NEWS

221/19

ROHDE&SCHWARZ

Over the air

OTA measurements are the norm for 5G, and they require new T&M solutions throughout the value chain

General purpose

High-end network analyzer sets new standards in performance and operation

Broadcast and media

Quality monitoring of audio/video live streams as a cloud service

Networks

Automatic setup and management of corporate data networks

NEWS

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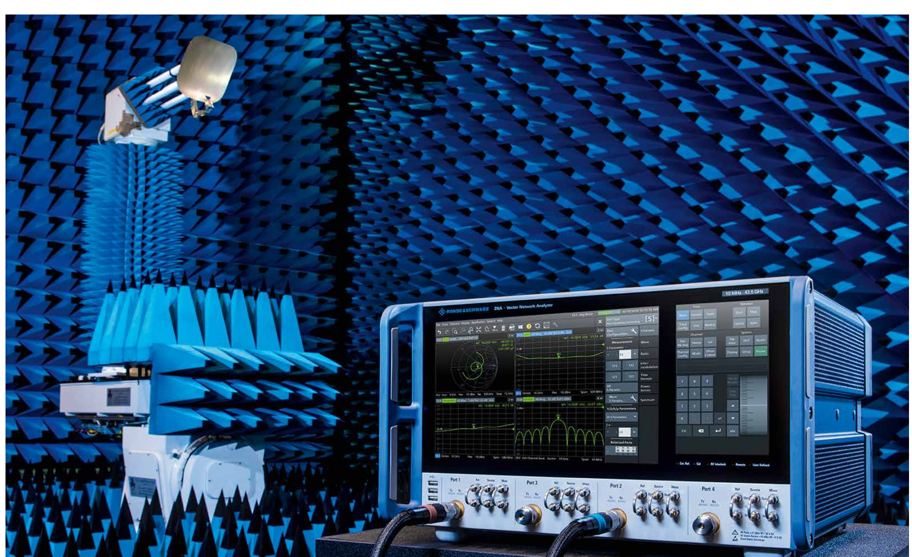
Cover feature

For development and test engineers in the mobile communications sector, the good old days of connecting devices under test to T&M instruments with an RF cable are coming to an end. Why? Because many new wireless products no longer have antenna connections that can be used to connect a cable. This can be attributed to two trends: MIMO technology – a prerequisite for all future high-performance wireless transmission methods – has made the air interface a key element in device design that plays a major role in determining the performance of any wireless product. Beamforming is one of the functions that is implemented using MIMO. Antenna measurements are the only way to determine whether beamforming is working properly. The second major trend involves communications via millimeterwaves. This is leading to miniaturization of antennas, which are combined in larger numbers to form antenna arrays that are integrated with the RF frontend to form complete units. "Over the air" is thus the new T&M paradigm for 5G, Gigabit WLAN and other state-of-the-art wireless systems. However, achieving the customary precision of wired measurements with OTA turns out to be challenging. Hermetically sealed RF-shielded test chambers that include complex mechanical hardware will be standard equipment in the development labs, type approval labs and factories of the future. Rohde & Schwarz has developed a complete line of these test chambers for various applications. Given the underlying constraints of antenna physics and compared to earlier generations of OTA test equipment, all of these chambers are remarkably compact and deliver the field uniformity needed for conclusive measurements in the smallest possible space (page 8). The T&M instruments that benefit from this include the new 5G testers from Rohde & Schwarz. The totally new platforms R&S®CMX500 (for signaling tests) and R&S®CMP200 (for non-signaling tests) come with their own OTA chambers (page 20). For an overview of massive MIMO, a driving force for OTA, see our brief compendium starting on page 14.

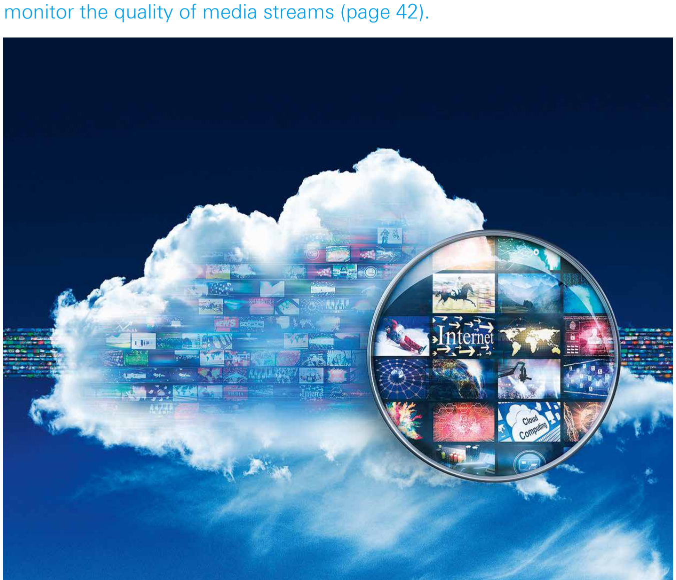
Overview NEWS 221/19

The 5G tester fleet is complete. Two new and two tried and tested platforms share the tasks (page 20).

The multichannel architecture of the new R&S®ZNA high-end vector network analyzer enables simultaneous amplitude and phase measurements on up to eight signals, making it ideal for testing antenna arrays (page 28).



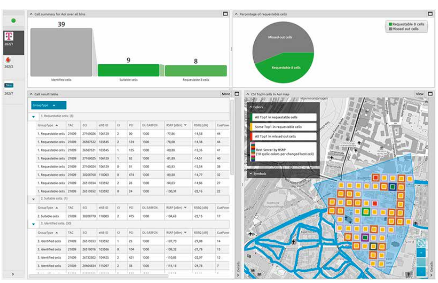
The future of audio/video monitoring is in the cloud. The new R&S®PRISMON.cloud web-based service makes it extremely easy to monitor the quality of media streams (page 42).



R&S®GSACSM is a software solution for monitoring and analyzing satellite signals. It is ideal for operators of satcom systems, regulatory authorities, and public safety and security authorities (page 62).

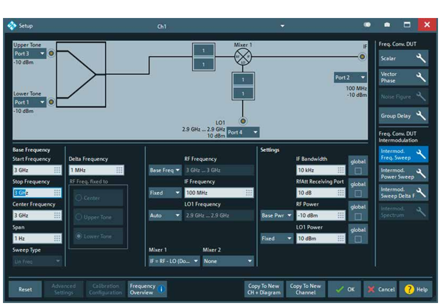
First signaling tester for Bluetooth® Low Energy

Practically every communications product today can connect via Bluetooth. Bluetooth Low Energy (BLE), introduced with Bluetooth version 4.0, is the de facto standard. For testing BLE products, the Bluetooth Special Interest Group (SIG) has only specified a direct test mode (DTM) using a control cable. This can be a problem for manufacturers, especially in case of very small products such as smartwatches or IoT sensors. It is practically impossible to test complete products of this type in their enclosure. Moreover, the cable impacts the RF properties due to its proximity to the antenna. Another problem is that the DTM test program does not cover real operating conditions. For example, it does not support frequency hopping. What is needed is a more comprehensive but also less complicated approach to testing. This is now possible with two new BLE signaling options for the R&S®CMW500 wideband radio communication tester. Supporting direct test mode (still required for certification testing) as well as advertiser mode and test modes for Bluetooth Classic, the R&S®CMW platform has the widest array of test techniques for R&D, production and service applications. The BLE signaling mode includes transmitter and receiver measurements up to Bluetooth version 5.0. Hopping can be restricted to two channels, which is very practical for fast production testing. Wherever possible, the tests are based on the DTM test cases in order to produce comparable results. SIG conformance tests in DTM are now a mere formality.



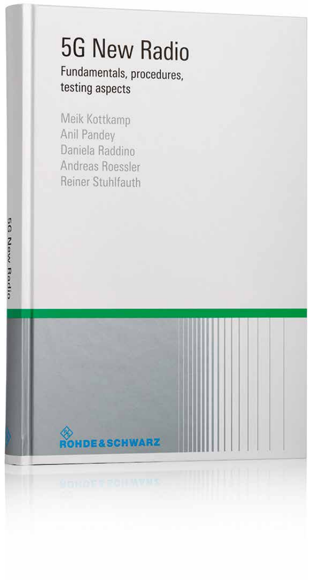
Mobile communications analysis system for forensic investigation

In order to check alibis or obtain information about possible perpetrators, police will sometimes consult data from mobile network operators with the permission of a judge. The first case requires a traffic data inquiry and the second a non-individualized cell inquiry. Any specific inquiry can involve a large number of cells (sometimes over one hundred) that can be received at the location in question. Researching all of the cells would require a great deal of effort and is not allowed in every country. Analysis techniques are used to filter the cells and narrow down the possibilities for the inquiry. For this application, Rohde & Schwarz developed the R&S®NESTOR-FOR software module for the R&S®NESTOR network analysis suite. Combined with a network scanner (e.g. from the R&S®TSMx family), which can be conveniently carried in a backpack to the location under review, the software quickly provides a graphical/tabular overview of the local cells. The analysis encompasses every operator and mobile communications technology. The software ranks the different cells in terms of the probability of access by a mobile phone. The investigating authority can then make an informed decision about which cells to include in the inquiry. This ranking often reduces the list down to only a few cells.



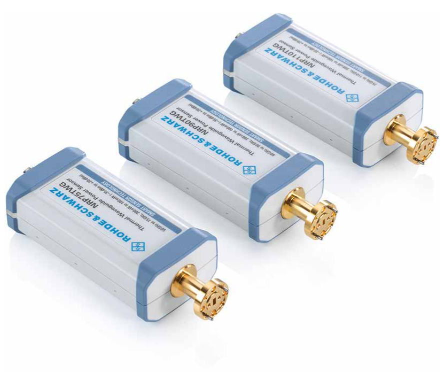
Virtual network analyzer

Many network analyzers are integrated into production lines, where they run under program control. Until now, new test programs had to be developed using either a spare instrument or a line instrument, which was then unavailable in production during the development work. The R&S®ZNXSIM virtual network analyzer eliminates this hardware requirement for the user and decouples software development from instrument availability. Basically, R&S®ZNXSIM is just licensed operation of the original instrument firmware, which can be downloaded free of charge from the web, on a PC. For the firmware to run, a dongle that is linked to a specific model – either the new top-of-the-line R&S®ZNA (see page 28) or one of the midrange models R&S®ZNB/C/D/BT – must be purchased. The complete base firmware for the corresponding instruments can be used. Customers wishing to also program time domain measurements such as eye diagram analyses require an additional option.



5G on the dissecting table

Everyone is talking about 5G. Many articles have reported on 5G performance as well as its countless potential applications in almost every area of life. However, the choices are few and far between when it comes to hard facts about 5G technology. A new English-language book from Rohde & Schwarz is helping to fill this gap. Five of the company's mobile communications specialists provide in-depth insights into the 5G NR system in this 460-page work. The Fundamentals chapter examines the system architecture and physical access techniques. This includes detailed treatment of advances vis-à-vis the 4G system in areas such as beamforming and bandwidth segmentation. The chapter is rounded out by a section on test and measurement aspects. The Overall Procedures chapter examines 5G NR from the user equipment perspective. Every aspect is covered – from power-on through establishment of a data connection to the processes that occur during mobility in the network. The description of non-standalone (NSA) mode, which will be used for mixed operation with LTE during 5G's initial phase, is followed by a chapter on 5G standalone (SA) mode. The highly illustrated hardcover edition is available from booksellers (ISBN: 978-3-939837-15-2). A regularly updated online version is available free of charge after registering (see QR code).



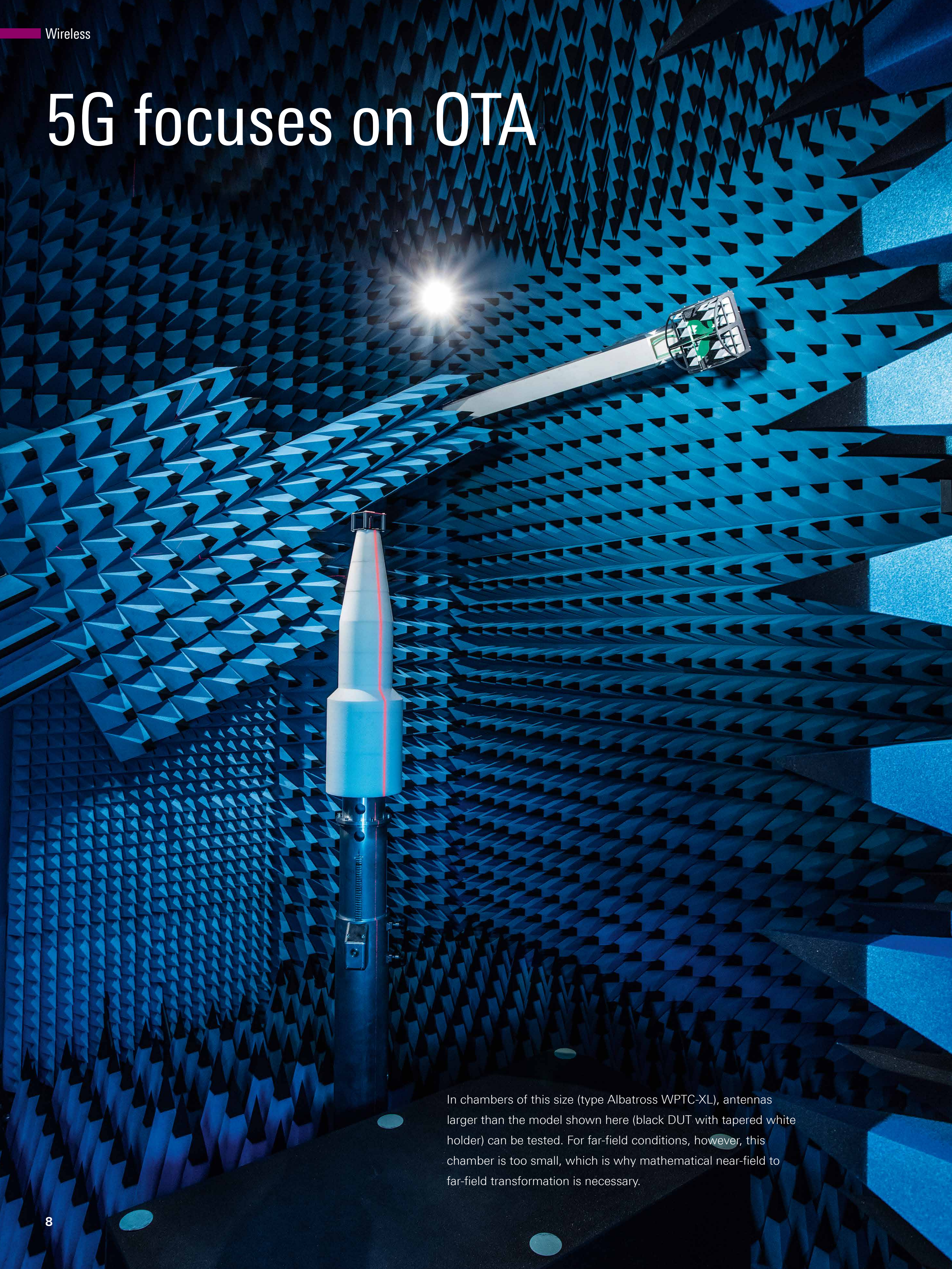
Power sensors for waveguide systems

Waveguide sections are widely used in millimeterwave applications due to their low transmission losses. Test instruments for use with waveguide systems should also have a waveguide frontend, since a waveguide-to-coax transition would diminish the accuracy and dynamic range. To satisfy this need, Rohde & Schwarz has extended its line of power sensors with some new models. The R&S®NRPxxTWG sensors for the ranges from 50 GHz to 75 GHz (WR15 connector), 60 GHz to 90 GHz (WR12) and 75 GHz to 110 GHz (WR10) cover diverse applications involving satellite, radar and communications technology. Unlike other commercial solutions that use diode rectification, the new sensors are based on the thermal measuring principle, which always produces true RMS values regardless of signal shape. The sensors are thus suitable for signals with any kind of modulation. Across the entire 55 dB dynamic range (–35 dBm to +20 dBm), the sensors rapidly reach a stable measured value (e.g. in less than one second at –10 dBm). The waveguide sensors also have all of the usual benefits of the R&S®NRP power meter family. They can be used alternatively on the R&S®NRX base unit or connected via USB to a computer or test instrument. With their plug & play design, they are immediately ready for operation with no calibration required. For customers who require extremely high accuracy, the sensors can be traced back to national calibration standards.

Advanced TV and DAB transmitter technology for the VHF band

With thousands of transmitters sold, the R&S®THx9 is the most successful family of high-power TV transmitters in the world. The success of this product line is due to its unique combination of economical operation, convenience and future viability. The latest development stage (Evo) was initially focused on UHF transmitters, but network operators can now also enjoy superior technology for the VHF range (band III) with the R&S®THV9evo. The liquid-cooled transmitters are available for DTV and DAB with output power from 1.3 kW to 30 kW. They feature high energy efficiency of up to 50 %. Thanks to the adaptive efficiency optimization that is implemented, network operators can benefit from high efficiency even after the transmission parameters are modified. Besides their energy cost savings, the digital exciter is another major benefit of these transmitters. The purely software-based exciter makes it possible to fully exploit the flexibility of new standards such as ATSC 3.0 – even including future developments. The MultiTX concept allows multiple transmitters to be installed in a space-saving manner in a single 19" rack. Despite all of their sophistication, the transmitters are easy to operate using the pull-out touch display.

5G focuses on OTA



In chambers of this size (type Albatross WPTC-XL), antennas larger than the model shown here (black DUT with tapered white holder) can be tested. For far-field conditions, however, this chamber is too small, which is why mathematical near-field to far-field transformation is necessary.

In 5G, highly integrated massive MIMO antenna systems that support beamforming are superseding classic sector antennas. These systems must be characterized over the air – a challenge for T&M manufacturers and system developers alike.

Achieving the needed high channel capacity in a 5G network requires rolling out massive MIMO base stations along with networks and mobile stations implementing both microwave and millimeterwave technologies. In 5G, the microwave range is designated as frequency range 1 (FR1, 410 MHz to 7.125 GHz) and the millimeterwave range as frequency range 2 (FR2, 24.25 GHz to 52.6 GHz).

In FR1, the main innovation effort is on the base station (BS). Active arrays (massive MIMO arrays) are deployed that can have hundreds of antenna elements. Massive MIMO has two objectives. First, it allows the generation of multiple independent data streams for simultaneous coverage of multiple mobile stations (multi-user or MU-MIMO). Second, beamforming can be used to direct these streams at specific remote stations. This focuses the energy in order to increase the coverage area, reduce interference and boost the data rate. There is also a bonus side effect of lower energy consumption, which reduces overall network costs.

In FR2, the transmission systems use large available bandwidths at frequencies around 28 GHz and 39 GHz. These high frequencies lead to high path loss based on the formula $F = (4\pi rf/c)^2$ and large electromagnetic field absorption in nearby objects. Array antennas with their improved gain help reduce this loss.

Performance metrics quantified over the air

In FR2, the need for low path losses and small dimensions is leading to highly integrated solutions combining antennas, modems, amplifiers and phase shifters. Consequently, there are no longer any RF contacts for connecting test instruments via cables. This is why over-the-air (OTA) test solutions are needed in order to characterize the transmit and receive antennas. Such solutions are also needed to verify whether the transmission lobe is pointed in the right direction.

The metrics to be determined include antenna parameters for the radiated and received power such as the effective isotropic radiated power (EIRP), total radiated power (TRP), effective isotropic sensitivity (EIS) and total isotropic sensitivity (TIS). There are also transmitter-specific metrics such as the error vector magnitude (EVM), adjacent channel leakage ratio (ACLR) and spectrum emission mask (SEM).

Antenna characteristics are generally measured in the homogeneous far field (FF). However, far-field conditions at FR2 frequencies for base station antenna sizes do not begin until a distance of many meters from the antenna. Using direct FF probing and applying the Fraunhofer distance (FHD) criterion for the far field ($r = 2D^2/\lambda$, D is the antenna aperture), a 75 cm massive MIMO device under test (DUT) radiating at 2.4 GHz would require a test chamber with a range of at least 9 m. Even a 15 cm smartphone transmitting at 43.5 GHz would require a testing distance of 6.5 m. This distance is required to create a region encompassing the DUT, the quiet zone (QZ), with the necessary phase constancy. The impinging field must be as uniform as possible and approach a plane wave with phase deviation below 22.5 °.

Theoretical research shows that actual FF behavior in the peak directivity region can start much closer in than the FHD. Research results proved, for example, that the FF EIRP or EIS of a 15 cm DUT radiating at 24 GHz can be accurately determined at a distance as short as 1.14 m. This distance reduction of about 70 % is achieved at the cost of increased longitudinal taper error. Also, side lobe levels cannot be evaluated accurately at shorter distances.

While direct FF measurements at shorter distances are not practical for all applications, they are beneficial in cases where the necessary conditions are met. This is because large anechoic chambers have high costs of ownership and limited dynamic range due to the path losses. The simplest scenario is the “white box” case where the antenna location within the device and its aperture size are known and the aperture fits entirely within the QZ. If this is not the case or if the DUT has multiple antennas situated on opposite edges of the enclosure, then we have the “black box” scenario where the radiating currents can flow anywhere within the DUT. Due to the potentially larger aperture, a significantly larger QZ must be implemented, making direct FF measurements difficult. For such situations, we can employ near-field to far-field transformations (NFFF) as an alternative.

Software NFFF transformations

A first efficient approach for reducing the FF distance (and thus the necessary size of the shielded chamber) involves the use of software transformation methods. The mathematical implementations may vary, but the concept is generally the same: at least two polarization components of the

Fig. 1: The R&S®ATS1000 is an example of a spherical measuring system that supports both direct far-field measurements and software-based near-field to far-field transformation. The DUT can be precisely positioned with the aid of a laser. The system can be equipped with a hemispherical climatic chamber that fully encloses the DUT and allows measurements under climatic stress across a wide temperature range.

electromagnetic field (E, H or a mixture of the two) are measured in magnitude and phase over a spherical surface encompassing the DUT.

The measured data is processed using mathematical functions to propagate the fields towards larger distances and extract far-field radiation components. From the Huygens principle, the knowledge of two phasors (complex amplitudes) is enough to reconstruct exactly all six field components outside the surface. Alternative transformation methods use spherical wave expansion (SWE), plane wave expansion (PWE) or integral equation resolution, along with techniques to improve computational efficiency or accuracy by taking parameters such as the spatial sampling rate, scanning area or truncation into account.

Fig. 1 shows a system capable of measurements using spherical scanning around the DUT. The DUT is positioned on a turntable rotating in azimuth. A dual-polarized Vivaldi antenna is mounted at the tip of a boom rotating in elevation. The DUT is connected to one port of a vector network analyzer (VNA). The antenna ports for the two polarization planes are connected to two other VNA ports, enabling measurement of complex S-parameters such as the transmission and reflection coefficient.

Near-field measurement methods often rely on assumptions applying to this above-described case of "passive or RF-fed antenna testing":

- The antenna feed port is accessible with a signal fed to the antenna that is used as phase reference
- The RF signal is a continuous wave (CW) signal
- Reciprocity applies so that transmit (TX) and receive (RX) patterns are identical at the same frequency

There are workarounds available in TX cases where such assumptions do not apply. Hardware and processing implementations to retrieve the propagation phase vary, for example using interferometric techniques or multi-port phase-coherent receivers, with the addition of a dedicated phase reference antenna that has to be installed in the vicinity of the radiating DUT. Alternative approaches include phaseless methods where the phase information is retrieved from magnitude-only measurements.

The RX case is more complex because usually the entire RX chain must be measured since the sensitivity is verified based on attainment of the minimum required data throughput. The reciprocity assumption does not apply since the RX RF component chain is in general different from the TX RF chain. Furthermore, for a receiving DUT with no antenna test port, the power available at the input to the RF frontend cannot be straightforwardly predicted. There is also no access to a phase reference in this case so that the software NFFF transformation becomes inapplicable. Therefore, effective isotropic radiated power (EIRP) can be evaluated accurately in the near field using software NFFF but not effective isotropic sensitivity (EIS).

Software NFFF methods reach their limits when attempting to determine transceiver metrics such as EVM, ACLR and SEM. Such information must be extracted directly from the modulated signal. However, software NFFF solutions only process the complex amplitude values used to derive a three-dimensional representation of the antenna characteristics. Using advanced T&M methods, however, this is not a major limitation since compact measuring systems can create an "indirect far field", allowing measurements to be performed that are comparable to the true far field.

Hardware-based near-field to far-field transformation provides clarity

Different testing methods enable direct OTA assessment close to the antenna without applying a software transformation. In these hardware approaches, the idea is to physically create far-field conditions in a specified quiet zone (QZ) region within a short range. This "indirect far field" can be created in a compact antenna test range (CATR) or by using plane wave synthesis.

Compact antenna test range

A CATR uses a parabolic reflector to transform a spherical wavefront from the DUT into a planar wavefront (Figs. 2 and 4). The quality of the measurement results that can be obtained with a CATR depends on the reflector quality. The edge shape and surface roughness influence the frequency range in which an acceptable quality quiet zone can be produced. The edge configuration limits the lowest operating frequency while the surface roughness determines the upper frequency. Serrated or rolled edges prevent diffraction that could otherwise significantly contaminate the QZ. The reflector size with serrated/rolled edges is generally at least two times the DUT/QZ size whereas a reflector with sharp edges is three to four times the size of the QZ.

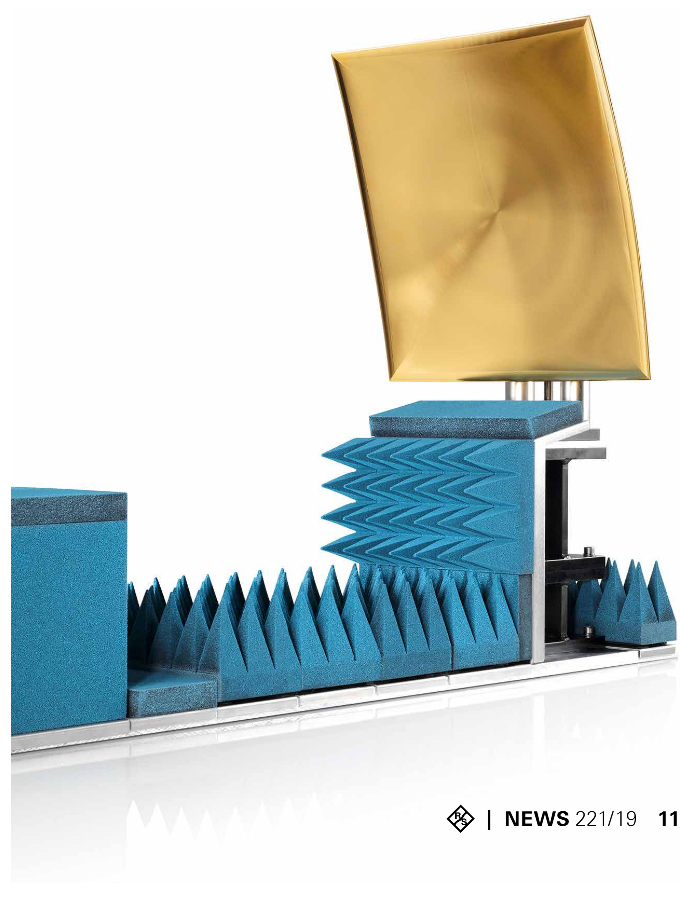


Fig. 2: The reflector's shape and manufacturing precision are important quality parameters in a CATR system. The R&S®ATS800B CATR benchtop system is a cost-effective solution for development and research laboratories that need high-quality measurement results.

The feed antenna's radiation pattern has a direct impact on the size of the QZ since the reflector essentially "projects" the pattern onto the QZ. Since the QZ size depends more on the reflector characteristics than on how far the DUT is from the reflector, it is much easier to create a large QZ inside small enclosures, which makes testing simpler. The CATR test setup shown in Figs. 2 and 4 fits inside a chamber measuring only 2.1 m × 0.8 m × 1 m (R&S®ATS800R). A direct FF measuring system would require a range of up to 14.5 m.

CATRs are of great interest for testing mobile and base stations operating in 5G NR FR2 since they considerably reduce the size of the test environment and produce measurement results directly, i.e. without any further NFFF computations. In addition, CATRs have the same capabilities as an FF system in terms of direct measurements of RF transceiver metrics in both TX and RX mode. Finally, since the path loss of such a system only occurs in the region between the feed and the reflector, the dynamic range of a CATR system is also improved compared to a direct FF approach.

Fig. 3: The R&S®ATS1800C test chamber is used for (pre)conformance testing of reference designs and mobile devices. The positioner can accommodate DUTs with sizes up to about DIN A4 and weighing up to several kilograms.

Plane wave synthesis using a phased antenna array

While CATRs can be built for 5G millimeterwave DUTs using relatively compact and lightweight reflectors (20 kg to 40 kg), the reflector weight increases significantly in FR1 – up to hundreds of kilograms for DUTs the size of base stations. The cost, fabrication time and handling of the large, heavy reflectors becomes prohibitive. An "electronic version" offers a lightweight, cost-effective alternative. It consists of an antenna array with multiple elements that are individually controlled in amplitude and phase to produce a planar wavefront starting at a relatively short distance.

Rohde & Schwarz has developed such a planar wave converter (PWC) consisting of 156 wideband Vivaldi antennas and a network of phase shifters and attenuators. This PWC array is 1.7 m wide and creates a spherical QZ of 1 m diameter at a distance as short as 1.5 m in the frequency range from 2.3 GHz to 3.8 GHz (Fig. 5). A combined-axis positioner is used to position the DUT (e.g. a base station antenna) in the QZ. In the figure, the DUT is a calibration antenna that is used to control the levels of individual RF channels as well as to determine the path loss of the entire test system. The PWC is reciprocal and has only one RF input/output, which can be connected to a signal generator, spectrum analyzer or vector network analyzer.

Summary: OTA measurements are simpler than ever

The need to test 5G components over the air requires new, more sophisticated measuring equipment than previous mobile communications technologies. The challenge for T&M manufacturers is producing such equipment at competitive prices while ensuring simple operation. The solution is a measuring system that can reliably assess the behavior of a DUT in the far field without having to install large shielded chambers that satisfy the Fraunhofer far-field criterion. Near-field techniques employing software transformations are suitable for evaluation of EIRP and TRP quantities. When RX or demodulation is involved with a DUT using multiple non-identical RF transceivers, methods utilizing hardware field transformations such as CATR and PWC can overcome the limitations of software NFFF. They also provide compact and reliable alternatives to direct far-field measurements, putting them in pole position for future 3GPP RF conformance testing of mobile devices and base stations.

Dr. Benoît Derat, Dr. Corbett Rowell, Dr. Adam Tankielun, Sebastian Schmitz

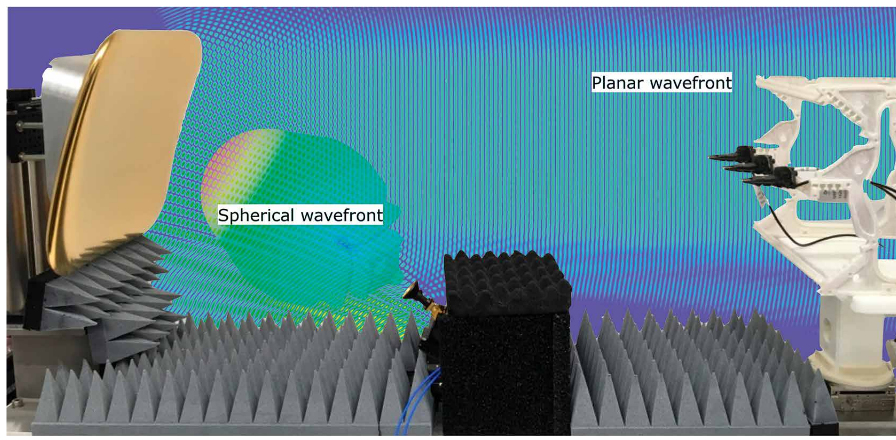


Fig. 4: Compact antenna test range (CATR) with a roll-edged reflector collimating a spherical wavefront into a planar wavefront (fields computed with a model of the actual setup implemented in the CST MWS simulation software at 28 GHz).

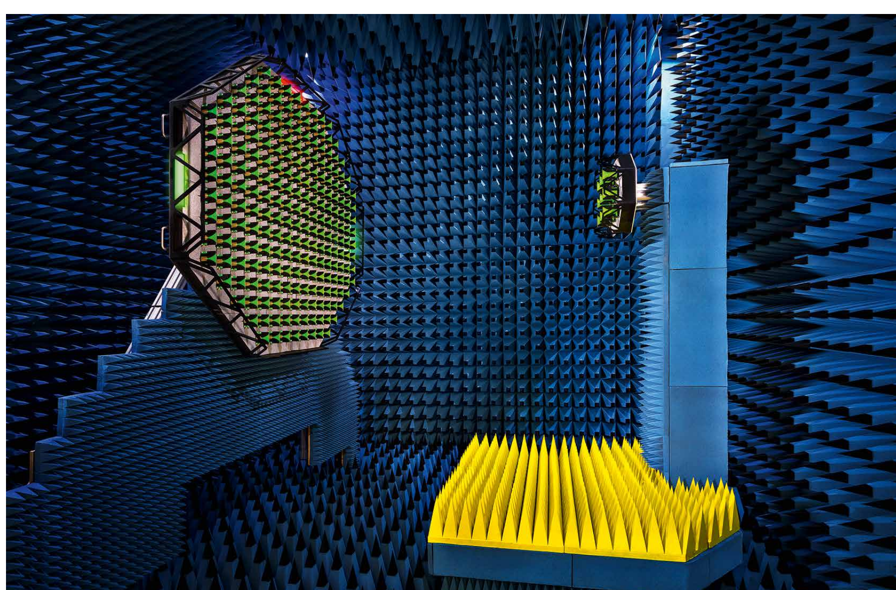


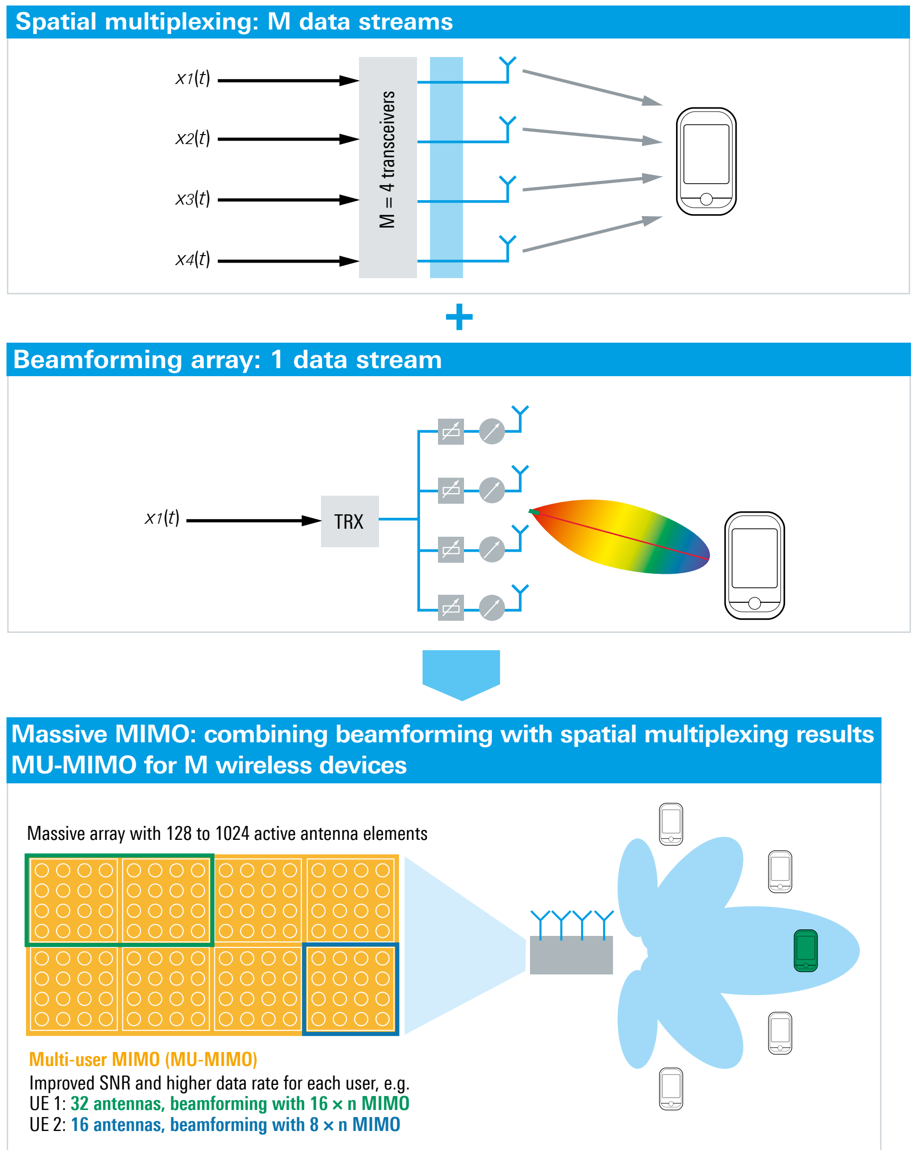
Fig. 5: The heart of the plane wave converter measuring system from Rohde & Schwarz is the R&S®PWC200 phased array (left). In place of the DUT is a calibration antenna array mounted on a great circle cut positioner.

Small massive MIMO compendium

What is massive MIMO?

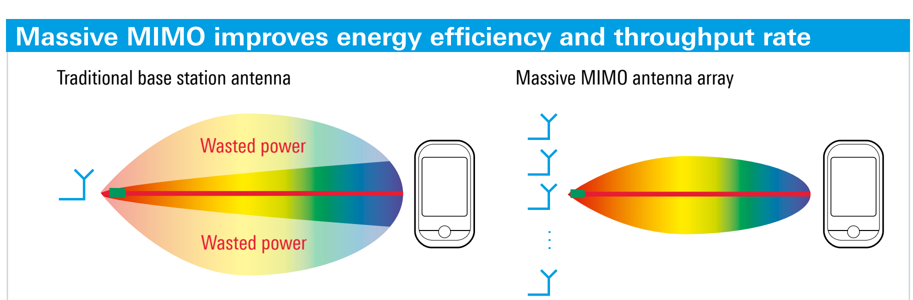
Multiple input multiple output (MIMO) technology uses multiple antennas at the transceiver to improve transmission performance. Either multiple transceivers transmit via separate antennas over uncorrelated propagation paths to achieve higher throughput for one or more users (spatial multiplexing), or the same output signal is transmitted via multiple antennas and combined in the receiver to improve the signal quality (RX diversity).

Thanks to the large number of antenna elements in massive MIMO systems, both concepts can be combined. An antenna system that supports beamforming as well as spatial multiplexing is known as a massive MIMO system. Although massive MIMO is applied only in base stations, wireless devices are also using increasing numbers of antennas to implement MIMO techniques.



Why massive MIMO?

Beamforming with massive MIMO focuses the transmitted energy, effectively increasing the energy efficiency – an important aspect when operating a mobile communications infrastructure since radio transmissions are the main contributor to energy costs. Beamforming also increases the range and reduces interference between cells. Range is very important at 5G millimeterwave frequencies due to the high path attenuation. Massive MIMO in the FR1 range will be primarily used to transmit spatially separated streams for multiple receivers (MU-MIMO).



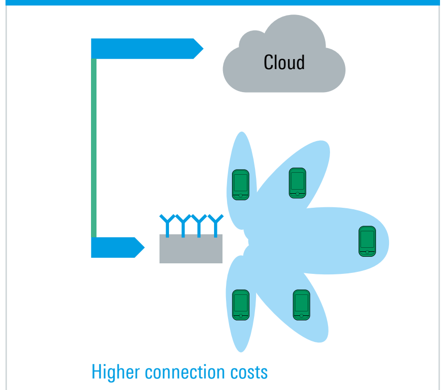
Technical challenges of massive MIMO

Massive MIMO is a sophisticated concept that requires system designers to solve a number of problems.

Ideal pattern

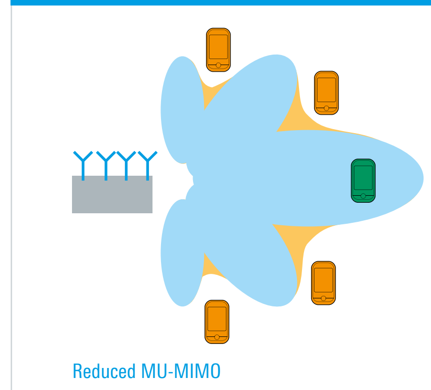
Resulting pattern

Data bottleneck



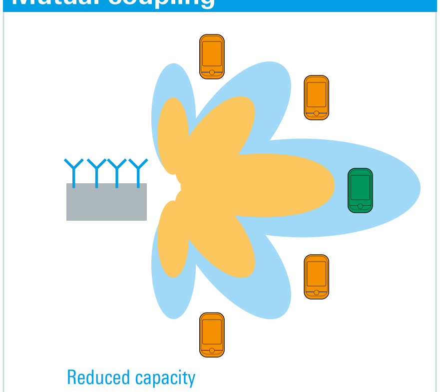
The high data throughput of a massive MIMO system requires an ultra wideband connection between the base station and the core network.

Calibration



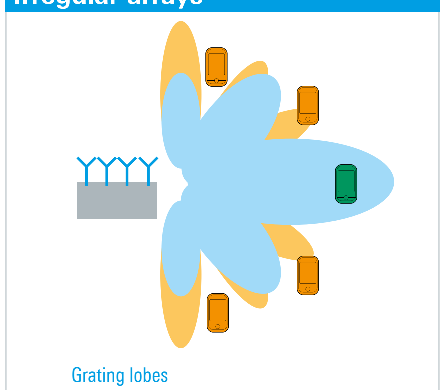
Antenna arrays that have not been properly calibrated can radiate in unwanted directions. This beam squinting means less than optimal coverage for the receivers.

Mutual coupling



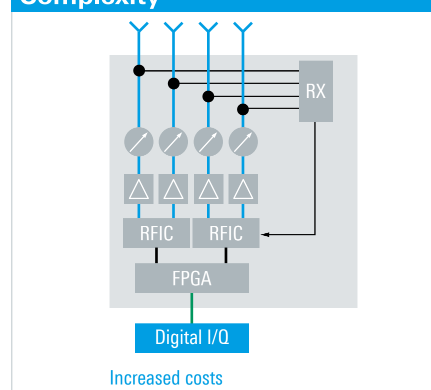
Mutual coupling between antenna elements leads to energy loss and thus a reduction in the maximum range.

Irregular arrays



In practice, some antenna arrays will need to be designed with non-geometric shapes that may result in dissipating energy in undesired directions.

Complexity



Massive MIMO systems represent a new level of complexity from a design, manufacturing, calibration and deployment perspective. This level of complexity requires new approaches to design and testing.

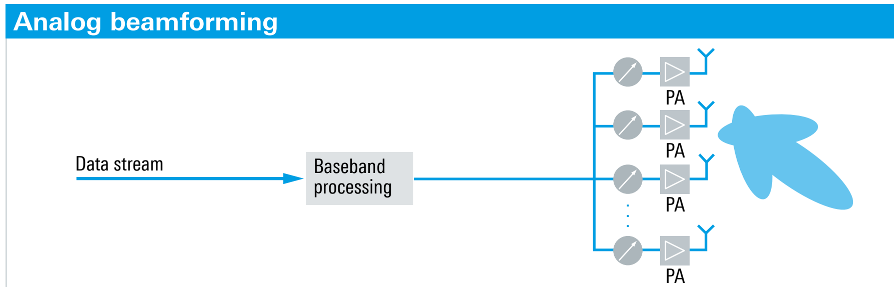
Different beamforming techniques

In order to achieve a certain directivity with antenna arrays, the amplitudes and phases of all antenna elements must interact in a defined way. There are three possible approaches.

Analog beamforming

The traditional approach, used for example in radar applications, uses phase shifters and power amplifiers to steer the beam into the desired direction and reduce the sidelobes to a minimum. The small amount of hardware makes this a cost-effective method for building a beamforming array of lower complexity. Typically, an analog beamforming array is connected to one RF chain generating only one beam at a time, and the range of the phase shifters limits the applicable frequency range.

Analog beamforming



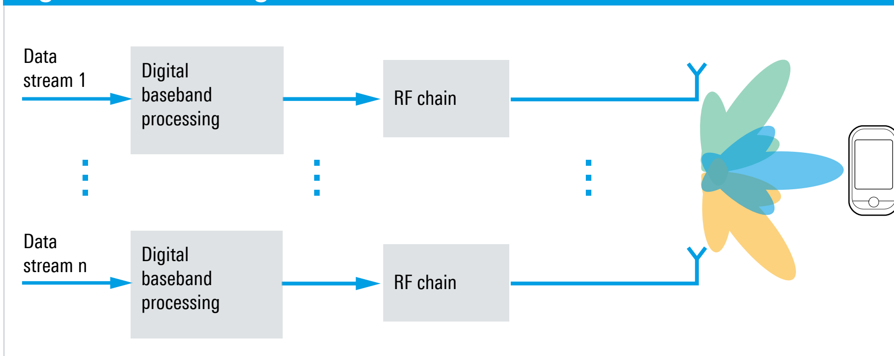
Digital beamforming

This more advanced architecture is not actually used to steer beams. Instead, it optimizes coverage of the different receivers with individually computed path streams. Each antenna has its own transceiver and data converters, allowing it to handle and generate multiple independent data streams. The base station and wireless device form a control loop where the BTS uses pilot signals from the wireless device to continuously adjust the precoding matrix for that device. Each receiver therefore receives perfectly tailored signals via diverse paths. This type of feedback control works best in TDD systems where the radio channel is reciprocal in the uplink and downlink.

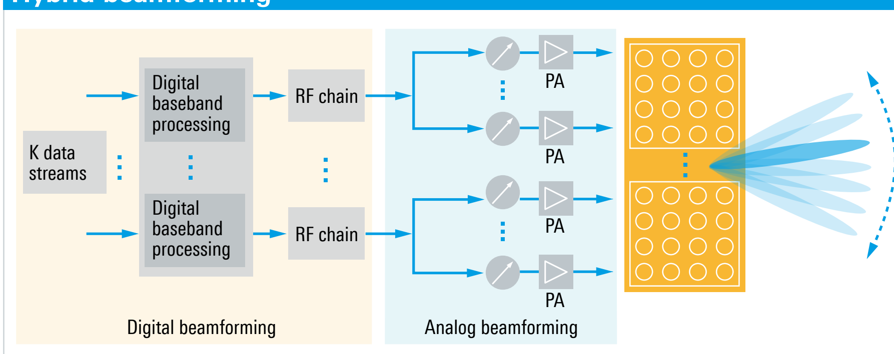
Hybrid beamforming

Hybrid beamforming balances the cost and performance advantages and disadvantages of analog and digital beamforming. Targeting higher frequency ranges, such designs combine analog beamforming arrays with digital preprocessing stages.

Digital beamforming



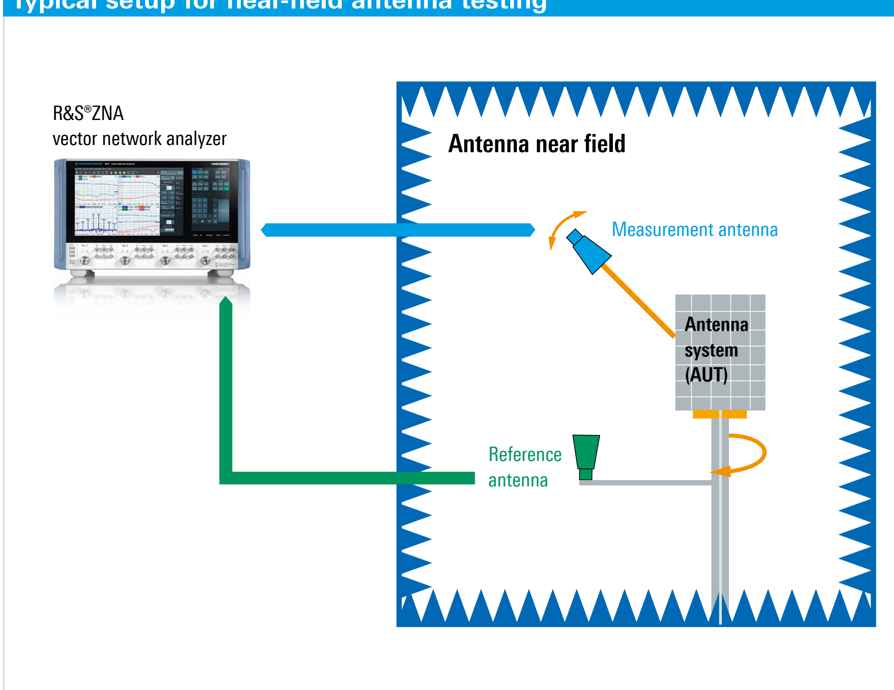
Hybrid beamforming



How do you connect the antenna array in a test setup?

The directivity of antenna arrays requires an over-the-air (OTA) test setup. Passive antennas use the traditional testing approach in which the generator in a vector network analyzer (VNA) supplies a signal to the antenna under test. The signal from the AUT is received by the measurement antenna and fed to a receiver port on the VNA. This test is straightforward to implement and delivers comparable results.

Typical setup for near-field antenna testing



Massive MIMO antennas, on the other hand, are integrated together with signal processing and RF circuitry to form complete units that are connected to the base station via a digital interface such as CPRI. As a result, the phase of the emitted signal cannot be accessed, but this information is crucial in order to convert near-field measurements to far-field data.

One possible workaround is to steer a beam by using a smaller number of neighboring antenna elements to reduce the antenna aperture, which allows a far-field scenario to be created in a test chamber under certain circumstances. Near-field test solutions from Rohde & Schwarz are based on a reference antenna (field probe) positioned at a constant distance to the AUT, providing a reference phase.

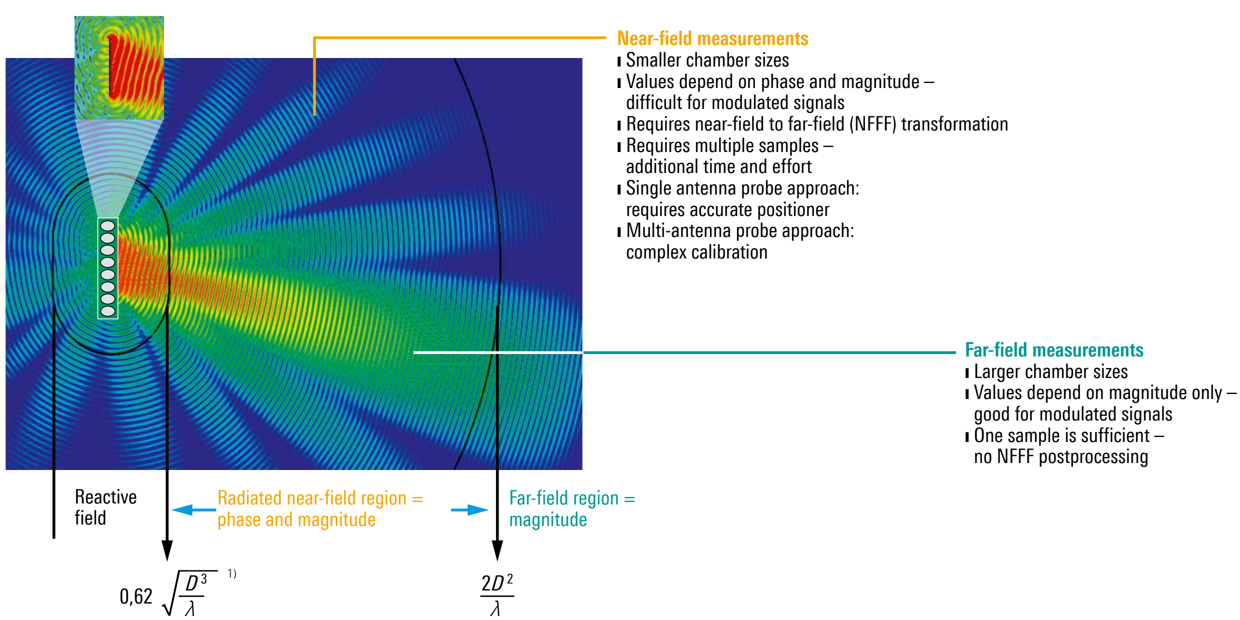
Measurements in the near field are very time-consuming and do not deliver all of the relevant parameters. It is faster and more universal to perform measurements in the quasi far field, but this requires more complicated test equipment (see below).

Near field or far field?

The distance between the antenna under test (AUT) and the measurement antenna is crucial for OTA measurements. Electromagnetic coupling with intruding objects such as measurement antennas at a distance smaller than the first Fresnel zone (typically only a few centimeters) occurs in the very near field, or reactive field, which is why measurements are not possible here. Measurements in the adjacent radiated near field depend on magnitude and phase and require complicated postprocessing to convert the data to the far field. The data comes from sample measurements on specific trajectories or on a spherical surface around the AUT. The test setup has to have a 3D positioner to allow the measurement antenna to access every point on the sphere.

Rohde & Schwarz has proposed additional methods for near-field and far-field estimation. One of these methods is based on power measurements at different distances. Another approach is based on the half-power beamwidth that reduces the aperture size D to the size of the "radiating part" D^* that is typically smaller. A further approach considers that only the main beam is of importance for measurands such as EVM, resulting in a significantly reduced distance between the AUT and the measurement antenna.

Measurement aspects in the near field and far field



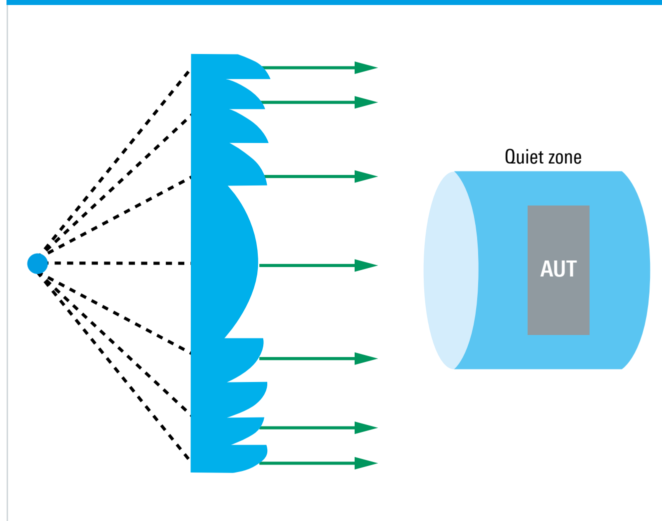
[1] Typically for radiators with $D > \lambda/2$

How do you create far-field conditions at short distances?

Theory recommends testing antenna arrays under far-field conditions, especially when performing EVM measurements, since the phase varies in the near field. The easiest method of generating far-field conditions is to extend the distance between the AUT and the measurement antenna as described by the Fraunhofer diffraction. For large arrays, however, this can lead to distances of dozens of meters. Therefore, near-field to far-field (NFFF) transformation methods are commonly used.

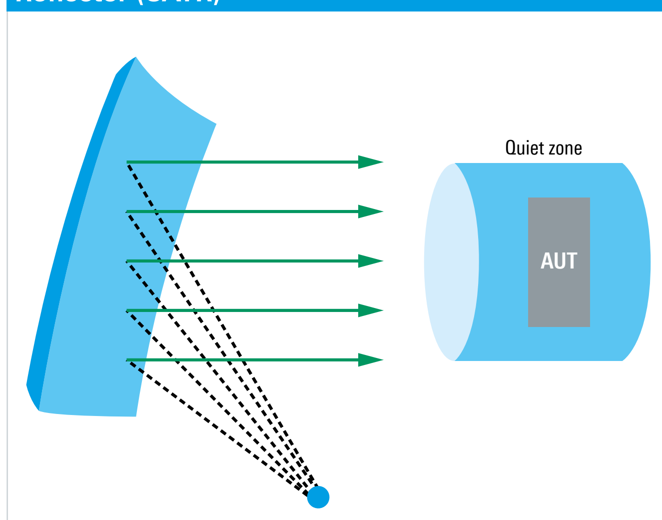
The idea of using a Fresnel lens is well known in the optical world. In the RF world, this method is rather complex and involves high costs, making it unfeasible for industrial applications.

Fresnel lens (Fourier optics)



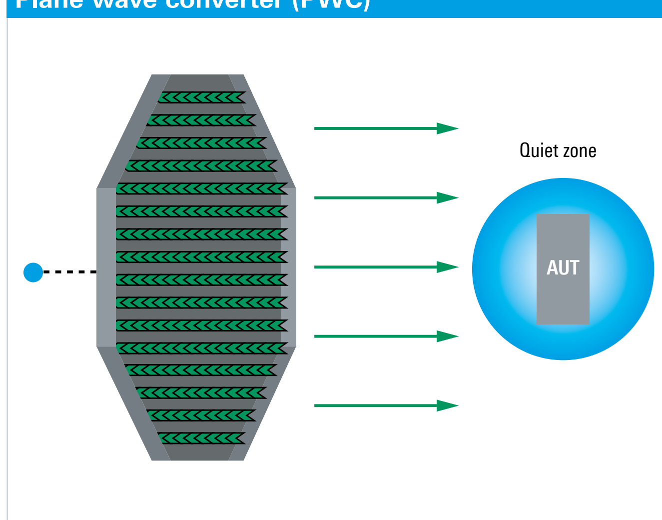
Compact antenna test ranges (CATR) are well known in the industry. A reflector is used to generate a cylindrical quiet zone – a zone where the observed phase difference to a plane wavefront is below a user-specific tolerance. The reflector size is typically around two to three times the diameter of the quiet zone. The roughness of the reflector surface should not exceed a value of about λ/100 (approx. 0.1 mm for the FR2 range of 5G). In order to attain high field quality in the quiet zone, the reflector edges must be either serrated or rolled.

Reflector (CATR)



Wave synthesis with an antenna array is an elegant way of generating a homogenous field in a very small space. Rohde & Schwarz developed such a solution for sub6 GHz frequencies: the R&S®PWC200 plane wave converter. It uses phase shifters and an octagonal 1.7 m diameter antenna field to generate a spherical quiet zone with a diameter of 1 m at a distance of 1.5 m, allowing operation under tight space constraints in laboratories.

Plane wave converter (PWC)



T&M equipment for massive MIMO components

Massive MIMO testing covers a wide range of applications, taking into account technical aspects such as near field, far field, frequency, antenna type and parameters to be tested. Test configurations and tests considerably differ when testing in R&D, manufacturing and in the field. Upcoming application areas such as beamforming certification and verification and production-oriented testing will generate new requirements when it comes to accuracy, speed, costs, etc.

There are four key components to any massive MIMO measuring system:

Shielded chamber

Various sizes to cover near-field and far-field aspects, shielding and absorption capability, chamber access, etc.

Measurement antenna

Key considerations are frequency range, size and calibration.

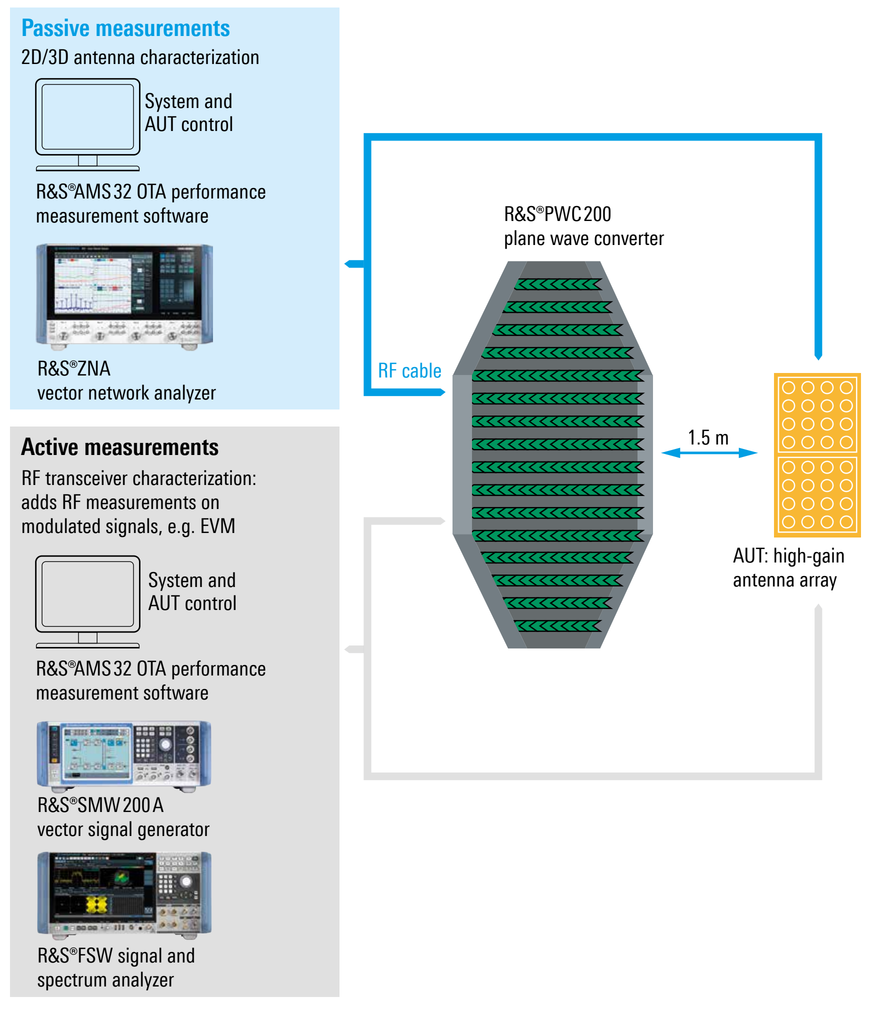
AUT fixture and measurement antenna positioner

A spherical pattern measurement around the AUT is required to measure parameters such as EIRP, EIS and TRP. The measurement quality depends on factors such as the precision and reproducibility of positioning the measurement antenna.

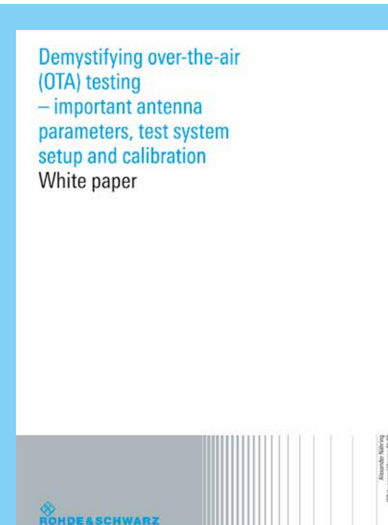
T&M equipment

The required T&M equipment depends on the specific measurement task. A typical massive MIMO test system includes vector network analyzers, signal generators, signal analyzers, wireless communications testers and power sensors.

Test setup based on a plane wave converter for antenna arrays



A white paper providing detailed information about OTA test and measurement solutions can be downloaded from the Rohde & Schwarz website.



The new 5G testers

Testing 5G NR products requires new test and measurement approaches. Technologies such as massive MIMO, substantially higher bandwidths and data rates than in 4G, and the use of millimeterwaves have greatly increased the necessary computing power while making OTA measurements compulsory and creating challenging requirements for RF hardware. In the future, the following testers will be workhorses for 5G measurements in development, QM acceptance testing and production:

The R&S®CMX500 radio communication tester (bottom left) is the new test platform for signaling tests in all 5G frequency bands. It works together with the tried and tested R&S®CMW500 tester (top left) to provide support for mixed operation with LTE (5G NSA), which will be predominant worldwide in the first years.

Measurements in the FR2 range (mmWave) are performed in OTA test chambers such as the R&S®CMQ200. In combination with the new R&S®CMP200 non-signaling tester (top center), it provides a compact solution for production testing of 5G FR2 components. For production tests in the FR1 range (sub6 GHz spectrum), the R&S®CMW100 tester is the right choice (not shown). The R&S®CMX500 and R&S®CMP200 are operated via unified test software (right). The software provides access to the measurement functions via a browser-based user interface.

Reproducibly simulating complex field tests in the lab

New options boost the quality of field test approximation for mobile devices in the R&S®CMWcards graphical development environment.

The test cycle of a mobile device starts with testing individual signaling functions and ends with field tests in the operational network of the operator. Field tests are the most meaningful in terms of the end user experience, but they are also the most time-consuming and costly. In addition, they are not always reliably reproducible in all details because operational networks are constantly changing. This makes troubleshooting more difficult.

Another challenge is testing the interaction of embedded modules with the higher-level system. This can lead to malfunctions that cannot be verified by testing the components separately. For drive tests, mobile communications devices in passenger vehicles and telematics applications in the logistics industry are especially relevant. Smooth interaction of all modules in mobile systems is considerably more important with 5G since time-critical low latency applications can also be implemented with the new standard.

A test solution that combines the advantages of lab tests and field tests would be ideal. The R&S®CMWcards test suite now offers developers and test engineers two modules that make measurement data from the field accessible for laboratory analysis.

Convenient field-to-lab signaling for R&S®CMWcards

R&S®CMWcards on the R&S®CMW platform provides a high-performance development environment for test cases for mobile communications standards from 2G to 4G (Fig. 1). The tool does not require a programming language. Test cases can be created using a graphical user interface, merged into test sequences and performed automatically.

The R&S®CMW-KT030 field-to-lab option imports signaling data from drive test log files into R&S®CMWcards. It extracts MIB/SIB messages, cell properties, RRC configurations and NAS configurations. It can import files from Rohde&Schwarz tools such as R&S®QualiPoc, R&S®ROMES and R&S®Nestor. It supports the Open Log open interface and the log formats of chip manufacturers such as Qualcomm, Intel and MediaTek. This data can be used to simulate local network scenarios at

Fig. 1: R&S®CMWcards on the R&S®CMW500 platform.

the logic level. Another option allows you to simulate specific RF conditions at the measurement site where the data was collected.

The R&S®CMW-KT041 RF power replay option processes the RF data from the log files. Fig. 2 shows the overall field-to-lab workflow.

Drive tests can last several hours, generating a corresponding volume of recorded log files. But testers and developers are usually only interested in short sections of the drive test. Therefore, predefined filters are used to identify relevant information in the imported data.

Field-to-lab workflow

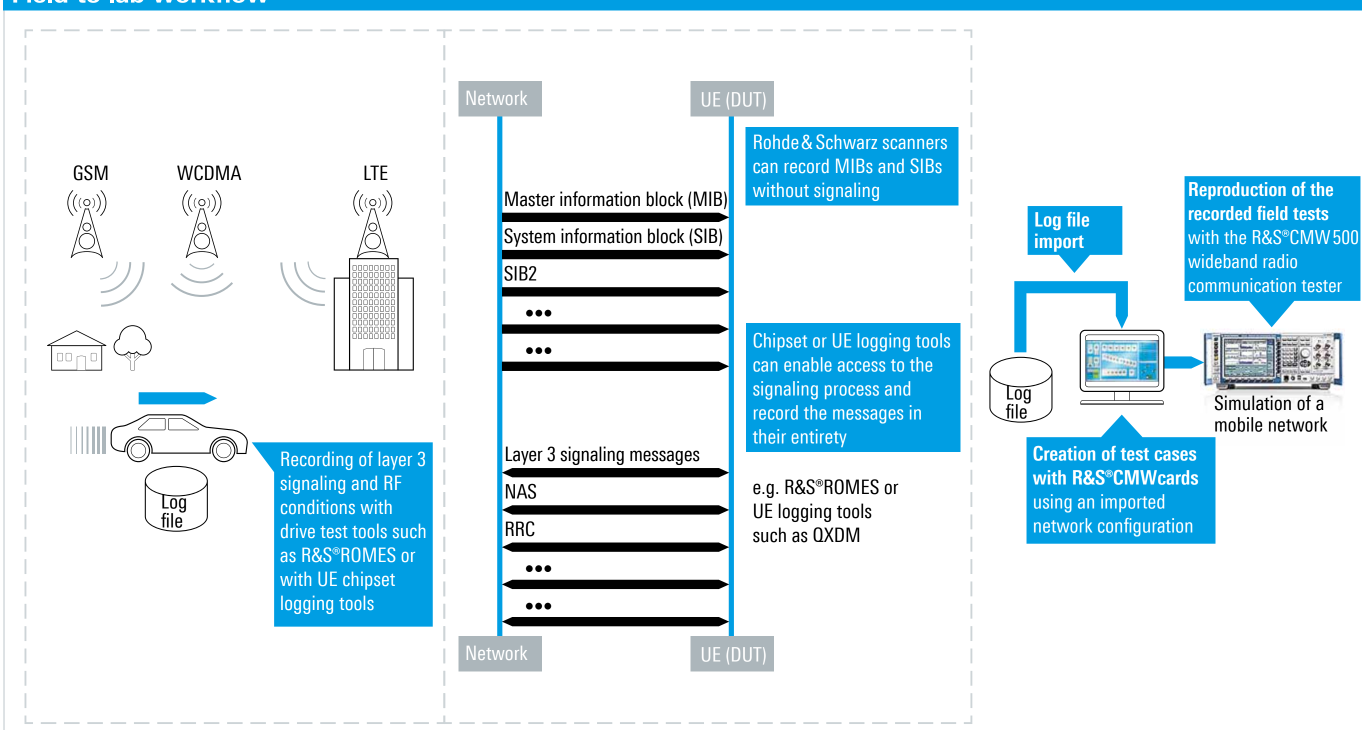
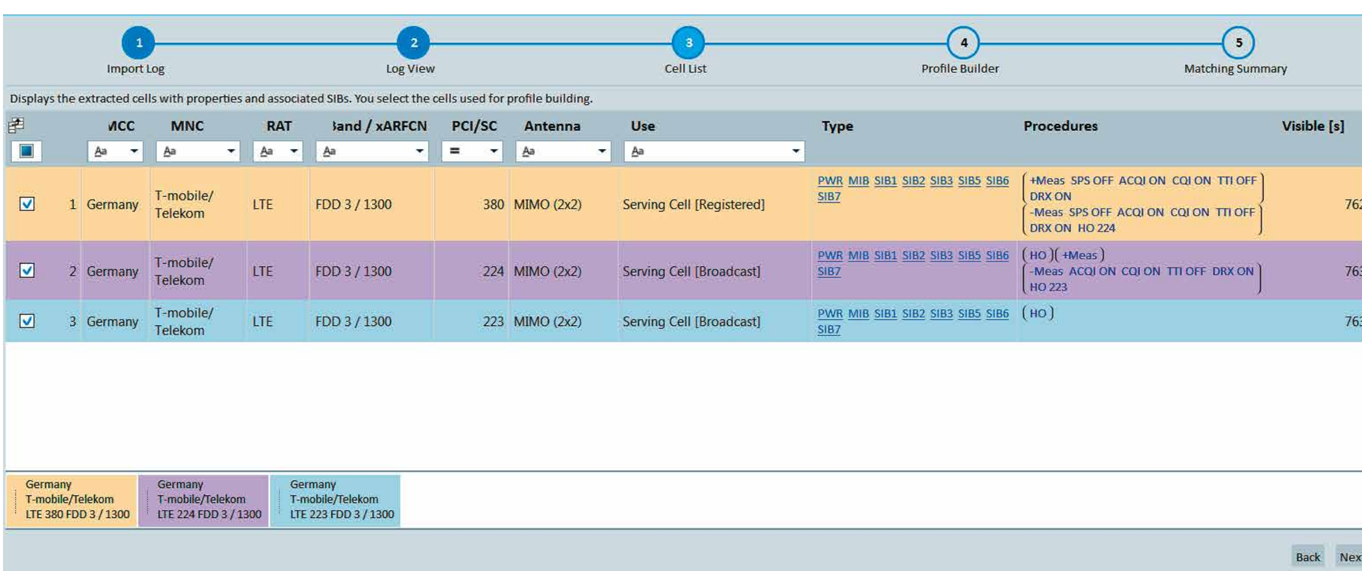


Fig. 2: Field-to-lab workflow from the field test to the lab test.

Fig. 3: List of selected cells with respective log data.



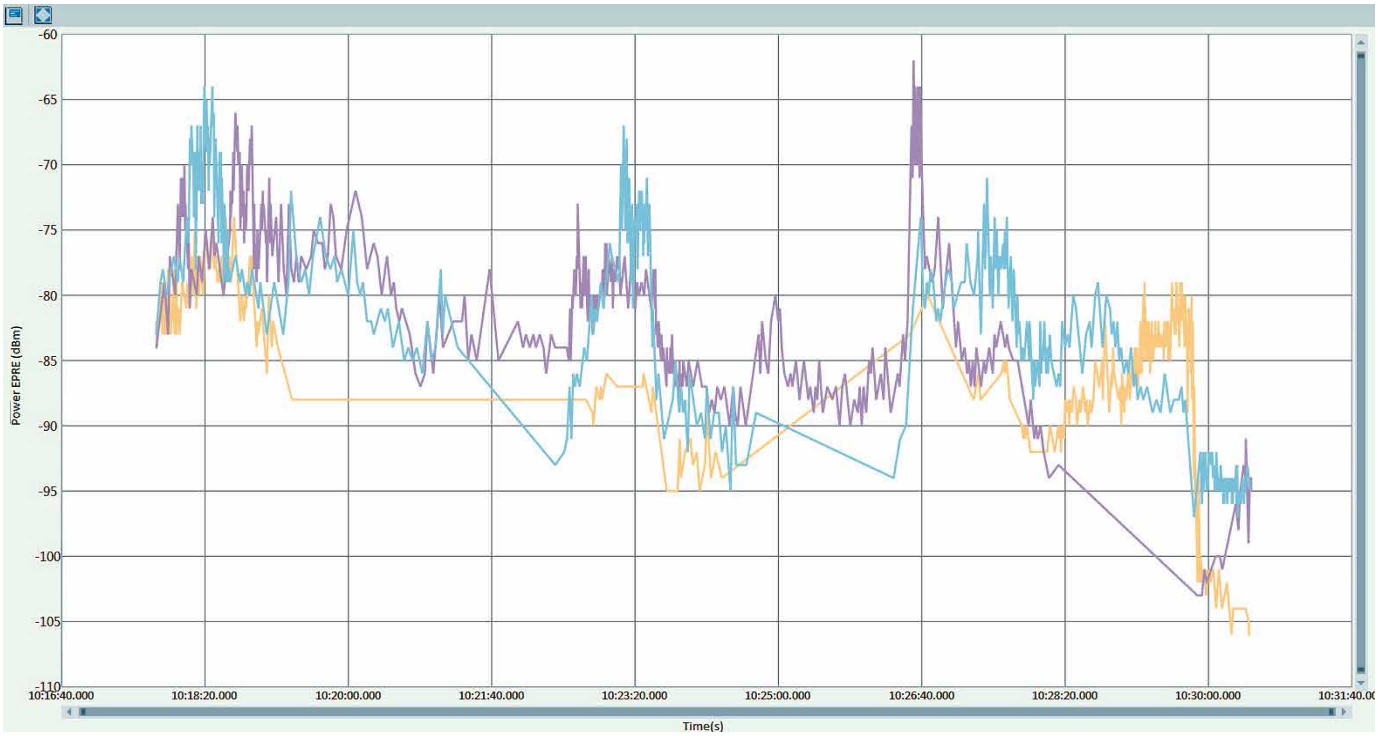


Fig. 4: The recorded RF levels of the selected cells plotted in the time domain.

Extensive filter and analysis tools are used to select relevant cells (together with their cell data and message types) from the list of recorded events. The information they contain, such as MIBs/SIBs and RRC procedures, is listed (Fig. 3) and the corresponding RF levels are shown on a graph (Fig. 4).

Network profiles can be created from the selected cells and cell parameters and incorporated in signaling sequences of test cases defined in R&S®CMWcards. The scenarios can be augmented with the RF parameters measured in the field so that lab procedures such as registration and cell selection/reselection are performed with exactly the same network and cell parameters as in the field test. Even handover and out-of-sync scenarios are realistically simulated with the recorded RF levels.

For error analysis, R&S®CMWmars provides an extensive and proven toolkit for processing test logs that drastically reduces the time needed to identify the cause of the error in the field test.

With the network profiles obtained from the field tests, the test plans in R&S®CMWcards, e.g. for regression tests, can be reused in test suites for specific network operators. This is done by simply dragging and dropping the network profile onto a test case or a test campaign. The test case maps that are changed by the network profile are marked, making it easy to understand and adjust the operator-specific modifications. This enables improved prequalification for field tests and reduces the probability of errors in future drive tests.

The R&S®CMW-KT030 field-to-lab option and R&S®CMW-KT041 RF power replay option in R&S®CMWcards provide a comprehensive and convenient toolset that can greatly reduce the number of test drives necessary for mobile devices, and efficiently simulate and resolve errors in the lab. The test cases can easily be integrated into regression suites, increasing the quality of future versions of the mobile devices before the first field tests. Plans are in place to extend the field-to-lab option by adding RF aspects and the creation of complete fading profiles based on the Doppler shift and delay data from field test measurements. A 5G enhancements is also planned for the near future.

Dr. Wolfgang Kalau

In brief

New walk test system ready for 5G networks

Freerider walk test systems have been used for years now as part of quality test campaigns for mobile communications, e.g. in the New York City subway. These systems automatically provide quality data that is accurate to the meter for all receivable mobile communications services. This is especially relevant in places that are only accessible on foot, such as shopping centers, airports, stadiums and pedestrian zones. Results of this kind are appealing to network operators who need to compare performance with the competition – as well as to users, who in many cases rely on measurement results published in major test magazines when choosing a provider.

The inner workings of the R&S®FR4 Freerider4 (Fig. 1) have been fully redesigned compared with version 3. Up to 12 test smartphones can now be used to simultaneously gather data and transfer it to the system computer. Such analytical power is sometimes needed for simultaneous testing of different quality criteria in multiple networks. Video and voice quality measurements require a certain amount of time and should not slow down any other concurrent measurements. In addition to these quality of service criteria, it is important to determine on-site RF conditions. If the field strength is too low or interference is occurring, a local service quality drop-off detected by the test smartphones can be easily clarified. Measurements of this type are the domain of the new RF scanners in the R&S®TSMx6 family. With their modular design, these scanners allow the right system to be assembled for every test campaign (Fig. 2). In extreme cases, five scanners with 20 MHz bandwidth can be connected in parallel to form a virtual 100 MHz scanner, allowing broadband real-time measurements in the 5G millimeterwave bands as soon the appropriate cells are rolled out. This frequency range (24 GHz to 30 GHz) is covered by the new R&S®TSME30DC downconverter, which has five IF outputs for feeding the same number of scanners. The measurement software transparently integrates the downconverter, so the user does not have to worry about any settings. A single scanner plus downconverter is enough to perform nearly simultaneous measurements on all network technologies, including the 5G bands. Fast switching is performed between the millimeterwave and FR1 range. Customers requiring realtime performance or a wider dynamic range, or who wish to perform 4×4 MIMO measurements in LTE, can connect additional scanners.

The Freerider4 is easy to operate via a tablet or notebook connected to the system computer via Wi-Fi. The actual measurement software depends on the specific application. For benchmarking campaigns, SmartBenchmarker comes into play, while the powerful R&S®ROMES4 analysis suite is used primarily for network optimization. Public authorities can use R&S®NESTOR, e.g. for crime scene forensics (see p. 6).

During measurements, there is no need to take hold of the backpack. A central button is used to start and stop the system. All components are powered from a central battery unit with enough energy for a test campaign lasting several hours. Despite the fan cooling, which allows operation across a wide temperature range, the system runs silently. Shocks and vibrations are easily handled, making vehicle-based measurements another possibility. In the latter case, the system can be powered from the vehicle's battery.

(red)

Fig. 1: The backpack has room for all required components. The Freerider4 is operated using a notebook or tablet.

Fig. 2: The miniature scanning system for the Freerider4 supports all mobile communications standards, including 5G with millimeterwave bands: R&S®TSMA6 RF scanner with integrated computer (middle), system battery (below) and R&S®TSME30DC downconverter (above).

WLAN 802.11ay: up to 176 Gbit/s over the air

The new WLAN standard advances into higher frequency ranges and promises significantly higher data rates and larger range. The R&S®FSW85 signal and spectrum analyzer provides the appropriate T&M functionality.

The IEEE 802.11ad WLAN standard introduced a few years ago for high data rate transmissions in the 60 GHz band can no longer provide the required data rates and range for a variety of current applications. That is why the IEEE 802.11ay extension is currently being specified, with the development of chipsets and components already underway.

In place of 2.16 GHz bandwidth offered by 802.11ad, the enhanced 802.11ay standard can deliver 8.64 GHz total bandwidth by combining up to four channels (channel bonding). The available frequency range has been extended to 71 GHz. MIMO with up to eight streams per channel is also possible. With only four streams at 44 Gbit/s, data rates of up to 176 Gbit/s can be achieved. This is additionally supported by higher-order modulation schemes such as 64QAM. The new standard also promises larger transmission range.

The new standard is mainly intended to replace Ethernet and other wired transmission standards, e.g. to transport video content to monitors, to integrate augmented reality (AR) and virtual reality (VR) headsets and glasses, and to exchange large data volumes between computers and mobile devices very quickly over the air, a capability perfect for cloud-based applications. As a result, insiders expect potential applications not only in homes but also in business and industrial environments, e.g. in open-plan offices and production plants. The high bandwidth eliminates the need for complex cable installations, saving costs and allowing a more flexible design of the work environment. The standard also facilitates quick connection of service providers. For example, with 802.11ay, network operators can connect base stations to the core network more easily than by using radio relay setups.

In view of the wealth of new possibilities offered, many manufacturers of WLAN applications have already started development of 802.11ay transmitters and receivers. While the technology is very promising in terms of extremely high data rates, device development is very costly and complicated. Chip and component manufacturers not only need state-of-the-art production technologies, but also the T&M equipment that can handle frequency ranges up to 71 GHz as well as modulation bandwidths of at least 2 GHz.

The R&S®FSW85 signal and spectrum analyzer (Fig. 1) covers the relevant frequency band without any frequency converters and also offers the necessary demodulation bandwidth.

Fig. 1: R&S®FSW85 signal and spectrum analyzer in combination with R&S®RTO2064 oscilloscope for analyzing WLAN 802.11ay signals with high sensitivity at bandwidths up to 4.32 GHz.

Fig. 2: Analysis of a 2 GHz wide WLAN 802.11ay signal. Along with graphical representation of the signal in the time and frequency domain, display of the constellation diagram and other results, users especially appreciate EVM and other numerical results.

With the R&S®FSW-B2001 option, it provides 2 GHz internal bandwidth, turning it into a one-box solution that can analyze, i.e. measure the modulation characteristics of, one channel of an 802.11ay signal. The instrument does this with a sensitivity of –37 dB, corresponding to an error vector magnitude of approximately 1.5 %. A dedicated internal measurement application (R&S®FSW-K97) provides all results of interest at the push of a button. Along with tabular listing of the modulation characteristics, display of the preamble content and the transmitted bits, it visualizes diverse diagrams that enable the user to identify problems and improve transmission quality (Fig. 2). If signals are very weak or need to be measured over the air interface, which is often the case in this frequency band because the antennas are usually integrated on the PCBs, a preamplifier such as the R&S®HA-Z24 can be connected to improve the signal-to-noise ratio. If more than 2 GHz bandwidth is required, e.g. when two channels are bonded, this requirement can be met by combining the R&S®FSW85 with an R&S®RTO2064 oscilloscope to provide 5 GHz analysis bandwidth. The frequency response of the combined signal analyzer and oscilloscope is fully equalized; the data is automatically loaded into the R&S®FSW85 without the user noticing that the oscilloscope is being used instead of the internal R&S®FSW85 A/D converters. The user simply adjusts the bandwidth in the R&S®FSW85 measurement application.

Spectral measurements such as adjacent channel power and spectrum mask can be directly performed on the R&S®FSW85, including preselection up to 85 GHz – unmatched by any other signal and spectrum analyzer on the market. This feature offers substantial benefits, i.e. significantly fewer spurious signals and higher sensitivity for spectral measurements. For OTA measurements, strong interfering signals outside the wanted band can be suppressed to avoid distortion of results.

Of course, it is also possible to use a signal and spectrum analyzer together with an external harmonic mixer, such as the R&S®FSW43 with the R&S®FS-Z90, to achieve up to 5 GHz analysis bandwidth for measuring modulation characteristics. However, these combinations do not offer the advantage of preselection for spectral measurements.

Dr. Wolfgang Wendler

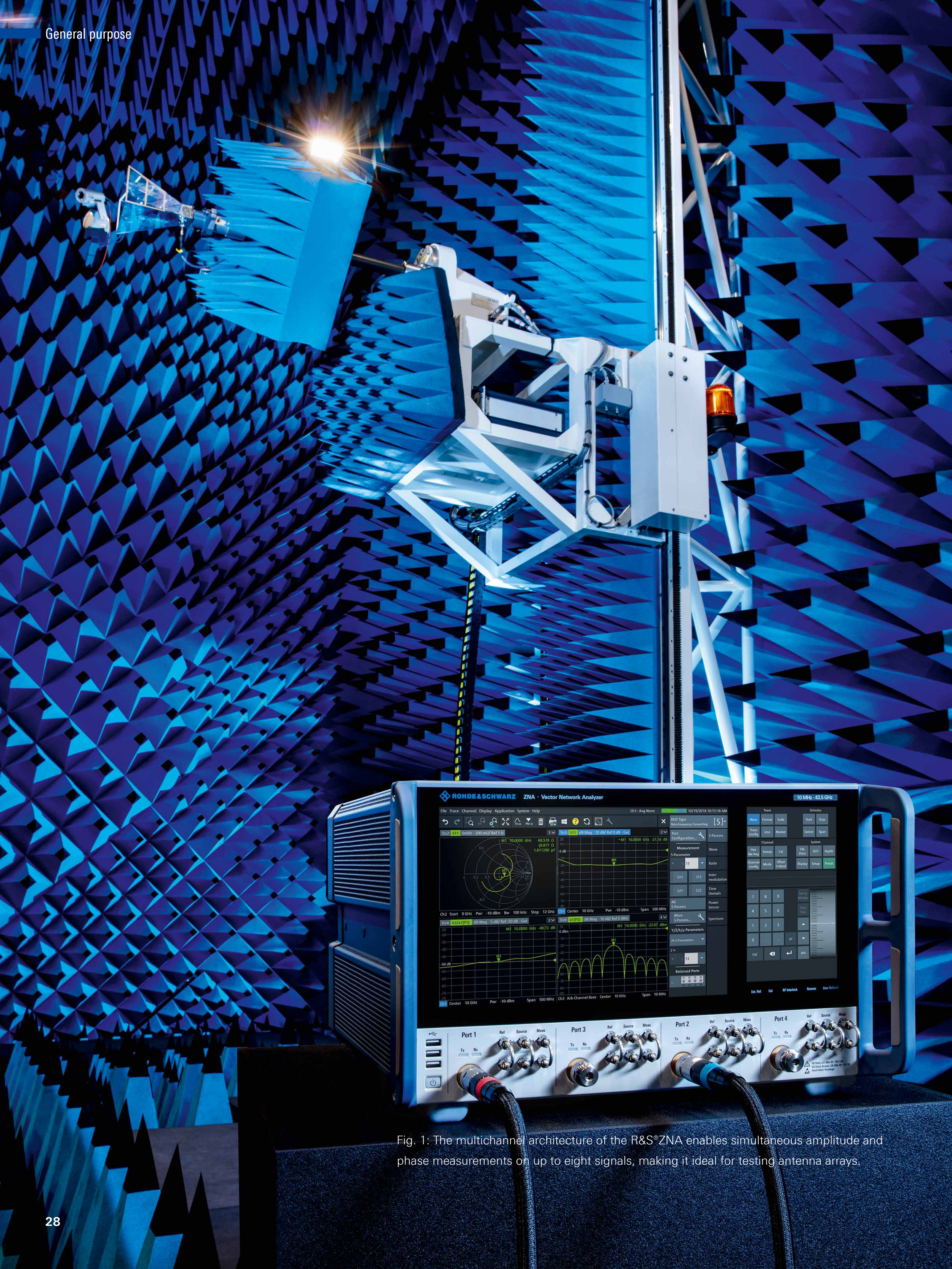


Fig. 1: The multichannel architecture of the R&S®ZNA enables simultaneous amplitude and phase measurements on up to eight signals, making it ideal for testing antenna arrays.

The network analyzer for today's technology

Component characterization nowadays can be a challenging task due to the complexity of the DUTs. The new R&S®ZNA vector network analyzer masters this task like no other.

Network analyzers have to meet various requirements. In the aerospace and defense sector, the emphasis is on stable data and reproducible measurements. Research institutes and universities demand top performance and versatility from a measuring instrument. The R&S®ZNA high-end vector network analyzer meets the needs of both user groups, as well as all other demanding users.

To fulfill the growing requirements on high-frequency components in practical applications, test and measurement equipment must be able to characterize components quickly and precisely. This requires excellent RF properties and versatile measurement functions. However, extensive instrument settings are usually necessary to use these functions, and it takes a lot of experience and familiarity to set them up properly. Automatic test configuration and operating aids that support users can significantly boost productivity, especially when working with network analyzers. Development of the R&S®ZNA vector network analyzer (Fig. 1) was driven by these two main objectives: excellent data and efficient operation.

The R&S®ZNA offers the flexibility necessary to master current and future test requirements for characterizing active and passive components. Its modular, high-performance hardware architecture with four signal sources and eight measurement receivers supports complex tasks such as intermodulation measurements on mixers or beamforming and MIMO tests on 5G antenna arrays. The extremely low noise floor of less than 0.001 dB at 1 kHz IF bandwidth and an outstanding dynamic range of up to 170 dB provide the basis for stable and reproducible measurements.

A market innovation is the DUT-centric operating concept with configuration wizards that significantly accelerates and simplifies instrument setup. The R&S®ZNA is the first vector network analyzer to feature touch-only operation (Fig. 2). This enables application-based configuration of the user interface to simplify and accelerate test setups as much as possible.

The R&S®ZNA is initially available with frequency ranges up to 26.5 GHz or 43.5 GHz and with two or four test ports each. The 43.5 GHz version is available with a choice of 2.92 mm or 2.4 mm connectors. The 2.4 mm version is specified over the entire frequency range. The 2.92 mm version is specified up to 40 GHz with typical values provided for the range from 40 GHz to 43.5 GHz.

Mixer and amplifier characterization easier than ever

Configuring measurement traces and various test parameters to determine the mixing loss in terms of amplitude and phase as well as for matching and isolation measurements is usually a time-consuming task. The DUT-centric operating concept of the R&S®ZNA make this task unnecessary. After selecting the DUT type and defining some basic parameters such as the frequency range and power level, the user directly selects the test parameters and quantities, and the instrument configures the test setup. This means measurements can be configured quickly without specific knowledge of the optimal analyzer settings, which saves time and ensures high reproducibility.

The phase-coherent signal sources allow phase delay and group delay measurements without a reference mixer. The second internal local oscillator (LO) enables simultaneous measurement of RF and IF signals, resulting in higher measurement accuracy and doubling the measurement speed compared to previous test approaches.

Intermodulation measurements on active DUTs can be performed as a frequency sweep with fixed or variable carrier spacing, or as a level sweep. Digital automatic level control (ALC) delivers the precise amplitude of both carriers over the entire frequency range, regardless of the DUT's input reflection coefficient.

The electronic power sweep range up to 100 dB (Fig. 3) significantly simplifies compression point measurements on amplifiers and eliminates the influence of switching operations that occur with mechanical attenuators. The FFT-based spectrum analysis enables deeper analysis of the behavior of a DUT when S-parameter measurements are not sufficient. Interference signals in converters and TX/RX modules are detected quickly, while the measurement setup does not affect the measurement result thanks to the scalar system error correction.

The four internal pulse modulators, which can be driven either by internal or external pulse generators, enable point-in-pulse measurements with up to 30 MHz measurement bandwidth. They deliver pulse profile measurements up to 50 times faster than conventional measurements, with a resolution as fine as 8 ns. This capability is often required in the A&D and wireless sectors where many amplifiers can only be tested in pulse mode.

Quick and reliable measurements on frequency converters without LO access

Frequency converters without LO access, such as are used in the satellite industry, are difficult to measure due to their frequency drift. To solve this problem, Rohde&Schwarz has developed a patented test solution for determining phase delay and group delay. It uses a two-tone method to simultaneously measure both signal tones, making it immune to the effects of frequency converter drift. Since both tones are affected by this drift, they cancel each other out in the measurement result. The R&S®ZNA also features an LO tracking function to compensate for drift effects that exceed the measurement bandwidth. For such an application, the second internal LO doubles the measurement speed.

Highest dynamic range for filter measurements

The high-rejection filters used in A&D applications and base stations impose stringent requirements on the dynamic measurement range of network analyzers. Not only is a wide dynamic range essential for measuring very low signal levels, it also enables the use of a larger IF bandwidth for the desired dynamic range and leads to faster and simpler filter tuning.

In reverse coupler mode, the R&S®ZNA has a typical dynamic range of up to 170 dB (Fig. 4). A segmented sweep with different measurement settings for the passband and cutoff band prevents saturation of the measurement receiver in the filter passband.

Fig. 2: The R&S®ZNA does not have any mechanical keys. All measurement-related data and menus are displayed on a large touchscreen. A smaller screen is used for general instrument configuration.

Fast and accurate antenna characterization

The high sensitivity and wide dynamic range of the R&S®ZNA are also required for fast antenna measurements (near-field and far-field measurements in CATRs, radar cross-section). The direct IF inputs on the rear of the instrument for frequencies up to 1 GHz cover a wide spectrum of IF frequencies used by external mixers in antenna systems. The parallel measurement receivers enable amplitude and phase recording of up to eight signals, which means the horizontal and vertical polarization of measurement and reference antennas can be determined simultaneously.

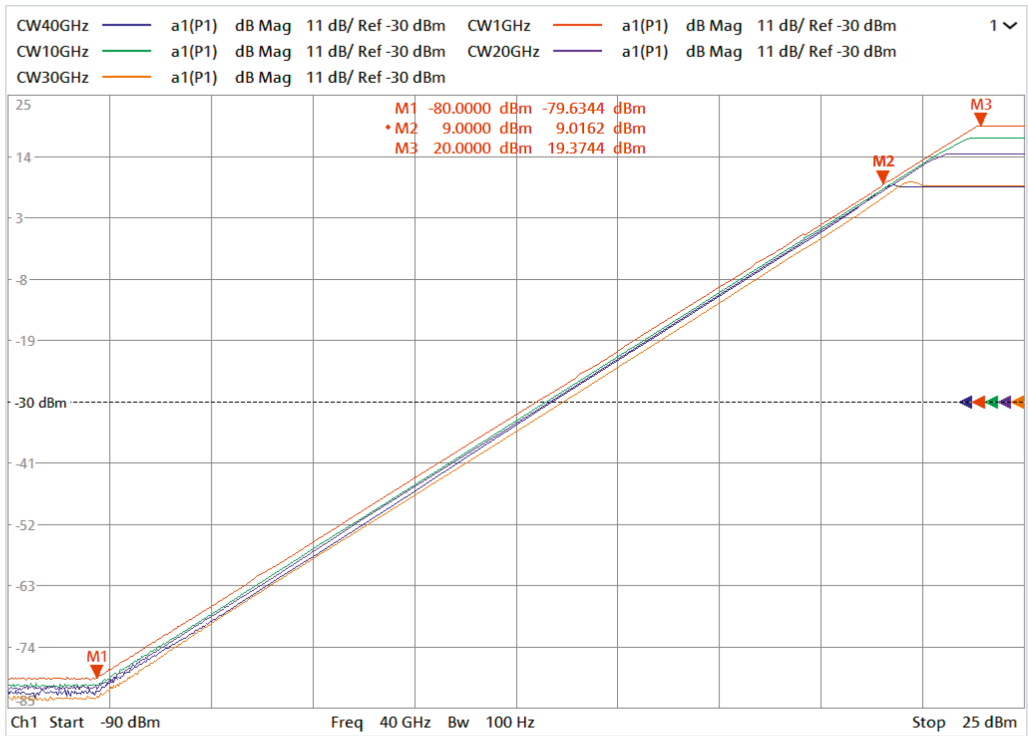


Fig. 3: The wide power sweep range of 100 dB for compression point measurements is not only unique in the industry, it is also realized fully electronically.

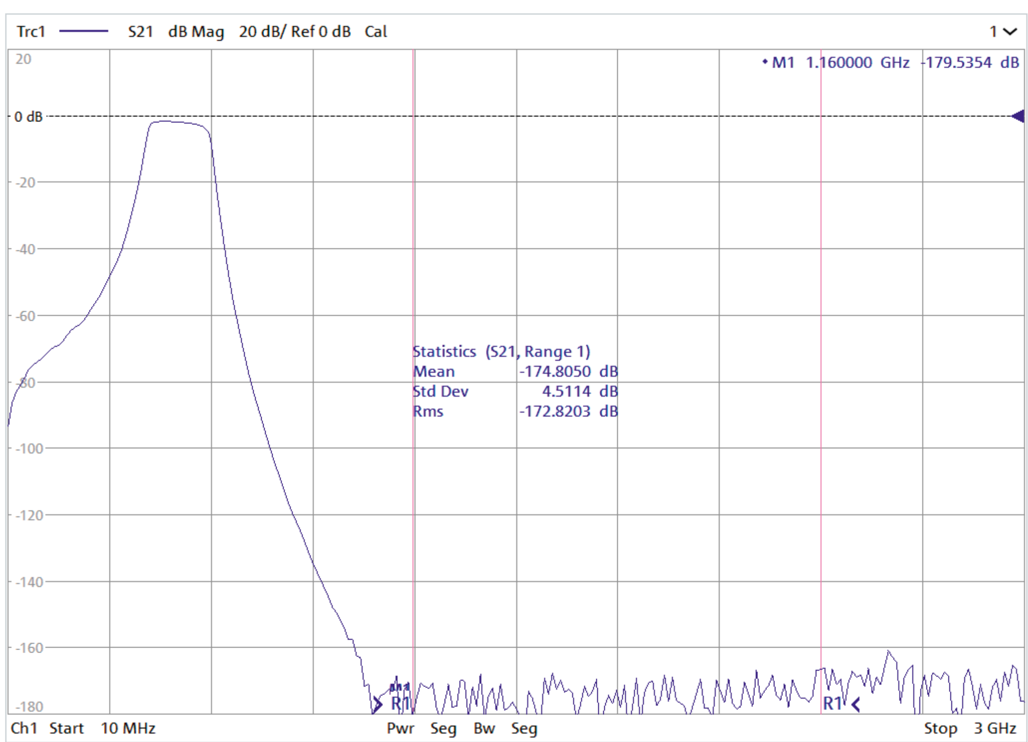
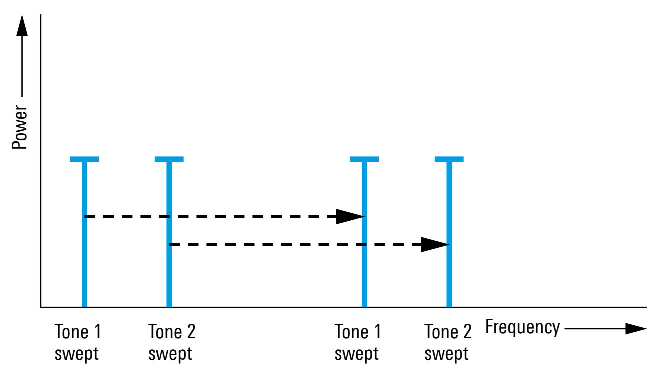
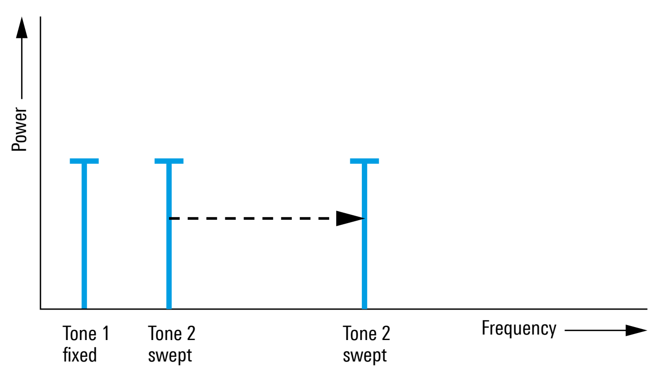


Fig. 4: High-rejection filters can be characterized with a 170 dB dynamic range.

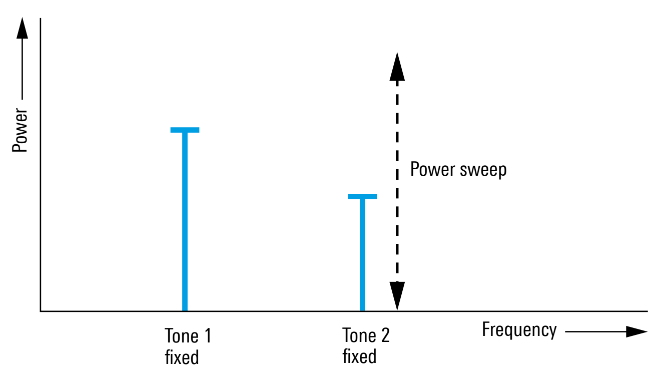
Frequency sweep with fixed carrier spacing



Frequency sweep with variable carrier spacing



Level sweep with fixed carrier spacing



Example: intermodulation measurements on amplifiers and mixers with the R&S®ZNA

The R&S®ZNA determines the intermodulation properties of amplifiers and mixers quickly and with high accuracy. It offers three types of measurements:

- Frequency sweep with fixed carrier spacing
- Frequency sweep with variable carrier spacing
- Level sweep with fixed carrier spacing

Wide dynamic range and digital ALC for challenging intermodulation measurements

The R&S®ZNA offers major benefits especially when measuring amplifiers with very small intermodulation products. Its wide dynamic range and the excellent power handling capacity of its receivers make it possible to measure low intermodulation distortion within seconds instead of minutes.

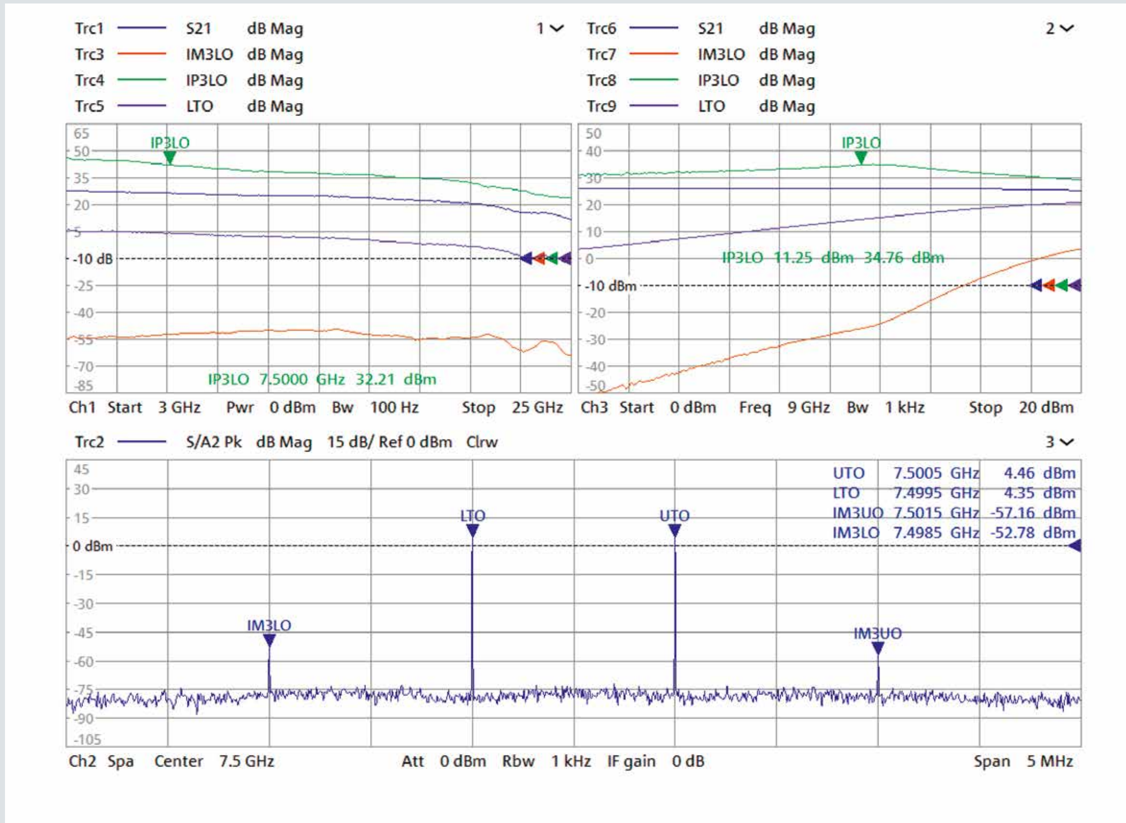
When measuring intermodulation, precise control of the power applied to the DUT inputs is vital. The R&S®ZNA makes no compromises here. Automatic level control (ALC) combined with system error correction ensures a precise amplitude for the individual carriers over the entire frequency range, regardless of the DUT's input reflection coefficient.

High output power and flexibility

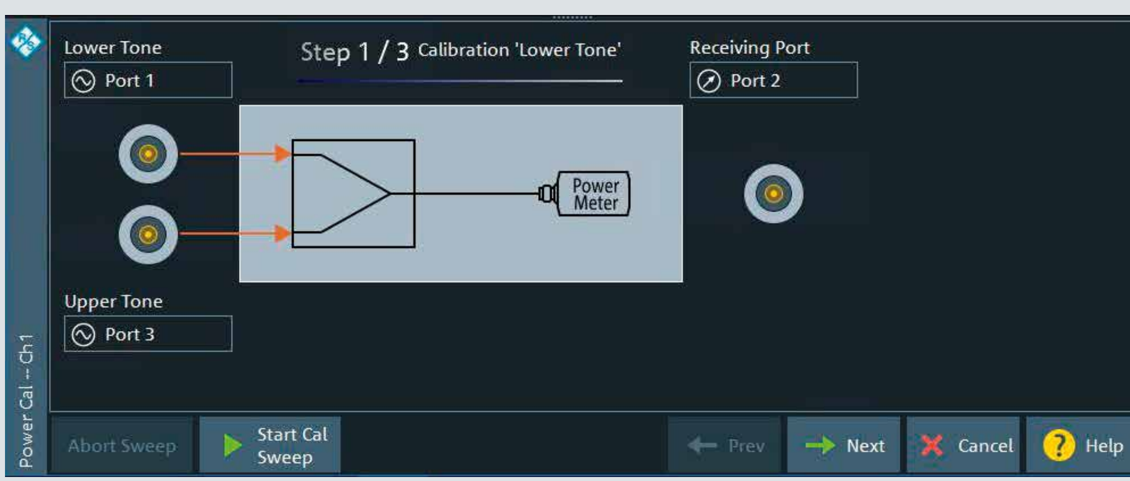
Featuring four independent signal sources, the R&S®ZNA can even perform intermodulation measurements on mixers without requiring an external signal generator. The analyzer delivers high output power of up to +20 dBm per test port. If this is not sufficient, the R&S®ZNA can flexibly loop external amplifiers into the signal path and precisely control them via ALC.

DUT-centric approach simplifies configuration of intermodulation measurements

The DUT-centric approach of the R&S®ZNA supports intuitive navigation during intermodulation measurements. To configure a measurement, the user first selects the DUT type and is then guided through a dialog to define the test setup, the DUT connections, the measurement quantity or type (for example, IMx versus frequency, where x is 3, 5, 7, etc.), the power level at the DUT input and output, or a spectrum measurement. In the case of manual four-port calibration, for example, the DUT-centric approach reduces the number of required steps (i.e. connection of calibration standards and power sensors) from 26 to 16.



Comprehensive amplifier characterization, including intermodulation products, IP versus frequency, spectral measurements and other quantities.



Power calibration wizard for the intermodulation measurement on an amplifier.

Frequency converters for measurements up into the terahertz range

In addition to basic research, imaging, antenna measurements and material measurements, commercial applications such as automotive radar (77/79 GHz) and mobile communications (5G NR) in the millimeterwave and terahertz range are becoming more common. The R&S®ZNA can be extended up to these frequencies with frequency converters (Fig. 6). Rohde & Schwarz frequency converters feature high output levels and a wide dynamic range – both important for on-wafer measurements and antenna characterization. By using the direct IF inputs, effectively bypassing the input mixers, the dynamic range can be improved by an additional 7 dB. Up to four converters can be connected to the R&S®ZNA to characterize frequency-converting multiport and differential DUTs. Even with a two-port device, two converters can be used without an external signal generator for the LO signal.

Calibration methods for every measurement task

A broad spectrum of calibration methods, including traditional TOSM, TRM, TSM, TOM, TRL/LRL, UOSM and adapter removal, ensure accurate measurement results for every measurement task (Fig. 5). Digital ALC compensates for thermal drift after calibration. Manual economy and high-end calibration kits with individual S-parameter characterization, automatic calibration modules with two or four ports, inline calibration modules, and power sensors for level calibration can be used for calibration according to the measurement task.

Conclusion

R&S®ZNA users can easily keep pace with the rising requirements of RF technology. With its high-performance and function-rich hardware, it can handle even the most challenging measurement tasks. The analyzer has four internal phase-coherent signal sources that enable independent control of the signal frequency at each port as well as phase measurements on mixers. It has two internal local oscillators, a true multichannel receiver architecture, pulse modulators and extensive trigger and synchronization options. These hardware features make the R&S®ZNA a universal, compact test system for characterizing passive and active DUTs. Intermodulation measurements on mixers and receivers can be performed without external signal generators, minimizing test times and simplifying test configuration. Finally, the DUT-centric approach boosts productivity with a configuration wizard and leads to valid measurement results without detours. The touch-only operation with two independent screens is unique.

Andreas Henkel

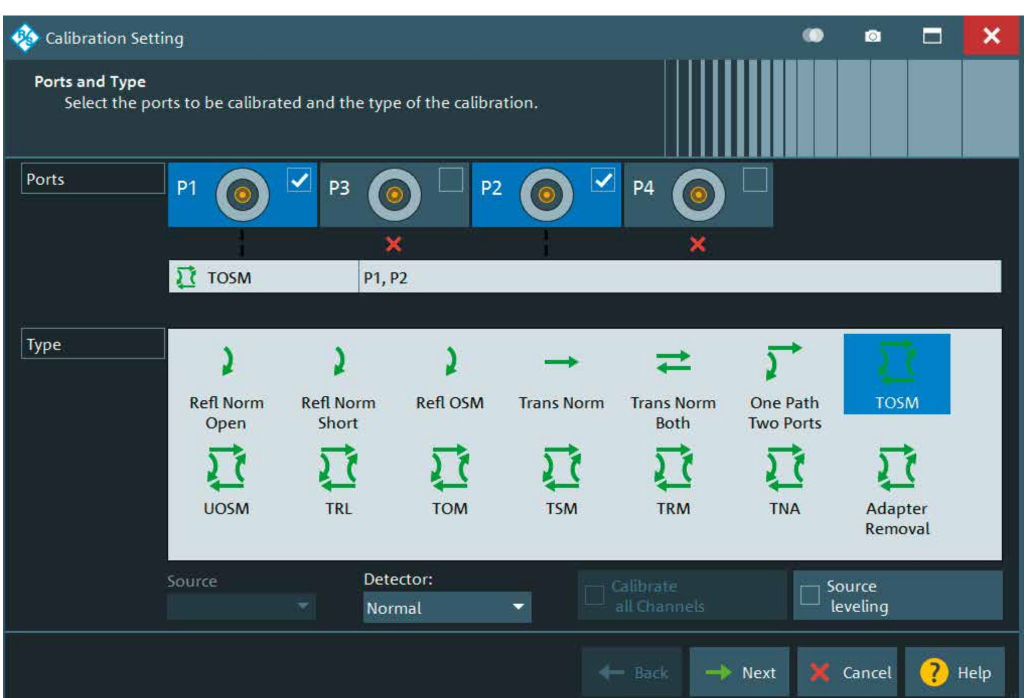


Fig. 5: Selection of calibration methods with the R&S®ZNA.

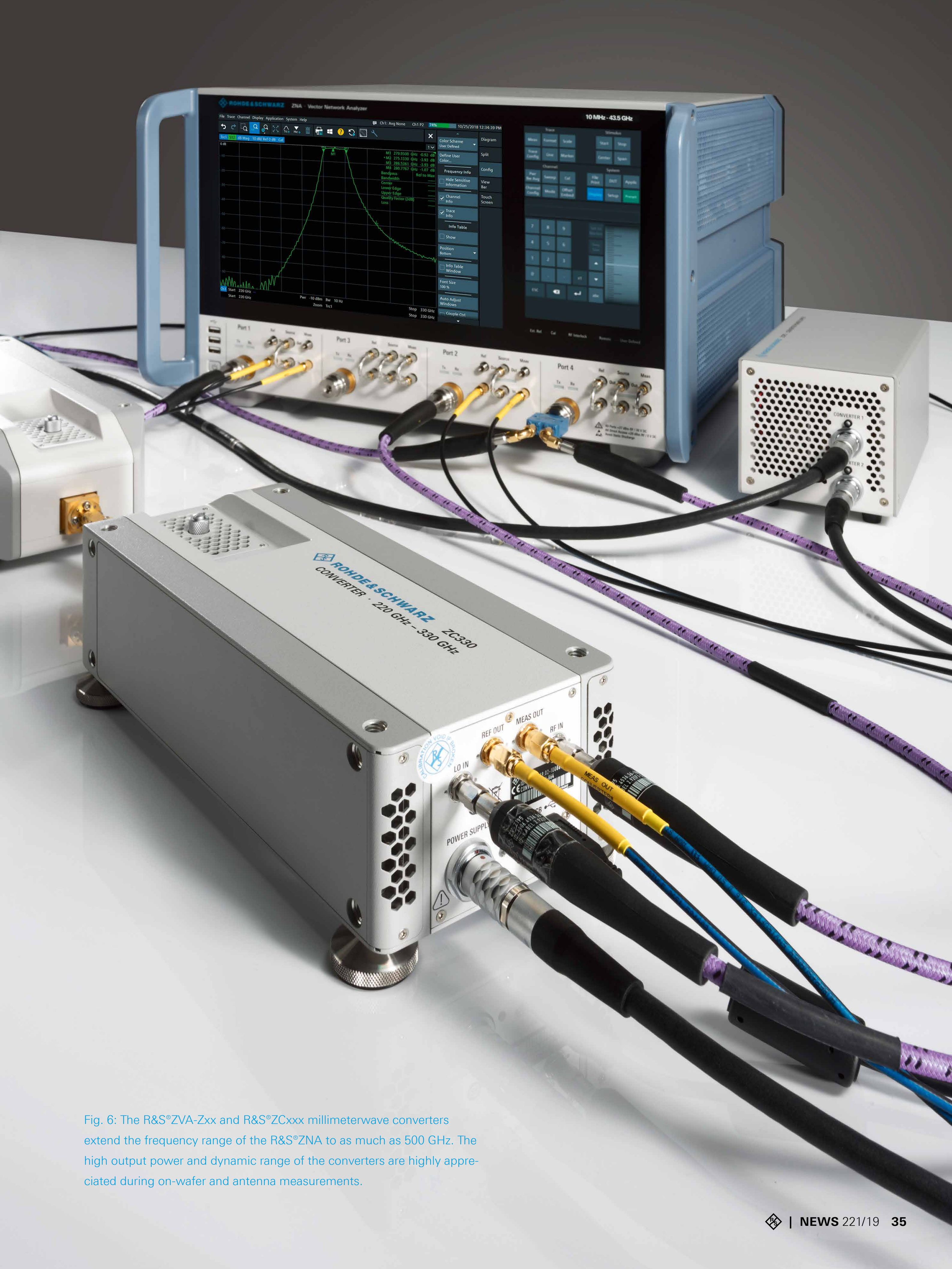
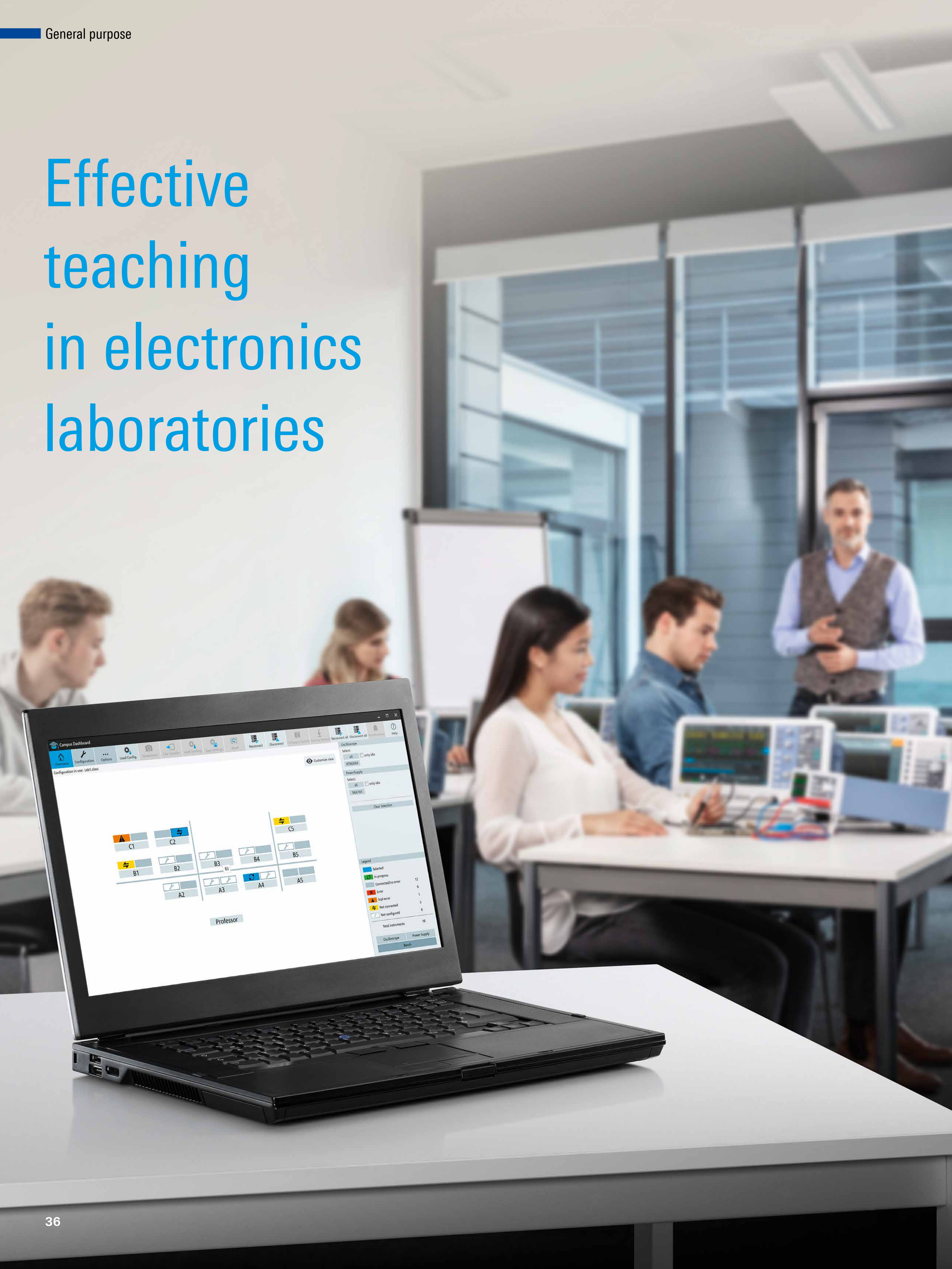


Fig. 6: The R&S®ZVA-Zxx and R&S®ZCxxx millimeterwave converters extend the frequency range of the R&S®ZNA to as much as 500 GHz. The high output power and dynamic range of the converters are highly appreciated during on-wafer and antenna measurements.

Effective teaching in electronics laboratories



The R&S®CDS campus dashboard software simplifies teaching of student groups in training laboratories with multiple workbenches. The software also speeds up the process of administering and maintaining the test instruments from a central computer.

Universities and colleges with specializations in electronics or related topics typically train their students in the practical aspects of electrical engineering in large laboratories with many identically equipped workplaces. Due to the wide range of possible applications, training is required on various instruments. As a result, each workplace is generally equipped with several instrument types such as oscilloscopes, spectrum and network analyzers, function generators and power supplies.

Individual attention – despite a large number of students

Nowadays, laboratories of this kind can have 20 or more workplaces – a major challenge for the teacher. First, the teacher must ensure identical starting conditions for all of the students. Moreover, individual attention is desirable to produce the best learning outcome. Finally, at the end of the session, the results need to be documented. Without the proper tools, all of these activities are a significant burden – especially for a single teacher.

Simple virtual lab setup

The R&S®CDS campus dashboard software simplifies teaching of large groups by turning the teacher's computer into a control desk that communicates with the training instruments via Ethernet. Using this central computer, it is possible to set up identical conditions on all of the instruments and record the training results. In addition, the software allows remote access to all instruments and can perform collective firmware updates.

R&S®CDS supports up to 100 workplaces represented as virtual lab. The layout only has to be configured once for the actual lab setup. Then, the software automatically connects to the test instruments on the network (Figs. 1 and 2). Various oscilloscopes, spectrum and network analyzers as well as power supplies from Rohde & Schwarz are supported. The maximum number of instruments is 300.

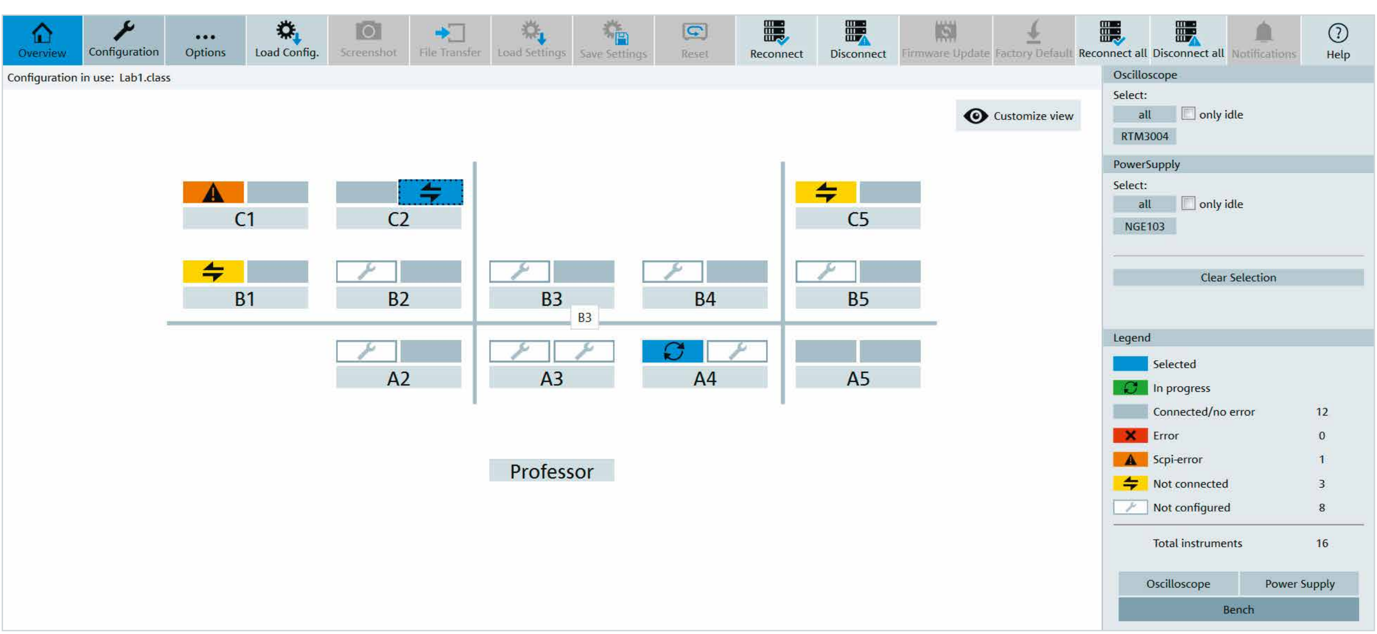


Fig. 1: The user interface of the R&S®CDS campus dashboard software mirrors the physical lab setup with up to 100 workplaces and 300 test instruments as a virtual lab.

Effective routines for teachers

Once the virtual lab has been properly set up, the teacher can use R&S®CDS to execute all supported functions with just a few mouse clicks. In this manner, identical conditions are set on all workbenches. The settings on one instrument serve as the model and are mirrored to all instruments of the same type. Similarly, the results for all course participants are collected at the end of the session using a central command that takes screenshots on all instruments and saves them on the control computer. In order to provide individual attention to the students, the teacher can access each instrument and remotely control its functions (Fig. 3).

Fig. 2: The virtual lab only has to be configured once according to the actual lab layout. Each workbench can have up to four test instruments. Various oscilloscopes, spectrum and network analyzers as well as power supplies from Rohde & Schwarz are supported.

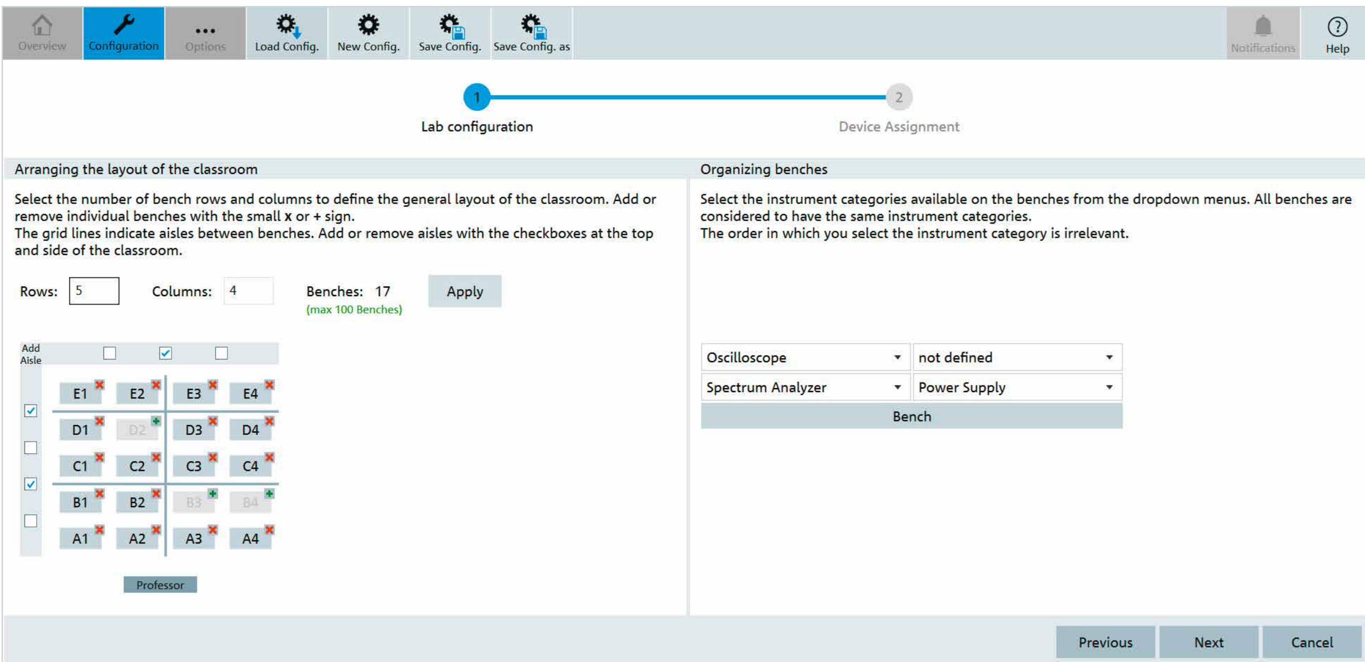
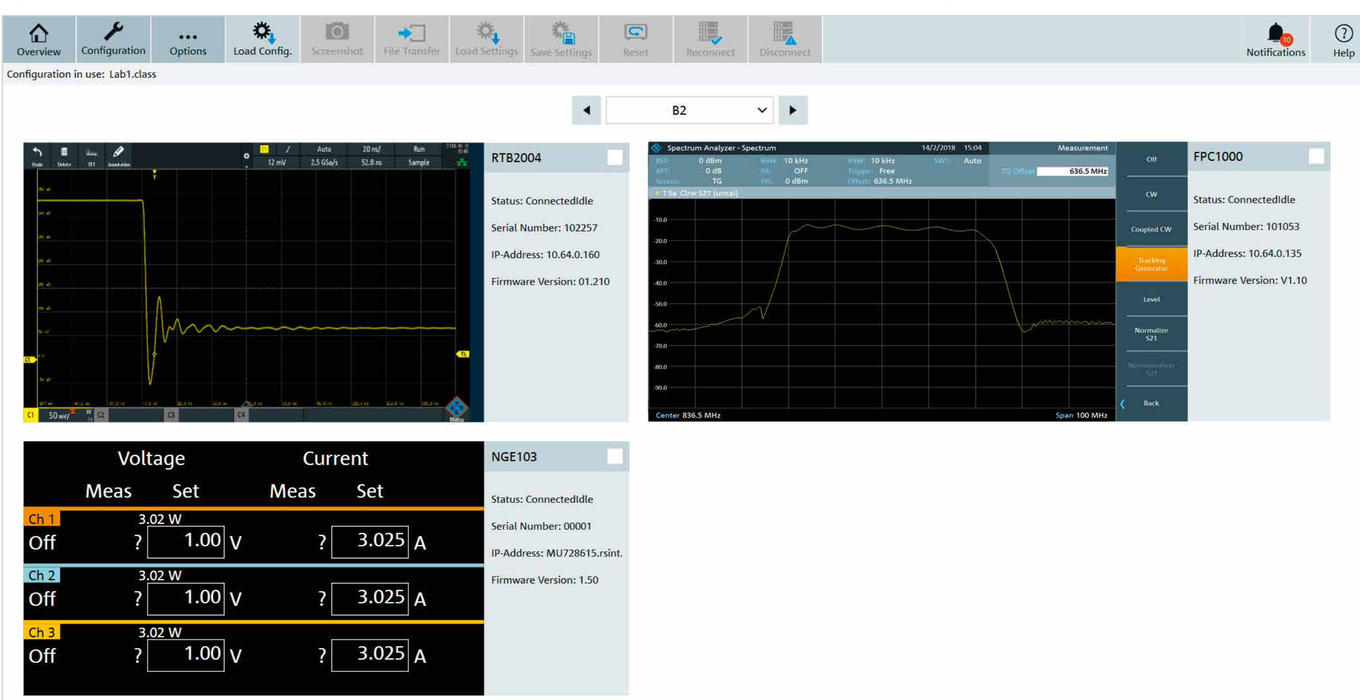


Fig. 3: The teacher can select each individual test instrument, capture the screen content and make settings.



Keeping the lab up to date

The R&S®CDS campus dashboard software not only simplifies teaching, but also makes it easy to keep the firmware status of the test instruments up to date (Fig. 4). A free demo version of the software with limited functionality can be downloaded from the internet in order to get an impression of how the software works. For more details, visit www.rohde-schwarz.com/campus-dashboard.

Dr. Tim Paasch-Colberg

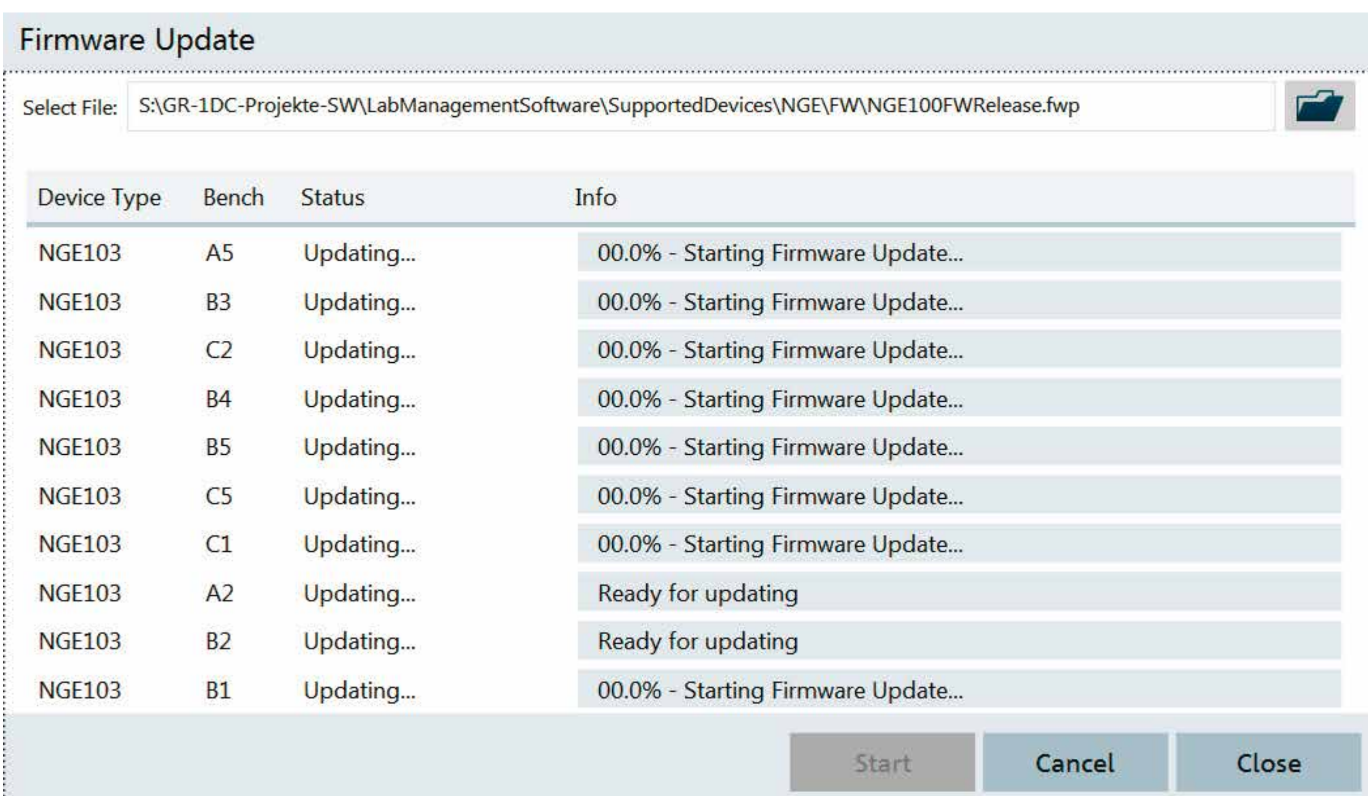
Key facts about the R&S®CDS campus dashboard software

- Optimize teaching routines in large student laboratories
- Control up to 300 individual test instruments from one workplace
- Train students efficiently on oscilloscopes, spectrum and network analyzers and power supplies
- Set identical conditions for all workbenches
- Easily document training results
- Remotely control all instruments
- Centrally manage firmware updates

Compatible instruments

- **Oscilloscopes:** R&S®RTC1000, R&S®RTB2000, R&S®RTM3000, R&S®RTA4000
- **Spectrum analyzers:** R&S®FSH, R&S®FSC, R&S®FPH, R&S®FPC1000, R&S®FPC1500
- **Network analyzers:** R&S®ZVH, R&S®ZPH
- **Power supplies:** R&S®NGE100, R&S®NGE100B

Fig. 4: Central management of firmware updates for all instruments saves a great deal of time.



Noise factor measurement with smart noise sources

New noise sources for the R&S®FSW and R&S®FSV3000/R&S®FSVA3000 signal and spectrum analyzers improve measurement accuracy and simplify operation.

The maximum data transmission rate of a communications system and the sensitivity of a radar system are largely dependent on the signal-to-noise ratio (SNR) of the signal. The SNR mainly depends on the noise factors of the components in the signal path, particularly with low input levels. The noise factor is the ratio of the input SNR to the output SNR of a linear two-port device, such as an amplifier. The noise factor is frequency dependent and is typically given as a decimal logarithmic value in decibels (dB), in which case it is called the noise figure. Knowledge of the exact noise figure is essential for the development, optimization and production of virtually all RF systems.

In the past, noise factors were determined using a dedicated noise tester, but now noise figures and gain are often measured with a spectrum analyzer. This is done using the Y-factor method, which yields accurate results even with small noise figures. For this measurement, a noise source with a known excess noise ratio (ENR) is used in addition to the spectrum analyzer. The ENR indicates the increase in the spectral intensity of the noise (the power spectral density, or PSD) when the noise source is switched on.

Fig. 1: Measuring the gain and noise figure of an amplifier with the R&S®FS-SNS40 smart noise source and the R&S®FSVA3030 signal and spectrum analyzer.

Fig. 2: The R&S®FSV3-K30 measurement application for noise factor and gain. The noise figure and its measurement uncertainty are displayed graphically at the top left.

The following formula is a good approximation:

ENR in dB = PSD in dBm/Hz + 174 dBm/Hz

–174 dBm/Hz is the noise floor at room temperature. The measurement is made by comparing the noise power at the spectrum analyzer input with and without the noise source switched on. Before measuring, a one-time calibration is required, in which the noise power of the noise source without the DUT is measured at the spectrum analyzer input.

The new R&S®FS-SNS smart noise sources from Rohde & Schwarz enable precise noise figure and gain measurements (Fig. 1). The measurement applications – R&S®FSW-K30 for the R&S®FSW signal and spectrum analyzer and R&S®FSV3-K30 for the R&S®FSV3000 and R&S®FSVA3000 signal and spectrum analyzers – have been upgraded for this purpose. Both applications control the noise source power supply and automatically read the ENR tables and the VSWR of the noise source. The ambient temperature is also constantly measured and taken into account when calculating the noise figure. In addition, the applications continuously calculate the measurement uncertainty and process it to be displayed in a table or graph along with the measurement result (Fig. 2).

The R&S®FS-SNS smart noise sources are connected to the spectrum analyzer by a cable with a 7-pin connector that transfers the data and provides a 28 V supply voltage for the noise sources. The noise sources are available now in three models with maximum frequencies of 26.5 GHz, 40 GHz and 55 GHz.

Martin Schmähling

Monitoring in the cloud

The future of audio/video monitoring is in the cloud. Instead of dedicated test and measurement equipment, all you need is the address of an internet service that provides monitoring functions. A new cloud product makes it extremely easy to monitor the quality of media streams.

Launched about two years ago, R&S®PRISMON is a pioneering product for monitoring audio/video data streams in the production environment, i.e. within a studio's network. R&S®PRISMON.cloud extends this capability to the delivery network. It monitors A/V streams that reach their audience via OTT over the internet and gives internet broadcasters and content providers an easy way to assess the technical quality of their transmissions from the user perspective.

The task: live stream monitoring of webcasts

Our media landscape is changing. Most media consumption now takes place over the internet, which makes it challenging for providers to ensure quality of service (QoS). Broadcast studio operators can only ensure QoS within their scope of influence. For instance, they can use R&S®PRISMON (Fig. 1) to monitor the quality at various points in their networks. However, once the data stream is fed into the internet, they can't see what happens in the rest of the delivery chain. To get a reliable overview of the quality that viewers experience requires quality sensors that tap into the data on the internet at the point where the user receives it. This is the only quality control method available to content providers, who usually do not operate their own network. R&S®PRISMON.cloud provides such virtual sensors.

Quality monitoring with R&S®PRISMON and R&S®PRISMON.cloud

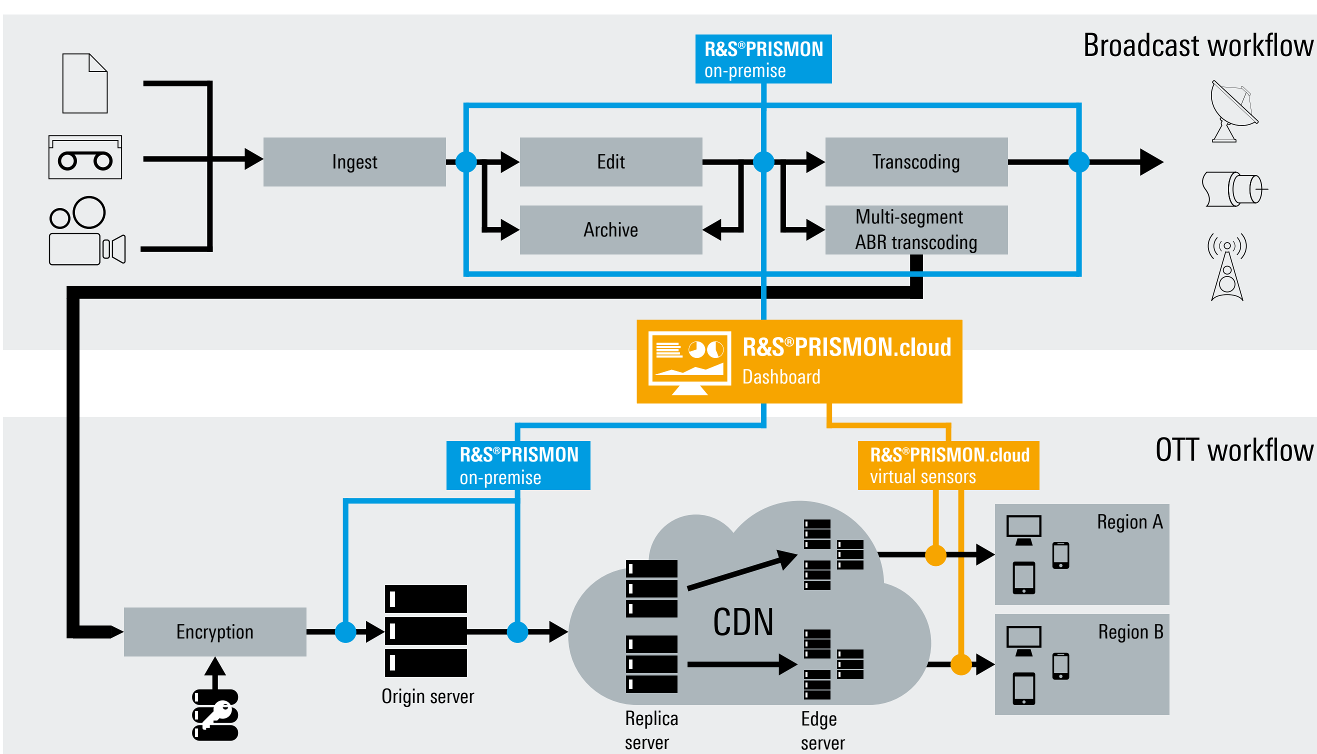


Fig. 1: Strategically located virtual R&S®PRISMON and R&S®PRISMON.cloud sensors transfer their data to the R&S®PRISMON.cloud dashboard, providing an integrated end-to-end view of the quality of your entire delivery chain.

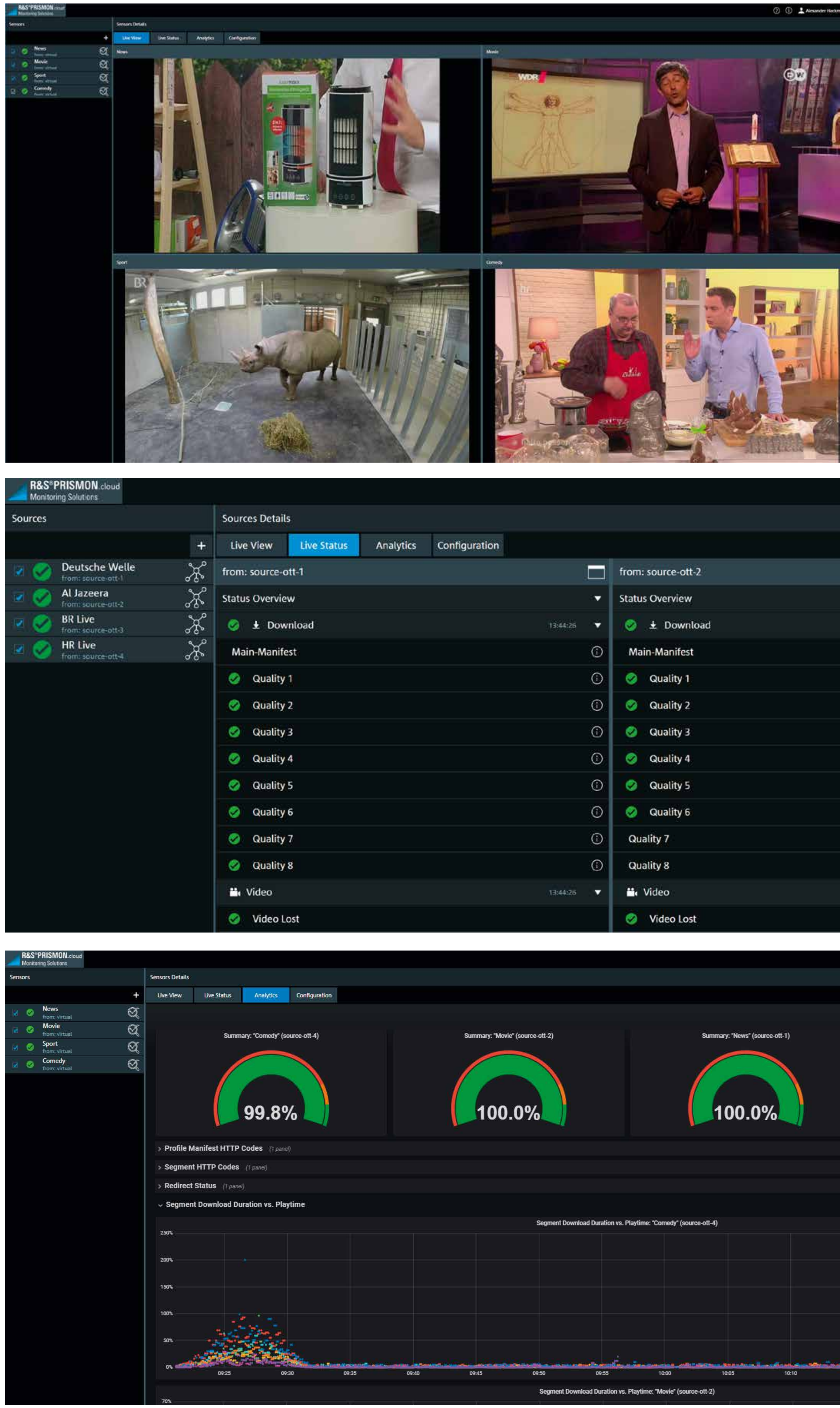
The new paradigm: monitoring as a service (MaaS)

R&S®PRISMON.cloud was developed in close cooperation with customers. The focus was on easy and flexible use. This applies not only to the technology, but also to the administrative and business aspects. The result could hardly be more user-friendly. Users can subscribe to the service on the Rohde & Schwarz product page for a period of three or twelve months. They manage and operate the service from their browser. Two packages are available to meet both simple and extensive monitoring requirements. Interested parties can try the service for a month free of charge.

The price of the service depends on the number of sensors needed. Each sensor monitors a fixed URL assigned by the user. Usually several streams with different quality and data rates are distributed over this URL to offer each user a resolution matching the capability of their current network connection (adaptive bit rate streaming). The terminal devices dynamically adapt to the link conditions and access the best stream that still enables smooth transmission. A R&S®PRISMON.cloud sensor can monitor up to eight such streams whose quality is displayed in a cloud dashboard.

The basic SILVER sensor delivers live data to the dashboard, including audio and video status with alerts for incidents such as lost video and lost audio as well as eight selectable quality parameters such as bit rate and buffer status. The GOLD sensor provides a lot of other information, saves the measurement data and processes it for reports in a timeline format (Fig. 2). Fig. 3 lists the package features.

Fig. 2: The tabs on the dashboard GUI offer different types of information: live view of the streams, live status and analytics (from top to bottom).



The entire delivery chain at a glance

When distributing live streams to a global audience, such as for a major sports event, it is of course necessary to do more than simply collect quality samples from the internet. The entire delivery chain has to be constantly monitored, from the recording location to the studio and various points on the contribution network to the internet feed point. Combined deployment of R&S®PRISMON and R&S®PRISMON.cloud provides a single-source solution. R&S®PRISMON, which features a broad range of functions tailored to the production environment, is either installed on an existing customer server or positioned together with a Rohde & Schwarz hardware platform at key points in the content delivery network (CDN). The hardware solution is necessary if the customer works with SDI data or operates a mixed SDI/IP ecosystem.

The R&S®PRISMON product family handles every broadcast contribution and distribution monitoring task, including generating video walls.

Fig. 3: Sensors can be ordered as needed. A trial version lets you test the full functional range for a full month at no charge.

	TRIAL.sensor	SILVER.sensor	GOLD.sensor
Conditions	max. 30 days / 1 sensor only	subscription-based	subscription-based
Live view			
Thumbnail pictures approximately every 10 s	•	•	•
Live status report			
Download status (for up to eight qualities: measured bit rate, HTTP codes, buffer storage, pts timestamp)	•	•	•
Video status (video lost, black image, still image)	•	•	•
Audio status (audio lost, silent audio)	•	•	•
Analysis (storage and analysis of data in timeline format)			
SLA status	•		•
Segment download duration vs. playtime	•		•
Profile manifest HTTP codes	•		•
Redirect status	•		•
Segment HTTP codes	•		•
Segment bit rates: signaled/measured	•		•
Segment video buffer level	•		•
Segment audio buffer level	•		•
Metadata	•		•

R&S®PRISMON.cloud was chosen "Best of Show" at NAB Show 2019.

R&S®PRISMON and R&S®PRISMON.cloud both report to the R&S®PRISMON.cloud dashboard, making administration easy. The operator can view the dashboard on a monitoring center or a mobile device and keep an eye on the quality of the entire chain. Errors anywhere are immediately visible. Full transparency and control – it can't get better than that.

Positive response

R&S®PRISMON.cloud was launched in April at the National Association of Broadcasters (NAB) Show 2019 to overwhelmingly positive feedback. The fact that a combination with R&S®PRISMON generates an all-IP end-to-end view of the whole delivery chain attracted a lot of interest. It therefore came as no surprise when a jury of engineers and experts awarded the product "Best of Show" – an annual award presented at the trade show by the magazine TV Technology. The jury's decision is based on criteria such as innovation, feature set, cost efficiency and potential use.

Interested parties can quickly and conveniently get a taste of what to expect from R&S®PRISMON.cloud by ordering the free TRIAL.sensor version, which allows them to test the full functional range of the GOLD sensor for one month. The QR code links to the ordering page.

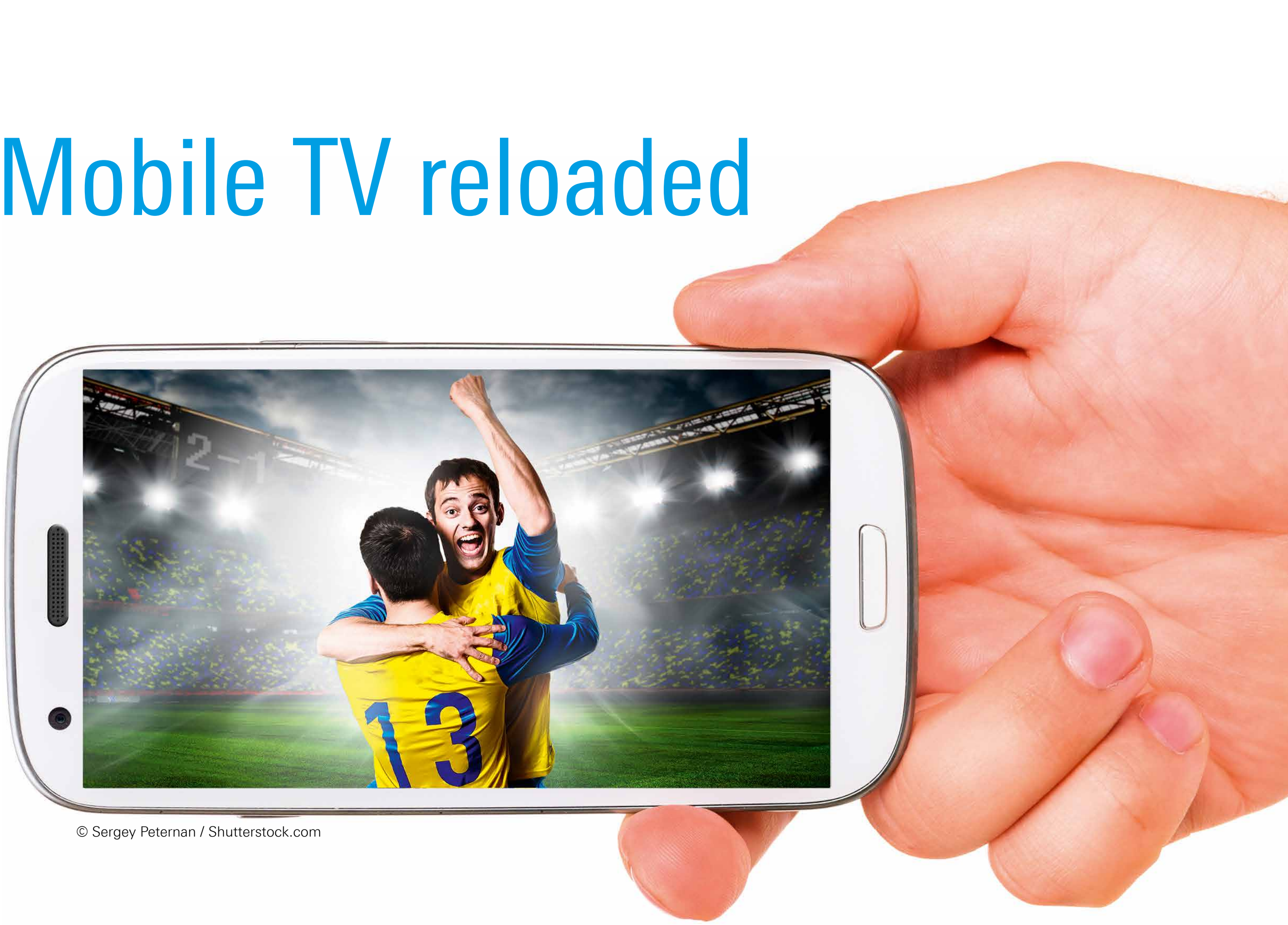
Dr. Alexander Hackmann

Features and benefits of R&S®PRISMON.cloud

- CAPEX savings thanks to flexible deployment and dynamic up/downscaling of monitoring resources as needed
- Easy-to-use setup wizard for immediate deployment of new virtual sensors at distributed locations – directly from your browser
- Quality information from the entire delivery chain in a simple KPI dashboard when linked with R&S®PRISMON
- Live multiview, automatic content analysis and real-time fault detection allow permanent QoS monitoring and fast response to problems
- The monitoring dashboard can be accessed from anywhere via laptop, tablet or smartphone
- The cloud-based infrastructure and ongoing development make sure the product is always up to date

www.prismon.cloud

Mobile TV reloaded



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In the wake of the 5G rollout, an old idea could gain new life: enabling television viewing on mobile devices. A pilot project is testing the feasibility.

The idea of offering television on mobile devices is not new. Since 2006 there have been various attempts, mainly in European countries, to establish the DVB-H (H for handheld) standard based on the DVB-T digital terrestrial television standard. However, these efforts proved to be in vain long before the last active service (Finnish DVB-H) was shut down in 2012. Developed before the smartphone era, the system with its screen resolution of 320 × 240 pixels was outmoded and there were only a limited number of devices that supported it.

Back to the beginning

Several mobile communications generations later, the situation is different. 4G systems can easily transfer high-resolution video, but the rapidly growing use of video-on-demand services and live streaming is pushing state-of-the-art networks to their limits. 5G can help, but it can only provide significant support once 5G standalone networks in the millimeterwave bands become operational, which will take several years. However, it is a waste of transmission capacity to overload IP networks designed for point-to-point connections with multicast transmissions. Classical broadcasting is still the best solution for this, provided it is delivered to consumer devices in a modern form.

Standardized mobile communications technologies for multicast transmissions have been around since 2006 when the Multimedia Broadcast Multicast Service (MBMS) subsystem was specified in 3GPP Release 6 (UMTS). With Release 9, it made its way into LTE in the form of evolved MBMS (eMBMS) and in Release 14 (LTE-Advanced Pro), it reached the current development stage, called Further evolved MBMS (FeMBMS). Although a standardized broadcast mode for 5G was not yet ratified, 3GPP could be able to incorporate FeMBMS largely unchanged into Release 16 because the system technology enables true integration of broadcasting into the mobile communications world (Fig. 1). Both are now based on signal feed over IP networks and OFDMA at the air interface. The transmitter gets its payload and configuration data via 3GPP-compliant protocols. The signal conditioning of a DVB-T2 transmitter can be adapted to the FeMBMS specifications with reasonable effort. The frequencies are already compatible

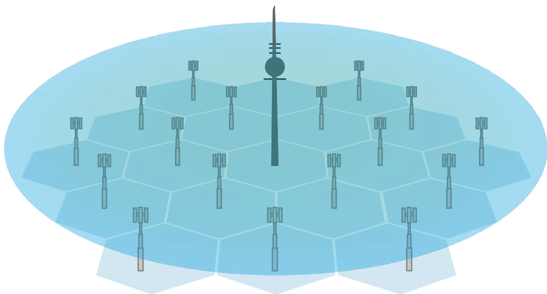


Fig. 1: FeMBMS networks combine the advantages of mobile communications infrastructures and TV infrastructures. A television transmitter (high power, high tower) integrated into a single-frequency network can supply an area with a radius of 60 km to 70 km with excellent video quality and offload many mobile network cells.

if the signals are transmitted in the original TV bands, which were added to the mobile communications frequencies as a digital dividend during broadcasting digitalization or as a result of spectrum repacking. Compatible mobile devices must support receive-only mode without a SIM card so that the service can also address devices that are not registered in a mobile network, for instance television receivers.

A relatively significant question aside from all technical considerations remains open. How can mobile network and TV network operators, chipset and device manufacturers and content providers be motivated to arrive at an agreed system rollout? All of these parties are needed to launch the service. The answer is a win-win situation for everyone concerned. Mobile network operators get a way to offload the data burden of broadcast content. TV network operators get a new, attractive application area for their transmitters in times of declining demand for terrestrial television. Content providers, e.g. internet broadcasters, can be assured of full-coverage, high-quality supply. And the mobile device market – which has not had any true innovations in recent years – gets a convincing reason for new product purchases. Entertainment is only one of the possible applications. The service can be used to transmit more than video, for instance data such as software updates for a large number of similar devices in the internet of things or in future vehicle fleets.

Fig. 2: The setup needed to transmit FeMBMS signals is not that complex. The test installation in the Ismaning station consists of the Rohde & Schwarz transmitter with a modified modulator and antenna equipment from Kathrein. On the left is an open version of the diversity antenna.

Field trial

Since there is no practical experience available for a system based on FeMBMS, the research project 5G Today was initiated in Germany. Under the leadership of the Broadcast Technology Institute (IRT), project partners Rohde & Schwarz, Kathrein, Bavarian public broadcaster Bayerischer Rundfunk (BR) and Telefónica are investigating the practical aspects of the system in a project that runs until the end of October 2019. The basis is a reference implementation of all transmit and receive components.

The trial takes place in Upper Bavaria. Two modified Rohde & Schwarz R&S®THU9evo transmitters with 5 kW and 6 kW amplifier power (100 kW ERP) and operated by BR at Wendelstein and in Munich-Ismaning form a single-frequency network on channel 56 (754 MHz to 758 MHz), which was provided by Telefónica (Fig. 2). The transmitters enable reception in the Munich municipal area and along the main traffic arteries between Munich and Salzburg. Kathrein has installed its own diversity-capable antenna system developed for this purpose and also provided the mobile measuring system, which has been built into a baby carriage for transport in public areas (Fig. 3). Its equipment includes an R&S®TSMW network scanner as the RF frontend.

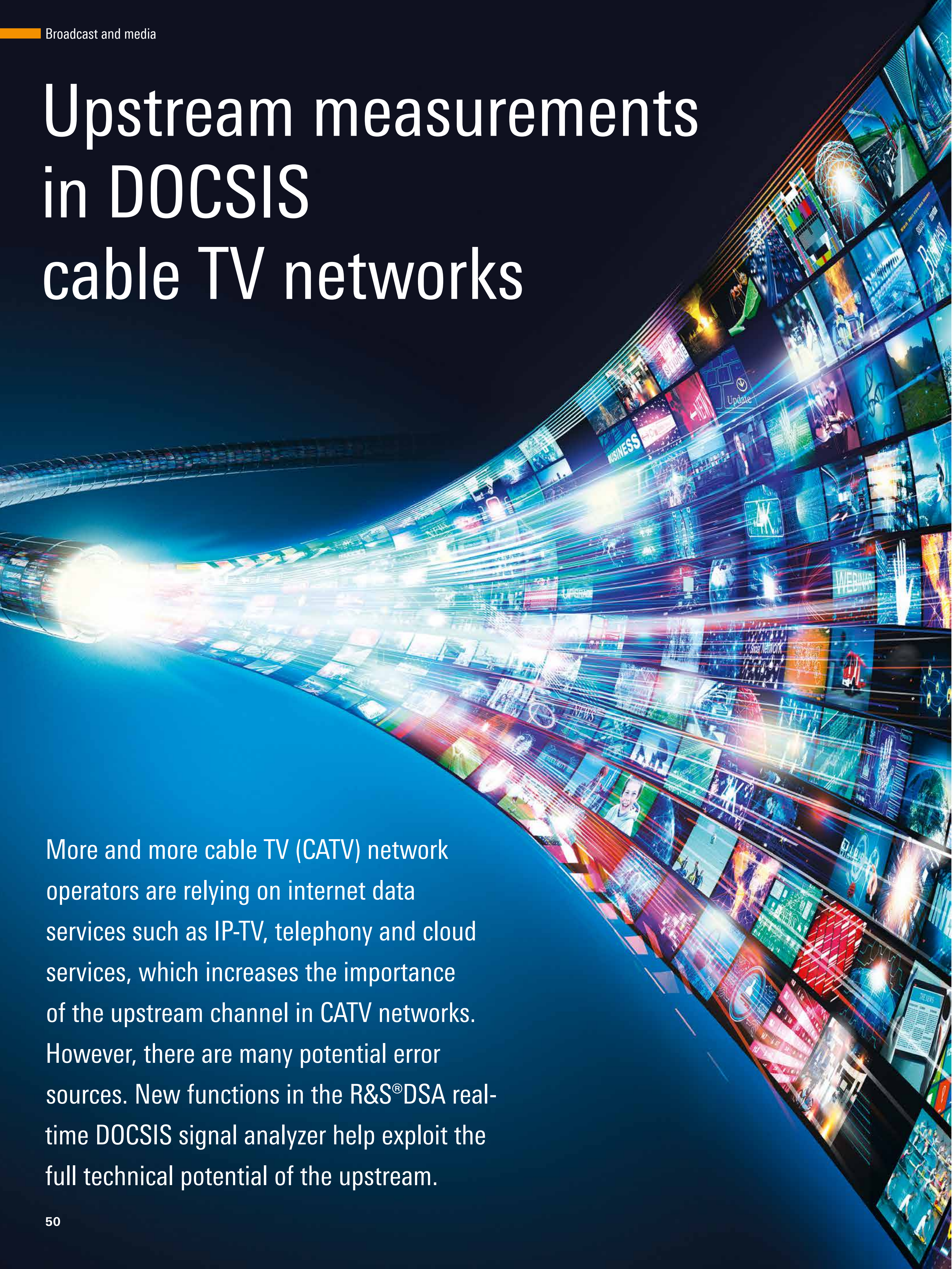
The transmitter obtains the payload and configuration data via 3GPP-compliant protocols from an LTE Evolved Packet Core (EPC). The R&S®BSCC broadcast service and control center handles this task in the research project. An R&S®AVHE100 headend feeds the program content provided by BR to the R&S®BSCC.

The 5G Today project comes at the right time, before the expected 5G wave reaches consumers. The technical insights from the project can be used to fine-tune FeMBMS standardization in 5G and improve the launch conditions for a rollout of commercial FeMBMS networks. The industry gains valuable information for prototype development.

(Red)

Fig. 3: The Kathrein measurement baby carriage (in transport mode on the left and in measurement mode on the right) combines retro charm with advanced analysis technology. It houses GPS and measurement antennas, an R&S®TSMW network scanner, a computer with signal analysis software and the power supply.

Upstream measurements in DOCSIS cable TV networks



More and more cable TV (CATV) network operators are relying on internet data services such as IP-TV, telephony and cloud services, which increases the importance of the upstream channel in CATV networks. However, there are many potential error sources. New functions in the R&S®DSA real-time DOCSIS signal analyzer help exploit the full technical potential of the upstream.

Fig. 1: The R&S®DSA real-time DOCSIS signal analyzer's new functions are very useful for detailed analysis of upstream signals in CATV networks.

The upstream – a challenge for CATV network operators

Since the introduction of DOCSIS 3.1, many CATV network operators have begun replacing existing DOCSIS 3.0 channels with DOCSIS 3.1 channels or operating additional channels in the upper frequency range at up to 1218 MHz. While the rollout process was relatively straightforward in the downstream, it is proving more difficult to introduce DOCSIS 3.1 in the upstream. Network operators have to deal with the problem of interference caused by defective installations or inadequately shielded end-user equipment. Frequently, the interference will add up at a headend's cable modem termination system (CMTS) and prevent the use of constellations greater than 64QAM. Tracking down all of this interference requires pinpoint analysis of the upstream signals. This capability is supported by new functions in the R&S®DSA real-time DOCSIS signal analyzer (Fig. 1).

DOCSIS 3.1 – also a technical revolution in the upstream

Version 3.1 of the data over cable service interface specification (DOCSIS) is the first to use OFDM signals with multicarrier modulation to transmit internet data in hybrid fiber coax (HFC) cable TV networks – with bandwidths up to 192 MHz and constellations up to 4096QAM in the downstream (toward the cable modem). In the past, internet users were mainly interested in high data rates in the downstream, but today there is growing demand for high data rates in the upstream (toward the headend) in order to upload photo albums or videos to the cloud or YouTube, for example. DOCSIS 3.1 meets this need by supporting OFDMA signals with bandwidths up to 96 MHz and constellations up to 4096QAM.

Upstream analysis in conjunction with the R&S®SFD

The quality of the upstream signals depends on various factors. Besides the interference issues mentioned above, the condition of the various connectors, coaxial cables, diplexers and trunk amplifiers also plays a significant role. One of the new upstream analysis functions in the R&S®DSA works in combination with the R&S®SFD DOCSIS signal generator. This instrument duo provides an easy-to-use solution for in-depth testing of upstream components over large distances in the field or in the lab (Fig. 2).

Unlike previous solutions that used simple signal generators limited to continuous, single-carrier QAM (SC-QAM) signals, the R&S®SFD allows measurements with pulsed upstream signals exhibiting the characteristics of OFDMA signals (DOCSIS 3.1) and A-TDMA signals (DOCSIS 3.0). Upstream tests with broadband OFDMA signals and up to 4096QAM modulation are possible without a CMTS with its complicated parameter settings and without cable modems.

Testing in the upstream

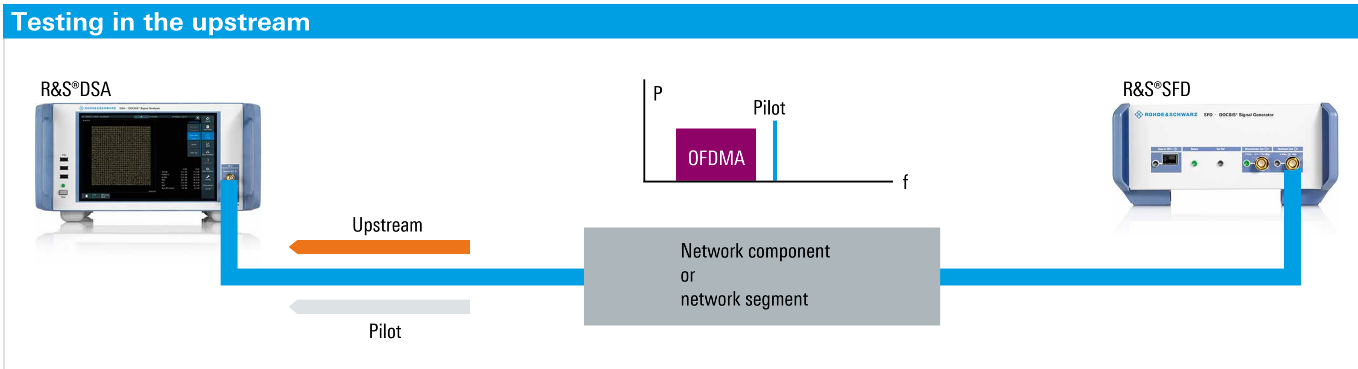


Fig. 2: Testing network components or a network segment in the upstream with the R&S®DSA and R&S®SFD.

In order to synchronize with the pulsed upstream signals, the R&S®DSA requires information about the propagation time and signal parameters. To transmit this information to the R&S®DSA, the R&S®SFD signal generator inserts a subcarrier at a user-defined frequency. On the R&S®DSA, only the frequency of this carrier has to be entered. The analyzer configures itself accordingly and begins the measurements. It analyzes all parameters that are relevant to the physical layer, including the signal level, MER, BER, constellation, microreflections, amplitude response, group delay and much more.

Upstream analysis during live operation

During live operation, several hundred cable modems normally share the upstream in a cluster. The upstream capacity is allocated using time and frequency division multiplexing. The individual modems are assigned mini slots and specific channels in which the modems may transmit data packets to the CMTS.

To ensure interference-free operation, the cable modems must comply with the individual requirements they receive from the CMTS. Each cable modem must first register with a CMTS to synchronize its timing and set the modem output level within a specified range ("initial ranging"). To ensure that timing errors are constantly corrected and the cable modem's output level is dynamically adapted to the upstream conditions, this process is repeated about every 20 to 30 seconds ("station maintenance") after the modem has been registered.

The CMTS organizes these processes using timestamps, upstream channel descriptors (UCD), MAP tables (bandwidth allocation MAP), media access control (MAC) messages and service identifiers (SID) that are sent to the cable modems via the downstream channels. The upstream channel descriptor is especially important. It tells the cable modem the signal parameters it must use to transmit data back to the CMTS. Interaction between the CMTS and its registered cable modems is continuously dynamically adapted to the current requirements for bandwidth consumption and signal quality in the upstream. In order to analyze pulsed upstream signals, the analyzer needs information about the signal parameters since, unlike the downstream signals, these parameters are not transmitted.

For continuous monitoring and maintenance of DOCSIS infrastructure in CATV networks, the DOCSIS 3.1 standard introduced proactive network maintenance, which specifies the measurements that the cable modems and upstream receivers of a CMTS must perform. The signal quality of upstream signals can be queried right where the CMTS or a remote PHY component (remote RF interface of a CMTS) is located. Multichannel upstream receivers can be placed in a CMTS and output their measurement results to special handheld devices. Both methods are limited by the fact that the upstream signal quality can only be measured at the ends of the upstream channel instead of anywhere on the path between the cable modems and the CMTS. This is where dynamic upstream analysis with the R&S®DSA comes into play.

Upstream signal analysis in HFC CATV networks

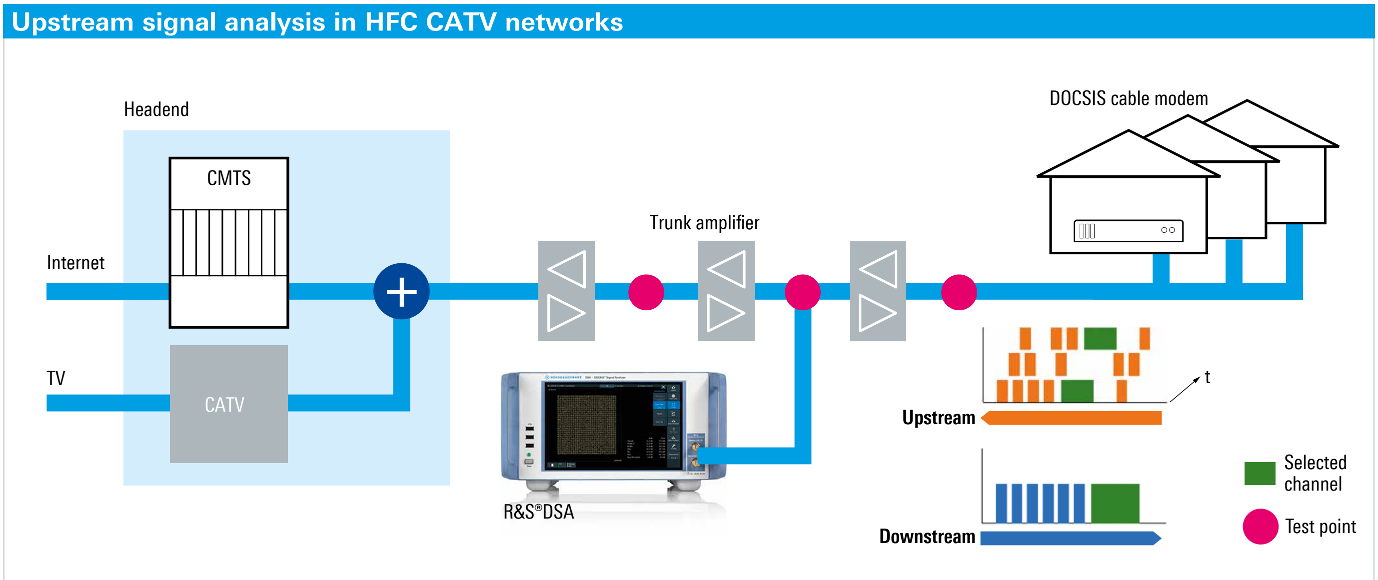


Fig. 3: Measurements are possible anywhere on the path if suitable test outputs are available.

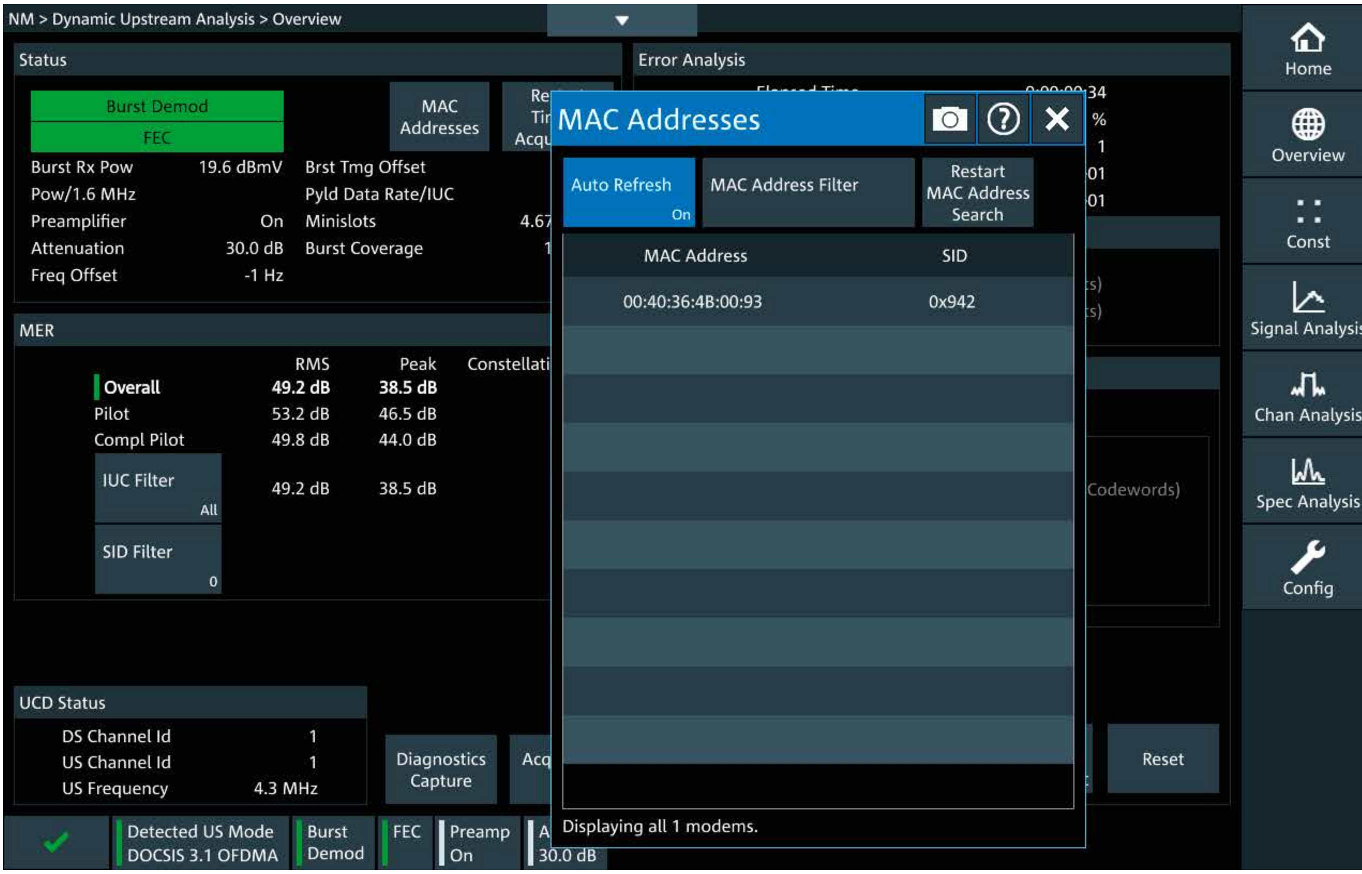


Fig. 4: Comprehensive analysis functions are available for pulsed upstream signals.

Dynamic upstream analysis

The new dynamic upstream analysis function requires model 03 with its two separate RF receivers for the upstream and downstream.

Measurements in the lab or in the field can be performed anywhere on the path between the cable modems and a CMTS or a remote PHY component. All that is needed are suitable test outputs to allow simultaneous access to the upstream and downstream signals (Fig. 3).

Once the user has selected a primary DOCSIS 3.0 or DOCSIS 3.1 downstream channel, the R&S®DSA starts acquiring DOCSIS timestamps, MAC messages and UCDs. Afterwards, the frequency of the OFDMA or A-TDMA upstream channel to be analyzed is entered. In a further complex step, the R&S®DSA optimizes its internal timing based on the distances to the CMTS and the cable modems, and then its upstream receiver self-configures based on the UCDs received via the downstream.

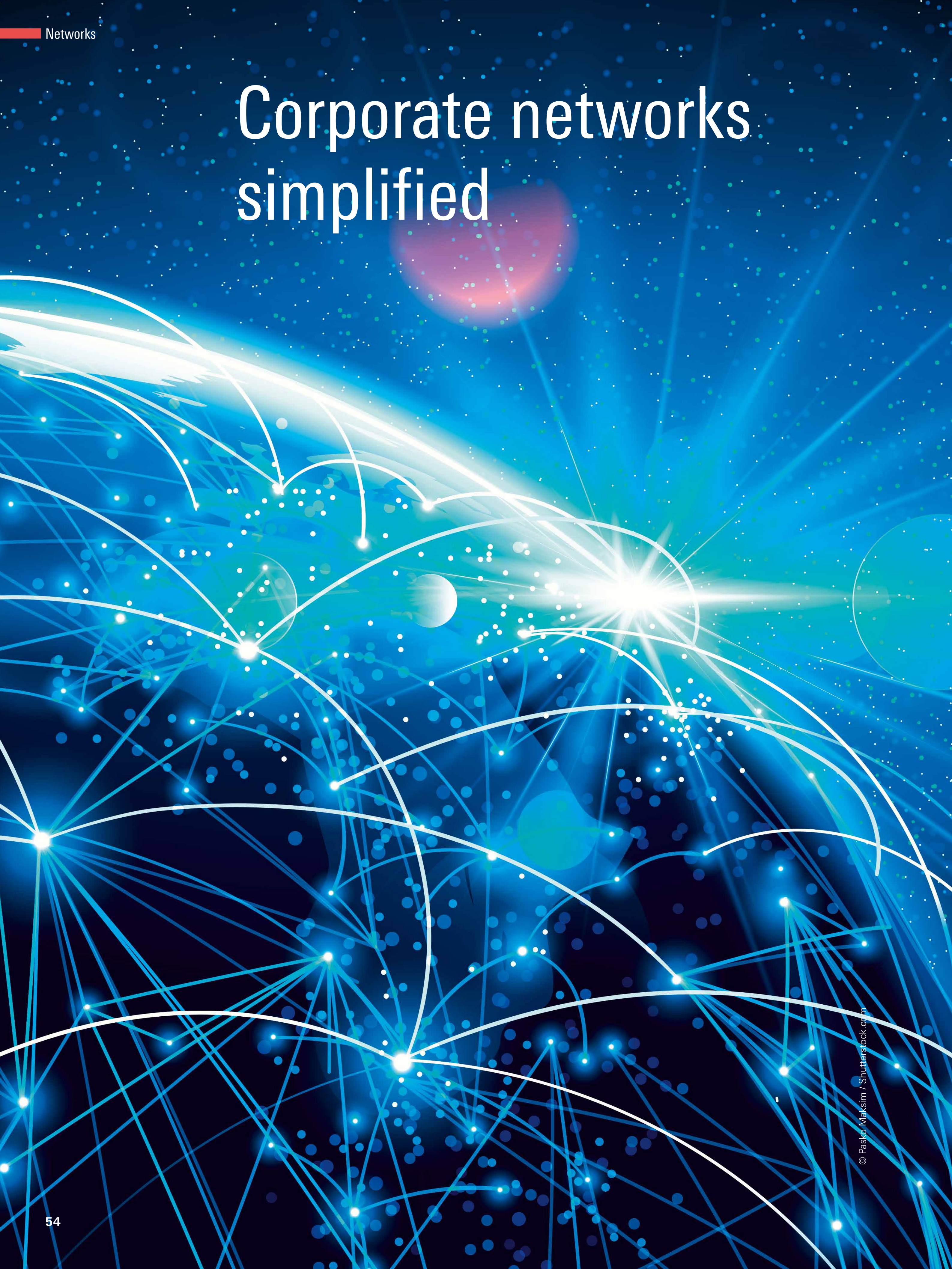
When these preparations are complete, the R&S®DSA starts continuously scanning the selected downstream channel for relevant MAP messages for the designated upstream channel in order to detect the appropriate pulsed upstream signals and create a list of associated SIDs. To perform measurements on a specific cable modem, this list can be filtered by MAC address or SID. The selection can be further refined to search for data packets of a specific type that can be identified via interval usage codes (IUC).

Just like in OFDMA, A-TDMA and upstream analysis modes, comprehensive analysis functions can be applied to the detected pulsed upstream signals (Fig. 4). Key measurements such as MER, BER and MER versus subcarrier for OFDMA are also available.

With its specialized upstream analysis functions and outstanding precision, the R&S®DSA real-time DOCSIS signal analyzer is the perfect solution for network operators and developers of network components who want to maximize performance and quality.

Werner Dürport

Corporate networks simplified



Every company needs a data network, as well as specialists who design, install, administrate and maintain the network. Now this never-ending manual effort is a thing of the past. The management cloud of Rohde & Schwarz subsidiary LANCOM shows how even very large networks can be mainly administered automatically with minimal staff effort.

A router with a few access points is often sufficient for a small business, but the network structures of large companies or chains can encompass several thousand network components distributed over various locations. In the past, a lot of time and staff effort was required to install and maintain such networks. With smart cloud technology, this is now significantly more efficient, more reliable and more secure. If the gateways, routers, switches and hotspots are suitably prepared in the factory, large networks can be set up ready for operation as fast as the components can be installed on site. The entire network logic is automatically distributed to the hardware over the cloud (Fig. 1). The products from LANCOM Systems are designed for this modern form of network administration. The company's operating systems – LANCOM Switch OS and LCOS – support software-defined networking via the management tool LANCOM Management Cloud (LMC).

The LMC is a cloud service for LANCOM products provided to customers either directly by LANCOM or by its distributors. Network users and owners are fully relieved of the burden of technical support and can concentrate solely on their business activities. The network administrator has central control over the network and all of its components, which may be located anywhere in the world.

Hierarchical procedure: network, locations, devices

The LMC planning tools are used to define a customer network step by step at the abstract level. The question of which device types will ultimately perform the network functions is initially irrelevant. For each customer, the administrator specifies a structure composed of subnets that can later be administered collectively with just a

Modern network management

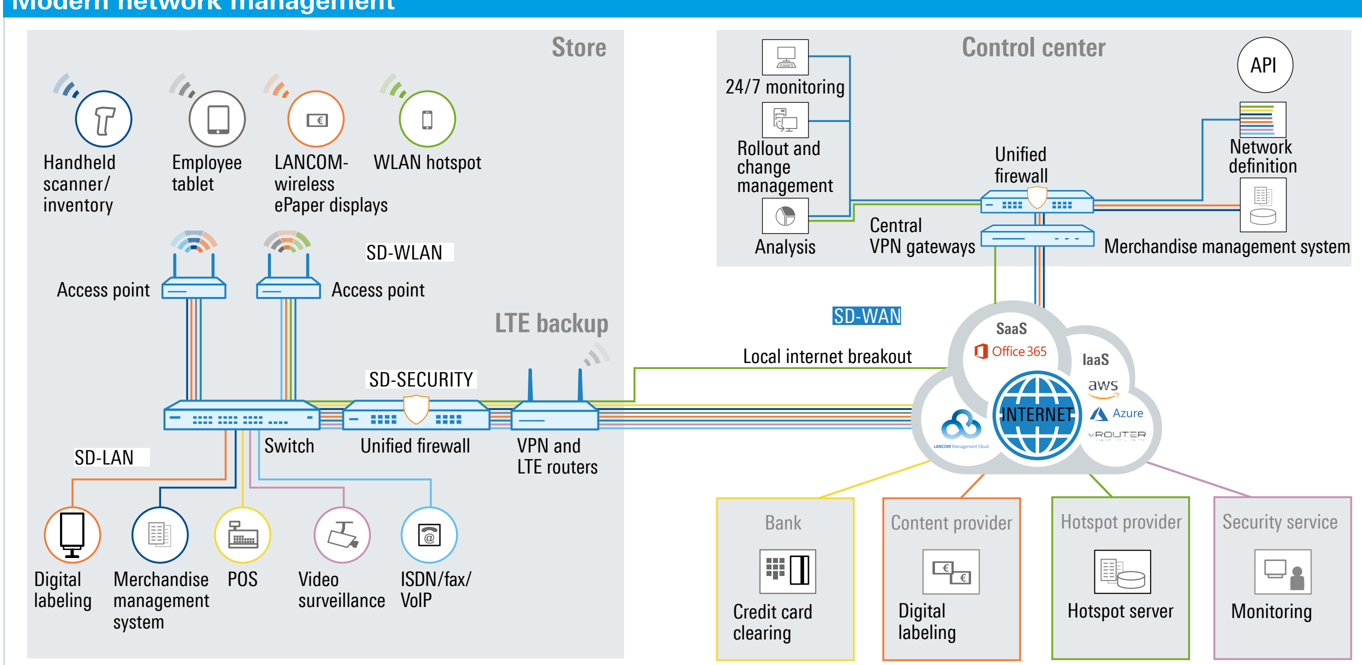


Fig. 1: Typical network structure of a chain store company administered over the LANCOM Management Cloud.

few commands. For example, LAN and WAN functions can be administered separately, or subnets can be specified for different user groups and functions, such as telephony. An IP range is then assigned to the overall network, such as the address space of a class B network. It is automatically segmented and broken down to the locations once they are named. The LMC automatically handles restructuring, such as adding new locations, by completely reconfiguring the network if necessary in order to restore a uniform network appearance.

The next step is to configure the basic attributes of the subnets and to parameterize them. If, for example, all members of a subnet need to be securely connected via a VPN, then VPN connections are automatically set up between all locations where members of this subnet are present. This is done in a way that achieves maximum security over every link segment, depending on the components that will later be deployed there. Allocation of WLAN SSIDs for the routers, VLAN IDs for the switches and WLAN hotspot attributes can also be performed from a central location.

Once the network has been abstractly defined, it is then implemented, starting with the assignment of real locations. This is done by simply entering their postal addresses, with visualization handled by Google Maps. In the case of large networks with many components, it is advisable to visualize the local situation using building plans, which can be uploaded to the LMC (Fig. 2). These plans provide an overview, improve maintainability and help with the optimal placement of WLAN components in particular.

Device selection comes only after the network architecture has been established. All components to be used in the network are registered with the LMC using their serial numbers and cloud PINs. They can then be assigned to the locations. This administrator's work is now almost complete. The network more or less sets itself up: once the devices are physically connected, they automatically fetch their location-specific configurations from the LMC over the internet. Particularly with chain businesses, which may have several hundred similarly equipped locations, this automatic process makes an enormous contribution to efficiency. However, the rolled-out configuration of each component can be individually overwritten if an adaptation to special conditions is necessary. This is done by simply selecting and editing a component in the location plan.

Full transparency

Approximately 60 percent of the human cerebral cortex is involved in perceiving, interpreting and responding to visual input. This explains the preference for visualizing user interfaces and

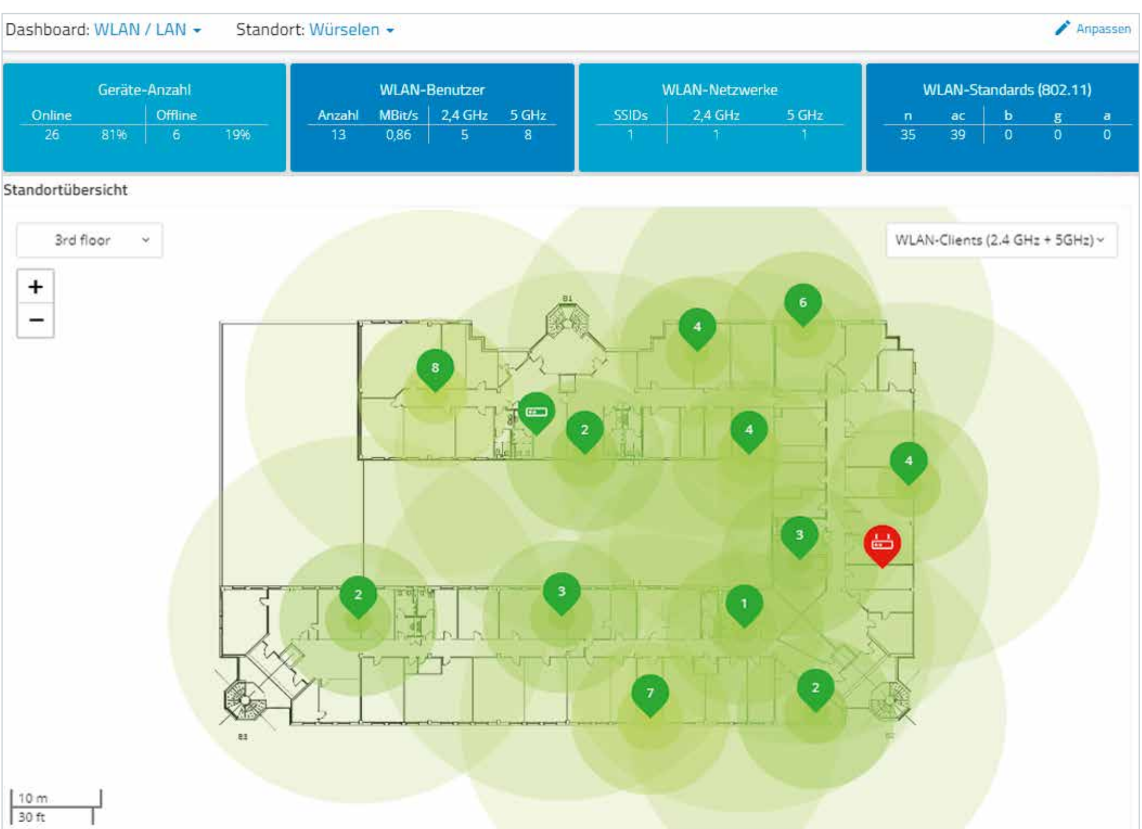


Fig. 2: WLAN networking can be planned conveniently with building floor plans. The expected coverage by the access points is displayed.

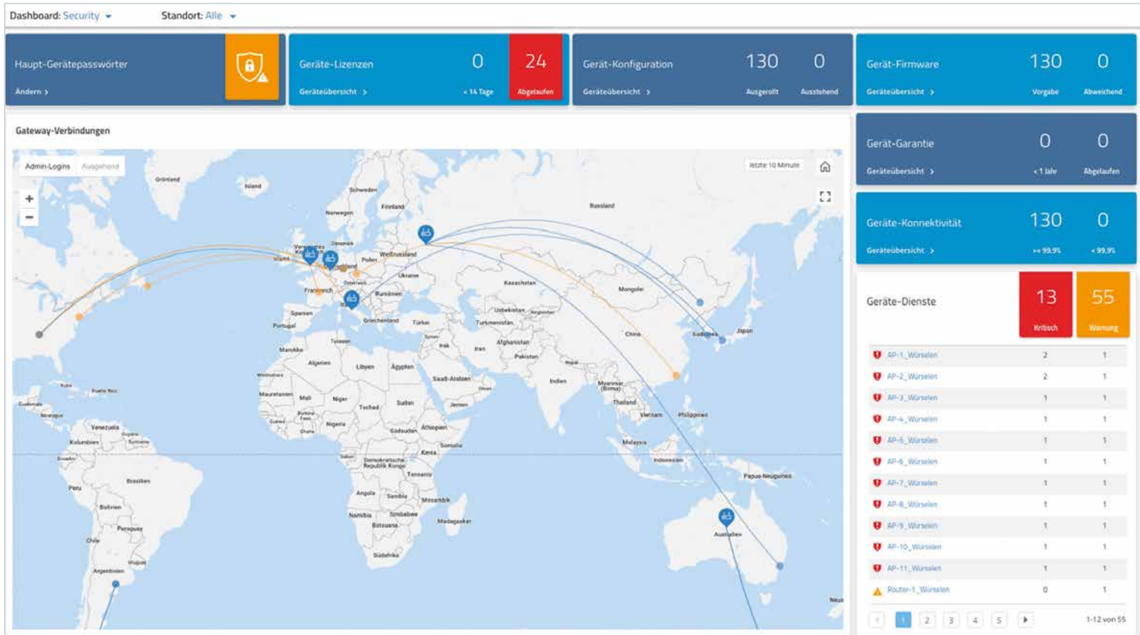


Fig. 3: The security dashboard indicates critical points in the network.

information about complex systems as much as possible. The LMC is no exception to this rule. The administered networks, their components, status data and statistics are graphically processed at every level of detail and presented on dashboards, so that any desired information is available within a few seconds (Fig. 3). For example, the operational status of all VPN tunnels between the locations can be seen at a glance on the world map (Fig. 4). Devices without a password or with outdated firmware can be identified quickly. Furthermore, all kinds of useful statistics are available, such as throughput, error rates and user volume. Malfunctions trigger alerts and can be localized immediately. However, technical details are usually only of interest to the administrator. To enable the customer to also keep an eye on their network, the project observer role is available in the LMC. The observer can view all dashboards, but cannot directly perform any actions. Other roles are allocated permissions at various levels.

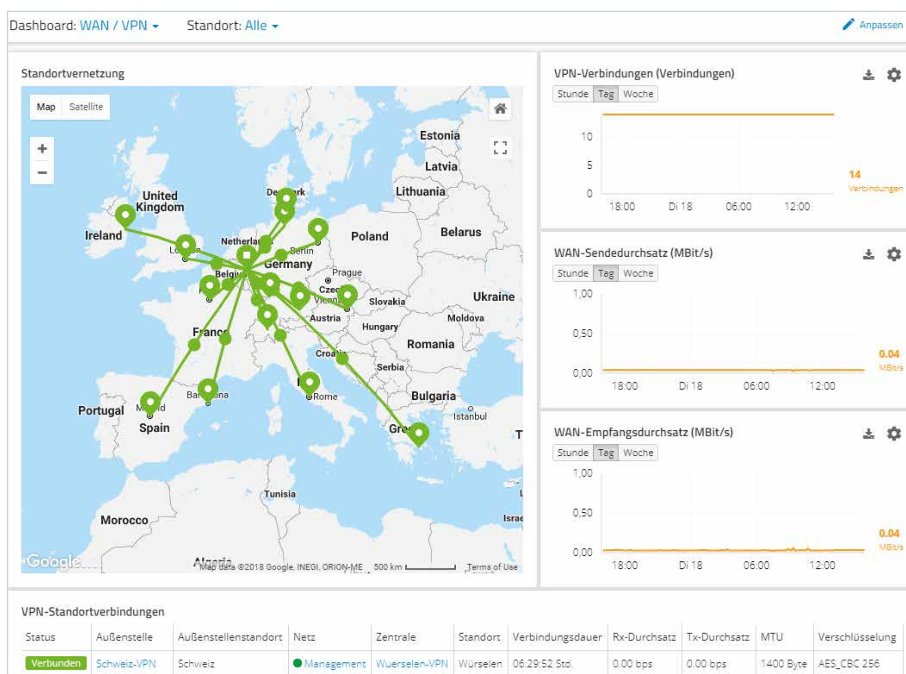


Fig. 4: Green means secure: all VPN tunnels are set up. Clicking on a location displays the connection details.

For networks of every size

One of the advantages of the LANCOM Management Cloud is its scalability. Network size and geographic distribution of the locations are not an issue. Large chains in particular benefit from automatic network rollout. A considerable number of such customers, including several German retail chains, are already using this service. One of them is the shoe chain RENO, whose 300 German stores are networked with LANCOM technology (see the following article).

(Red)

Network revolution gets off on the right foot

With software-defined networking, the shoe chain RENO makes its store network future-proof and saves massive amounts of time and money.

A customer pays with a debit card at the POS, while an employee handles a customer order online using a tablet. Stock levels and POS data are constantly synchronized with the control center in real time, and all phone calls are made with IP-based connections. To ensure smooth running of the many processes, which are often complex, and be prepared for future challenges, RENO has migrated its entire network infrastructure to software-defined networking over the cloud.

"There were many reasons for us to update our store networking, such as a migration to IP-based phone connections," explains Matthias Schäfer, Director of Information Technology at Hamm Reno Group GmbH. The main objective of the shoe vendor, active across Europe, was to make their store network future-proof. For high performance and failsafe connections, the majority of the more than 300 locations in Germany will be linked over VDSL. WLAN will bring mobile applications to the stores and form the basis for an integrated omnichannel approach. "For us, it was important right from the start to address these complex requirements with a network that can be easily and flexibly administered," notes Schäfer.

The shoe chain found what it was looking for with the network solutions provider LANCOM Systems. "We opted for the package consisting of VoIP routers, switches and WLAN, along with the LANCOM Management Cloud, a central, cloud-based entity for administration of all network components," says Oliver Kasper, Group Leader IT Infrastructure at Hamm Reno Group GmbH.

Automatic and smart rollout

The rollout of the store network was handled together with LANCOM and Diebold Nixdorf, one of the world's leading specialists in retail technologies. The entire network is centrally rolled out, administered and monitored via the LANCOM Management Cloud. The administrator simply specifies the general conditions for the network design, and the system automatically implements all adaptations and changes. The hardware infrastructure in the stores is relatively simple. A single VoIP-capable router, a switch and one or two WLAN access points are all it takes to provide all the services.

The POS systems are connected via the router to the control center," explains Schäfer. "Electronic cash clearing, customer frequency measurement, tablet communications, employee time recording, all order handling processes and synchronization with the ERP system also run over the router. Additionally, there are maintenance access points and integration with alarm systems and electricity meters." This also applies to telephony in the stores, which likewise runs over the router since the migration to IP-based phone connections. "Thanks to the new VoIP-capable hardware components, we were able to keep our existing analog phones and did not have any new CAPEX here," notes Kasper. The router simply handles the conversion between analog and IP. The necessary failsafe backup is provided by an integrated LTE modem, which restores internet access over the mobile network in the event of a VDSL disturbance.

The store employees work with tablets that communicate with the internet and the corporate network over WLAN. "The WLAN supports the implementation of our omnichannel concept and is an important prerequisite for the smooth operation of various processes," says Schäfer. For example, customers can order items online even if they are not available in the central warehouse but in stock at one of the stores. The order process is handled in the store via a tablet.

Massive time savings with a cloud-administered network

Using the LMC as a central management point simplifies many aspects of configuration and monitoring of the overall network. "The advantages of the management cloud are especially noticeable with previously time-consuming tasks such as firmware updates. This works for all locations with a single mouse click," says Kasper. In addition, all performance data of each network component is displayed. This makes troubleshooting easier for administrators. As a result, problems are identified and resolved faster. The time savings are enormous. For example, in the past each router had to be individually updated for a firmware update. That took at least 10 minutes per store, which works out at about 50 hours for 300 stores. "With the new solution, that is reduced to a few mouse clicks and a few minutes. That's a really big difference," comments Kasper. "It means we certainly save several hundred hours per year," adds Schäfer.

WLAN hotspots for customers based on the new agile network are also planned. "We want to first get some experience with the new service in a few stores before rolling it out for the entire company," says Schäfer. With the new network and the cloud management solution at their side, the shoe chain is confident that they are well equipped for this next step.

(Red)

Typical network components for a chain such as RENO (top to bottom): LANCOM 1793VA-4G router for VDSL transmission rates up to 300 Mbit/s with integrated LTE modem; LANCOM GS-2326P+ switch with 24 Gigabit Ethernet ports and two combo ports for networking of up to 26 devices; LANCOM LN-830acn dual wireless access point for simultaneous IEEE 802.11ac and 802.11n operation.

Three generations in the ice

For decades now, shortwave technology from Rohde & Schwarz has ensured reliable communications between the Italian Antarctic research stations and their European home bases when no satellite link was available.

Fig. 1: After 30 years, just as reliable as on the first day: the 1 kW R&S®XK859C1 transceiver (left) at the Mario Zucchelli Research Station.

In 1988, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) equipped the Mario Zucchelli Antarctic Research Station located in Terra Nova Bay (Ross Sea) with shortwave technology from Rohde & Schwarz. ENEA purchased a 1 kW R&S®XK859C1 transceiver, a 150 W R&S®XK852C1 transceiver and an R&S®EK890 receiver – the top-of-the-line products at that time (Fig. 1). Based on positive experience with this technology, the Concordia Station, which is jointly operated with France (Fig. 2), was similarly outfitted 14 years later with shortwave equipment from Rohde & Schwarz. Initially in operation only during the summer months, the station was equipped with one R&S®XK852C1 and one R&S®XK2100L transceiver (each with 150 W). At the start of this year, a 1 kW transceiver from the M3SR®Series4100 family was added. All three generations of equipment ensure reliable contact with the European home bases when no satellite radio link is available. Amateur radio products were also tested during this time period, but they fell victim to the climatic conditions at the sites, where the average temperature is –54.5 °C.

Reliable climate forecasting more urgent than ever

The Concordia Research Station is located 3233 m above sea level on the Antarctic Plateau at a site known as Dome Concordia (Dome C). The station is jointly maintained by the French and Italian polar programs. Along with the Russian Vostok Station and the American Amundsen-Scott South Pole

Station, it is the third Antarctic research station that is constantly manned. In the 1990s, Dome C was selected by the European Project for Ice Coring in Antarctica (EPICA) as part of efforts to find the oldest ice on earth. The objective was to reconstruct the climate history of the earth and improve forecasting of future climatic developments.

Drilling performed from 1996 until the end of 2004 reached a depth of 3270 m, which was only a few meters from the bedrock. The oldest ice sample that was obtained is about 800,000 years old. Based on analysis of the geological archive, however, we know that prior to the so-called middle Pleistocene transition (i.e. immediately before on a geological timescale), cold (glacial) and warmer (interglacial) ages alternated every 40,000 years. Afterwards, the alternation period increased to about 100,000 years. The reason for this change is unknown, and therefore represents a topic of current research by Concordia scientists, including representatives of the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven. Rock samples offer no clues, since they do not contain any residual gases. As a result, it is necessary to look deeper into the ice in chronological terms. Finding suitable drilling locations was the previous stage milestone for the EPICA follow-up mission "Beyond EPICA – Oldest Ice (BE-OI)". Researchers are now hoping to find what they are looking for. Only about 40 km from the station, an area with a diameter of 3 km has been identified. Drilling will not begin until 2021 and will be initially limited to a depth of 100 m in order to test the technology. By 2024/2025, however, the goal is to completely penetrate the ice sheet at the drilling site, which has a depth of 2750 m. This will be followed by the evaluation process, requiring an additional year.

In addition to the Europeans with their BE-OI project in the vicinity of Dome C, other teams are also working to break through the one million year mark, including the Japanese at Dome Fuji and the Chinese at Dome A. The International Partnerships in Ice Core Sciences (IPICS) was formed to encourage friendly competition in this race.

Guiseppe Di Riso, Robert Träger

Fig. 2: The Italian-French Concordia Research Station has been manned year-round since 2005.

Monitoring and analyzing satellite signals

R&S®GSACSM communication system monitoring is a software solution for monitoring and analyzing satellite signals. It has a wide array of useful features for operators of satcom systems, regulatory authorities, and public safety and security authorities.

Operators of satcom systems are required to constantly monitor the status and quality of their satellite links. Regulatory authorities need access to the measurement results for the links in order to check for errors or tolerance violations that can impact the quality of other services. Public safety and security authorities have to access the relevant data for identification and intelligence purposes (Fig. 1). To support these applications, Rohde & Schwarz developed R&S®GSACSM communication system monitoring in cooperation with its INRADIOS subsidiary.

R&S®GSACSM enables worldwide access to RF sensors such as spectrum analyzers and power sensors as well as control of signal generators. Complete loopback or system tests can be remotely executed on large-scale installations, e.g. on antenna systems. The software works with the user's existing Rohde & Schwarz equipment. Multiple users can simultaneously access the measurement data from the sensors. R&S®GSACSM combines analysis and digital demodulation methods on a graphical interface to allow consistent, user-friendly settings for a wide variety of instrument types.

R&S®GSACSM requests digitized signal fragments from the sensors, which it then demodulates and analyzes. The software automatically configures all of the relevant sensor parameters (center frequency, sampling rate, signal recording length, etc.). All of the demodulation and analysis functions are implemented in software and can be extended via updates.

Key features of R&S®GSACSM

- Multichannel power measurement, history logging and alarm trapping
- Classic software-based spectrum analyzer functions
- R&S®GSACSM can be directly installed on Rohde & Schwarz test instruments such as the R&S®FSW signal and spectrum analyzer for reduced hardware expense
- Autonomous detection and identification of:
  - Satellite signals (DVB-S2, DVB-S1, etc.)
  - PCMA signals
  - TDMA signals
  - Carrier in carrier
  - DVB-CID signals
- Simultaneous access to multiple remote spectrum analyzers
- Offline analysis of recorded signal files
- Remote spectrum monitoring over narrowband links and long latency links

Target group	Application scenarios
Satellite operators	Continuous monitoring of satcom links, status monitoring and alarm trapping based on carrier parameters such as E_b/N_0, C/N, data rate, receive power, etc.
Regulatory authorities	Interference detection based on carrier-in-carrier analysis. Using CiC, for example, it is possible to look in or "under" a carrier in order to demodulate and classify potential interfering signals.
Public safety and security authorities	Identification of unknown satcom signals using the extensive carrier analysis functions provided by R&S®GSACSM. Detection of modulation methods and error protection coding for intelligence purposes.

Fig. 1: Target groups and application scenarios for the R&S®GSACSM communication system monitoring software solution.

R&S®GSACSM modules

The software typically includes these modules:

- **R&S®GSACSM sensor:** Recording/digitization of signals from instruments connected to the R&S®GSACSM server via a network or TCP/IP connection, e.g.:
  - R&S®FSW, R&S®FPS, R&S®FSV signal and spectrum analyzers
  - R&S®FSC, R&S®FSG, R&S®FSL spectrum analyzers
  - R&S®TSME6 drive test scanner
  - R&S®NRQ6 power sensor
  - R&S®OSP open switch and control platform
  - R&S®ESMD wideband monitoring receiver
  - R&S®MSR200 dual satellite receiver
- **R&S®GSACSM server:** This software controls and manages user interaction with the sensors. It transfers or processes the measurement results, manages access rights for individual users, and controls multi-user access to the RF sensors. R&S®GSACSM server performs cyclically recurring measurements and saves the results (e.g. spectrum data, I/Q signal files, power values) in a database.
- **R&S®GSACSM user:** This graphical user interface plays the role of a classic multi-screen, multi-sensor desktop monitoring application. Fig. 2 shows the system's different operating modes.

Examples of standalone and client/server scenarios

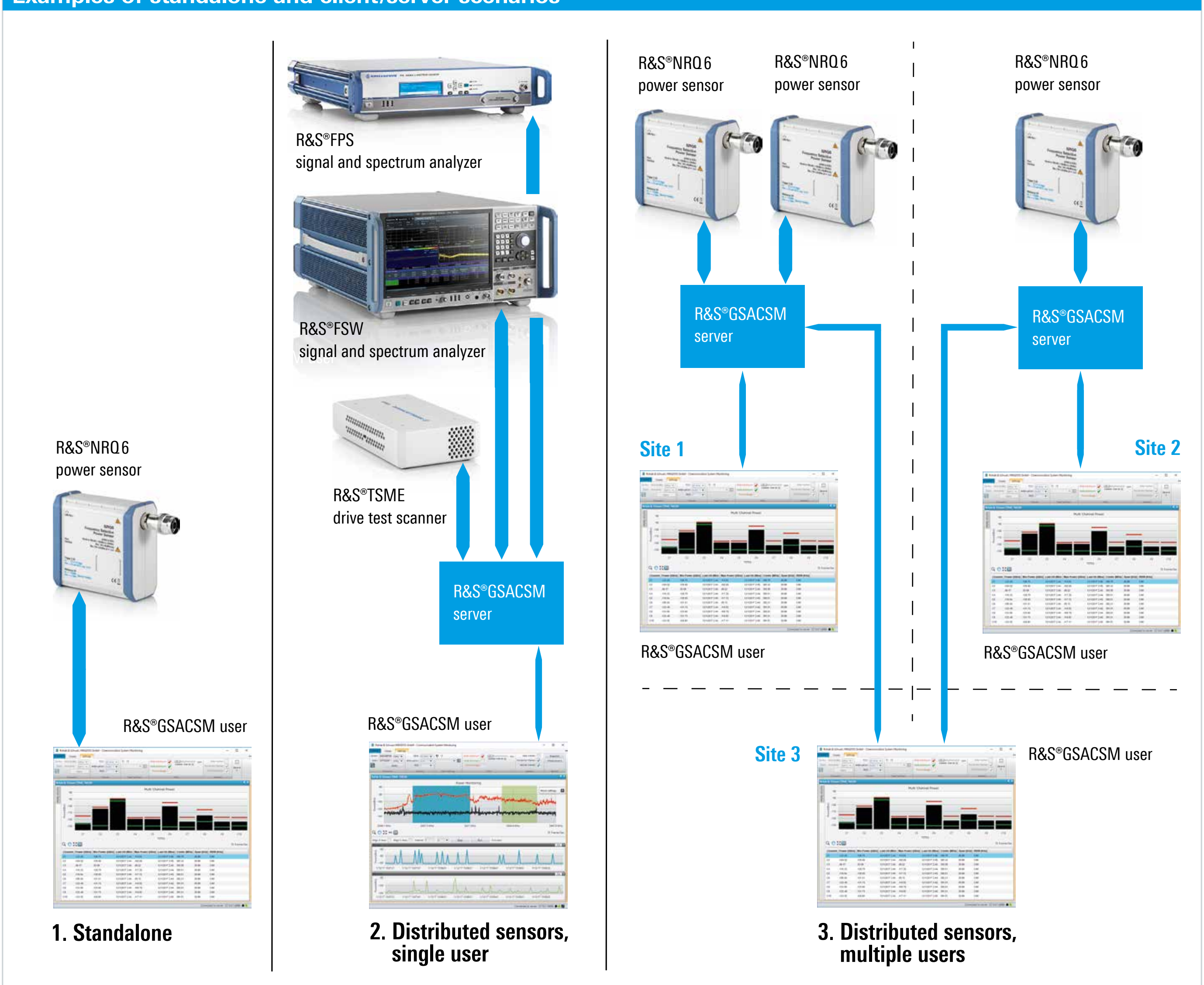


Fig. 2: Possible R&S®GSACSM operating modes.

R&S®GSACSM server can also run directly on certain Rohde & Schwarz test instruments without a separate computer (e.g. on the R&S®FPS or R&S®FSW). This is beneficial for users who already own these instruments and want an easy way to extend them with R&S®GSACSM or who do not have space for extra hardware. Often there is no way to provide additional processing capacity for monitoring purposes, e.g. in mobile satcom terminals. Here too, installation of R&S®GSACSM on an existing Rohde & Schwarz instrument is a way to extend system functionality.

Remote controlled spectrum and signal monitoring

R&S®GSACSM accesses the distributed sensors via network or TCP/IP connections. The software not only supports monitoring of signals from a single instrument, it can also simultaneously operate a number of different RF sensors. Fig. 3 shows some of the single carrier per channel (SCPC) and TDMA satellite signals that can be detected.

Manufacturer (SCPC)	Modem designation
COMTECH	LDPC 2/3
	LDPC 3/4
	VersaFEC 0.642L
	VersaFEC 0.789L
	VersaFEC 0.803
IDirect	TPC 0.793 Infinity
Radyne	TPC 3/4 VSAT defacto
Various	TPC 3/4
Various	TPC 7/8
Various	TPC 7/8 VSAT defacto

Manufacturer (TDMA)	Modem designation
Viasat	LinkWay, LinkWayS2, SurfBeam, SkyLinx DDS
Nortel	DASA SKYWAN (IDU 200, 3000, 5000, 7000)
PolarSat	VSATPLus II VSATPLus 3
Nera	SatLink
Gilat	SkyBlaster, FaraWay, SkyEdge SkyEdge II, DialAway, SkyStar VARIANT
Hughes	DIRECWAY (IPoS), PE5
Shiron	InterSKY
Comtech / Radyne	SkyWire
Advantech Satellite Networks	Various
Tachyon Networks	Various
NEC	NEXTAR48 (IC), NEXTAR4A (OC), NEXTAR Bandwidth On Demand, NEXTARV0

Fig. 3: SCPC and TDMA satellite signals that can be detected by R&S®GSACSM, and manufacturer-specific modem designations.

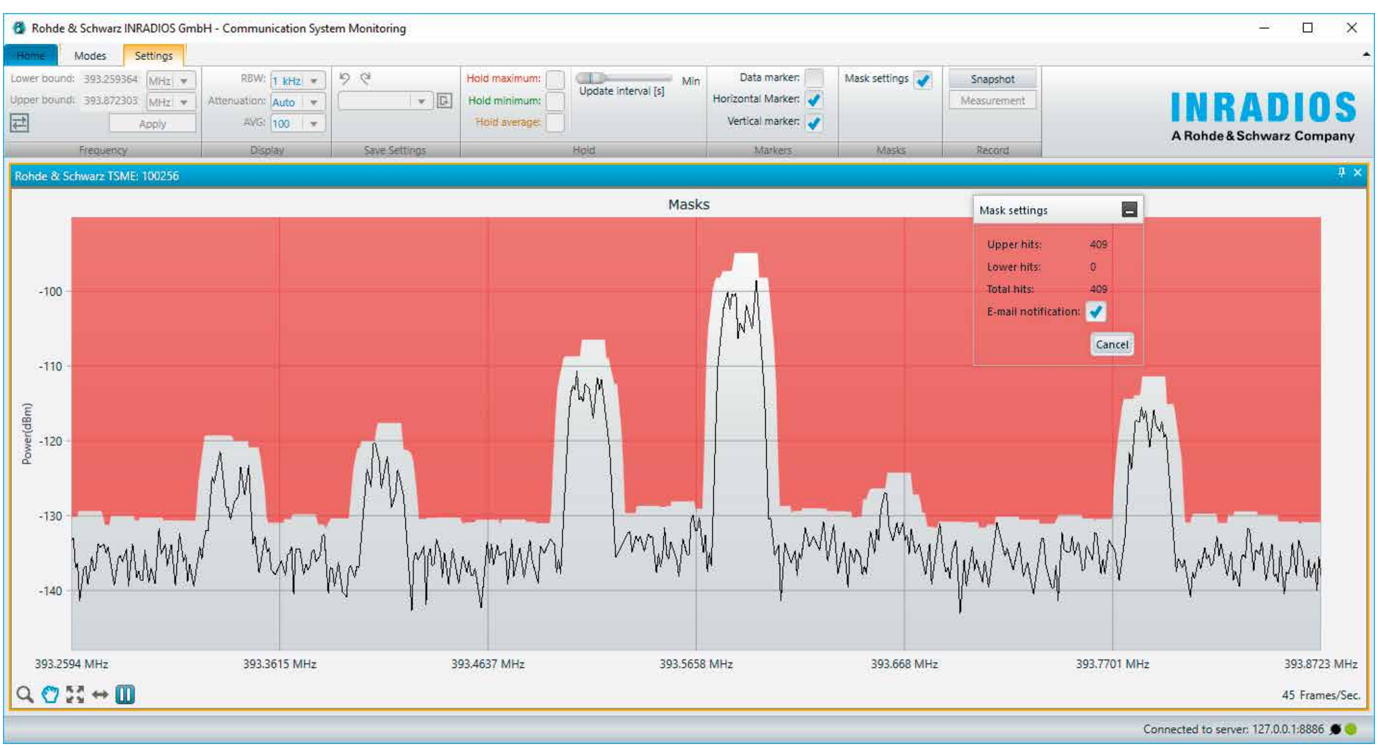


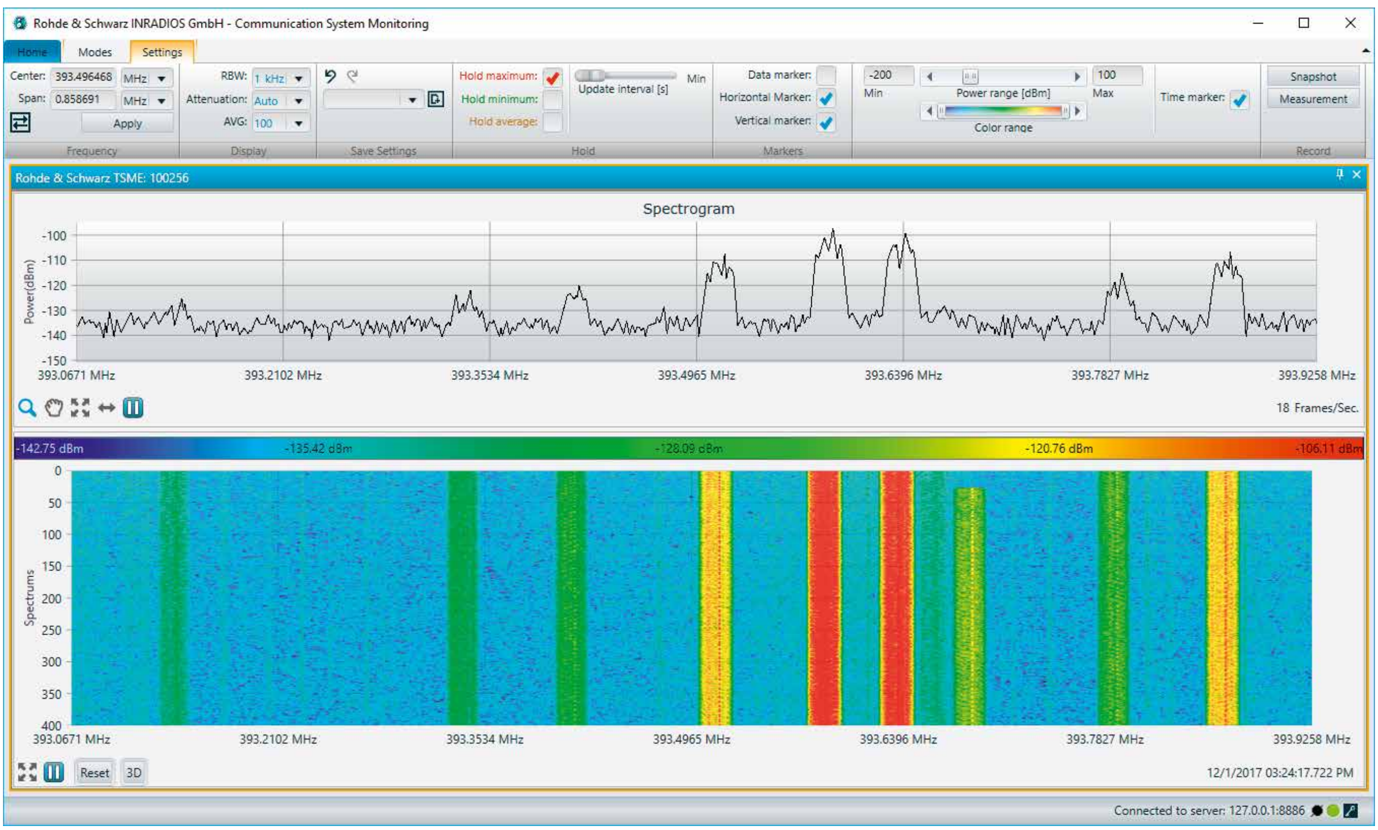
Fig. 4: Users can define spectrum signal masks to ensure that every suspicious carrier is immediately identified. The R&S®GSACSM server can also run on test instruments such as the R&S®FSW signal and spectrum analyzer, i.e. a separate computer is not required.

Spectrogram to identify signal parts using color-coded waterfall charts

Systems using R&S®GSACSM can monitor the power spectral density of any spectrum analyzer input signal. This helps identify potential unwanted signal sources. The spectrogram function with 2D and 3D waterfall charts is very helpful in this regard (Fig. 5).

Spectrum density measurement identifies sporadic signal parts

The spectrum density measurement monitors time-varying and superimposed signals by continuously capturing and analyzing spectrums over time. Rare or superimposed events that cannot be detected using ordinary spectrum analyzer functions can be visualized in a spectrum density chart.



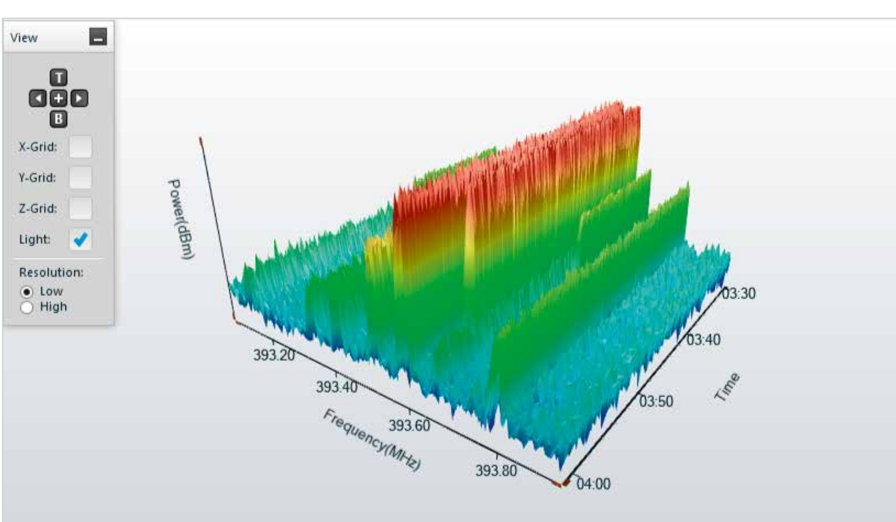


Fig. 5: The spectrogram function produces color-coded 2D and 3D waterfall charts that are useful for identifying signal parts.

Alarm trapping helps automatically identify suspicious signals

Alarm thresholds in R&S®GSACSM inform users when unwanted signals occur. Users can define spectrum signal masks to ensure that every suspicious carrier is immediately identified (Fig. 4). Besides identifying suspicious carriers, it is also possible to monitor the frequency and power stability of wanted carriers. The system collects statistics and can send alerts via email when errors occur.

Identification of underlying signal sources via carrier-in-carrier detection

Under-carrier detection and signal identification

With its R&S®GSA1400/20 CiC separator, R&S®GSACSM detects and identifies paired carrier multiple access (PCMA) signals (Fig. 6).

Identification of suspicious interferers using under-carrier detection

The R&S®GSA1400/10 CiC separator's under-carrier detection feature detects and identifies unwanted asymmetric signals underneath a wanted signal. The demodulated signals and all necessary signal parameters are clearly presented, making it easy to correctly interpret the measurement results.

This is an essential feature of the R&S®GSA1xxx VSAT intercept solution. It makes it possible to intercept signals transmitted using paired carrier multiple access technology or asymmetric carrier-in-carrier in a duplex link.

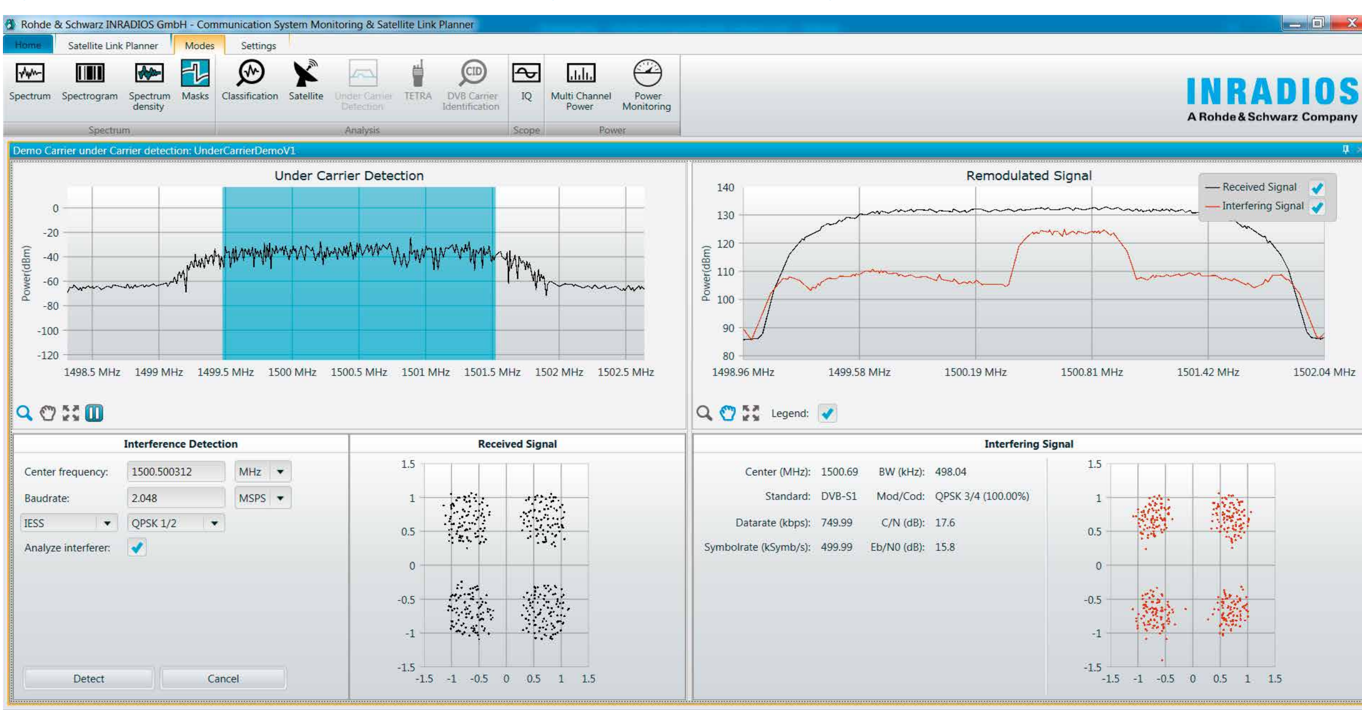
Satellite transponder monitoring

R&S®GSACSM can scan user-specific satcom carriers (e.g. DVB-S, DVB-S2, DVB-RCS, etc.) and evaluate the signal quality as well as the modulation and coding schemes, making it possible to quickly detect anomalies or impairments on individual carriers and notify the user (Fig. 7). Typical impairments that are automatically detected include:

- Carrier missing or signal not recognizable
- Highly fluctuating carrier center frequency
- Carrier bandwidth or baud rate outside standard limits
- Reduced carrier-to-noise (C/N) ratio

In modern satcom systems, lots of signal interference can occur between satellite signals such as DVB-S2. To be able to quickly identify and eliminate such interference, the DVB consortium has developed a carrier identification standard (DVB-CID) for satellite transmissions that allows the host carrier to be identified. R&S®GSACSM provides a software-based DVB-CID demodulation function to automatically detect and

Fig. 6: The R&S®GSA1400/10 CiC separator detects hidden signals and separates overlapping components.



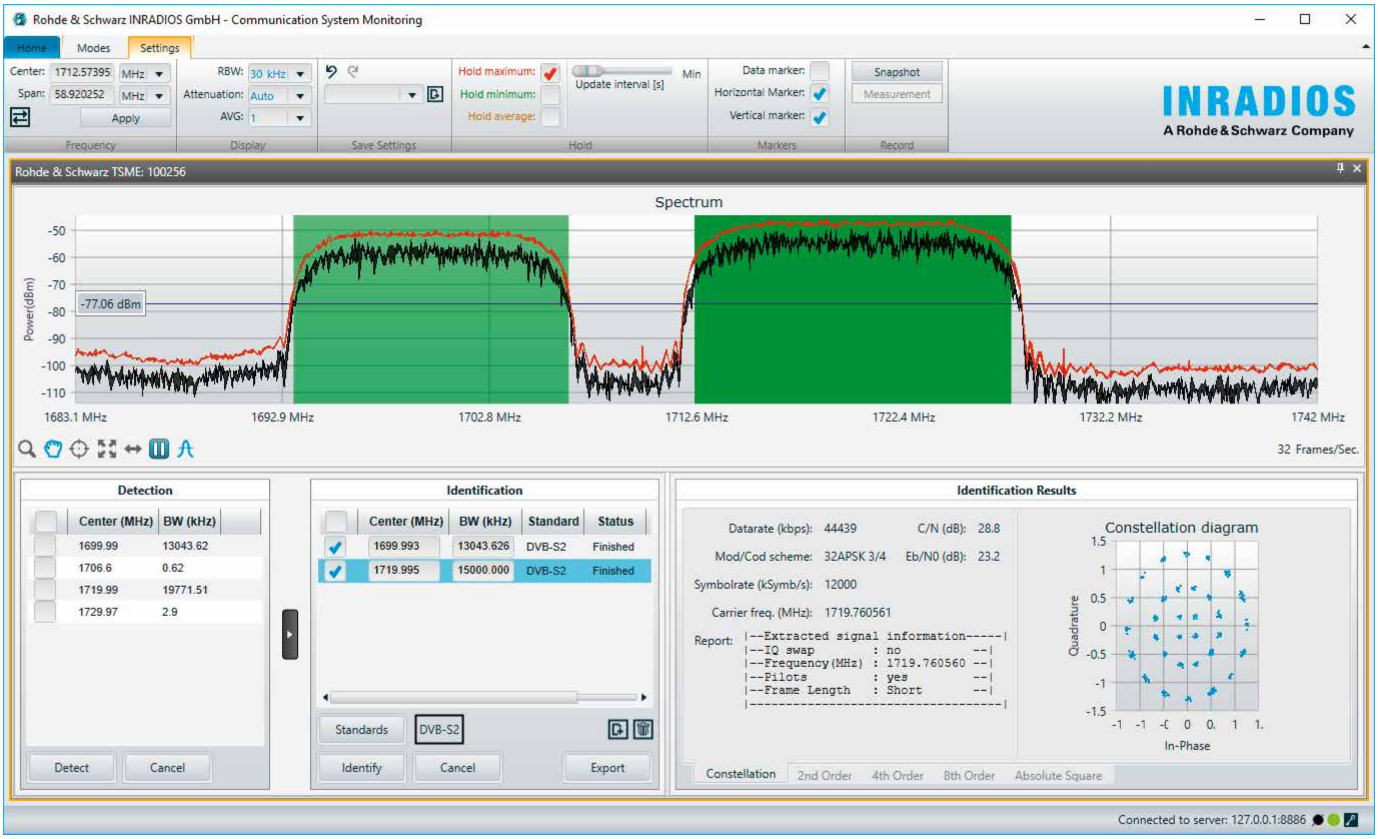
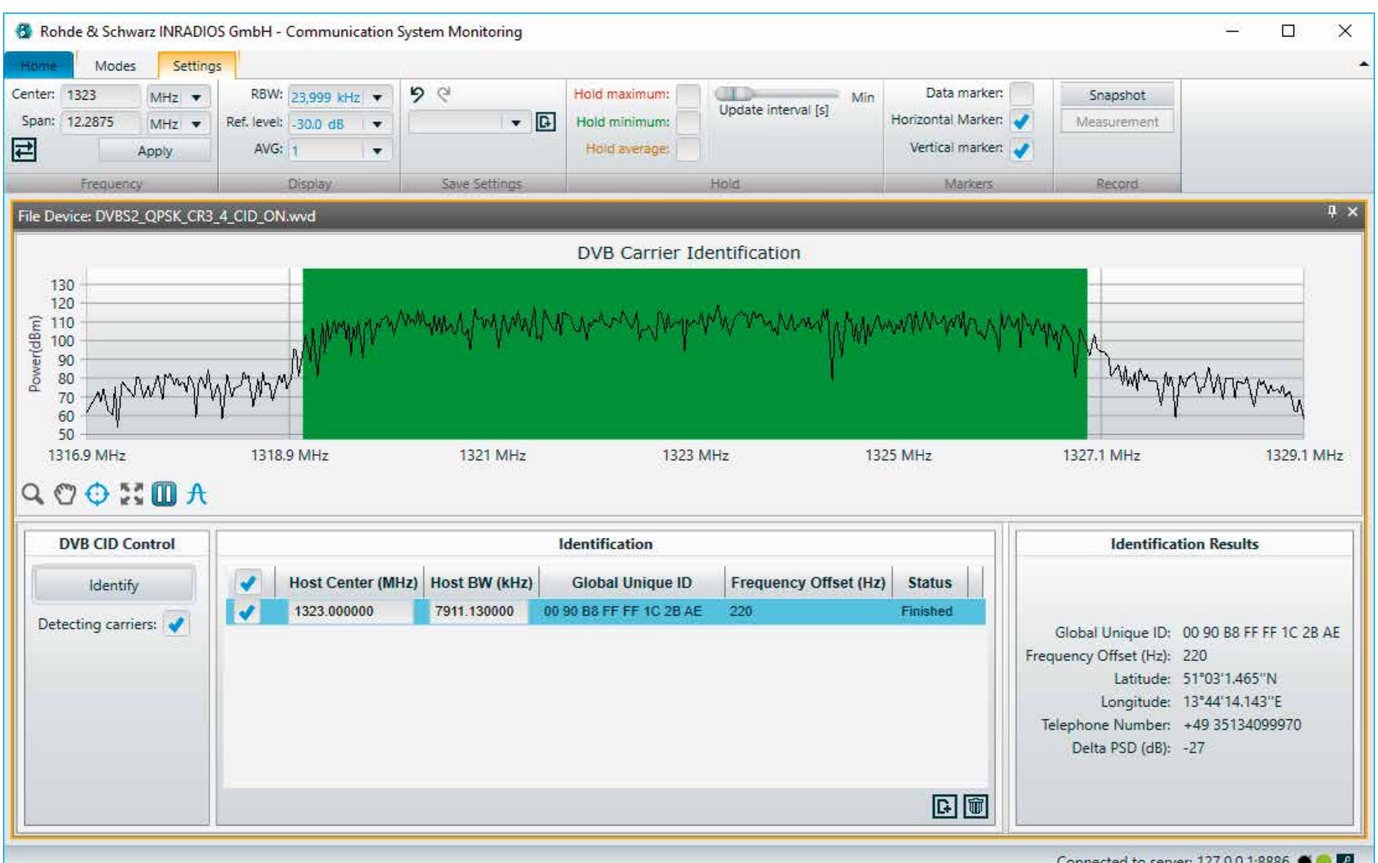


Fig. 7: R&S®GSACSM automatically identifies and demodulates all signals in a user-specific spectrum.

Fig. 8: Via carrier ID (CID), DVB-S signals can be unambiguously assigned to their operator.



identify the CID of unknown or interfering signals. The CID-specific global unique ID, the uplink GPS coordinates and the operator's telephone number (if available) are extracted. The global unique ID allows customers to precisely identify their satellite signal. Fig. 8 shows continuous spectrum scanning to detect and demodulate the CID signal until all CID-specific parameters have been successfully identified.

Station and channel measurements with R&S®GSACSM and pilot feeding

In addition to ordinary signal monitoring and analysis, the received signal power is an important criterion for sat operators. It is also mandatory for sat operators to monitor spectral power density masks for their carriers in order to prevent interference to adjacent satellite systems. R&S®GSACSM can be used together with signal generators from Rohde & Schwarz to perform extensive measurements. The ground station is retrofitted with a so-called pilot path in addition to the actual receive path. The pilot path provides a pilot signal that can be used to measure the frequency-dependent gain of the entire receive path ("station gain") from the LNB to the L-band interface (Fig. 9). Based on the measured values, additional carrier parameters can be calculated:

- Spectral signal power density at receive antenna
- EIRP or power density at satellite
- EIRP of carrier at satellite antenna (downlink)
- Signal attenuation due to free-space propagation, rain and atmospheric attenuation using known beacon signals

If the satellite beacon power is known, the signal level or gain can be determined at any point on the transmission path (from satellite to modem) for each component (e.g. antenna – satellite, path, LNB, etc. including influence of optical converters). Based on regular measurements, it is possible to detect aging effects and take appropriate countermeasures – all during live operation.

Dr. Steffen Bittner; Dr. Marco Krondorf

Measurement of frequency-dependent gain

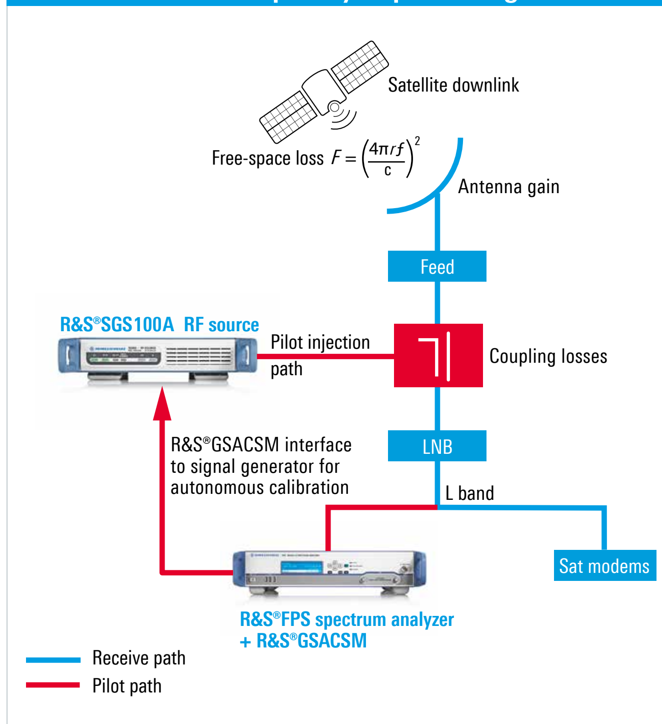


Fig. 9: Using the pilot path, the frequency-dependent gain can be determined for the entire receive path.

Pixel Power now at Rohde & Schwarz

Rohde & Schwarz has acquired Pixel Power Ltd., a technology leader in professional television broadcast software. The company in Cambridge, UK, has been in the market for over 30 years and counts well-known broadcasters among its customers.

Pixel Power develops playout software that enables highly automated editing, versioning, management and playout of broadcast content. One focal point is graphics software for the efficient creation of dynamic overlays such as logos and other insertions. Another is master control systems for the playout process. Pixel Power is pioneering the virtualization of these products. These solutions can be installed on local computers, in a private data center or public cloud. Customers benefit not only from leading, future-proof technology, but also from the use-based business models (OPEX/pay-per-use/pay-per-feature) offered by Pixel Power.

With this acquisition, Rohde & Schwarz is expanding its portfolio in the field of studio equipment, post production and playout, and can now comprehensively cover its customers' needs.

Pixel Power software makes it possible to overlay dynamic text and graphic effects on video signals during playout – in real time.

Egypt pioneers DVB-T2 in North Africa

As the host of the Africa Cup of Nations 2019 soccer tournament, Egypt is taking advantage of the occasion to upgrade its terrestrial television network to the latest technology. Although a digital system with DVB-T has been on air for some time, it has not achieved the desired market penetration, in part due to bottlenecks in the supply of terminal equipment. The launch of DVB-T2 is therefore being accompanied by a publicity campaign to prepare the population for the transition. Egypt is the first North African country to deploy a second generation television standard.

The Egyptian National Media Authority (ENMA) commissioned Rohde & Schwarz to supply the transmitters for the first stage of the network, which started operation on June 21 – just in time for the kickoff of the Africa Cup. In close cooperation with local partner Integrated Communication Systems (ICS), nine sites were equipped with R&S®THU9evo UHF transmitters to provide coverage to the urban areas. Broadcasts from each site – eight SD channels and one HD channel – are monitored by the R&S®PRISMON monitoring system, which detects and reports picture and sound disturbances. The contract also includes a number of T&M instruments and project support services.

German Federal Network Agency rolls out new direction finding infrastructure

Last year, the German Federal Network Agency (BNetzA) completed a major upgrade of its nationwide VHF/UHF direction finding network. In a phased project starting in 2013, 34 stationary and mobile stations have been equipped with new direction finders and antennas, control software and accessories from Rohde & Schwarz. The project was supported by comprehensive services, including site surveys, implementation of stationary stations up to full operability.

With their new R&S®DDF550 wideband direction finders, BNetzA is well equipped to deal with future radio signals. Advanced communications technologies are increasingly using signal types that older equipment cannot easily handle. The direction finding system's real-time bandwidth up to 80 MHz, selectable polarization and active/passive switching, allows operators to adapt the system to the transmissions and signal environment. The resulting reliable directional data helps BNetzA quickly eliminate radio interference and track down unlicensed transmissions.

The cooperation between BNetzA and Rohde & Schwarz has a long history. With the latest update, the agency is now operating their sixth generation of Rohde & Schwarz direction finders.

Updated direction finding station in Grünwald near Munich.

Rohde & Schwarz joins the Urban Air Mobility initiative as new partner

Rohde & Schwarz has joined the Ingolstadt UAM initiative as an industry partner. The Urban Air Mobility initiative is supported by the European Commission. Its aim is to research the deployment of aircraft for urban mobility through practical studies. The suitability of deployment areas and the necessary general conditions are being investigated in trial projects. Ingolstadt, with local companies Audi and Airbus, the University of Applied Sciences as a member of the research network for artificial intelligence, the Fraunhofer Application Center with its "Connected Mobility" project and a planned test route for autonomous driving, is ideal as the Bavarian hub of the initiative.

Urban air mobility depends on the seamless integration of various technologies into aircraft, such as onboard sensors, flight connectivity and air navigation. As a T&M expert in the aerospace, wireless and automotive fields, Rohde & Schwarz offers the right T&M solutions. Manufacturers can use these solutions to verify the proper system performance of their aircraft, which is a decisive factor for safety and reliability in urban airspace.

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Air taxis like CityAirbus could become a familiar sight in metropolitan airspace in the foreseeable future.

Rohde & Schwarz and CAAS collaborate on research for satellite based ATC communications system

Rohde & Schwarz and the Civil Aviation Authority of Singapore (CAAS) have signed a research collaboration agreement to conduct a design study on a satellite based ATC communications system.

As an air navigation services provider (ANSP), CAAS controls air traffic over 800,000 square kilometers of oceanic airspace northeast of Singapore and around 670,000 aircraft movements per year. To provide radio coverage in their control area, they operate several radio stations on remote islands that do not belong to the territory of Singapore, and they communicate via satcom with suitably equipped aircraft. Since these two facts make them dependent on external infrastructures, CAAS wants to implement an innovative ATC communications solution that will be designed in collaboration with Rohde & Schwarz.

The objective is to manage voice traffic between the controllers and aircraft via CAAS satellites. What makes this special is that normal VHF aviation radio frequencies will be used instead of the microwave frequency bands typically used for satcom. Aircraft can continue using their standard radio equipment and will not even notice the intermediate satellite link. CAAS will be able to provide full coverage of their control area with their own resources and gain additional transmission capacity for the continuing growth in air traffic. Based on preliminary studies, both parties are confident that the system is feasible.

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CAAS is not only responsible for air traffic control in the Singapore airspace, it also controls a large flight information region (FIR) in the surrounding area.


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