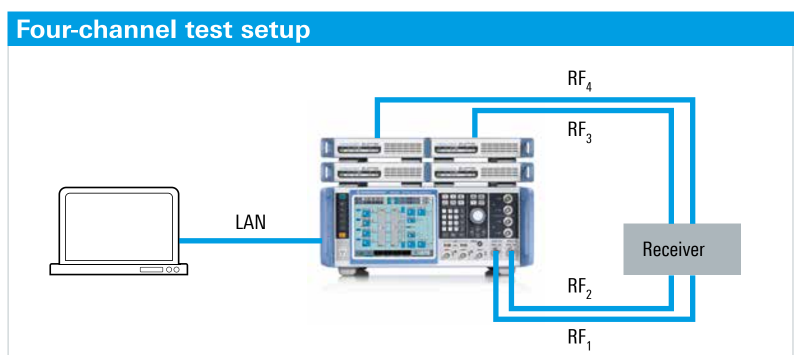


Fig. 11: Four-channel test setup up to 20 GHz in only six height units, consisting of the R&S®SMW200A vector signal generator, two R&S®SGS100A and two R&S®SGU100A generators.

The R&S®Pulse Sequencer software is available as a free download, e.g. at

https://www.rohde-schwarz.com/software/smw200a/

It can be used together with the R&S®SMx-K300 / SMx-K301 / SMx-K350 or SMW-K308 options for the R&S®SMW200A, R&S®SMBV100A and R&S®SGT100A vector signal generators. Options subject to charge are only required when the signals need to be replayed on vector signal generators.

Signal integrity measurements using network analyzers

Users of an R&S®ZNB or R&S®ZNBT network analyzer can now take advantage of a new option: R&S®ZNB/ZNBT-K20 makes it possible to display eye diagrams – a time domain analysis function that is commonly used when analyzing signal integrity. By integrating this function into T&M equipment that is at home in the frequency domain, the transmission characteristics of components for analog and digital systems can be determined simultaneously in the frequency and the time domain.

Growing data rates place ever higher demands on the quality of signal transmission paths. There are many factors that influence signal quality, including the effects of cables and connectors. Characterizing all components in a test setup as comprehensively as possible in the time and frequency domains is therefore a vital requirement. The R&S®ZNB and R&S®ZNBT network analyzers with their excellent RF characteristics and high measurement speed are the instruments of choice for this task. The new R&S®ZNB/ZNBT-K20 option makes them even more universal, as it adds the capability to display eye diagrams to the R&S®ZNB/ZNBT-K2 time domain option (Fig. 1). This is done by measuring S-parameters in the frequency domain, transforming the results into the time domain and then applying convolution to the user-defined input bit sequence.

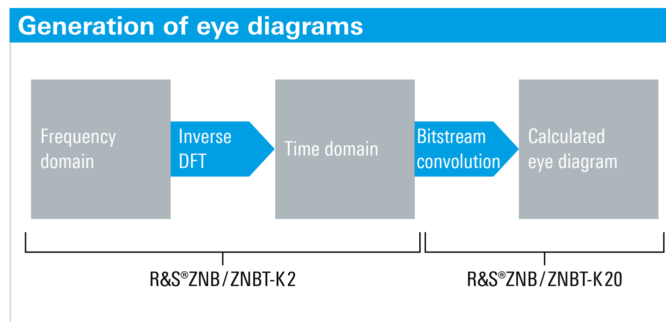
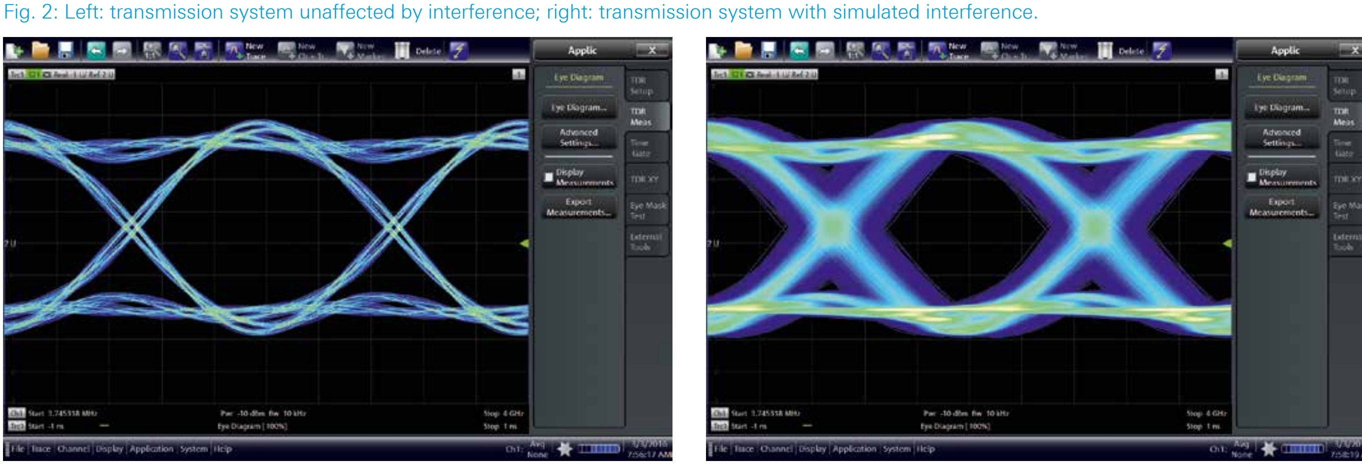


Fig. 1: The new R&S®ZNB/ZNBT-K20 option generates an eye diagram from the S-parameters transformed from the frequency into the time domain.

Signal integrity visible at a glance

The repeated superposition of logic level transitions delivers a graphical result known as an eye diagram, a representation typically used in the time domain. Common types of interference such as jitter, noise or transient response distort the evaluation of the logic states, manifesting themselves as a partially or completely closed eye diagram (Fig. 2). The eye diagram immediately shows how influences from the device under test (DUT) and from other components affect the transmission system – a substantial advantage that makes the eye diagram very attractive.

Fig. 2: Left: transmission system unaffected by interference; right: transmission system with simulated interference.



Simulation of various types of interference

If the transmission quality of a system approaches tolerance limits, interference such as jitter or noise can be virtually added to determine a system's robustness to these effects, which are to be expected in real life, and determine whether a system satisfies defined performance requirements under these conditions (tolerance analysis). The vivid graphical representation in the form of an eye diagram facilitates analysis.

Improving signal quality through preemphasis and equalization

Systems theory describes various methods that can be used to improve the quality of signal transmission paths when they are subjected to interference. Such methods include preemphasis and equalization. In the case of preemphasis, a potentially undesired change in the signal, caused by the DUT, is counteracted by predistorting the input signal in order to balance out the distortion of the DUT characteristic. Equalization, on the other hand, compensates for the power loss typical of high-frequency signal components by raising the transmission characteristic on the receiver end to a higher level toward higher frequencies. The R&S®ZNB/ZNBT-K20 option can implement these two methods by way of calculation. The effect of these measures is immediately visible from the eye diagram.

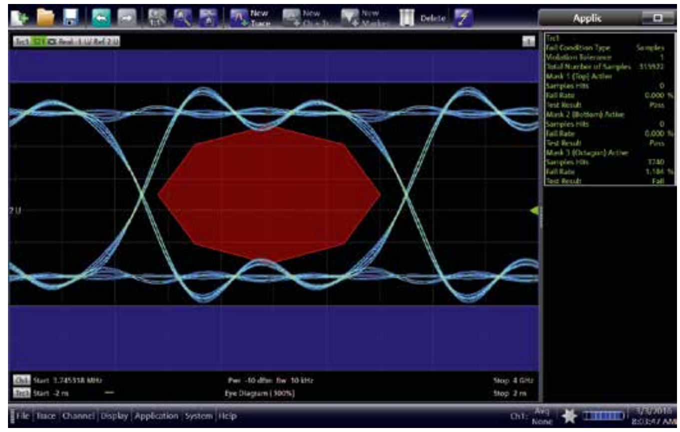
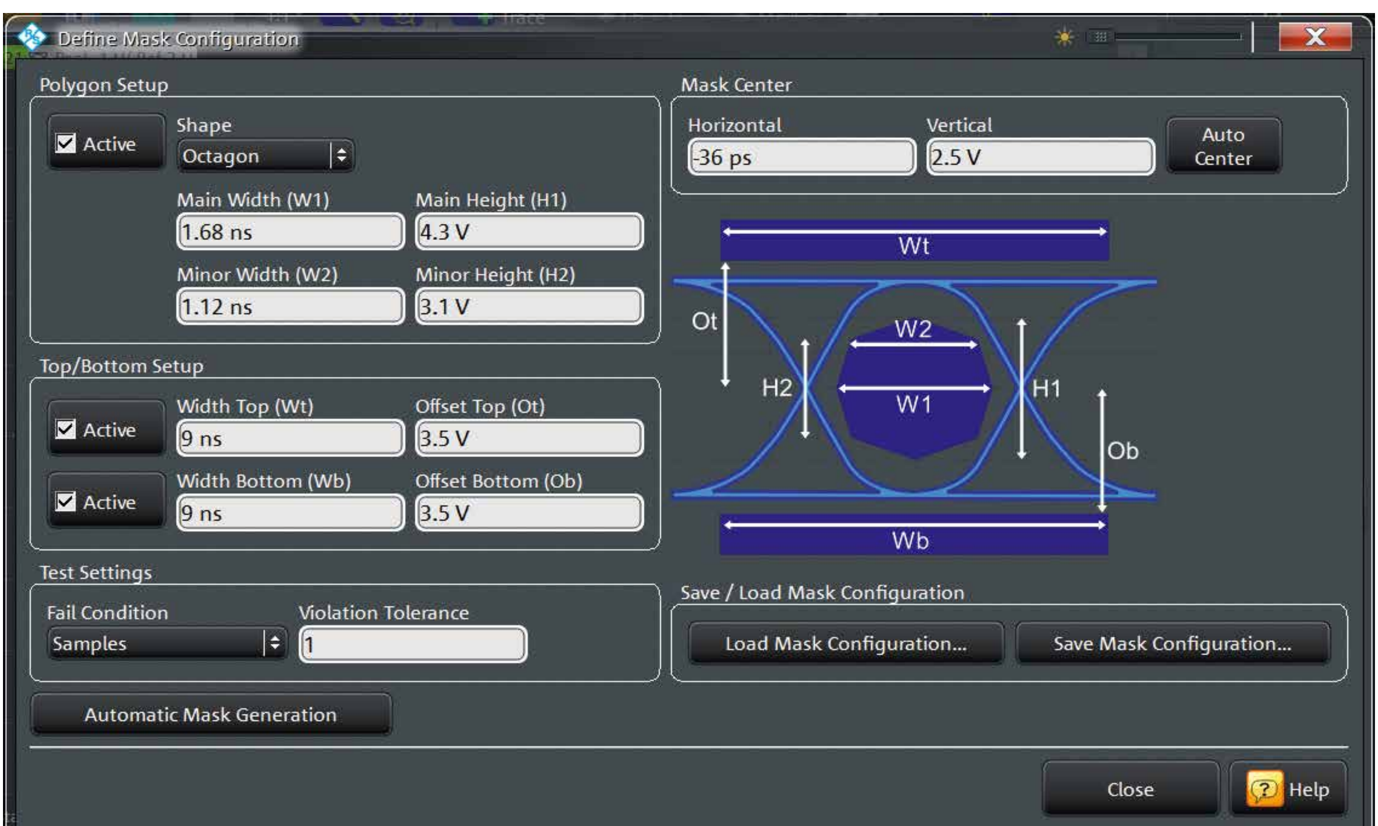


Fig. 3: Mask tests with predefined or user-configured masks.

Fig. 4: Mask configuration menu.



Fast pass/fail analysis with configurable mask tests

In addition to classic pass/fail testing to verify compliance with limit values, R&S®ZNB/ZNBT-K20 offers a mask test function that can be used to check whether measured values fall within the permitted range. Mask violations are signaled with a pass/fail indication (Fig. 3).

Standardized interfaces such as USB, HDMI and DVI must comply with the specifications laid down in the standards. The masks are individually configurable, simplifying signal quality analysis in development (Fig. 4).

Easy to operate due to full integration into network analyzer firmware

The R&S®ZNB/ZNBT-K20 menus seamlessly integrate into the intuitive network analyzer GUI. Configuring the eye diagram display takes just a few steps – no need to switch to external software or restart the instrument. All setting functions are easily accessible. Thanks to a clear-cut representation of the signal flow, users always keep track of the settings and can quickly switch relevant parameters on or off (Fig. 5).

Highest accuracy through system error correction and embedding/deembedding function

The eye diagram is a familiar tool especially for oscilloscope users. However, considering today's high data rates and the associated high transmission frequencies, time domain measurements become increasingly complex and error-prone. Vector network analyzers, which deliver such measurements as standard, offer an interesting alternative. Expanding an R&S®ZNB or R&S®ZNBT network analyzer with the R&S®ZNB/ZNBT-K20 option provides users with the best of both worlds.

Network analyzers offer the following advantages:

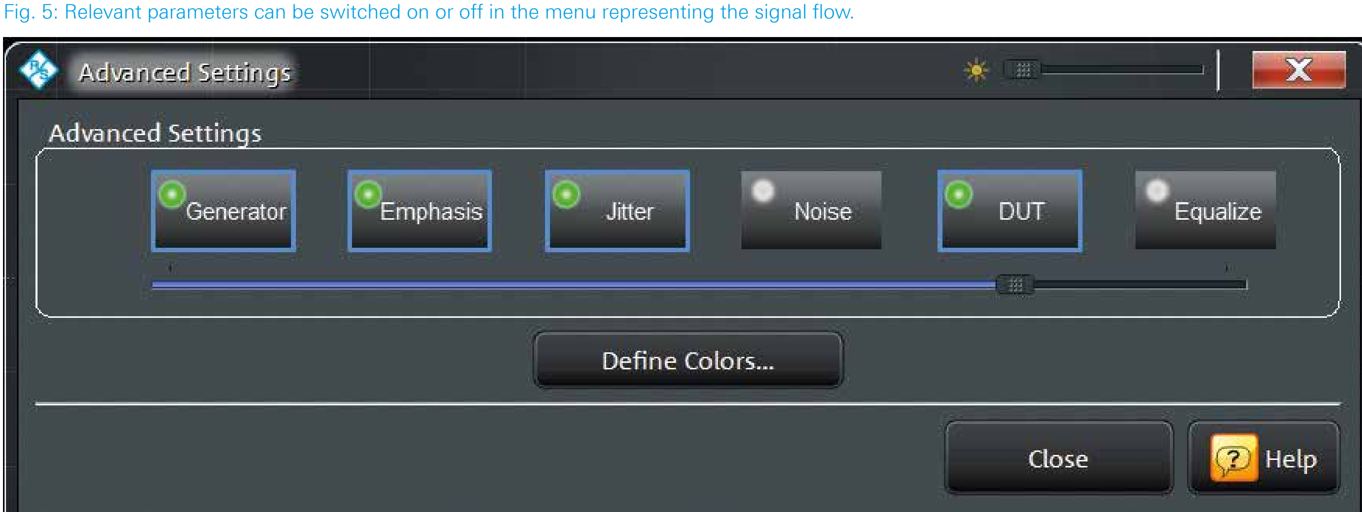
- High measurement accuracy due to vector system error correction (compensation for reflections and losses)
- Embedding/deembedding function for adding/removing virtual networks (e.g. test fixtures, adapters) in the frequency and time domain
- Gating function to eliminate the effects of discontinuities (e.g. connectors, adapters)
- Simultaneous frequency and time domain measurements
- Large bandwidths up to 40 GHz with the R&S®ZNB40
- Realtime measurement and continuous update of eye diagrams for adjustment purposes
- High dynamic range

Summary

Network analyzers equipped with the R&S®ZNB/ZNBT-K20 option can display eye diagrams and deliver comprehensive, precise signal integrity measurements. The new software option is fully integrated in the intuitive R&S®ZNB/ZNBT network analyzer GUI, allowing users to configure measurements quickly and conveniently for maximum efficiency in development.

Anja Paula

Fig. 5: Relevant parameters can be switched on or off in the menu representing the signal flow.



Focus on embedded designs

Fig. 1: Engineered for multidomain challenges: the new R&S®RTO2000 oscilloscope.

The new R&S®RTO 2000 oscilloscopes offer excellent signal fidelity, up to 16-bit vertical resolution and high acquisition rates in the 600 MHz to 4 GHz class. A broad range of tools along with user-friendly operation and documentation functions facilitate time-correlated analysis of the wide variety of signals found in embedded designs.

Embedded designs, i.e. the large-scale integration of components based on a variety of technologies, represent the greatest T&M challenge in development and service today (see box below). These demanding measurement tasks require intelligent solutions such as those offered by the new R&S®RTO 2000 oscilloscope (Fig. 1), the all-in-one test instrument for multidomain applications. Its comprehensive toolset includes functions for time, frequency, logic and protocol analysis – a variety that in the past required several single-purpose test instruments.

Multidomain functionality for integration tests

The low-noise frontends and high-resolution A/D converters allow the R&S®RTO 2000 analog input channels to perform highly accurate measurements in the time domain across a large dynamic range. Users benefit from reliable results, whether performing easy voltage level checks over time or specialized measurements such as jitter analyses on clock or data signals or power analyses on switched-mode power supplies. The box on page 45 provides an overview of the highlights of the new oscilloscope.

Testing embedded designs

The staggering need for cost-efficient and powerful communications and control electronics for industry, motor vehicles and the entertainment and smart home sector is driving the integration of electronic circuits. These advanced embedded designs integrate a variety of functional units and technologies. The processor, power management, digital communications interfaces, local program memory, data memory and sensors all operate in the smallest of spaces. The next integration step is radio modules. The variety of signal waveforms is quite large, ranging from RF radio signals, analog signals from sensors or protocol-coded signals from the control interfaces (Fig. 2).

This complexity represents a challenge for developers because highly integrated designs are significantly more prone to mutual interference. Undesirable interactions must be eliminated with an exact time reference at the system level.

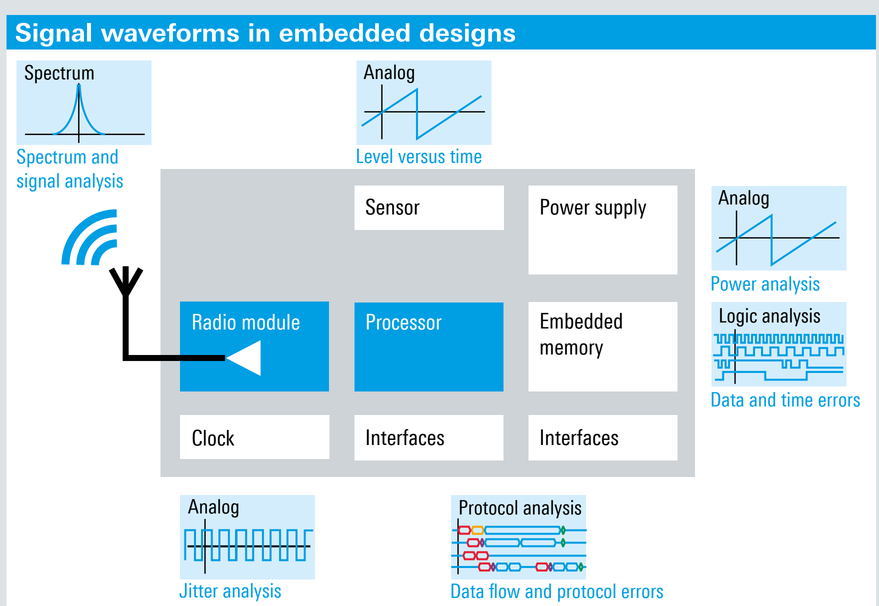


Fig. 2: Multidomain application in a state-of-the-art embedded design: analog measurements in the time domain, measurements in the spectrum as well as protocol and logic analysis.

The 16 digital channels extend the oscilloscope's test resources, e.g. to precisely measure the logical level (high, low) on digital interfaces over time. Even timing errors in parallel interfaces are quickly detected.

The many tools for analyzing protocol-based serial interfaces provide a broad spectrum of trigger and decoding options for a variety of standards, including I²C, SPI, USB and Ethernet. The R&S®RTO2000 allows both analog and digital channels to be used for protocol decoding. The oscilloscope uses its hardware-assisted protocol triggering to reliably and quickly trigger on details such as addresses or data.

Even in situations where spectrum analyzers are the first choice for precise measurements on radio interfaces, the R&S®RTO2000 is highly suitable for acquiring radio signals thanks to the high dynamic range of its analog channels. When testing at the system level, the channels deliver a precise time correlation to the other functional units in embedded designs.

Fig. 3 shows the variety of measurement options in an Internet of Things (IoT) application with a Wi-Fi radio module. Channel 1 (yellow) acquires the Wi-Fi signal and displays it in the time domain. However, the signal waveform is not clearly recognizable until it is viewed in the spectrum (Math4). Channel 3 (orange) shows how the radio activity affects current consumption. The timing of the USB interface control commands is also visible. The R&S®RTO-K60 option decodes the signals acquired on channels 2 and 4 (green and blue) into readable USB data.

Analysis of smaller currents with respect to system functions

Once the initial functional tests on the electronic design are completed, circuit optimization starts. For mobile applications, minimizing current consumption is paramount. This requires a measurement instrument that can resolve low currents down into the 1 mA range while also correlating the timing of current changes to switching activities, e.g. when transmitting radio sequences or entering power save mode.

The large dynamic range and high sensitivity of its analog input channels make the R&S®RTO2000 ideal for measuring low voltages and currents. The R&S®RT-ZC30 option is a sensitive current probe that can measure currents down to 1 mA at 120 MHz bandwidth. In HD mode, dynamic variations as small as 100 µA can be resolved.

Fig. 3: Example of a multidomain application – IoT module with Wi-Fi radio module, battery-operated power supply and USB interface.

R&S®RTO2000 highlights

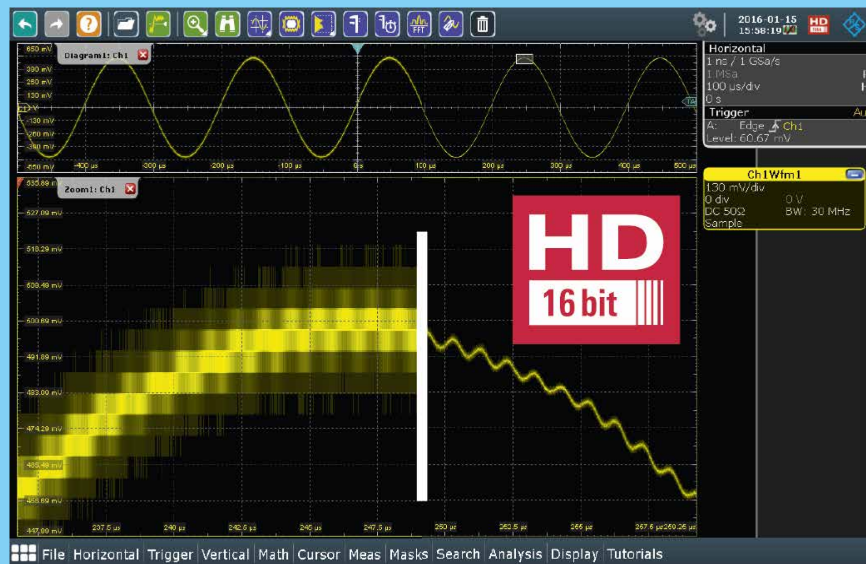


Fig. 4: Zoom of a sine wave with superimposed modulation with 16-bit HD mode turned off and on.

Components developed in-house

The basis for the high degree of sensitivity and dynamic range offered by the R&S®RTO2000 are the low-noise frontends and the proprietary 10 GHz single-core A/D converters. The minimum effective noise of < 100 µV, the A/D converters' more than seven effective bits (ENOB) as well as the channel-to-channel isolation of > 60 dB are just a few examples. Such characteristics make the analog channels ideal for analyses in the frequency domain as well as for measurements in the time domain.

Investigating signal details often requires a higher vertical resolution. The R&S®RTO2000 achieves up to 16 bits in high-definition (HD) mode. In HD mode, high-quality, adjustable lowpass filters downstream of the A/D converter limit the signal bandwidth (Fig. 4). The user can select the appropriate combination of resolution and bandwidth. Even the digital trigger system benefits from the high resolution in HD mode and can trigger on the smallest of signal details.

The oscilloscope offers not only high-performance analog signal processing. It also features powerful digital signal processing based on a proprietary ASIC. Its fast parallel signal processing is clearly superior to external PC-based postprocessing. The R&S®RTO2000 acquires, processes and displays up to 1 million waveforms per second, even when histograms, masks or cursor measurements are running. This capability, which is unique in the lab oscilloscope class, is the key to fast and successful detection of sporadic errors.

The acquisition memory can be extended up to 2 Gsample, also unique in this class. Sufficient memory is available for acquiring long pulse or protocol sequences. The history function also benefits from this memory depth because more waveforms are available for detailed analyses.

Scalable for every application

The R&S®RTO2000 is versatile enough to adapt to specific applications. 2-channel and 4-channel models are available with bandwidths of 600 MHz, 1 GHz, 2 GHz, 3 GHz and 4 GHz plus optional acquisition memory upgrades. Bandwidth upgrades are available for all models.

All hardware options, including the digital channels for logic analysis and a 10 MHz OCXO reference clock, are plug-ins that can be installed on-site. For specialized tasks, software options can be enabled on the oscilloscopes at any time. Available software options include, for example, triggering and decoding options and automated compliance tests for serial interfaces, as well as options for jitter, power and spectrum analysis.

Simple to use with touchscreen and R&S®SmartGrid

In spite of its power and functional range, the R&S®RTO2000 remains extremely easy to use thanks to its brilliant 12.1" touchscreen. The R&S®SmartGrid function ensures that all waveforms and other information are clearly and understandably displayed. Important tools such as cursors, measurements and undo/redo are on a toolbar for quick access. The app cockpit provides access to applications such as the triggering and decoding functions, compliance and signal integrity tests, I/Q analysis and even customer-specific development tools. The R&S®RTO simplifies documentation of measurements. Screenshots, waveforms, events and instrument configurations can be stored with a simple press of a button.

Using an analog channel to perform current measurements provides a fixed time reference to the other measurement signals. Fig. 5 shows an example of a current probe in channel 3 (orange) measuring a current of 1.7 mA during a sleep sequence. The current consumption is correlated with the radio signal output on channel 1 (yellow) and the system activity at the UART interface. During the sleep sequence, the module does not transmit any radio signals, but it receives regular paging signals from the base station. The current consumption briefly increases to 105 mA and the module transmits a UART-coded communications signal on the clear-to-send (CTS) line, which is acquired with a digital channel.

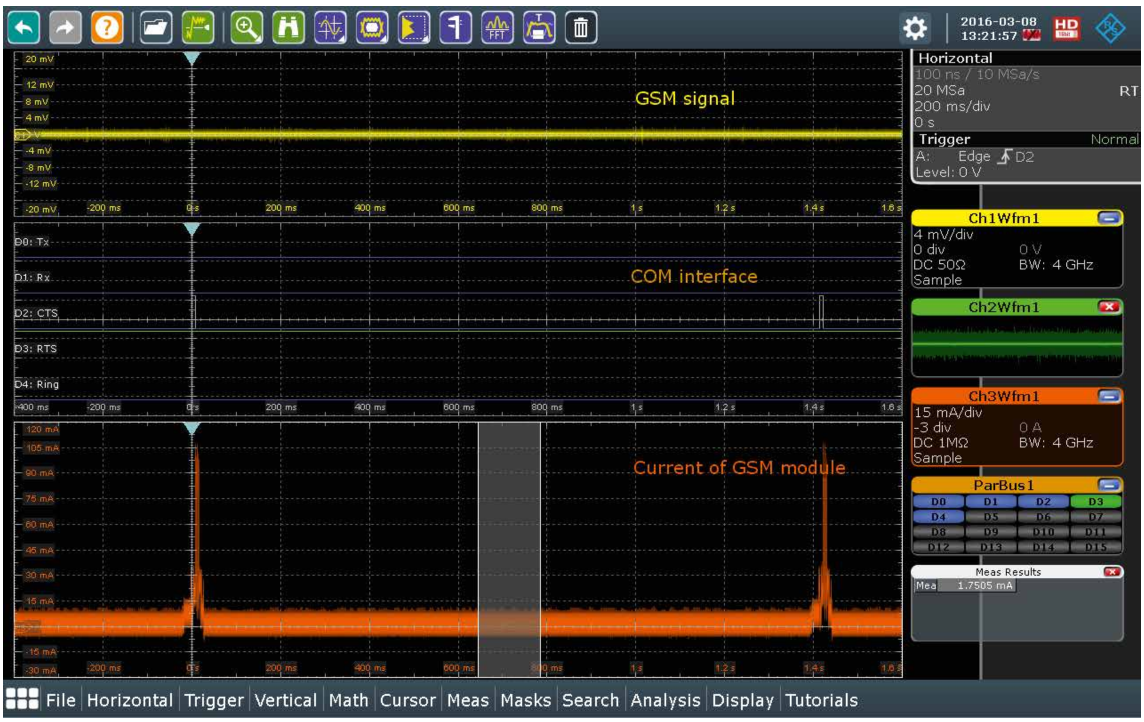


Fig. 5: Measurement of the current consumption of an embedded design in sleep mode. The base station remains in contact with the GSM radio module via paging (short current pulses).

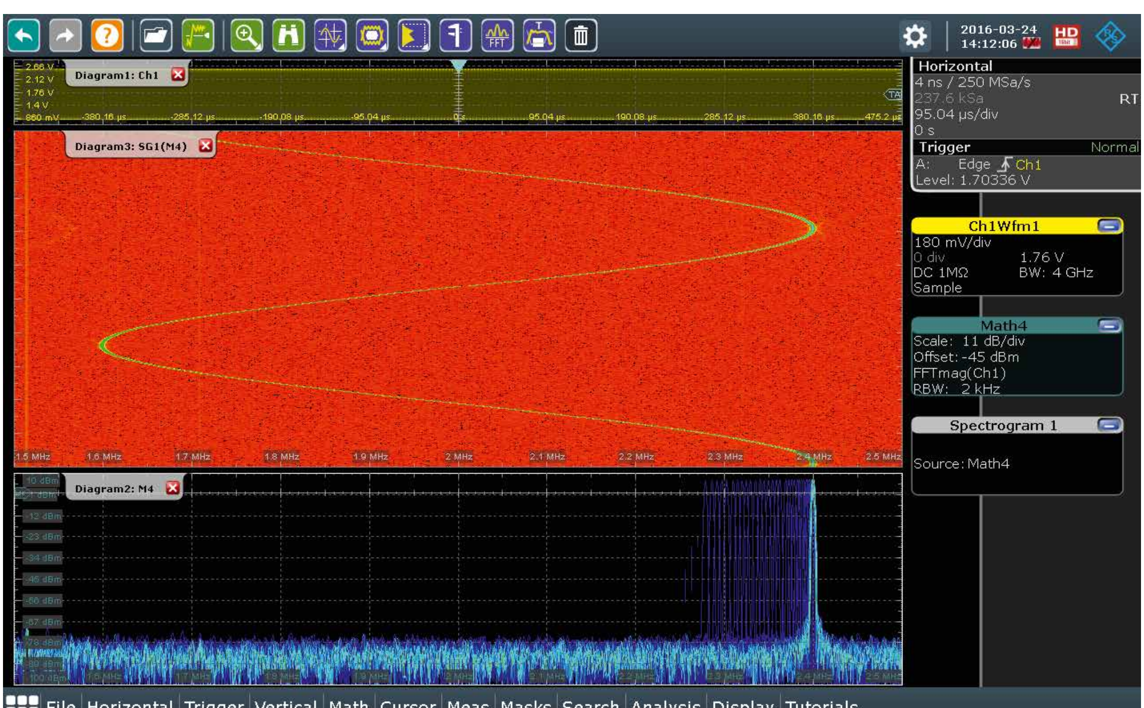


Fig. 6: The spectrogram shows the frequency modulation of the signal.

Enhanced debugging in the spectrum

The powerful FFT-based spectrum analysis function on all R&S®RTO2000 analog input channels opens up additional possibilities, e.g. analyzing radio signals, EMI debugging to find interferers in the spectrum or spectral analysis of power supplies. In contrast to conventional FFT implementations in oscilloscopes, the R&S®RTO2000 achieves a greater resolution and display speed with its digital downconversion (DDC), in which the FFT calculation can be limited to a selected frequency range.

User-friendly functions such as automated measurements, peak lists, max. hold detectors and mask tests support debugging in the spectrum. One unique characteristic is the spectrogram, which visualizes the changes in frequency components over time (Fig. 6).

Zone trigger in the time and frequency domains

Another unique function is the new zone trigger, which can be used to graphically differentiate between events in the time and frequency domains. Up to eight zones of any shape can be defined and logically linked as trigger conditions. A trigger is initiated when test signals intersect defined zones or when those zones are not touched. This makes it possible to detect interferers in the spectrum during EMI debugging or to separate read and write cycles in memory controllers. The example in Fig. 7 shows how the zone trigger is used in the spectrum to measure the current and voltage load during a GSM radio burst.

Summary

The R&S®RTO2000 is a unique combination of versatility, measurement speed, precision and convenience. Time, frequency, logic and protocol analyses work hand in hand. Unmatched in this class is the acquisition rate of up to one million waveforms per second. The instrument's high dynamic range proves effective not only in the time domain but also in the frequency domain, where the R&S®RTO2000 offers unparalleled analysis performance thanks to hardware-based FFT. Industry-leading 16-bit resolution in HD mode, which can always be fully used by the trigger system, uncovers the finest of signal details. The R&S®RTO2000 is the first instrument to offer a zone trigger for the frequency domain and capture events that are primarily defined by their spectral signature. The highly variable configurations and operating options make it possible to quickly solve demanding measurement tasks.

Guido Schulze

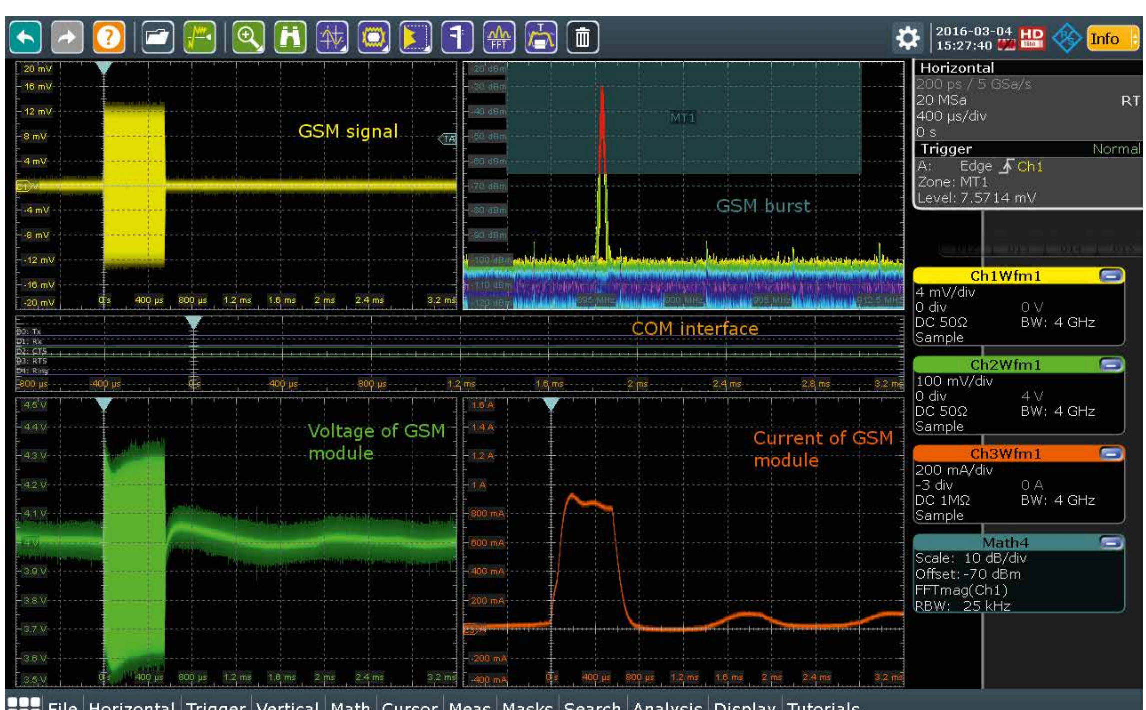
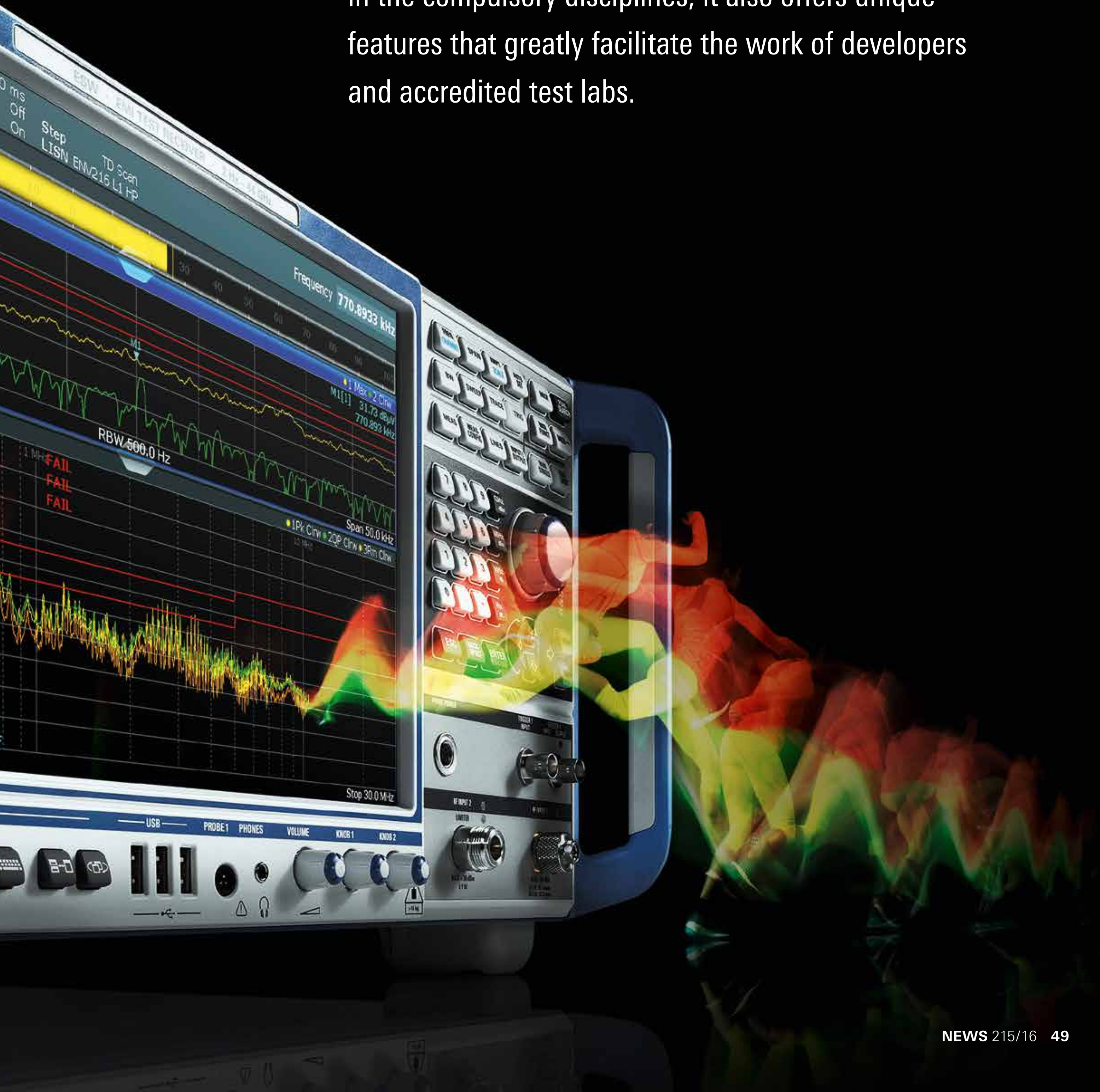


Fig. 7: The zone trigger in the spectrum focuses the measurements on the GSM burst signals.


ROHDE&SCHWARZ
Meas BW
Att
Input
(QPK) 9 kHz
10 dB
1 DC
Meas Time
Preamp
PS
1 Bargraph
Max Peak
24.70 dBµV
3 IF Analysis
CF 770.8933 kHz
2 Scan
Limit Check
Line EN55022A
Line EN55022Q
Start 150.0 kHz
POWER
SYSTEM
MODE
SETUP

Uncovers every disturbance

Standard-compliant EMI test receivers must meet very high requirements with respect to their RF characteristics. Not only does the R&S®ESW perform brilliantly in the compulsory disciplines, it also offers unique features that greatly facilitate the work of developers and accredited test labs.



The R&S®ESW EMI test receiver offers outstanding performance in terms of dynamic range, speed and accuracy. With its integrated preselection filters, 20 dB preamplifier and highly linear frontend, it meets the requirements of all relevant commercial and military EMC standards, including CISPR, EN, MIL-STD-461, DO-160 and FCC, as well as the special requirements posed by the automotive and aerospace & defense (A&D) sectors. The instrument comes in three models, from 2 Hz to 8 GHz, 26 GHz and 44 GHz.

Product highlights

- Extremely fast time domain scan thanks to FPGA-based signal processing
- Widest available dynamic range (1 dB compression point of +15 dBm)
- Numerous configurable preselection filters, including notch filters for the suppression of ISM bands, plus optional highpass filters
- Conventional heterodyne (standard) and realtime spectrum analysis (option)
- Extremely sensitive measurements starting at 2 Hz for automotive and A&D applications
- Large touchscreen with MultiView function to display multiple operating modes, showing all relevant information at a glance

EMI tests take time – although less than ever with the R&S®ESW

Conventional measuring receivers scan a frequency range of interest in many small, sequential steps. Completing a standard-compliant measurement can take several hours. Recent advances in digital signal processing, however, have brought forth solutions that speed up these measurements by many orders of magnitude. FFT-based time domain scans can be performed so efficiently today that the stringent level accuracy requirements defined in the EMC standards can be met without any problems. Even the CPU-intensive digital weighting filters in EMI detectors no longer represent a performance obstacle. FFT-based measurements have been officially approved for CISPR compliance measurements since 2010, when the industry presented proof of their suitability using appropriate measuring instruments. The R&S®ESU, which preceded the R&S®ESW, was the first commercially available test receiver that supported the FFT-based approach. The R&S®ESW now performs EMC compliance measurements even faster thanks to FPGA-based signal processing (unlike the R&S®ESU, which used the on-board CPU). Frequency scans in the CISPR bands require just a few milliseconds, and conducted disturbances can be measured in realtime with the option of running CISPR detectors (quasi-peak and CISPR-average) in parallel. Spectral signal components with a bandwidth of up to 30 MHz are covered without any time gaps. With a virtual step size of ¼ of the resolution bandwidth and FFT windows overlapping by > 90 %, the R&S®ESW achieves level measurement accuracy significantly better than that required by CISPR 16-1-1.*

* A comparison of the two modes is presented in a white paper, "Comparison of time domain scans and stepped-frequency scans in EMI test receivers," found under search term 1EE24 at www.rohde-schwarz.com.

Speed is a crucial factor when testing devices that can be operated, or measured, only during a short period of time – either because they change their behavior (fluctuating or drifting disturbances), or because extended operation might be destructive, or because their operating cycle calls for high speed (as in the case of power window regulators in motor vehicles). The extremely fast time domain scan delivers results very quickly, making it easy to handle such scenarios.

Scan tables for fast results

In receiver mode, disturbance measurements are controlled by the settings in the scan table. The scan parameters are presented in a table and can be individually configured for each task and DUT with up to ten independently defined subranges. The same scan table is used for the time domain scan function, where the step size is set to ¼ of the resolution bandwidth by internal coupling. In this mode, the receiver delivers standard-compliant measurement results for the entire CISPR band B after two seconds, using two CISPR detectors, this period including the required settling time of one second. This means that a complete standard-compliant measurement takes a total of four seconds for single-phase and eight seconds for three-phase DUTs, translating into virtually no delays attributable to the instrument (Fig. 1 and Fig. 2).

Band	Frequency	Resolution bandwidth	Measurement time	CISPR detectors	Total measurement time
CISPR band B	150 kHz to 30 MHz	9 kHz	100 ms	peak	110 ms
CISPR band B	150 kHz to 30 MHz	9 kHz	1 s	quasi-peak and CISPR-average	2 s
CISPR band C/D	30 MHz to 1000 MHz	120 kHz	10 ms	peak	620 ms
CISPR band C/D	30 MHz to 1000 MHz	9 kHz	10 ms	peak	840 ms
CISPR band C/D	30 MHz to 1000 MHz	120 kHz	1 s	quasi-peak	80 s
CISPR band C/D	30 MHz to 1000 MHz	9 kHz	1 s	quasi-peak and CISPR-average	67 s

Fig. 1: Measurement times for standard settings in different CISPR bands.

Since the R&S®ESW delivers an overview of the disturbance scenario within seconds, disturbance signals that vary over time or intermittent disturbance signals with low repetition rates can be detected already during the development phase by performing repeated measurements. The observation period can be extended in order to better capture disturbances that change with time. A small investment in measurement time produces reliable results, even for difficult-to-capture signals.

Maximum protection against overload

EMI measurements of unknown disturbances call for the highest possible RF dynamic range in order to prevent overloading caused by wideband disturbances or high carrier signal levels. Preselection filters (bandpass filters), which are typically included as standard in EMI test receivers – including, of course, the R&S®ESW – provide protection against overloading by allowing only a defined range of the RF spectrum through to the mixer. The CISPR/EN standards cover conducted disturbances starting from 150 kHz. Measurements are not performed below 150 kHz, as this range is inundated with AC line disturbances (an exception are the military and automotive sectors, where measurements are performed even though not expressly required by the standards). However, the levels below 150 kHz are sufficient to overload test instruments and make measurements impossible. CISPR therefore recommends a steep-edge 150 kHz highpass filter that suppresses the frequencies below 150 kHz by up to 60 dB, allowing measurements from 150 kHz to 30 MHz without overloading the test equipment. In addition to an impulse-protected input with 21 "normal" preselection filters, the

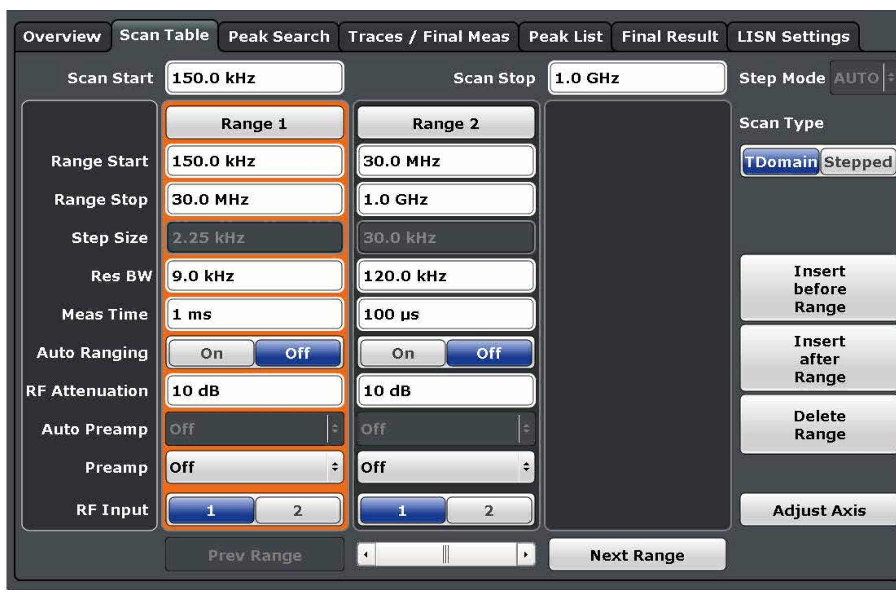


Fig. 2: Configurable R&S®ESW scan table with up to 10 subranges.

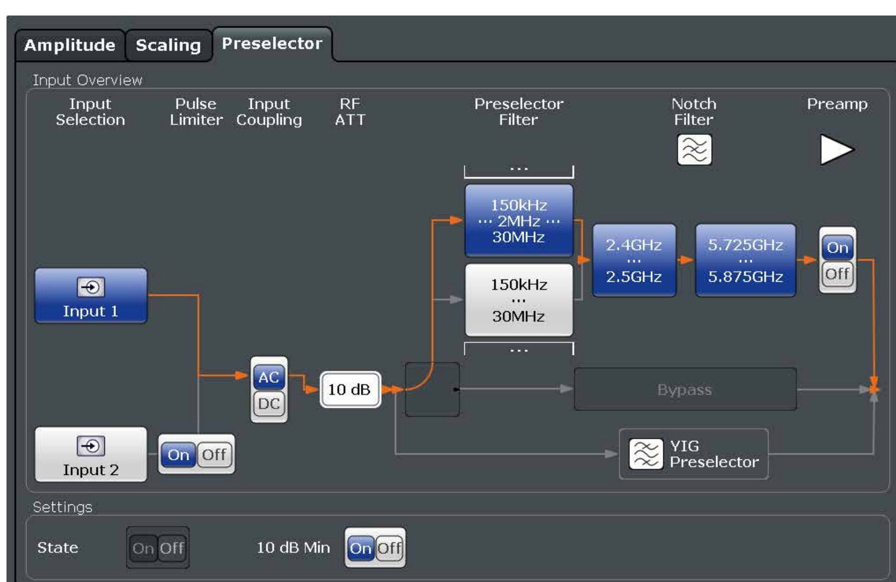


Fig. 3: Configurable preselection filters protect against overloading; special filters permit extremely sensitive measurements.

R&S®ESW offers a 150 kHz highpass filter as recommended by the standard as well as a 2 MHz highpass filter that prevents, for example, disturbance signals from switched-mode power supplies from reaching the sensitive frontend (Fig. 3).

High-level carrier signals are also present in the upper frequency ranges, e. g. in the license-free ISM bands where WLAN networks and Bluetooth® devices operate, such signals significantly limiting instrument dynamic range for the typical measurement tasks up to 6 GHz (CISPR 22/32 for DUTs used in IT). The R&S®ESW comes with high-end notch filters to suppress these bands at 2.4 GHz and 5.8 GHz, making it possible to measure the remaining frequency ranges better and with greater sensitivity (Fig. 4).

Fig. 4: Spectrum around the 2.4 GHz ISM band. Top: With the notch filter deactivated, a strong WLAN signal reaches the mixer.
Bottom: When activated, the notch filter keeps the spectral ISM band component away from the IF stage.

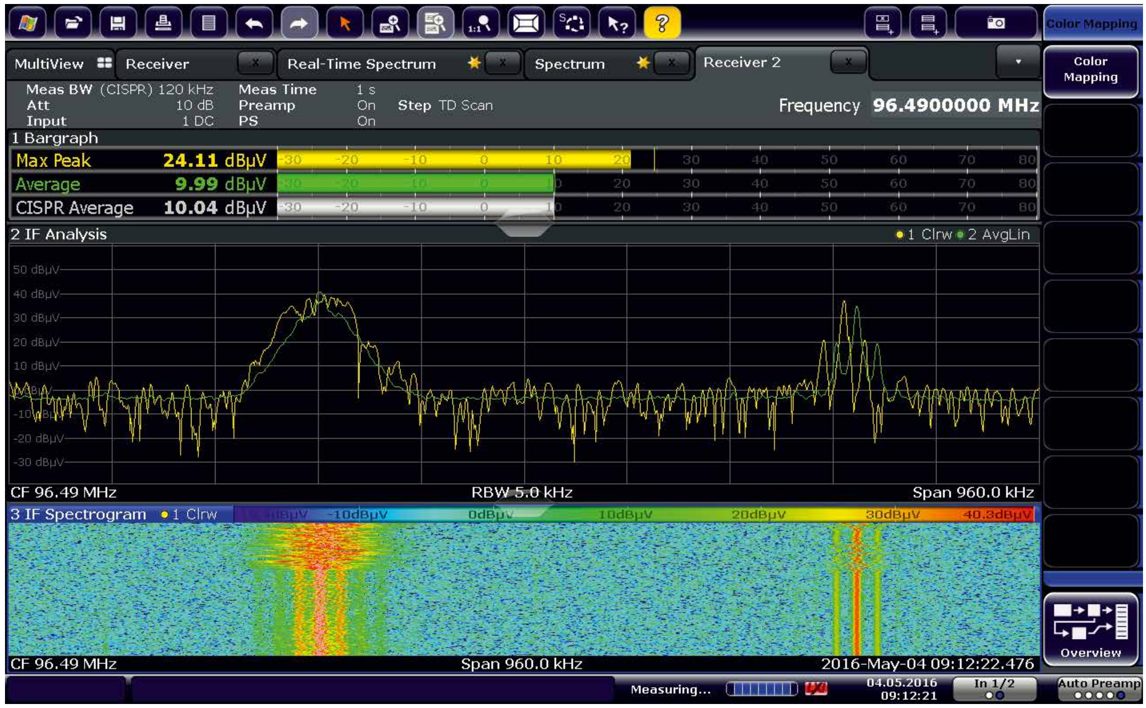


Fig. 5: IF spectrum display coupled to preview diagram via marker, plus spectrogram display.

IF analysis with spectrogram

The IF analysis function of the R&S®ESW provides a spectral display of an RF input signal in a selectable range around the EMI receive frequency. The IF spectrum display can be coupled to the bargraph display for the current receive frequency. Alternatively, the IF spectrum can be displayed together with the stored results from the preview measurement. The marker in the preview diagram can be used to control the center frequency of the IF spectrum (marker track function). The center frequency of the IF spectrum always corresponds to the current receive frequency. The test receiver can therefore be tuned to the signal of interest accurately and quickly. Any received signals can be quickly classified as disturbance signals or wanted signals. AM or FM audio demodulation can be activated in parallel, making it easier to identify detected signals, e.g. to recognize and exclude ambient interferers in open-area measurements. An IF spectrogram can be generated in parallel with the IF spectrum, making it easier to capture time-varying, sporadic or drifting disturbance signals (Fig. 5).

Spectrum analyzer included

The R&S®ESW is not only an EMI test receiver, but also a full-featured spectrum analyzer as is needed in labs for countless measurement tasks, including EMI analysis during development. With preselection activated, the R&S®ESW can even perform standard-compliant EMI measurements in spectrum analyzer mode, offering a third option beyond a classic test receiver and a time domain analyzer that users can take advantage of depending on preference and application.

Markers can be placed on the frequencies of EMI signals to carry out targeted analysis. Markers can be coupled with CISPR weighting detectors to enable direct comparison with limit values. The spectrum can also be displayed along a logarithmic frequency axis, which simplifies result analysis across a wide frequency range and displays limit lines in compliance with relevant standards. Critical frequencies are presented in a peak list and are used for fast, standard-compliant comparison of EMI signals with limit lines. In spectrum analyzer mode, the R&S®ESW measures with a resolution of up to 200 001 points. In classic test receiver mode with user-defined step size, the instrument captures and saves up to four million points per trace.

Realtime spectrum analysis with up to 80 MHz bandwidth

The realtime spectrum analysis function of the R&S®ESW (R&S®ESW-K55 option) facilitates rapid detection of sporadic and transient EMI signals, such as those caused by switching operations. These signals are difficult and time-consuming to detect using conventional methods. The realtime analysis window with a bandwidth of up to 80 MHz displays spectral events without time gaps, ensuring that no event is missed. This is achieved by means of special display modes that make the time behavior of disturbance signals immediately visible.

Spectral histogram for clear identification of pulsed and continuous disturbances

The R&S®ESW offers a spectrogram function (spectrum over time) that allows users to analyze the behavior of disturbance signals in the time domain in all operating modes (stepped-frequency scan, time domain scan, IF analysis, sweep and realtime mode). Each spectrum is presented as a horizontal line with different levels assigned different colors. The individual spectral lines are joined continuously. Recording is seamless at a rate of up to 10000 lines per second. In persistence mode, the R&S®ESW writes the spectra into a single diagram. The color of each pixel indicates how often a specific

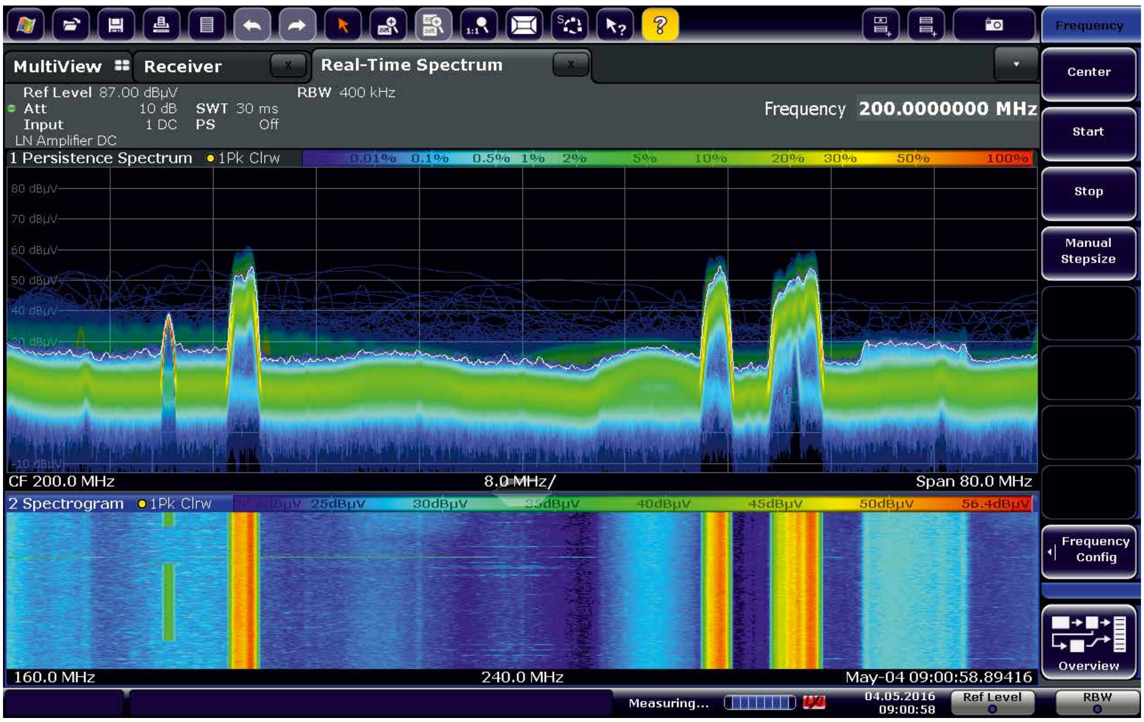


Fig. 6: Realtime spectrum with wanted and disturbance signals, shown in persistence mode.

Fig. 7: Big screen: The MultiView display mode delivers a running display of multiple operating modes on one screen.

amplitude occurs at a specific frequency. Frequently occurring signals are shown in red, for example, and sporadic ones in blue. If signals no longer occur at a specific frequency with a specific amplitude, the corresponding pixel disappears after a user-definable persistence period. This allows users to clearly distinguish between pulsed disturbances, which occur only for very brief periods, and continuous disturbances (Fig. 6). Different pulsed disturbances can easily be distinguished from one another.

MultiView: display of multiple operating modes

The MultiView function (Fig. 7) brings the measurement results from various operating modes together onto the 12.1" screen, greatly facilitating their comparison – e. g. the frequency spectrum in sweep mode together with a single-frequency measurement using the IF analysis function including a spectrogram display. Four independent single-frequency measurements can be displayed at a time, for example.

Outstanding sensitivity starting at 2 Hz

The emergence of electromobility creates new EMI test requirements in the automotive sector. In particular, the connection between a vehicle and a charging station involves high currents and long, unfiltered cable links – scenarios that prompt manufacturers and suppliers to perform EMI measurements starting at a frequency as low as 5 Hz. With a specified lower frequency limit of 2 Hz, the R&S®ESW is ideal for these applications (Fig. 8). Thanks to baseband conversion, signals up to 30 MHz are sampled right at the instrument input, completely eliminating the effect of the local oscillator in this frequency range. This results in high sensitivity of, for example, typ. –110 dBm below 10 Hz and typ. –120 dBm between 10 Hz and 100 Hz, meaning that the test receiver meets even the most stringent requirements.

Documentation made easy

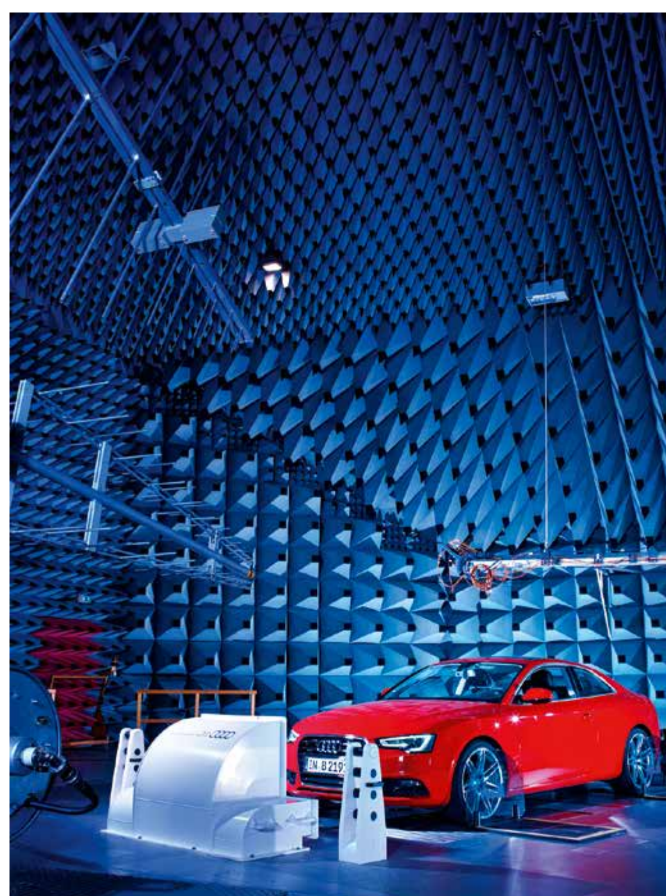
Certification measurements must be carefully and fully documented so that evidence of conformance can be furnished when required. The report generator of the R&S®ESW turns this into an easy task. All information that is necessary to track a measurement can be integrated into the report, including the description of the measurement task, the standards applied, the test procedure used, specific user-defined procedures, any applied transducers and limit lines, plus result graphs from the preview measurement, different DUT load states, final measurement results in tabular form and a graph of the final measurement. Sufficient space is provided for individual interpretation and commenting. Reports can be saved as templates and reused. Different templates can be defined, for example with individual customer logos.

Summary

As a market and technology leader, Rohde & Schwarz has long proven its expertise in the development of EMI test receivers. The existing high-end models R&S®ESIB and R&S®ESU have stood the test of time and are internationally acknowledged reference instruments. The new flagship R&S®ESW surpasses its predecessors not only in terms of measurement speed, but also offers a wider dynamic range, lower inherent noise and extremely high accuracy. Various operating modes, including conventional stepped-frequency scan, FFT-based time domain scan, IF analysis, frequency sweep and realtime spectrum analysis (all of which can be combined with a spectrogram display) support users in performing complex measurement tasks. And last but not least, there are the large, flexibly configurable touchscreen as well as convenient report configuration and generation.

Volker Janssen

Fig. 8: Electromobility expands the test scenarios for the automotive industry, adding EMI measurements starting as low as 5 Hz.



R&S®ESMD monitoring receiver evolves into a system-in-a-box

Fig. 1: The R&S®ESMD search and monitoring receiver is the ideal choice for monitoring tasks in difficult signal scenarios. All information is displayed either on its display or on an external PC that is connected via LAN.

The R&S®ESMD wideband monitoring receiver now offers more functions to better support signal recording, analysis and documentation. The new options upgrade it to a versatile system-in-a-box.

The R&S®ESMD wideband monitoring receiver (Fig. 1) is used in many radiomonitoring systems worldwide as a reliable and fast search receiver to detect short-time signals, or as a handoff receiver that provides high-quality I/Q data from wideband signals for subsequent signal analysis or demodulation. New options extend its application range to include tasks not performed by conventionel monitoring systems, making it a virtually autonomous small system. For example, real signal scenarios can be recorded for in-depth offline analysis at a later point in time. The recorded signals can be used to test radar and communications systems.

Displaying signals in the time domain

All Rohde & Schwarz radiomonitoring receivers process signals based on the same principle: the signal received is simultaneously processed in realtime on two different paths – the spectrum and the demodulation path. The demodulation path is used to accurately measure the levels and to demodulate analog signals. The fast Fourier transform (FFT) for displaying the realtime spectra takes place in the spectrum path. In these spectra, it is easy to distinguish between emissions on different frequencies. The additional waterfall diagram makes it easy to monitor the signal behavior over time.

Especially in the case of pulsed and TDMA signals, looking at the signals in the frequency domain is not sufficient to determine whether signals overlap or if a transmission system within a channel is disturbed. The new R&S®ESMD-ZS zero span option provides this type of insight by displaying the signals in the time domain in parallel with the realtime spectrum (Fig. 2). The calculation is performed in the demodulation path. The user can choose the section of the realtime spectrum that should be displayed in the time domain. Thanks to the parallel signal processing channels, the center frequency of the demodulation path can be placed anywhere within the 80 MHz realtime bandwidth. The demodulation bandwidth can be used to adjust the bandwidth for the time domain display up to maximum 20 MHz.

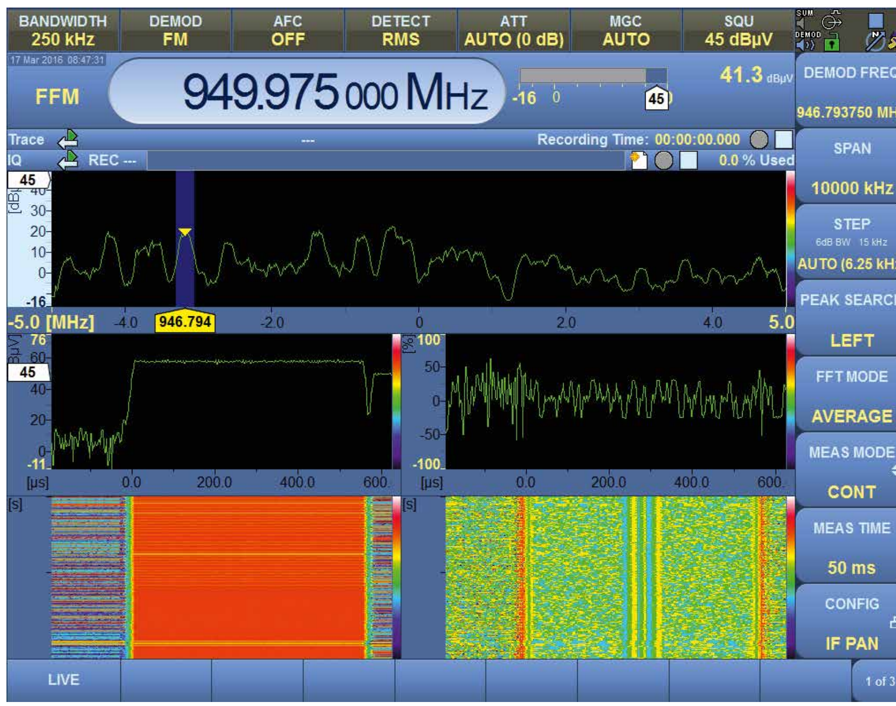


Fig. 2: Time domain display of a GSM signal. A GSM channel is selected from the realtime spectrum (top). The time domain display shows the amplitude (center left) and current modulation bandwidth in a timeslot (center right), and their historical values in the waterfall diagrams underneath.

R&S®ESMD: optimized for best reception on wideband, sensitive antennas

From the outset, the R&S®ESMD was developed with the aim of achieving optimal receive characteristics in the 8 kHz to 26.5 GHz frequency range for sensitive, wideband antennas. The entire signal processing functionality is optimized for a compromise between large-signal immunity and sensitivity so that low-level signals are not lost in strong signals such as those transmitted by base stations or broadcast transmitters.

The R&S®ESMD processes signals in realtime up to a bandwidth of 80 MHz and can therefore detect emissions even in the nanosecond range. An acquisition rate of up to 8 million spectra per second leaves no event undetected. This is one of the reasons for the popularity of the R&S®ESMD. The new functions make it even easier to record, analyze and document signals.

In the time domain, the user can choose between displaying the modulation bandwidth (in % of the set channel bandwidth) or the amplitude over time. The latter is equivalent to an oscilloscope function. A level trigger that responds to a rising or falling edge within the demodulation bandwidth stabilizes the display. TDMA signals in particular can be thoroughly analyzed for interference in the time domain since this view allows detailed insight into the individual channels. All signals with special time-related characteristics, for instance radar or pulsed signals, can be measured in detail with this function – without any additional software.

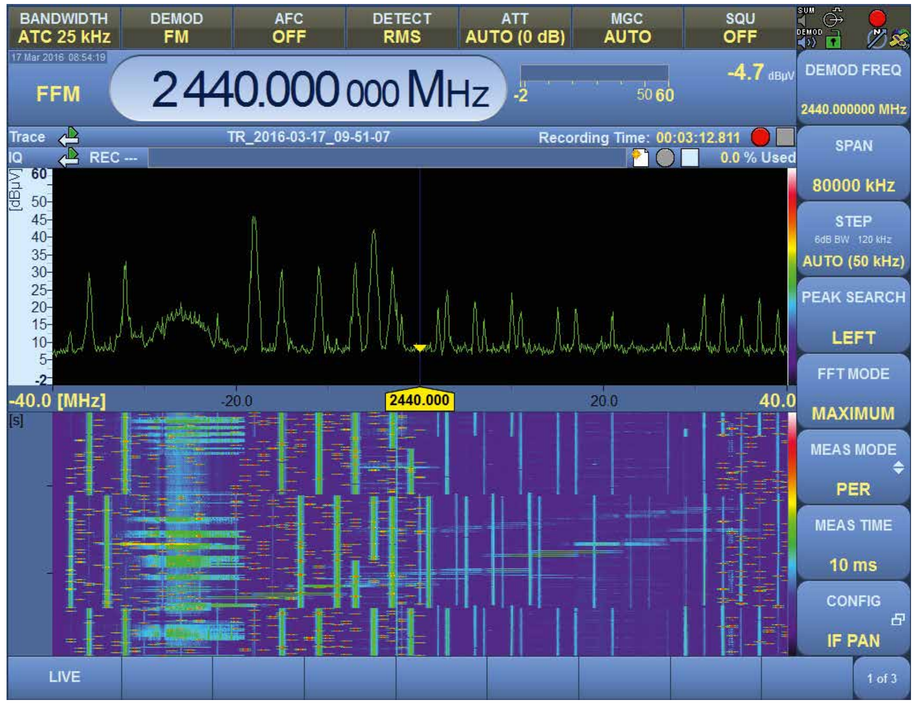


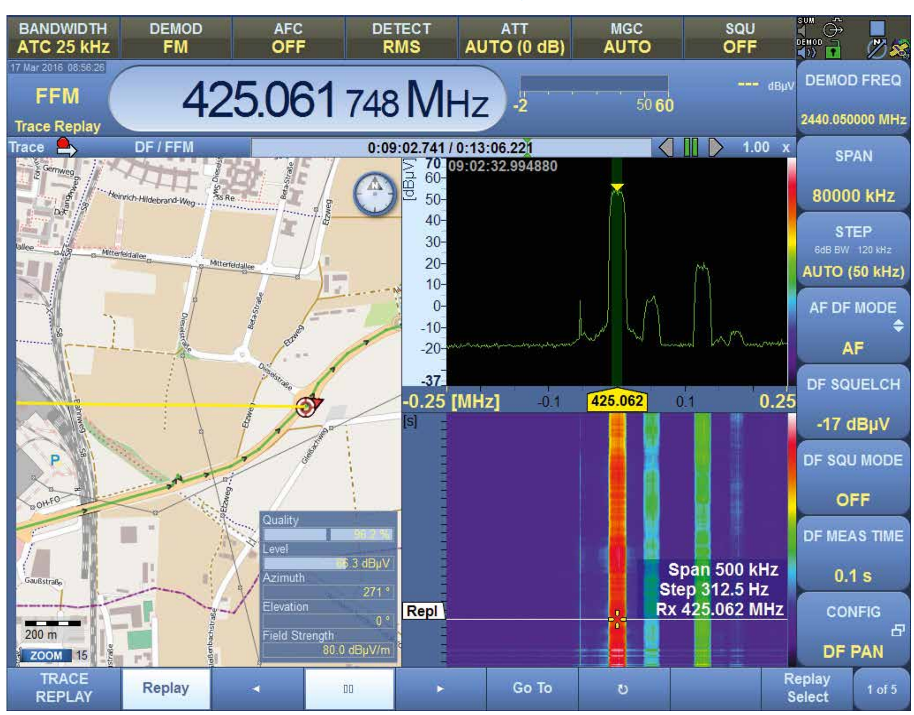
Fig. 3: Recording of a data stream from the 2.4 GHz ISM band in the fixed frequency mode with many Bluetooth® and WLAN signals.

Recording of all data streams

Thanks to its realtime signal processing capability, the R&S®ESMD can seamlessly output the information obtained from the received signals in a data stream (trace). This trace (with the exception of wideband I/Q data) contains realtime spectra, spectra from a fast panorama scan, level measurements, GPS information, DF results and demodulated audio signals, for example. The information is displayed either on the R&S®ESMD or on an external PC that is connected via LAN (Fig. 3).

With the new R&S®ESMD-IR option, which is controlled via the R&S®ESMD user interface, this data can be recorded in the 4 Gbyte internal memory and replayed from there. For example, during a drive test, the realtime spectrum, GPS information (from the internal R&S®ESMD-IGT GPS module) and bearings (if the R&S®ESMD is equipped as a direction finder) are recorded continuously. The internal map display (R&S®ESMD-MAP) shows the route during the drive test or when the recording is replayed (Fig. 4). For long recordings, the user navigates either on the time axis or via the moving profile. This georeferenced data facilitates documentation and helps with coverage measurements or when investigating major malfunctions.

Fig. 4: Replay of a drive test recording. Display of the route with DF results on the map and the recorded realtime spectrum over time in the waterfall diagram.



Extended wideband streaming options

Using the well-established R&S®ESMD-RR option, the R&S®ESMD can record I/Q data in its 4 Gbyte RAM, replay it and export it for later processing*. Thanks to the realtime event capture (REC) trigger that comes with the option, memory is more efficiently used because the trigger starts and stops recording according to adjustable criteria so that only the signals that triggered the recording are stored in memory (Fig. 5).

When replaying recorded I/Q data, the R&S®ESMD behaves as if it were in live mode. All functions, such as level measurement, demodulation and setting the center frequency and bandwidth, are available. In contrast to the live mode, the R&S®ESMD achieves a time resolution of just a few nanoseconds so that all signals can be precisely evaluated and measured in detail (Fig. 6).

The R&S®ESMD can stream this internally generated I/Q data to external recipients in realtime up to the full bandwidth of 80 MHz. Since the standard 1 Gbit LAN interface cannot stream such amounts of data, the new R&S®ESMD-DIQ option is recommended for this application. This option equips the receiver with an additional field programmable gate array (FPGA) board that accelerates the transmission and conversion for interfaces with higher transmission rates to external devices.

The R&S®ESMD is now able to stream data via the 10 Gbit Ethernet interface (R&S®RX-G10 option) or via the Rohde & Schwarz I/Q interface (included on the FPGA board). Both interfaces support bandwidths up to 80 MHz.

* This option is described in detail in NEWS (2014) No. 211, pp. 63–65.

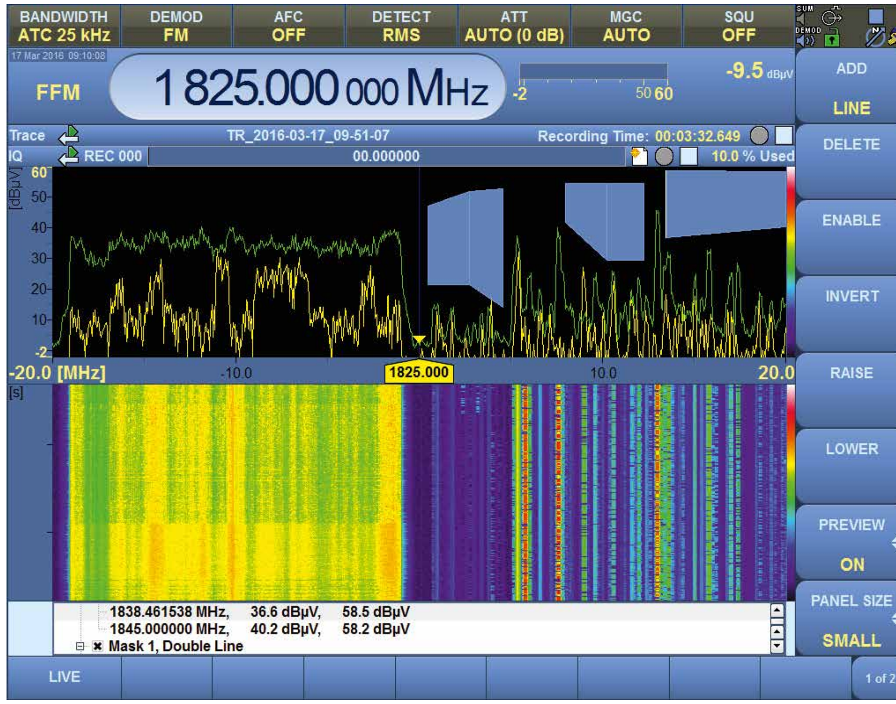
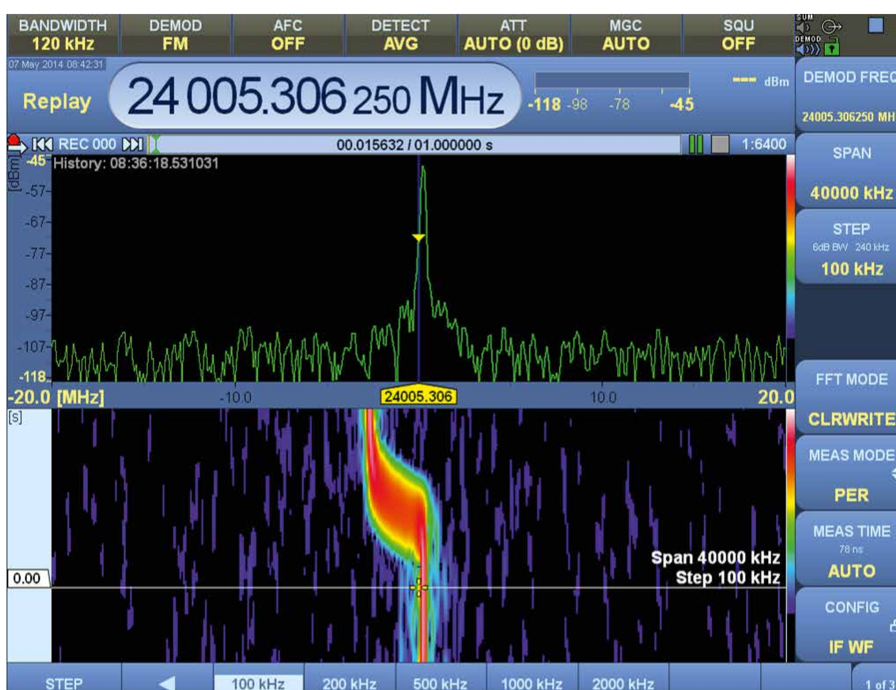


Fig. 5: Definition of a REC trigger in the LTE band (blue areas at top). The receiver displays the realtime spectrum (green) and at the same time the spectrum (yellow) that touches the trigger mask.

Fig. 6: Replay of recorded I/Q data of an FSK radar. The change in frequency is shown in the waterfall diagram with a time resolution of approx. 70 ns per line.



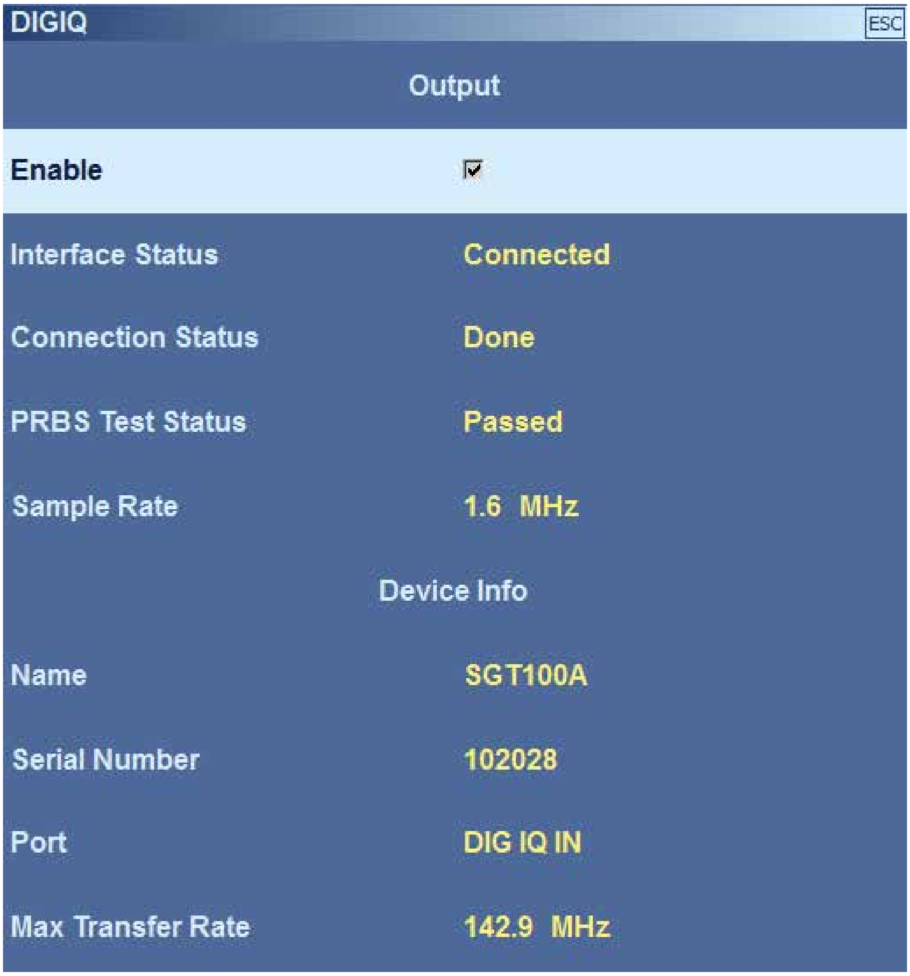


Fig. 7: Configuration dialog of the Rohde & Schwarz I/Q data interface when the R&S®SGT100A generator is connected to the R&S®ESMD. The two devices automatically coordinate the maximum data rate.

A recorder or a vector signal generator, such as the R&S®SMW200A or R&S®SGT100A, is connected to the I/Q interface (Fig. 7). When a generator is connected, it operates as an external IF output. An IF recording device or a signal analysis system for analog IF data can be connected to this output.

Thanks to the 10 Gbit Ethernet interface, the R&S®ESMD can be integrated into customer systems. Rohde & Schwarz offers suitable recording devices, such as the R&S®GX465 wideband recorder. What makes this interface special is its bidirectionality, which allows the R&S®ESMD to stream and receive wideband I/Q data up to the full bandwidth in realtime. This is advantageous when using the above-mentioned R&S®ESMD-RR option, which can then output / read data to / from an external memory. The recording capacity is effectively increased from just a few seconds to several hours.

R&S®ESMD, the versatile radiomonitoring solution

The new functions turn the R&S®ESMD into a universal radiomonitoring tool. Fast recording and replaying of various data, as well as in-depth data analysis in both the time and frequency domain qualify it as a full-fledged system-in-a-box for numerous tasks. The R&S®ESMD is a powerful tool for all users who perform measurements via an antenna, either in stationary or mobile use.

Benjamin Bulach

Center of Excellence at the Universität der Bundeswehr München

The Universität der Bundeswehr München (UniBwM, University of the Germany Armed Forces in Munich) founded a Center of Excellence in February 2016. The UniBwM managed to bring four internationally renowned, still-active researchers on board as founding members: Prof. Dr. rer. nat. Ignaz Eisele, Prof. Dr.-Ing. Dr. h.c. Günter W. Hein, Prof. Dr.-Ing. habil. Dr. h.c. mult. Ulrich L. Rohde and Prof. Dr. rer. nat. John G. Zabolitzky. The center aims to allow researchers who are no longer involved in current faculty activities the opportunity to continue using the UniBwM facilities to conduct research. Both the administration and facilities are made available to them for this purpose. The opportunity is available to emeritus professors of UniBwM and other universities. An interest in a joint research project was already expressed during initial talks. The idea to organize a "call for curiosity" at the university in order to seek innovative, interdisciplinary and unusual topic proposals enjoyed great resonance.

Three of the four founding members and the president (from left): Prof. Eisele, Prof. Rohde, President Prof. Niehuss and Prof. Hein.

Rohde & Schwarz builds second technology center

The topping out ceremony for the second technology center took place at the end of January 2016, eight months after breaking ground. Around 200 guests came to partake in the festivities. Rohde & Schwarz invests EUR 35 million in the building, which is the next step of the modernization efforts underway at company headquarters in Munich, where around 2600 of the roughly 9900 employees work. The 13,500 square meter state-of-the-art research and development building will mainly provide working space for developers. The six-floor building can accommodate around 600 employees.

The Technology Center II is due to be completed and occupied by the end of 2016.

Successful Technology & Innovation Day in Berlin

During the Berlinale in February 2016, Rohde & Schwarz organized its third event dedicated to the latest technical developments in the media industry. The partner was the Heinrich Hertz Institute, which opened the doors of its Innovation Center for Immersive Imaging Technologies to host the event.

Over 120 participants were interested in finding out more about the workflow involving the new high-definition standards.

Around 120 visitors took advantage of the opportunity to attend presentations and learn about the latest trends in production and distribution. The presentations given by numerous guest speakers from research and industry focused on high-definition standards such as UHD / HDR. Rohde & Schwarz demonstrated the entire live production chain for broadcasts from HD to 4K in HDR – from the film itself to its transmission. For a visual change of pace, spectators had the opportunity to watch virtual reality presentations on the topic of camera technology.

R&S®RTE oscilloscopes for CERN

Following a call for bids, CERN, the renowned European organization for nuclear research in Geneva, selected ROSCHI Rohde & Schwarz AG to supply up to 45 R&S®RTE oscilloscopes depending on the needs of the CERN research community. The contract also includes service and support for the oscilloscopes over a period of five years. CERN is the world's largest research center for particle physics where the most innovative equipment is used to study elementary particles. For the work on CERN experiments, a pool of 500 different types of instruments and equipment is available to the staff and over 10,000 visiting researchers from 85 nations. It includes high-voltage and low-voltage powers supplies, measuring instruments and generators. The R&S®RTE oscilloscopes were selected thanks to their outstanding performance as well as their operational capability at a magnetic flux density of 100 gauss (0.01 tesla).

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CERN's Globe of Science and Innovation located in Meyrin in the canton of Geneva, designed by architects Hervé Dessimoz and engineer Thomas Büchi.

Broadcast tester for compliance testing in Indonesia

In January 2016, the Ministry of Communication and Information Technology in Indonesia installed the R&S®BTC broadcast test center at its official test lab. This will allow the Balai Besar Pengujian Perangkat Telekomunikasi (BBPPT) to perform the official compliance tests for DVB-T2 receivers. The R&S®AVBrun test software, a PSI / SI and early warning system (EWS) test suite from StreamSpark as well as a management system will be implemented as well. A camera-based solution from Rohde & Schwarz was added to the test system, enabling the fully automatic testing of set-top boxes and digital TV receivers. This solution will ensure the successful rollout of digital TV in the ASEAN countries.

Delegates from the official test lab of the Indonesian Ministry of Communication and Information Technology visit the Rohde & Schwarz office in Jakarta.

Frequency management system for radio networks in Kenya

Four off-road vehicles for locating interferers complete the SMMS in Kenya.

In March 2016, the Communications Authority of Kenya (CA) inaugurated a new spectrum management and monitoring system (SMMS) from Rohde & Schwarz. The system will be used for the nationwide regulation of the frequency spectrum and ensures the undisturbed reception of radio services such as broadcasting and wireless communications. The core of the new solution is the R&S®UMS300 universal monitoring system. Altogether, the new SMMS consists of a central control station in Nairobi, eleven stationary measuring and direction finding stations as well as four off-road vehicles for the mobile position fixing of interferers. The SMMS enhances a still-functioning and also ITU-compliant Rohde & Schwarz solution from 1986.

Awards

Handheld from Rohde & Schwarz is the product of the year

Readers of the "Elektronik" magazine and the "elektronik-net.de" portal have selected the products of the year. After last year's success, Rohde & Schwarz again won first prize in the test and measurement category with its R&S®Spectrum Rider spectrum analyzer. Laura Sanchez, product manager for spectrum analysis, accepted the award. The R&S®Spectrum Rider is a mobile, handheld measuring instrument that impresses users above all thanks to its low weight and long battery life. It was introduced at the end of 2015.

"Elektronik" has been choosing the product of the year for 18 years. Readers can cast their votes for altogether 111 products in 11 categories. "Elektronik" is one of the industry's most important German-language trade media, with a print circulation of more than 31,000 copies.

The R&S®Spectrum Rider was the winner in the test and measurement category. Matthias Heise, "Elektronik" editor (left), congratulates Laura Sanchez.

GTI Award

At the Mobile World Congress 2016, the Global TD-LTE Initiative (GTI) presented Rohde & Schwarz with the distinguished GTI Award 2015, which recognizes companies that have shown outstanding achievements in the area of TD-LTE. This year, the company's user experience test solution impressed the jury. It essentially consists of the R&S®CMW500 multistandard test platform and the R&S®CMWrun sequencer software (see article on page 16). This was the third award in a row for Rohde & Schwarz. GTI awards the trophy each year at the Mobile World Congress in Barcelona.

This is already the third GTI award for the achievements of Rohde & Schwarz regarding the TD-LTE standard.

Oscilloscopes from Rohde & Schwarz sweep the board

The readers of the German trade magazine "Funkschau" awarded the HD option for the R&S®RTE and R&S®RTO oscilloscopes first place in the T&M instrument category in the 2015 ITC Product of the Year contest. Each year the biweekly trade publication, which has a circulation of around 35,500 copies, determines the best ITC products of the year. The readers' award has become one of the largest B2B surveys for the ITC sector in Germany. A total of 44,400 votes were submitted in 16 categories.

Just recently introduced, the R&S®Scope Rider handheld oscilloscope was one of the prize winners in the "MessTec & Sensor Masters Award" contest. The award is granted by the "messtec drives Automation" trade journal for especially innovative developments in T&M and sensor technology. The R&S®Scope Rider is a mobile oscilloscope with the functionality and user experience of a state-of-the-art lab oscilloscope.

Product Manager Sylvia Reitz and Mathias Leutiger, Director of Oscilloscope Product Management, accepted the award in November 2015.

Eutelsat honors Rohde & Schwarz France

During a 4K test broadcast, Rohde & Schwarz France was honored by satellite operator Eutelsat as a 4K innovation partner. The subsidiary provided the R&S®AVHE100 encoding and multiplexing solution, which was used successfully to broadcast a women's tennis tournament in Genoa.