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ROHDE&SCHWARZ

T&M instruments for use anywhere

Some measurements require using battery-powered mobile devices. Two new models demonstrate what the handheld class can do today.

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Cover feature

Not all DUTs can be put on a test bench. When it comes to jobs such as installation or servicing of industrial systems and stationary communications equipment, the testers must go to the DUT. This requires mobile instruments that meet every aspect of the task and deliver reliable results. They must be literally trim, handy, user-friendly and generate measurement results in just a few steps. It also doesn't hurt if they come with a few sophisticated extras that bring a smile to their users' faces. Instruments like these are few and far between, and some of what the market has to offer is not exactly state of the art. Developing high-quality T&M equipment costs money, especially if the goal is to capture in a handheld format the measurement functions generally housed in a roomy desktop cabinet. Achieving this takes a high degree of integration – a discipline Rohde & Schwarz mastered long ago. Two new families of instruments are excellent examples of the company's expertise. Both represent the avant-garde of a new form factor that provides a flexible design frame for all types of handheld devices. One of the newcomers, the R&S®Scope Rider oscilloscope, has lab-level quality with features unparalleled in its class such as a logic analyzer and measurement category CAT IV, enabling low voltage measurements without any restrictions. Its sibling, the R&S®Spectrum Rider spectrum analyzer, offers cutting-edge technology for indoor and outdoor applications backed by long battery life and operating aids such as a measurement wizard. In addition to their technical advantages, the models illustrate the tremendous importance that Rohde & Schwarz places on operating ergonomics and design. Work should be more than fast and easy; it should be fun. With this in mind, we are presenting two instruments that are truly a pleasure to use.

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Rohde & Schwarz subsidiary RPG Radiometer
Physics GmbH penetrates deep into space with
its measuring instruments (page 42).

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The German National Library relies on the
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A new software product oversees complex
radiomonitoring systems, small unattended
systems and remote sensors (page 55).

Paradigm shift for mobile phone production testing

A communications tester unlike any you've ever seen before: no 19" box, no moving parts, no noise, no dust-collecting openings, no rapidly obsolescing motherboards – instead pure RF T&M technology in an elegant, flat housing with a multitude of ports. While this might raise a few questions (Why? How does it work? Does it do less?), it is actually the result of an uncompromising translation of production testing requirements into a technologically sound design. The new R&S®CMW100 will eventually replace the R&S®CMW500, which has been sold by the thousands and is currently the market leader for production applications. It is actually less radi-

cal than it first appears. Its functional and software compatibility with its predecessor (testing without signaling) ensures a seamless transition. The new approach is based on two basic assumptions. The first is that long RF cables are potential sources of errors. Instead of the typical three to five meters for rackmounting, the R&S®CMW100 requires only centimeters since it is located right at the test fixture. The second is that computers, while critical for performance, obsolesce more rapidly than T&M equipment. The test software therefore now runs on a standard production PC. Up to eight DUTs can be tested in parallel and at much higher speeds than ever before.

Mobile network benchmarking perfected

Mobile network quality is assessed using test vehicles and a large number of test smartphones. In the past, the smartphones were mounted inside the vehicle and their antenna contacts were connected to the roof antenna via RF cables. But today's smartphones come with up to five cellular antennas, both to meet the requirements of multistandard devices and to support modern technologies such as MIMO. It's no longer practicable to simulate these conditions via roof antennas, especially when more than a dozen smartphones simultaneously go on a drive test. This is why the Rohde&Schwarz subsidiary SwissQual developed its patent-pending product,

TCM. TCMs, or test device containment modules, are compact climatic chambers for a single smartphone. They use an intelligent control system to ensure thermally uniform and stable test conditions and make it possible to use unmodified smartphones. TCMs are completely transparent with respect to RF technology. Configurable attenuation allows realistic simulation of multiple end-user scenarios (e.g. handheld, beside head). Because TCMs are climatically controlled, they can be operated in near open air conditions, e.g. in a specially designed vehicle roof box that can contain up to 16 chambers. Data is processed by the SwissQual Diversity Benchmarker II.

GNSS chipset tester for production and characterization

These days you won't find many mobile devices that don't use satellite navigation for positioning. This is reflected in the high production volume of global navigation satellite system (GNSS) chips and modules leaving the factories every month. Each unit is tested in order to eliminate costly returns due to malfunctions, therefore testing must be as efficient and cost-effective as possible. The new R&S®SMBV-P101 GNSS tester was designed with this in mind. Based on the tried and tested R&S®SMBV100A signal generator, which in the full GNSS configuration can simulate complex hybrid scenarios with up to 24 satellites with all

details, the new production tester only needs a reduced configuration and just one satellite each for the GPS, Galileo, Glonass and BeiDou standards in order to meet all production requirements. To ensure that initial production prototypes can also be characterized using a simple functional test, the generated signals are authentic and complete in every regard. The generated signals are calculated in realtime with seamless timestamping and support Doppler profiles like those of a moving receiver. The R&S®SMBV-P101 provides a stable CW high level signal to calibrate the test setup.
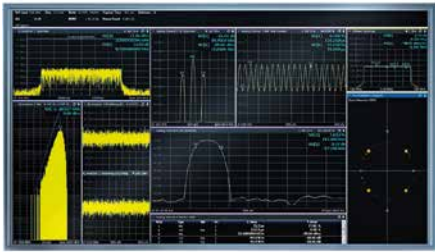
Comprehensive signal analysis on the PC

When equipped with the appropriate software functionality, a Rohde & Schwarz signal analyzer can thoroughly analyze numerous of signal types, including pulsed signals, wireless communications signals and vector-modulated signals. In the past, users were chained to the test instrument when they wanted to analyze test data, even when they were working with stored data sets and not live data. In these cases, the test instrument is actually superfluous because the analysis functions are pure software functionality. The new R&S®VSE vector signal explorer software takes this into account by allowing the analysis to be performed on any PC, completely independent of the test instrument. The data to be analyzed is loaded either as a file (I/Q or MATLAB®) or in realtime directly from an analyzer connected via LAN. R&S®VSE functions as a remote analysis and control station for all test equipment connected to the network, allowing convenient operation via a large screen along with other advantages. Economically priced instruments on which the R&S®VSE high-end analysis tools would not run can be used as the frontend, e.g. the R&S®FSL. R&S®VSE currently supports the R&S®FSL / FPS / FSV / FSW analyzer families and the R&S®RTO oscilloscopes.

An HF direction finder that misses nothing

The R&S®DDF1GTX high-speed scanning HF direction finder is the culmination of all of the DF know-how that Rohde & Schwarz has accumulated over the past decades. The result is an extremely sophisticated instrument with unparalleled technology. Developed for regulatory and security agencies, the R&S®DDF1GTX is capable of finding just about any signal in the HF spectrum, regardless of how short or weak the signal is. To achieve this, the R&S®DDF1GTX is equipped with ten receive channels for parallel sampling of antenna elements. In conjunction with the realtime bandwidth of 30 MHz, a single spectral snapshot is sufficient to analyze the entire HF range with all emissions that were on air at the time of scanning, including their bearing information. This is accomplished with a large number of extremely powerful field programmable gate arrays (FPGA) whose performance ensures the greatest possible probability of intercept. An inherent noise of 10 dB less than commercially available DFs ensures that even weak signals are reliably detected. Additional highlights include a super-resolution mode for locating different signals operating at the same frequency, beamforming for suppression of co-channel interferers, innovative large-aperture antennas and active/passive switchover.

Voice terminals for secure communications on naval vessels

The R&S®NAVICS from Rohde & Schwarz is a highly advanced communications systems for ships. The latest evolution of this system is being installed on the British Royal Navy's Type 26 GCS frigates that are set to begin construction in 2016. R&S®NAVICS handles all internal and external communications. This includes the HF/VHF/UHF/SHF radio system with a message handling system as well as ship-wide multiservice Ethernet with VoIP voice terminals, switches and gateways, e.g. to the WLAN with ATEX devices. Unlike conventional systems, the R&S®NAVICS components communicate exclusively via Internet protocol (IP), permitting the use of commercially available network technology. At the customer´s request, the network will be provided with accreditable security, i.e. it will be cryptographically protected. A key component is the VoIP voice terminal with integrated R&S®GB5900SM crypto module (figure). It can be easily mounted anywhere on board to enable voice communications on the ship and to external offices. Security filters at the gateways ensure that only approved destinations can be reached. The terminal is also available without a crypto module for civil maritime navigation.

Big data and the Internet of Things

How the mobile communications industry is meeting the challenge

Projects of the future such as the Internet of Things, enhanced mobile broadband and self-driving cars require extreme mobile network performance. 5G, the next generation of mobile communications, is expected to deliver the necessary performance. But thanks to continual technological enhancements, in particular LTE / LTE-Advanced networks provide an excellent evolution path. Here an overview.

If we take the 1990 specifications freeze for the 900 MHz GSM standard as zero hour, digital wireless communications has just celebrated its 25th birthday. There is, however, no sign of slowing down – far from it in fact. The hunger for data in cellular communications remains insatiable and the demand for further technological progress persists. A tenfold increase in mobile data traffic is expected over the next six years, and experts predict an exponential increase in the number of things (Internet of Things, IoT) that communicate with each other via mobile networks. The Ericsson Mobility Report reports 87 million new mobile subscribers in the third quarter of 2015 alone (with 13 million in India, 24 million in Africa and 7 million in China). Mobile subscriptions are forecast to reach 9.1 billion by late 2021. In 2015, the average smartphone user consumed 1.4 Gbyte of data monthly. This is expected to rise to 8.5 Gbyte by 2021. The combination of these two factors will result in exponential data traffic growth around the world.

This article describes how immense data volumes are being transmitted today and how mobile network operators are ensuring that they can offer their subscribers an excellent quality of experience in the future.

2G/3G/4G technologies and future improvements

Looking at the different 2G (GSM, GPRS, EDGE), 3G (UMTS, HSPA, HSPA+) and 4G (LTE / LTE-Advanced (LTE-A)) mobile technologies, it becomes clear that the introduction of new transmission methods on the air interface between base stations and wireless devices as well as the optimization of the mobile network architecture have resulted in

significant improvements. The theoretically achievable data rate per device has evolved from a few 100 kbit/s (EDGE) to 42 Mbit/s (HSPA+) to several hundred Mbit/s (LTE/LTE-A). State-of-the-art, commercially available LTE-A devices achieve 600 Mbit/s in ideal lab environments. In a real network, propagation conditions and the shared channel principle reduce achievable download speeds due to the fact that available bandwidth is divided among all active subscribers. Nonetheless, LTE/LTE-A technology has significantly enhanced available data rates and network capacity. The following innovations have been essential to this achievement:

❚ A wide system bandwidth of 20 MHz that can be provided to an individual subscriber as well as the ability to bundle up to five of these 20 MHz carrier frequencies for each subscriber (commonly known as carrier aggregation, CA). CA is the most significant improvement within LTE-Advanced in 3GPP Release 10.
❚ Use of spatial multiplexing (MIMO technology), i.e. using anywhere from two to eight/four transmit/receive antennas.
❚ Fast OFDMA multiplexing, i.e. the frequency and time resource allocation can be changed on a millisecond basis. The smallest resource that can be allocated to a wireless device is a resource block (RB) with a frequency of 180 kHz and a time duration of 0.5 ms.
❚ High-quality modulation methods, specifically QPSK, 16QAM, 64QAM and 256QAM.

A lean network architecture and pure packet-switched data transmission enable short network response times. LTE smartphones load Internet pages much faster than with older technologies.

Introducing LTE/LTE-A has allowed network operators to meet increasing demands. The success of this technology can also be seen in the fact that 442 commercial networks have been implemented in 147 countries around the world since the first commercial LTE network was launched in late 2009 (source: Global Mobile Suppliers Association (GSA), October 2015). The following section explores several key LTE improvements resulting from enhancements introduced by the 3GPP standardization body (as of Release 10, LTE is also referred to as LTE-Advanced or LTE-A).

LTE features a specific enhanced multimedia broadcast multicast service (eMBMS, see NEWS 213, p. 10) that makes it possible to allocate the same resources (frequency and time) to multiple subscribers within a cell. This is a highly efficient method of addressing mobile TV applications, for example, where many subscribers receive the same data simultaneously. This mode also allows wireless devices to install new software efficiently – a task that generally still takes place via individual data connections for each device.

Since WLAN is implemented in almost all wireless devices, WLAN connections are available in private homes and in many public locations. Many mobile network operators set up hotspots in exposed areas such as airports to provide an alternative means of accessing the Internet. The user of the wireless device can simply turn the WLAN function off and on to gain access. Some wireless devices also feature a dedicated application that automatically switches the device's data connection to WLAN as soon as it detects a hotspot with sufficient performance.

In such cases, all data traffic is routed either via the mobile network or WLAN. In the 3GPP specifications, a special mode is available to use, for example, an email application running in the background via WLAN while transmitting video data via LTE. However this has not (yet) been adopted in commercial networks. Generally, network operators gain considerably more flexibility when using WLAN and LTE and can provide their subscribers with higher data rates and more capacity. As an alternative, operating LTE/LTE-A in unlicensed frequency bands is soon to be enabled from a specification perspective (licensed-assisted access, LAA) and to be included in the upcoming 3GPP Release 13 in March 2016. Instead of switching from LTE to WLAN, LTE is used, for example, in the unlicensed 2.4 GHz ISM band and the data rate capability is increased using the carrier aggregation feature. A listen-before-talk function is added to LTE to avoid conflicts and ensure that access to bands is granted only when sufficient capacity

is available. Therefore, 3GPP provides complementary solutions using WLAN and LTE technology. Commercial deployments will decide whether and which of these solutions will be adopted.

LTE networks use the same frequency in every cell, which leads to intercell interference at cell boundaries. A wireless device with an active connection to a base station receives the signals of the neighboring cell's base station, which is sending signals to its connected devices. This causes interference and lowers achievable data rates, an effect that especially impacts heterogeneous network environments, i.e. network topologies in which multiple small (femto or pico) cells are operated within a large (macro) cell. Pedestrian zones are a good example. Small, high-capacity hotspots cover high-traffic areas, yet they may also be within the receive range of a higher-level cell that covers parts of the city. Coordinated multipoint transmission and reception

(CoMP) was introduced to counteract this effect. CoMP makes it possible to transmit a signal to a wireless device at the cell boundary in a coordinated manner. There are various ways of implementing this coordination. In the simplest case, it is merely decided which of the potentially available base stations is to be used for transmission. Other options include allocating resource blocks for wireless devices or directing the antenna beams of the base stations involved to minimize interference. Using MIMO technology and also influencing the baseband signal (precoding) in a coordinated manner allows optimal coverage at cell boundaries. An additional technology component named dual connectivity has been specified in 3GPP Release 12 to offer further improvement for heterogeneous networks. The wireless device is configured for connection to two base stations on two different carrier frequencies. The master base station (eNodeB in LTE) supplies the higher-level macro cell, and the slave eNodeB supplies the hotspot,

How does T&M equipment contribute?

Test and measurement equipment plays a central role in both introducing new technologies and in operating networks. Countless test solutions are required to develop and manufacture mobile devices, components, base stations and switching nodes. Test solutions are also needed when deploying the network and verifying its performance.

First, network operators have to select the right infrastructure products to operate their networks. Using instruments such as signal generators and signal and spectrum analyzers, they can qualify infrastructure products in order to select those that perform best. The Global Certification Forum (GCF) defines a broad range of tests as a prerequisite for wireless device certification. Many operators specify additional tests based on their specific network requirements. T&M equipment such as the R&S®CMW500 wideband radio communication tester emulates all required network functions and verifies whether a wireless device is behaving properly (functional test of implemented protocols) and whether the hardware

Fig. 1: RF and protocol testing systems help network operators select suitable wireless device providers. The test solutions ensure that the devices comply with mobile network standards.

i. e. a pico or femto cell. In this configuration, the master eNodeB uses parameters such as cell traffic and device speed to decide to use the macro cell or the hotspot for the data connection. Switching between the two is extremely fast and requires no additional signaling. This saves signaling capacity and minimizes handover errors. In wireless devices, interference at cell boundaries can be countered by employing improved receivers that recognize these specific types of interference and use appropriate algorithms to remove them from the received signal. Additional information about potential interference can also be provided by the network to improve such calculations. In the LTE standard, these technology components are called further enhanced inter-cell interference coordination (felCIC, included in 3GPP Release 11) and network assisted interference cancellation and suppression (NAICS, included in 3GPP Release 12).

The introduction of device-to-device (D2D) capabilities is of special importance, as these provide two fundamental new functions. First, the network-supported discovery function makes it possible for two spatially neighboring wireless devices to detect each other. Second, these devices and others in their vicinity will be able to exchange data directly, i.e. without going through the base station covering the area. However at least for the in-coverage case, i.e. if at least one device is located within cellular coverage, the whole process is authenticated and configured by the network. The introduction of this completely new functionality was primarily motivated by public safety considerations. Fire-service and police applications need to exchange large amounts of data (images, videos) within small groups of individuals, some of whom may be located outside network coverage areas, e.g. in the basement of a burning building. Exchanging data between wireless devices connected in this manner will initially be limited

to public safety and security applications. Initially, use by the general public will be confined to application-related broadcast services. Other commercial usage models are conceivable and are also under discussion as part of the 5G development process. In particular automotive use cases are applicable, i.e. potentially supporting autonomous driving.

Even though LTE/LTE-A networks are increasing in performance, comprehensive 4G coverage will take time. Efficient handover to 2G and 3G technologies remains critical. There are also many use cases where low data rates are sufficient. Here, the focus is on cost-efficient solutions with long battery life. In such machine-to-machine (M2M) environments, modules with e.g. GPRS technology designed to last years are often used. However, LTE/LTE-A has already ushered in several improvements to serve M2M applications. For example, there is a category 0 for LTE user equipment that reduces the

is correctly implemented (e.g. it complies with the specified maximum transmit power). Fig. 1 shows suitable conformance test systems, such as the R&S®TS8980.

When deploying base stations in the field, compact testers are needed that can be used to quickly verify whether regulatory requirements are being met (Fig. 2). Following deployment, operators need to adjust parameters, such as handover thresholds, and identify coverage gaps in order to optimize their network and ensure the best possible data rates. Fig. 3 shows a drive test solution for effective mobile network planning. QualiPoc from SwissQual implements a measurement application on a commercial smartphone. The test solution can be used like a normal app, enabling network operators to evaluate end user experience. In the operator's core network, where all data streams are processed, it is increasingly important to be able to analyze data traffic down to the packet level. This makes it possible to classify the data traffic and optimally route a service's data packets through the network. IP analysis technology from Rohde&Schwarz subsidiary ipoque

Fig. 2: Cost-efficient mobile T&M equipment is used to install a base station.

effort required to implement this class of devices (lower data rate requirements and no MIMO support). Processes have also been introduced to prevent mobile network overloading when large numbers of M2M devices attempt to access the network at the same time. Other enhancements, such as a reduced bandwidth (200 kHz) and even a reduction of the subcarrier offset from 15 kHz to 3.75 kHz, are currently discussed in 3GPP standardization (Release 13).

In summary, for the time being LTE/LTE-A technology covers the increasing requirements of mobile data traffic as well as M2M/IoT. Enhanced mobile broadband and IoT are also major aspects of the comprehensive discussion taking place on the next generation (5G). What is motivating the industry to introduce a new generation of mobile communications as early as 2020 (or even 2018 on a regional basis)? First, due to the constantly increasing number of subscribers and data rates, even LTE/LTE-Advanced

with all of their enhancements will not be able to cover the demand in the long term. Second, the definition of a new industry-wide use case class to significantly improve mobile network latency. These use cases will at least partly require extremely secure and reliable connections. It will then be possible to use cellular communications in the automotive industry (e. g. supporting autonomous driving) and in Industry 4.0 applications, opening up new sources of revenue. Latency requirements in the 1 ms range are impossible to implement with LTE/LTE-A. In addition to technology-based arguments, the previous development cycle indicates that the next technological step will take place in 2020. GSM was introduced in 1990, UMTS in 2000 and LTE in 2010. By the way, it should be mentioned that the 2020 Olympic Games will be hosted by Japan – a country that is heavily involved in the development of 5G (naturally not only for this reason).

Research institutes and development departments in major wireless communications companies are already conducting extensive studies in the field of 5G technology. These efforts are primarily dedicated to four technology blocks, which are being discussed as the solution for future requirements. Initial research efforts will identify which additional frequency bands can be made available by substantially increasing the bandwidth. This research covers the spectrum up to 100 GHz with bandwidths up to 2 GHz. Here, the significantly changed channel propagation conditions play a key role. Researchers must analyze these conditions before they can develop and evaluate appropriate channel models to assess new technologies (the next article shows how to analyze potential channels). The use of large numbers of transmit and receive antenna elements (order of magnitude: 100) is also under evaluation. They can be used to increase data rates in the frequency spectrum below 6 GHz through advanced MIMO techniques. In the

provides this insight. The same functionality is also of great interest for mobile device testing. When implemented on the R&S®CMW500, users can analyze which IP data streams (including protocols used) a smartphone maintains only due to applications running in the background.

There can always be unforeseen interference when operating mobile networks. Stationary network monitoring tools in the mobile network and mobile interference hunting solutions are used to identify and eliminate this interference as quickly as possible. For example, malfunctioning neon signs can create interference in a base station's receive band and negatively impact all data traffic in a cell. Fig. 4 shows a technician using a mobile measuring receiver and a directional antenna to locate interference sources.

Fig. 3: Network operators use T&M equipment to analyze network performance and optimize the end user experience.

high frequency range, they are necessary to provide the antenna gain required to achieve appropriate cell sizes. New air interface technologies are being discussed in connection with significantly higher frequencies and as a way to enable extremely short reaction times. Some of these interfaces have additional filter functions based on the OFDM technology implemented in LTE. Examples include universal filtered multicarrier (UFMC), filter bank multicarrier (FBMC), generalized frequency division multiplexing (GFDM) and filtered (sometimes called flexible) OFDM (f-OFDM). A more efficient network topology is also being looked into, a topology that is already starting to be used today. The fundamental idea is to design software functions that are specific to mobile communications and to implement them on open hardware platforms. This would make it possible to more affordably implement enhanced packet core (EPC) node functions in mobile core networks as well baseband functions of base stations. It would also enable

operators to move these functions to alternative platforms in the case of a hardware failure. Ultimately, the processes will be similar to those already in place in data centers today. Network function virtualization (NFV) and software defined networking (SDN) as well as network slicing are helping drive the flexible implementation of these functions in mobile networks. It should be noted that security aspects are extensively discussed in this context.

Summary

The high performance of LTE/LTE-A technology, its seamless cooperation with existing 2G/3G networks and the complementary use of WLAN enable network operators to meet their subscribers' continuously growing big data requirements. Broadcast/multicast solutions enhance system flexibility. M2M applications are already playing a major role. The increasing number of things that will be communicating with each other in the future (IoT) and new demands stemming from vertical branches of industry (automotive industry, health care, robot control, etc.) are expected to dictate a need for further significant enhancements. That is why researchers in the mobile communications industry are already discussing 5G as they look toward 2020 and beyond. Rohde & Schwarz and its subsidiaries SwissQual and ipoque offer a comprehensive portfolio for today's T&M tasks and are actively involved in 5G research and development.

Meik Kottkamp

For more information, visit:
ı www.rohde-schwarz.com/mobile-network-test
ı www.rohde-schwarz.com/technology/lte
ı www.rohde-schwarz.com/technology/5G

Even today, signal generators and signal analyzers are used to evaluate potential 5G components. They are indispensable due to their flexibility in terms of frequency range, bandwidth and transmission technology. They are also essential components of measuring systems used to analyze propagation conditions in new, undefined frequency bands (see next article). Multiport network analyzers will play a decisive role in implementing future antenna technologies. And finally, the influence of individual applications on data rates, signaling loads and current drain are under examination. This will be especially important for IoT modules as it must be possible to measure individual applications on the IP layer itself.

Fig. 4: Mobile measuring receivers with directional antennas help operators monitor operational networks and identify interference.

Channel sounding – in search of frequencies for wireless communications of the future

5G, the next generation of wireless communications, should be operational by 2020. But to make the planned, significant performance boost over today's networks possible, extensive preliminary investigations are required. Finding and characterizing suitable transmission channels will play an important role.

Still, no one yet knows with certainty exactly what 5G will be and with which methods and technologies these ambitious goals will eventually be reached. However, two key features clearly stand out. First, 5G will open up entirely new frequency bands into the millimeter-wave range (i. e. above 30 GHz) for commercial wireless communications applications (Fig. 1). Second, the wanted signal bandwidth will be significantly extended. These new channels require comprehensive analysis to ensure their optimal utilization. The most important method for characterizing cellular radio channels is channel sounding.

What goes around …

… does not always come back around. At least not when it comes to broadband radio signals and when anything but a perfect transmission path lies between the transmitter and receiver. To still be able to operate high-performance wireless communications under these circumstances, you have to know the exact characteristics of the radio channel. Its characteristics are provided by a channel sounder. Channel sounding is the process of determining the impulse response of a transmission channel, especially a cellular radio channel. The concept originated from classic acoustic measuring methods for determining distances, for example determining water depth with an echo sounder [1].

The channel impulse response (CIR) provides complex, comprehensive information on the impact of the channel of interest on a radio signal, including the magnitude and phase of the signal. It is therefore ideal for characterizing the channel. Signal echoes caused by reflections, distortions due to diffraction and scattering effects, shadow effects caused by buildings and trees, and even weather-related effects such as rain and snow have a detrimental influence on the radio channel. Fig. 2 shows an example of the squared magnitude of a time-variant channel impulse response, $h(t, \tau)$, known as the power delay profile (PDP).

A possible multipath propagation of the radio signal can be seen on the delay axis τ. The local maxima suggest strong, delayed echoes and, therefore, reflectors in the radio channel. In the example, changes of the channel impulse response over time can be seen along the time axis t. A possible cause for such a time variance is a moving receiver, or more generally, changing channel conditions.

In this example, the essential requirements for a channel sounder are already noticeable. In addition to a high sensitivity within the frequency range and bandwidths under consideration, the channel sounder must be fast enough to detect time changes in the channel. But it must also measure every single channel impulse response long enough to record the

Fig. 1: New spectra for mobile communications. Source: ITU Recommendation ITU-R V.431-7: Nomenclature of the frequency and wavelength bands used in telecommunications.

Frequency band	Frequency range	Wavelength range
Ultra high frequency (UHF)	300 MHz to 3 GHz	1 dm to 10 dm
Super high frequency (SHF)	3 GHz to 30 GHz	1 cm to 10 cm
Extra high frequency (EHF)	30 GHz to 300 GHz	1 mm to 10 mm

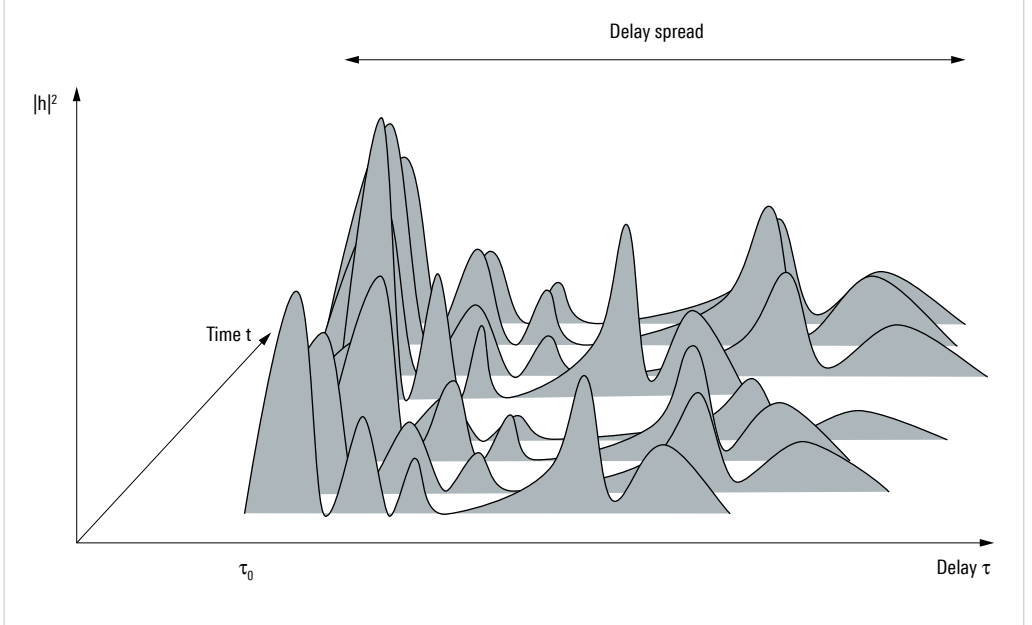| ITU band	Frequency range
X	8 GHz to 12 GHz
Ku	12 GHz to 18 GHz
K	18 GHz to 27 GHz
Ka	27 GHz to 40 GHz
Q	33 GHz to 50 GHz
U	40 GHz to 60 GHz
V	50 GHz to 75 GHz
E	60 GHz to 90 GHz

Influence of a channel on a radio signal

Fig. 2: Power delay profile (PDP) of a time-variant channel impulse response.

entire delay spread with the highest possible time resolution and dynamic range. Unfortunately, these are two conflicting requirements that can only be met with a compromise. The best possible compromise depends on the scenario, i. e. stationary measurements or measurements in strong time-variant environments (such as in a fast train). Clearly, a channel sounder should provide a very high degree of quality and flexibility, and that is why the solution presented here is perfect.

The channel impulse response can now be measured by correlating directly in the time domain. To do this, special auto correlation properties of specific compressed, periodic pulse signals are utilized [1]. These sounding signals have a very simple structure. For example, simple, maximum-length pseudo random binary sequences (PRBS), known as M-sequences, are suitable for this purpose. The idea of channel sounding is very simple. A periodic M-sequence is transmitted over the radio channel to be examined. The received signal is correlated at the "end" of the channel with the known M-sequence, which provides the desired channel impulse response. Of course, sounding sequences can be optimized, e. g. with respect to their spectral purity or their crest factor. This is why – in addition to M-sequences – Frank-Zadoff-Chu sequences and FMCW signals (chirp signals) known from radar technology are also used.

Why "5G channel sounding" in the first place?

The era of digital mobile communications began with GSM, but with this new era also came the challenge for base and mobile station manufacturers to deal with time and location dependent radio channels. In particular, the solution to the problem lay in the extensive measurement of radio channels and the following derivation of channel models. The channel models served as the main basis of development for the entire wireless communications system including cellular network planning tools. The channel models have been continuously developed up to today's fourth generation of wireless communications (LTE-A) [2]. Since the previous wireless communications generations usually operated in the same frequency bands below 3 GHz, it was relatively easy to adapt the channel models again and again. However, if networks operate in entirely new frequency ranges, such as in the millimeter-wave range, and extend the useful channel bandwidth to a multiple of the bandwidth used up to now, then the existing channel models are no longer sufficiently suitable [1]. New models, obtained only from the data of extensive channel sounding measurement campaigns, must be put in place. For this very reason, wide-ranging measurement campaigns in typical environments were launched, for example, by 3GPP at the "5G Workshop" in September 2015.

The solution

A channel sounding solution for the direct measurement of the channel impulse response consists of a high-quality, flexible transmitter for sounding sequence generation and a highly sensitive broadband receiver with very high dynamic range (Fig. 3). The R&S®SMW200A vector signal generator and the R&S®FSW signal and spectrum analyzer are two instruments found in the Rohde & Schwarz portfolio with just the right characteristics.

Test setup for channel sounding
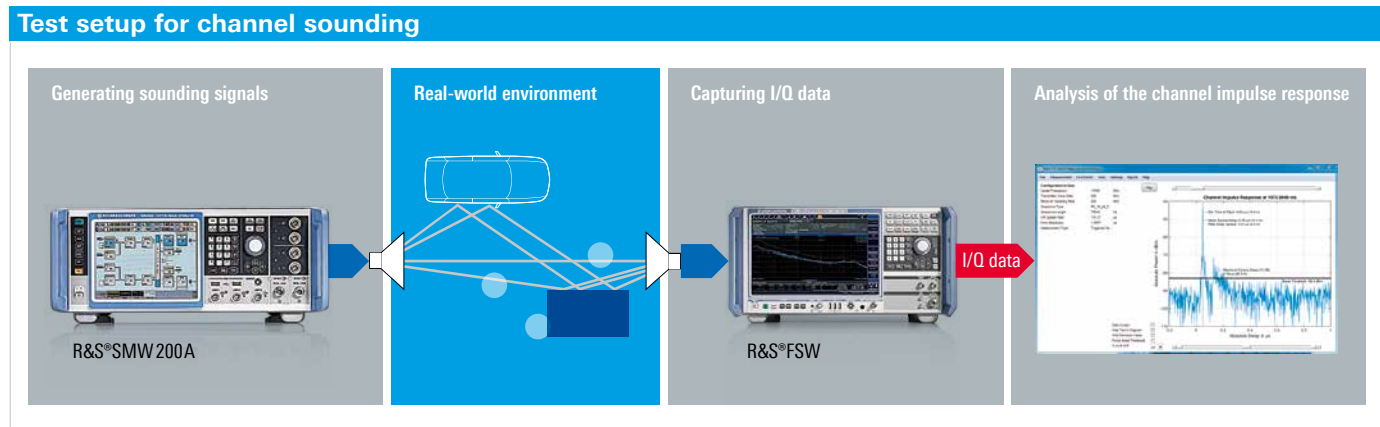
Fig. 3: Basic setup for the direct measurement of the channel impulse response (without cabling or antennas).

Fig. 4: Exemplary measurement of a power delay spectrum. The atrium of the Rohde & Schwarz training center in Munich served as a test site. The measurement was performed at 17 GHz using a 13 dBi horn antenna at the transmitting end (R&S®SMW200A) and an omnidirectional broadband antenna at the receiving end (R&S®FSW43) – a typical antenna choice for channel sounding measurement campaigns. The reflections from the floor and ceiling of the building stand out.
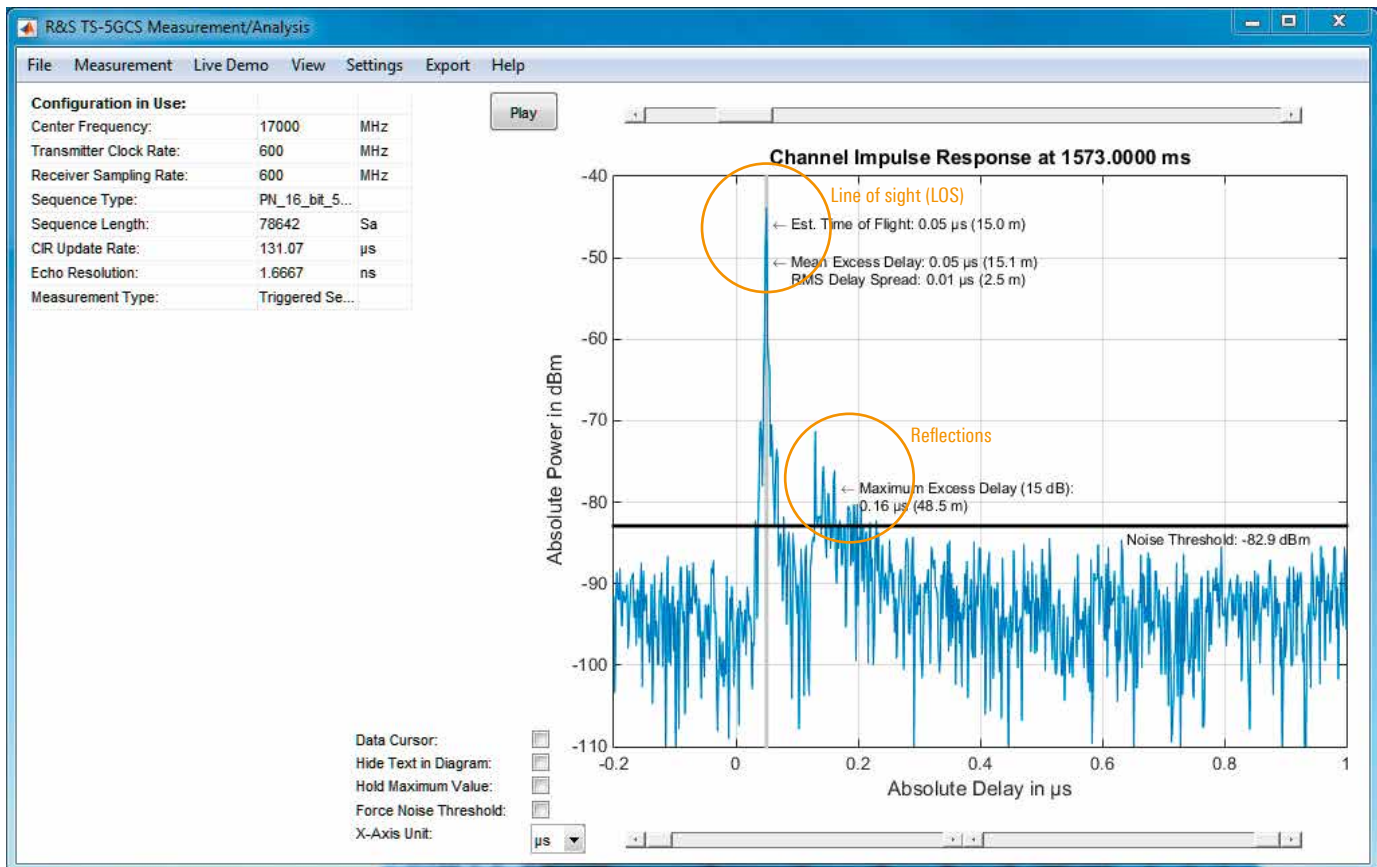
The new R&S®TS-5GCS MATLAB® based PC application software makes it easy to determine the channel impulse response. It evaluates the I/Q data provided by the R&S®FSW and calculates the channel impulse response by correlation with a calibrated original sequence. The measurement data is displayed graphically and can be exported in MATLAB® compatible format (Figs. 4 and 5). The user benefits from the superior, stable properties of the measuring instruments at frequencies into the millimeter-wave range and can concentrate on evaluating the data measured. Plus, the sounding software provides the necessary flexibility with regard to the sounding sequences. All sounding signals are delivered as R&S®SMW200A compatible waveforms. In addition, R&S®ARB Toolbox Plus allows users to adapt the sequences to their needs and generate their own sounding sequences.

Summary

The new R&S®TS-5GCS channel sounding software together with an R&S®SMW200A vector signal generator and an R&S®FSW signal and spectrum analyzer is a compact, highly flexible, stable and reproducible solution for channel measurement in the high frequency bands of the fifth generation of wireless communications. There is a suitable instrument version available for all frequency ranges and bandwidths, along with suitable transmit and receive antennas. The sounding software delivers the desired channel impulse responses in a surprisingly convenient manner.

Heinz Mellein; Johannes Köbele

References
[1] Radio Propagation Measurement and Channel Modeling, Sana Salous, Durham University UK, published 2013 by John WILEY and Sons Ltd.
[2] WINNER II D1.1.2, "Channel models", V1.2, 2008, available at http://www.ist-winner.org/deliverables.html.

Fig. 5: A three-dimensional power delay Doppler profile. For each echo, the corresponding Doppler frequency shift is shown. The profile illustrated here was not produced by measuring a real path, but was generated with the fading simulator of the R&S®SMW200A, which can very easily demonstrate and verify the operation of the channel sounding software.
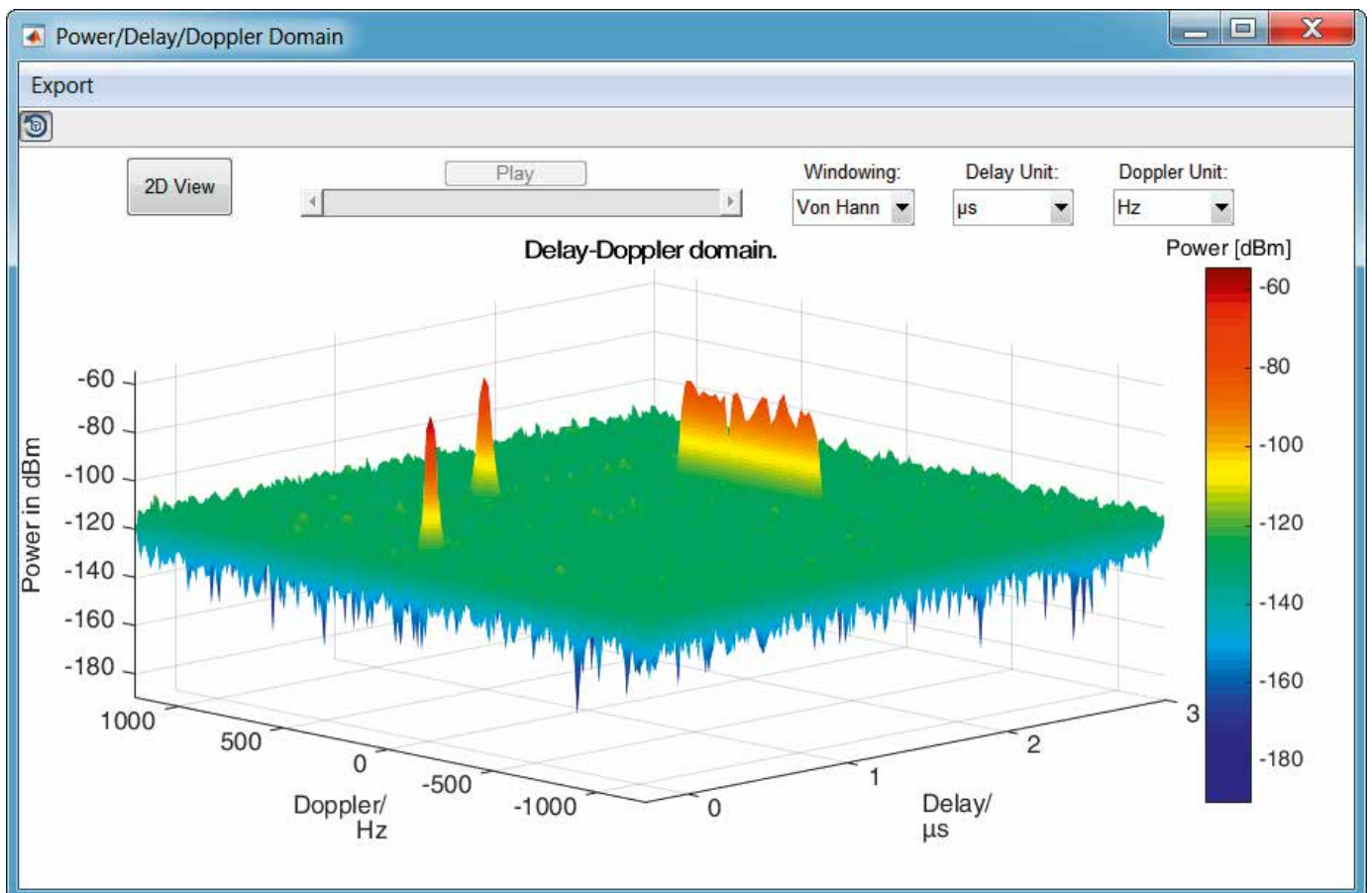
Testing IP-based wireless voice services

Mobile networks from the fourth generation (LTE / LTE-A) on use the Internet protocol for all services. Another infrastructure is required in addition to IP to ensure that traditional services such as voice communications continue to function. A 4G device only becomes a "phone" with the help of the IP multimedia subsystem. The R&S®CMW500 wideband radio communication tester can solve a variety of test-related problems.

All-IP communications opens up a whole new world of applications in mobile communications, but it also means that the circuit-switched services that were common in 2G (GSM) and 3G (UMTS) networks for voice transmission are no longer available. Instead, voice signals have to be packed in IP packets. In the past year, data services finally overtook voice telephony as the most important source of revenue for network operators, but voice telephony still accounts for a considerable share and cannot be technologically neglected. Most importantly, the voice quality cannot fall below the accustomed standard. In practice, such legacy services often cause problems in IP-based networks because packet loss, jitter and packet delays can occur during transmission. Ideally, the receiver should compensate

for these effects since – in the case of telephony – they considerably impact the voice quality. 3GPP-based networks such as LTE offer the ability to separate IP-based services on the transport layer and to provide an ensured quality of service (QoS) as needed. This is handled by a dedicated bearer that is triggered by the service in use. A dedicated bearer is a type of virtual channel with its own network address (port range) and specified performance characteristics. The prerequisite for this functionality is a high level of integration of services in the wireless device or modem.

Services such as Skype and Face-Time already offer functions like video telephony and messaging services. Such functions set user expectations, but since these over-the-top (OTT)

applications lack the aforementioned integration, they cannot ensure a certain QoS and therefore do not always deliver a satisfactory user experience. The user is also dependent on the proliferation of the application because the different services are generally not interoperable. The absence of mechanisms for handling emergency calls is also a significant drawback of these applications. Consequently, for voice support in LTE, appropriate mechanisms and architectures must be implemented in the mobile networks to ensure high quality for new features like video telephony as well as tried and trusted features such as classic telephony and emergency calls.

The IP multimedia subsystem
A key technology for integrating voice services in an LTE network is the IP multimedia subsystem (IMS). IMS offers a framework that supports IP-based multimedia services. IMS requires new network elements in the network architecture (Fig. 1).

IMS was developed by 3GPP during the UMTS standardization. It was since improved and is now also used for LTE voice services (voice over LTE, VoLTE) (Fig. 2). The session initiation protocol (SIP) is the base protocol of IMS. SIP uses an IP network to establish the connection between subscribers. To ensure a consistently high QoS, network operators have now started to roll out VoLTE services for voice and video telephony
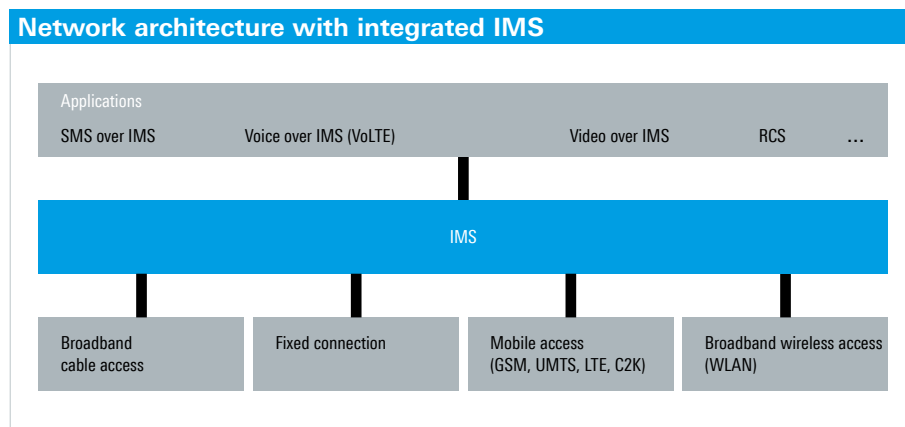
Network architecture with integrated IMS

Fig. 1: IMS as key technology in mobile networks.

IP multimedia subsystem (IMS)

	Signaling	Media transport			Utilities	
Application layer	SDP	Media coding				
	SIP	RTP	RTSP	RCTP	DNS	DHCP
Transport layer	TCP	UDP				
Network layer	IPv4, IPv6					
Access technology	LTE					

SDP   session description protocol
SIP   session initiation protocol
TCP   transport control protocol
RTP   realtime transport protocol

RTSP realtime streaming protocol
RTCP realtime control protocol

DNS   domain name server
DHCP dynamic host configuration protocol
UDP   user datagram protocol

Fig. 2: IMS protocol structure.

Testing with the R&S®CMW500
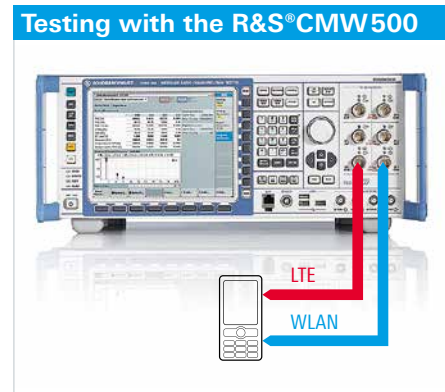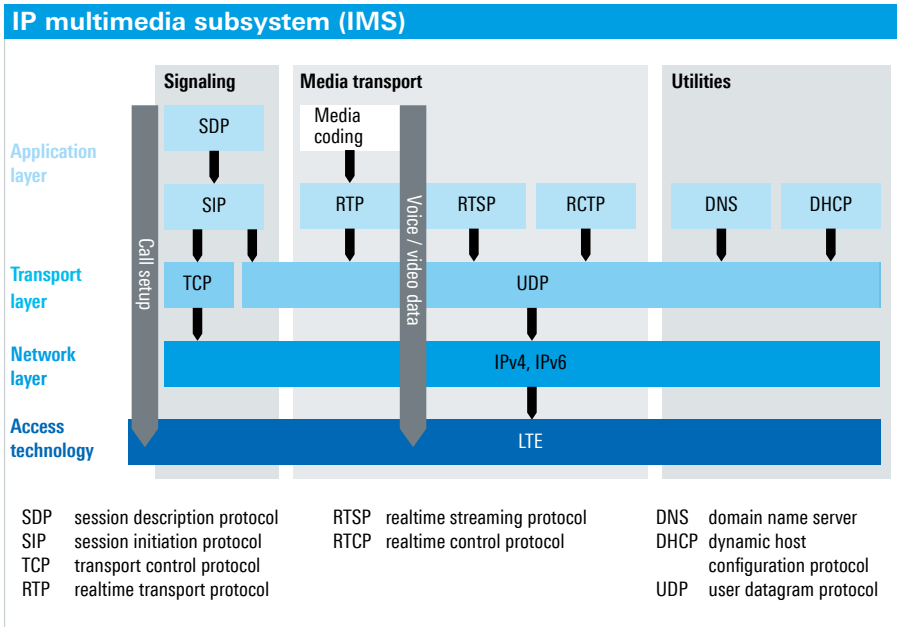

Fig. 3: Parallel testing of LTE and WLAN with the R&S®CMW500 wideband radio communication tester.

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based on IMS – with a guaranteed seamless transition to circuit-switched services, i. e. to 2G and 3G networks.

They are also working to ensure uninterrupted service and to integrate WLANs during the transition from outside to inside. Voice over WLAN (VoWLAN) is a network operator driven technology that also uses SIP/IMS to route voice over WLAN access points. Instead of using the network operator's closest base station for the call, the voice packets are tunneled through the Internet to a gateway provided by the network operator. This evolved packet data gateway (ePDG) creates a link between the LTE network and WLAN. IMS and upcoming generations of smartphones that support all of these mechanisms as standard will enable uninterrupted and high-quality voice service for all available access technologies.

VoLTE, VoWLAN and WLAN traffic offload testing with the R&S®CMW500

The R&S®CMW500 wideband radio communication tester comes with everything needed to test these mechanisms on mobile devices (Fig. 3). On the data application unit, the tester provides all access technologies and all necessary servers, such as an ePDG and an IMS server (Fig. 4). It tests the handover between LTE and WLAN as well as single radio voice call continuity (SRVCC), i. e. the handover between LTE and legacy networks such as GSM and UMTS.

Since mid-2015, the integrated IMS server has offered the ability to test several DUTs (IMS subscribers) in parallel. Now true end-to-end media connections between two mobile devices can also be tested.

VoLTE, VoWLAN and WLAN traffic offload testing

IMS   IP multimedia subsystem
ePDG   evolved packet data gateway
PDN-GW packet data network gateway
IPsec   Internet protocol security

SRVCC single radio voice call continuity
VoWLAN voice over WLAN
VoLTE   voice over LTE
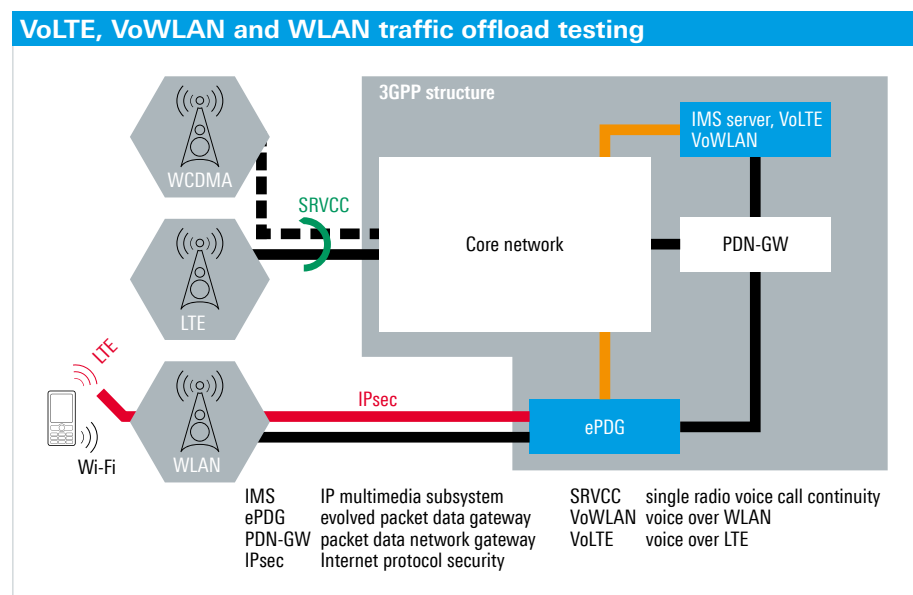
Fig. 4: LTE / WLAN traffic offload via an ePDG.

Testing with multiple virtual remote stations

Virtual subscriber 2
Tel.: #2110
Behavior: answer
Codec: narrowband
Endpoint: audio board

Virtual subscriber 3
Tel.: #2111
Behavior: no answer
Codec: n.a.
Endpoint: n.a.

Virtual subscriber 4
Tel.: #2112
Behavior: declined
Codec: n.a.
Endpoint: n.a.

Virtual subscriber 7
Tel.: #2115
Behavior: answer
Codec: wideband
Endpoint: audio board

Virtual subscriber 6
Tel.: #2114
Behavior: answer
Codec: wideband
Endpoint: loopback

Virtual subscriber 1
Tel.: #*
Behavior: answer
Codec: narrowband
Endpoint: loopback

Virtual subscriber 5
Tel.: #2113
Behavior: busy
Codec: n.a.
Endpoint: n.a.

Real subscriber 1
1220
5566778899

RF 1

RF 2

Real subscriber 2
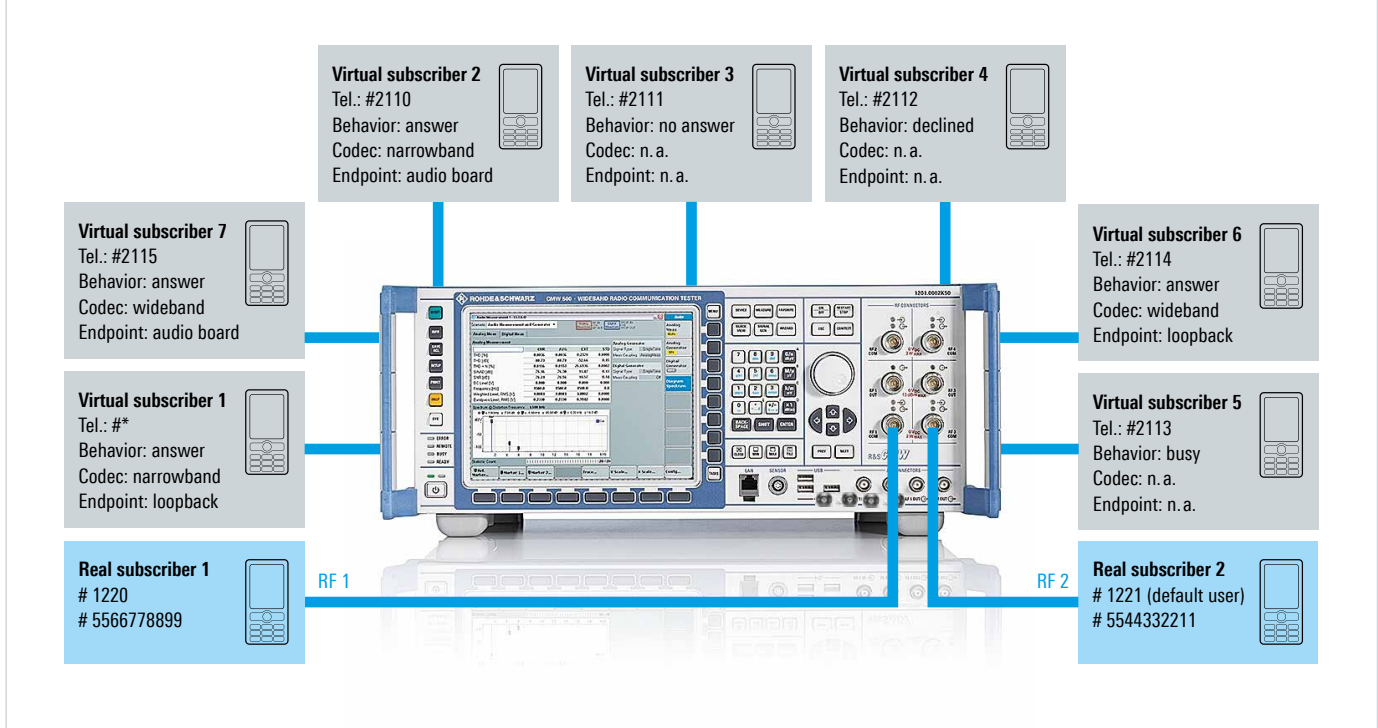# 1221 (default user)
5544332211

Fig. 5: The virtual subscriber concept in the IMS server of the R&S®CMW 500 allows testing under a variety of scenarios.

The new virtual subscriber concept allows users to create and test multiple virtual remote stations that have different characteristics and functionalities. A variety of scenarios such as codecs, error rates, etc. can be verified quickly and effectively. Real phones with different firmware can be tested against each other (Fig. 5).

The flexibility of IP and IMS enables network operators to easily and affordably integrate new audio and video codecs into the existing architecture. The new audio codec enhanced voice service (EVS) in particular is a milestone on the road to high-quality audio connections. At its highest quality level, EVS can transmit the entire human audible frequency range (Fig. 6). The R&S®CMW 500 with the R&S®CMW-KS104 option supports EVS-based voice over IMS calls for various wireless technologies, e.g. LTE and WLAN.

Precise VoLTE and VoWLAN analysis

The flexibility of IP-based communications also comes with unwanted side effects such as jitter and packet loss. The data is buffered in the receiver in order to minimize or eliminate these effects. To test the effectiveness of implemented measures, the R&S®CMW 500 tester's data application unit offers IP impairments to deliberately cause such errors and IP analysis to analyze them. The R&S®CMW-KM 051 deep packet inspection option allows users to verify the configured jitter profiles and measure the data loss. Combining and simultaneously analyzing the three areas of RF, protocols and data in one device enables users to precisely analyze the VoLTE and VoWLAN processes for errors. IP analysis can be used to correlate data packets from OTT applications to the corresponding applications and draw conclusions about their communications behavior (see below).

Typical codec bandwidths

Full band

Super wideband

Wideband

Narrowband

Level

0 dB
−3 dB

20 50   300   3400   7000   14 000 20 000
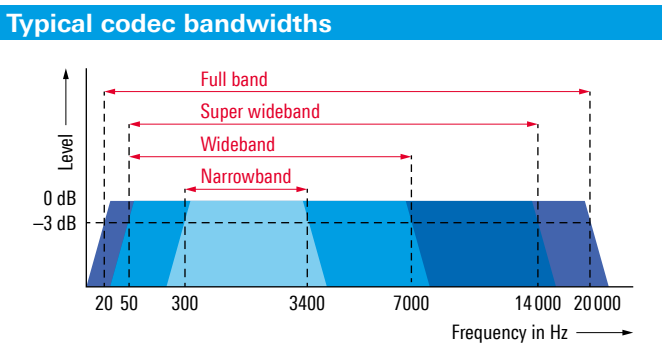
Frequency in Hz

Fig. 6: Typical transmission bandwidth of voice codes. The new EVS codec covers everything.

Focus on quality of experience

An important criterion when evaluating smartphones is their single-charge battery life. Batteries with higher capacity are too large and heavy to install in smartphones. Developers have to increasingly focus on the current drain of individual hardware components and especially applications. Application requirements and the modem's network settings need to be compatible.

Functions such as discontinuous reception (DRX), which is a power saving mode in LTE, reduces the power consumption and must also be tested in connection with VoLTE. Rohde & Schwarz offers a fully automated solution based on the R&S®CMWrun test sequencer software and R&S®CMW-KT051 software package. In the test setup in Fig. 7, instead of using the built-in batteries the R&S®NGMO2 remote controlled power supply, which is also a precise digital

voltmeter, supplies the smartphone with power. IP-based events can be correlated with the smartphone's power consumption. The R&S®CMW500 tester's deep packet inspection engine enables users to quickly see the correlation between an application, its data traffic and power consumption. Ineffective applications with optimization potential are easy to identify.

The setup in Fig. 7 can be extended for VoLTE by adding the R&S®UPV audio analyzer, making it possible to monitor the power consumption during a VoLTE call while simultaneously measuring the audio quality.

Summary

LTE networks and WLAN transmit voice just like other data: as a packet-switched IP stream. Special measures are needed to ensure the necessary QoS. Thanks to state-of-the-art network simulation and the R&S®CMW500

measurement capabilities, wireless device manufacturers can analyze the VoLTE and VoWLAN features of a device in detail. The tester's integrated data application unit with integrated servers for IMS and ePDG allows users to test the proper interaction between hardware and software for WLAN offload or SRVCC scenarios in a reproducible laboratory environment. Event-controlled power consumption measurements on smartphones show improvement potential in hardware components and applications. Network operators can identify error sources early on by accurately measuring the VoLTE performance under specific network characteristics. Mobile phone manufacturers and network operators have a universal tool to test various parameters with regard to functionality, voice quality and other relevant data in the lab before bringing a device to market.
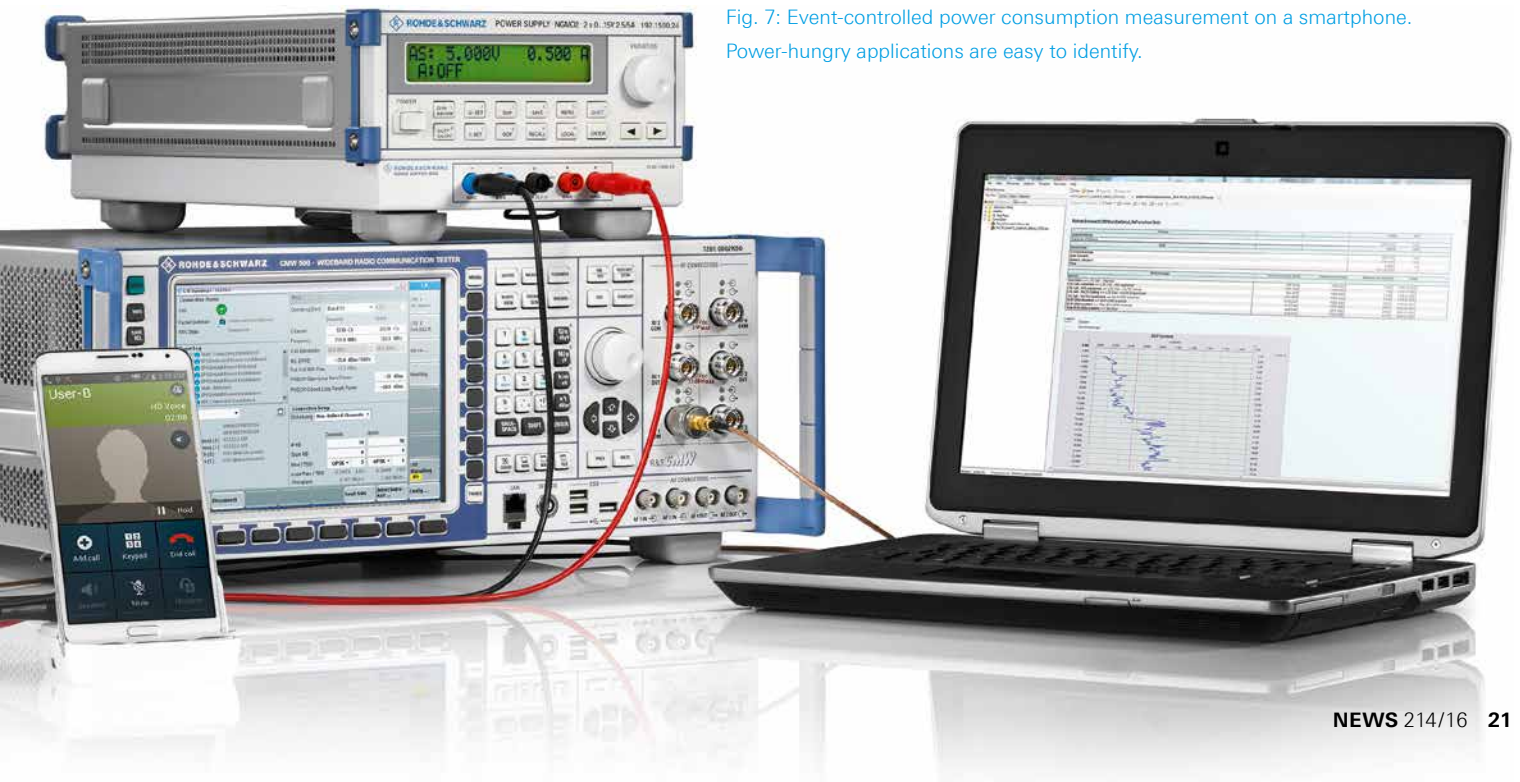
Christian Hof; Stefan Diebenbusch

Fig. 7: Event-controlled power consumption measurement on a smartphone. Power-hungry applications are easy to identify.

A new player in the handheld segment

Rohde & Schwarz has brought out the R&S®Scope Rider, the company's first handheld oscilloscope. But this instrument is so much more than that.

The R&S®Scope Rider combines the functionality and performance of a lab oscilloscope with the form factor and ruggedness of a battery-powered handheld device. An integrated logic analyzer and advanced measurement functions make it a universal tool for debugging embedded designs in the lab as well as for analyzing complex problems in the field.

With a base bandwidth of 60 MHz (expandable to 500 MHz), a sampling rate of 5 Gsample/s and the functionality of a lab oscilloscope, the R&S®Scope Rider is ideal for all applications where both a portable, rugged oscilloscope and the performance of a lab oscilloscope are needed. Specially designed frontend and 10-bit A/D converter components ensure the highest degree of sensitivity and precision in the signal display, equal to that of a lab instrument. The input sensitivity range extends from 2 mV/div to 100 V/div, permitting up to 200 V offset compensation, which is especially important when analyzing power electronics modules.

Making rare faults visible without triggering

A high acquisition rate is especially important when dealing with an unclear fault pattern (Fig. 1). It ensures that unexpected and infrequently occurring signal faults, such as sporadic interference in clock signals, are visible without explicit triggering on the fault state – something that often is not possible without advance knowledge of the fault signal. By using a dual-core-on-a-chip system, the R&S®Scope Rider achieves an acquisition rate of up to 50 000 signal waveforms per second, which clearly places it in the lab instrument class. Comparable handheld oscilloscopes manage only up to 100 acquisitions per second and cannot display sporadic faults without explicit triggering.

The powerful triggering system simplifies the analysis of complex signal waveforms. 14 different trigger types – more than offered by many benchtop models – make targeted acquisition and analysis of signal components possible. In addition to typical trigger types such as edge, glitch and pulse width, the R&S®Scope Rider can also be equipped with advanced trigger functions, including runt trigger, video trigger for analog and digital video systems, slew rate trigger and protocol trigger. The fully digital implementation of the trigger system eliminates the need for a separate analog trigger path, which increases trigger jitter, or for a downstream software trigger that can miss trigger events due to its inherent blind time. Instead, the R&S®Scope Rider trigger system provides continuous monitoring of the input signal for all trigger types.

Easy operation via keys or touchscreen

Easy operation of the large range of functions was a key requirement during the development of the R&S®Scope Rider. This requirement was met with a sophisticated touchscreen design, plus a keypad and a multifunctional rotary knob. The oscilloscope can be completely touchscreen or keypad operated. The keypad is especially important for use in the field when wearing gloves.

The keys operate on a simple principle: pressing a key once enables the corresponding measurement function and pressing the key a second time disables the function. Pressing and holding a key opens the setup menu for that measurement function. The resulting operation is so efficient that deep menu levels are rendered unnecessary.

Fig. 1: The high acquisition rate of the R&S®Scope Rider makes faults in this clock signal visible. The brightness-coded display makes it possible to see that rare fault signals are the source of the problem.
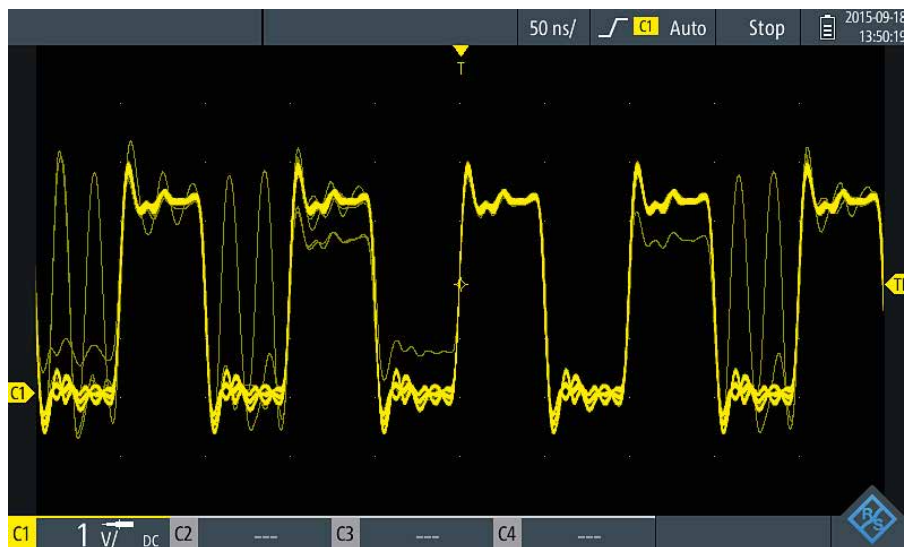
Special care was also taken in the development of the graphical user interface (Fig. 2). Color-coded channel indicators make it easy to allocate measurement results to the appropriate input channels. Measurement results are easy to read thanks to a font selected for its readability. Measurement and trigger functions as well as all other settings are explained using icons, eliminating the need to open the user manual in most cases. Last but not least, the intuitive user operation is supported by the 13 languages available for menu entries (Fig. 3).

Safety first

Due to their portability and rugged design, handheld oscilloscopes are used for a wide variety of service and maintenance tasks. A common application is checking and maintaining electrical drives, power electronics or the electrical power supply to industrial installations. When using conventional oscilloscopes with a common ground wire, inadvertently switching the ground and signal wires between two input channels would immediately lead to a short circuit and

A special font ensures good readability. The channel indicator shows which input channel is associated with the measurement results.

Color-coded channel indicators display the most important settings for each input channel.

Fig. 2: The carefully crafted user interface usually makes it unnecessary to open the manual.

Icons explain all essential oscilloscope functions, such as the automated measurement functions.

The Rohde & Schwarz logo provides direct access to all settings. Navigation is possible via both the rotary knob and the touchscreen.

Fig. 3: The user interface is available in any of 13 languages.

dangerously high currents. Isolated input channels eliminate this risk. The differential functionality of the isolated channels provides an additional advantage. This can mean the elimination of expensive active differential probes in many applications requiring differential measurements.

The oscilloscope's interface unit containing the digital logic interface and the USB and LAN ports is galvanically isolated from the instrument and from the input channels. This makes it possible to contact higher voltages without risk via the analog measurement channels and to simultaneously analyze digital control signals or remotely control the instrument via LAN (Fig. 4).

An instrument's measurement category and certified maximum RMS voltage are important safety considerations for an instrument that is used to measure hazardous live voltages. These determine the voltage peaks that the measuring instrument must withstand without damage while ensuring the safety of the user. The R&S®ScopeRider was developed for the highest measurement category, CAT IV, and allows measurement of voltages up to 600 V (RMS) in a CAT IV environment or up to 1000 V (RMS) in a CAT III environment (Fig. 5).
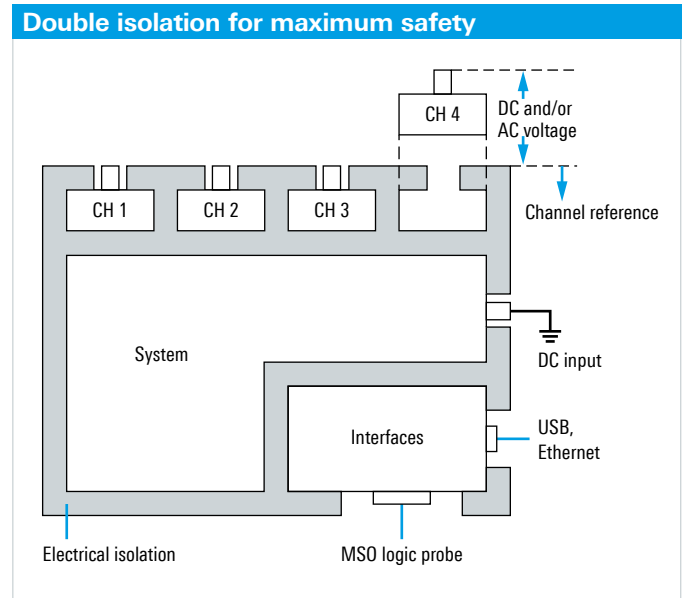
Double isolation for maximum safety

Fig. 4: The isolated input channels prevent short circuits caused by inadvertent swapping of ground and signal wires at two oscilloscope inputs. Power electronics measurements can be performed safely.

Measurement category	Description	Overvoltage requirements
0 (previously CAT I)	The DUT is not connected to the mains supply and therefore no overvoltages are expected.	No special requirements
CAT II	The DUT is plugged into the mains sockets or similar points. There is no permanent connection.	Maximum 6000 V overvoltage
CAT III	The DUT is permanently connected to the mains supply within a building after the circuit breakers.	Maximum 6000 V overvoltage at up to 600 V (RMS) measurement voltage. Maximum 8000 V overvoltage at up to 1000 V (RMS) measurement voltage
CAT IV	The DUT is permanently connected to the mains supply at the power source.	Maximum 8000 V overvoltage at up to 600 V (RMS) measurement voltage

Fig. 5: The measurement categories at a glance.

Five instruments in one

Troubleshooting in the field often requires a variety of measurement functions. The more functions a measuring instrument can provide, the fewer additional measuring equipment must be taken on a service call. This is why the R&S®Scope Rider integrates five essential measuring instruments:

▮ A handheld oscilloscope with two or four channels and the performance and functionality of a lab instrument
▮ A logic analyzer with eight digital inputs for analyzing digital control signals (Fig. 6)

▮ A protocol analyzer with trigger and decoder functionality for debugging serial protocols
▮ A data logger for long-term monitoring of readings (Fig. 7)
▮ A digital voltmeter in the four-channel instrument or a digital multimeter with all conventional multimeter measurement functions in the two-channel instrument

This makes the R&S®Scope Rider ideal for service and maintenance tasks on complex systems in the field as well as for day-to-day work in the development lab.
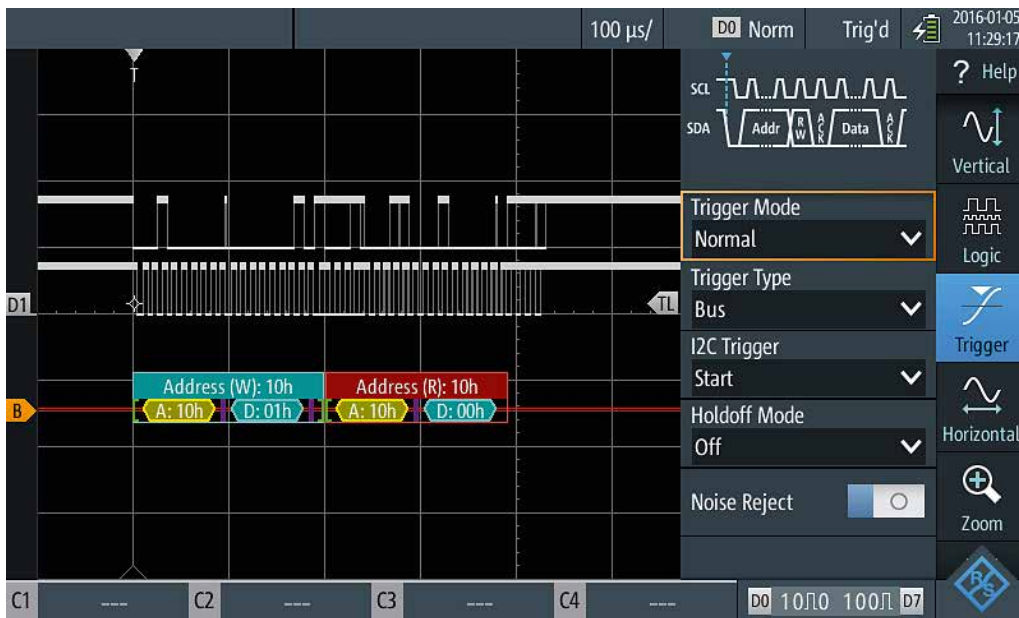

Fig. 6: The R&S®Scope Rider is the first handheld oscilloscope to offer a digital logic interface (mixed signal oscilloscope) and triggering and decoding of serial protocols.
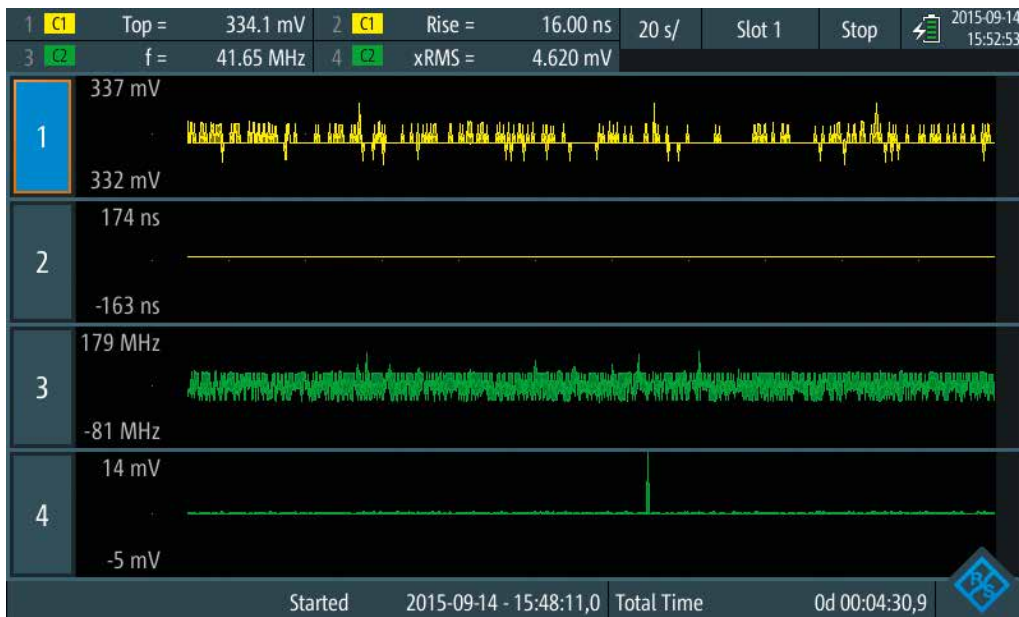

Fig. 7: Long-term monitoring with the integrated data logger.

WLAN remote control and one-touch documentation

For dangerous or unpleasant measurement situations, such as occur during high voltage testing or in environmental test labs, the R&S®Scope Rider is equipped with a WLAN module. It uses this module to create its own WLAN hotspot. The measurement can be operated directly from the web browser on a notebook, tablet or mobile phone (Fig. 8).

The one-touch documentation feature makes it exceedingly simple to save a day's measurements for later documentation. Screenshots, measurement data and configuration files are saved to the integrated SD card or to a USB flash drive by simply pressing a button and can later be transferred to the PC for documentation or further analysis.

Two base models, five bandwidth variants and numerous expansion options

R&S®Scope Rider buyers need only choose one of the two base models, i.e. either the two-channel instrument with an additional multimeter channel or the four-channel instrument with the digital voltmeter functionality for the oscilloscope channels (Fig. 9). Both have a base bandwidth of 60 MHz. All other optional features can be enabled via keycode. The instruments are delivered with the maximum functional scope, but the customer pays only for the features that are actually needed. The bandwidth can be upgraded to 100 MHz, 200 MHz, 350 MHz or 500 MHz. Other functions can also be enabled: the R&S®RTH-B1 logic analysis option (MSO), the R&S®RTH-K1 (I^{2}C/SPI) and R&S®RTH-K2 (UART/RS-232) protocol analysis options, the R&S®RTH-K19 advanced trigger functionality with special trigger types, and the R&S®RTH-K200 wireless LAN and R&S®RTH-K201 remote control options.

For additional information as well as product brochures and current offers, visit the market introduction page
www.2-minutes.com
or
www.rohde-schwarz.com/product/rth
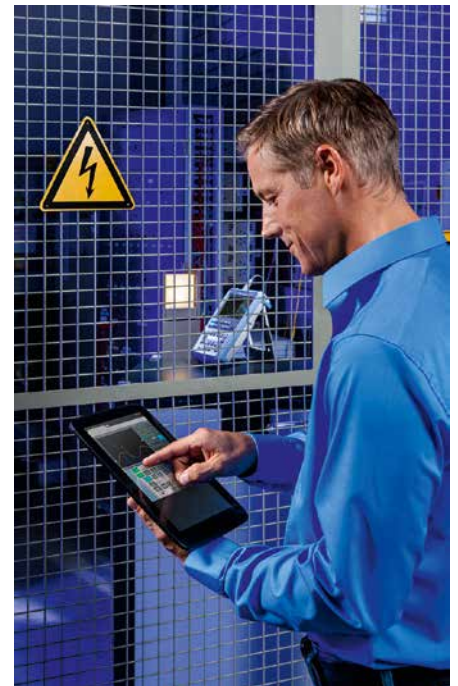
Dr. Markus Herdin

Fig. 8: In potentially dangerous applications, the R&S®Scope Rider can be operated via WLAN directly from a web browser.

Fig. 9: Two base models are available: the two-channel instrument with additional multimeter channel (left) or the four-channel instrument with digital voltmeter functionality for the oscilloscope channels.

Analysis of wireless charging systems with R&S®RTM 2000 multidomain oscilloscopes

Wireless charging for smartphones and other mobile devices is booming. A large Swedish furniture company has even introduced a new line of furniture with integrated wireless chargers to the market. The most widely used wireless charging standards are Qi and Rezence. When developing and validating such chargers, it is important to analyze their behavior in both the time and frequency domains. The fastest and most convenient way is when both domains are time-correlated in one oscilloscope.

Due to their flat design, wireless chargers can be integrated into everyday surroundings, and manufacturers from different industries are increasingly taking advantage of this fact. Wireless chargers are hidden, for example, in new cars and even in furniture. Many smartphones are also prepared for wireless charging. Users benefit from convenient charging without cables. Network operators also have advantages because charged phones potentially generate more revenue. This encourages network operators to provide chargers to fast food chains, for example.

Following the recent merger of *Power Matters Alliance* and Rezence developer *Alliance for Wireless Power*, there are currently two dominant standards: Qi and Rezence. The design challenges for developers are similar. What these are, and how they can best be met, is described below using the Qi standard as an example.

integrating more functions into oscilloscopes and optionally upgrading instruments. For example, the R&S®RTM 2000 multidomain oscilloscope offers a spectrum analysis and spectrogram option (R&S®RTM-K18). Thanks to hardware-implemented digital downconversion (DDC), which reduces the signals to the components relevant to the analysis, the spectrum of analog input signals can be analyzed at high speed – from DC to the instrument bandwidth. Measurement parameters can be independently optimized in the time domain (duration and resolution) and the frequency domain (center frequency, span and resolution bandwidth).

The following shows how these challenges can be quickly and elegantly mastered with the R&S®RTM 2000 oscilloscope.

Qi and its challenges for developers

Wireless energy transfer systems under the Qi standard use frequencies from 110 kHz to 205 kHz and can transfer up to 5 W. Fig. 1 shows the setup of a Qi charging system. These systems have four phases: selection, ping, identification / configuration, and power transfer. There are two areas of special interest in the development phase. One is the system behavior when a device is brought close to the charging station, i.e. the transition from the selection phase to the power transfer phase. The other is the analysis of the electromagnetic disturbances since the relatively weak signals for control compete with the strong signals of the 5 W power transfer. In both development tasks, it is essential to ensure the time-correlated monitoring of the digital signals of the control elements as well as the signals from the transmitter and receiver coils. An oscilloscope and an entry-level spectrum analyzer are required. Developers benefit from the trend towards
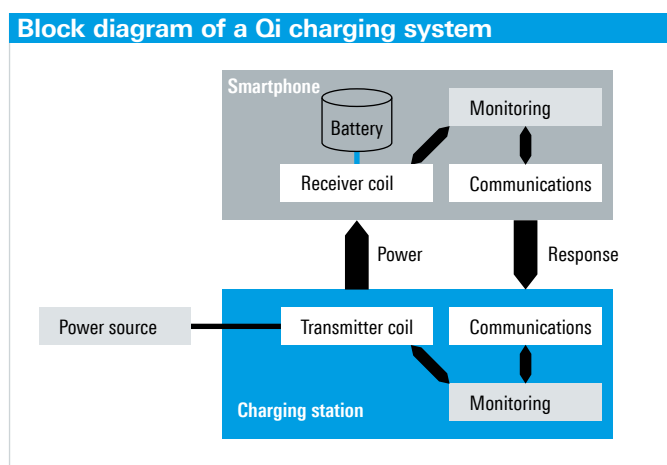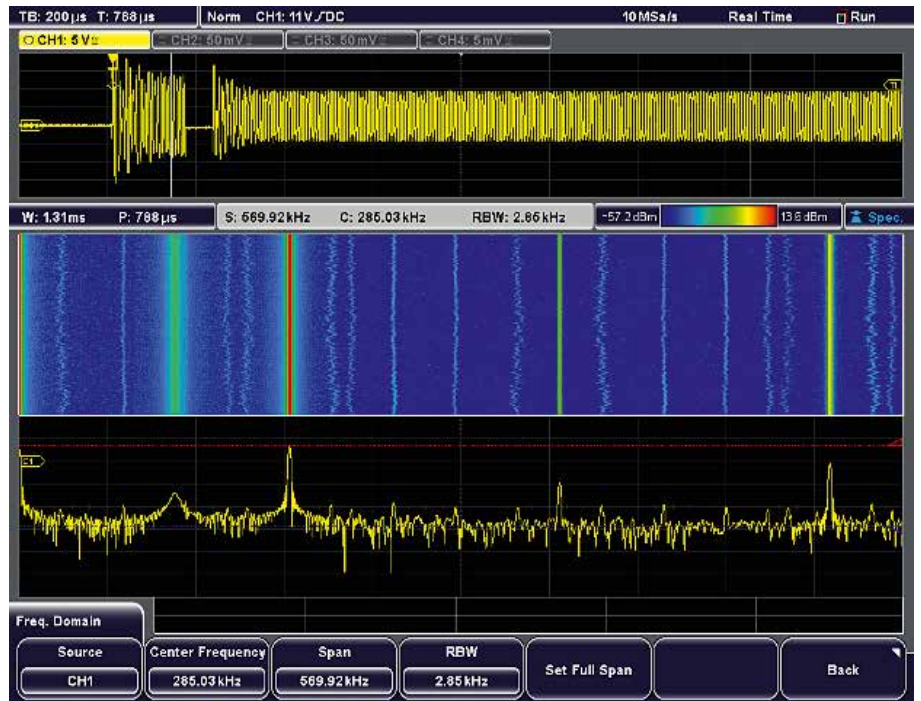
Block diagram of a Qi charging system

Fig. 1: Qi charging systems communicate with the smartphone and negotiate a power transfer contract.

Fig. 2: Analog ping signal in selection mode in three representations: time (top), frequency spectrum (below) and spectrum over time (spectrogram, center).

Characterization of the power transfer setup

In the selection mode, which is basically an energy-saving idle mode, the power transmitter in the charging station regularly transmits analog pings to monitor its environment (Fig. 2). If for example, the power transmitter detects a nearby object due to changes in the inductive field, the system proceeds to the ping phase. In this phase, the power transmitter executes a digital ping that requires a response in order to determine if the nearby object is a smartphone or another (metal) object. If the smartphone answers the ping signals, the system continues to the identification and configuration phase, otherwise it reverts to idle mode. In the identification and configuration phase, the charging station and smartphone first negotiate a power transfer contract based on configuration information, such as the required power. A time-correlated power transfer then takes place.

The method for controlling the required amount of power is not specified in the standard, but three processes have become established:
ı Frequency control: The resonance frequency is tuned, which affects the amount of power in the charging coil and therefore the transferred power.
ı Duty cycle control: At the inverter, the duty cycle is adjusted to the required power.
ı Voltage control: The voltage applied to the charging coil is adjusted.

The specification also allows parallel implementation of different methods.

There are two central aspects when characterizing frequency controlled designs. First, adherence to the various time intervals when negotiating the power transfer contract. This includes specific minimum times between two communications processes and the timely shutdown of power transfer in case of failure. Although times are comparatively long – in the millisecond range – nonadherence often leads to malfunctions. Secondly, a high dynamic range is required to measure the communications' weaker amplitude shift keying (ASK) signals. Once the connection is established, variations in the voltage levels often cause compatibility problems. Adherence to specified levels is also beneficial for energy efficiency and is required by various energy efficiency standards such as ENERGY STAR.

Optimization of coil design and energy efficiency

For efficient charging, it is important to precisely understand the frequency and amplitude adjustments of the carrier frequency f_c. The energy efficiency is strongly influenced by the coils' properties and material. The R&S®RTM2000, together with the spectrum analysis and spectrogram option, allows exact analysis of f_c adjustments during the handshake. Thanks to the oscilloscope's high dynamic range, the weaker ASK modulated signal on the comparatively large 20 V (V_{pp}) carrier can be measured as shown in Fig. 3. The correct time window for the analysis is selected based on this information. The actual modulation can be analyzed best in the spectrogram. There, the signal level is color-coded and plotted over time, making it easy to interpret changes such as

switching operations. The high FFT rate of the R&S®RTM 2000 makes even rapid frequency changes visible. Together with the R&S®RTM-K15 history and segmented memory option, the spectrogram marker shows the time of the acquisition and makes it possible to load the corresponding time and frequency waveforms from the deep 460 Msample memory. All oscilloscope tools can be used to analyze the loaded waveforms. For instance, the mask test offers an elegant way to identify signal anomalies in the analog signals that indicate errors.

Fig. 4 shows such a modulation of the carrier frequency f_c for adjusting a Qi circuit's power. In the upper quarter of the spectrogram, the charging station's idling frequency of 175 kHz is visible. As the load approaches, f_c first changes to 120 kHz and gradually adjusts to 205 kHz as the distance decreases. The blue max. hold trace – i.e. the envelope around the maximum values of all f_c spectra (yellow trace) – makes the analysis of the amplitude change particularly easy. The coil can be adjusted based on this analysis.

Analysis of electromagnetic susceptibility

Characterizing the electromagnetic susceptibility of the charging station is another important task. Not only does the large charging coil, together with the tracks on the board, act as a

perfect antenna; preliminary investigations during development help eliminate surprises later during electromagnetic compatibility assessment.

Specifically, two of the charging station states typically present the greatest challenges. First, the periodic pings when establishing a connection cause ripple and noise on the board tracks. Later, in the power transfer phase, the system has a fixed resonance frequency, making it more susceptible to external electromagnetic disturbance than in previous phases.

With suitable near-field probes, like those included in the R&S®HZ-15 set, the board tracks can be examined directly to quickly locate problem areas in the design (Fig. 5). Just like with a spectrum analyzer, the oscilloscope with the spectrum analysis and spectrogram option can be used to adjust parameters such as the center frequency, span and resolution bandwidth while measuring. This enables users to specifically analyze the frequency range of interest. Usually, fast and sporadic emissions can only be found with spectrum analyzers. But the DDC implementation in the R&S®RTM-K18 option makes it possible to detect these emissions with the R&S®RTM 2000 oscilloscope. Thanks to the additional ability to simultaneously monitor events in the time domain, causes can be more easily located. Countermeasures such as shielding can be chosen based on this analysis.
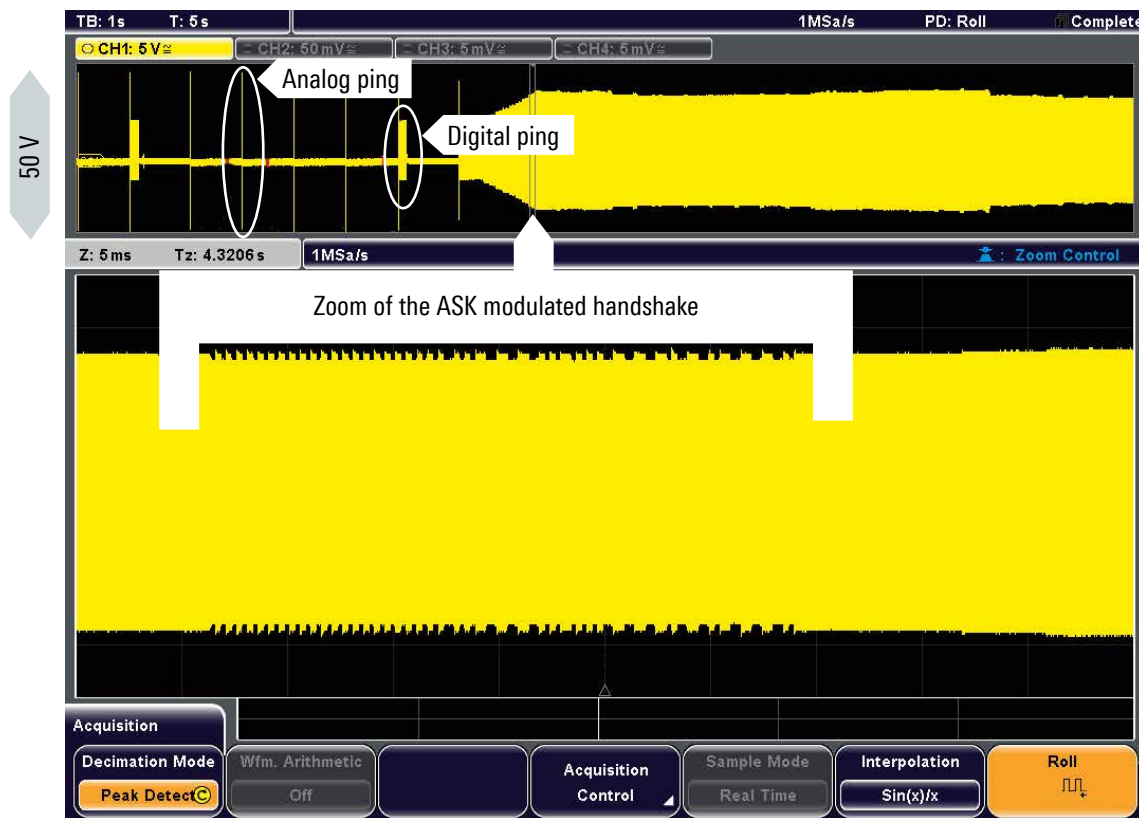

Fig. 3: Establishing the connection with analog and digital pings as well as the subsequent configuration phase with ASK modulation.

Summary

When developing wireless charging systems, different measurement functions are needed since these systems contain RF, digital, power and control components. With a multidomain oscilloscope like the R&S®RTM 2000, these measuring tasks are easily solved without the need for additional equipment.

Dr. Philipp Weigell

Fig. 4: A device approaches the charging station. For better focus, the time domain view is disabled.
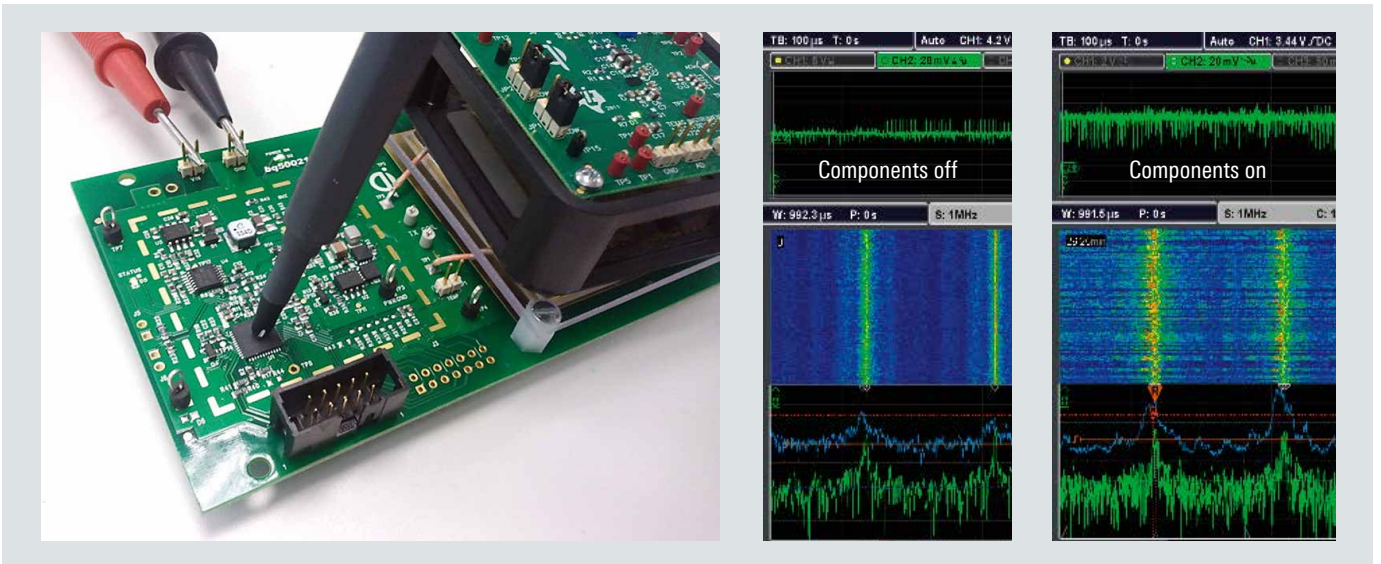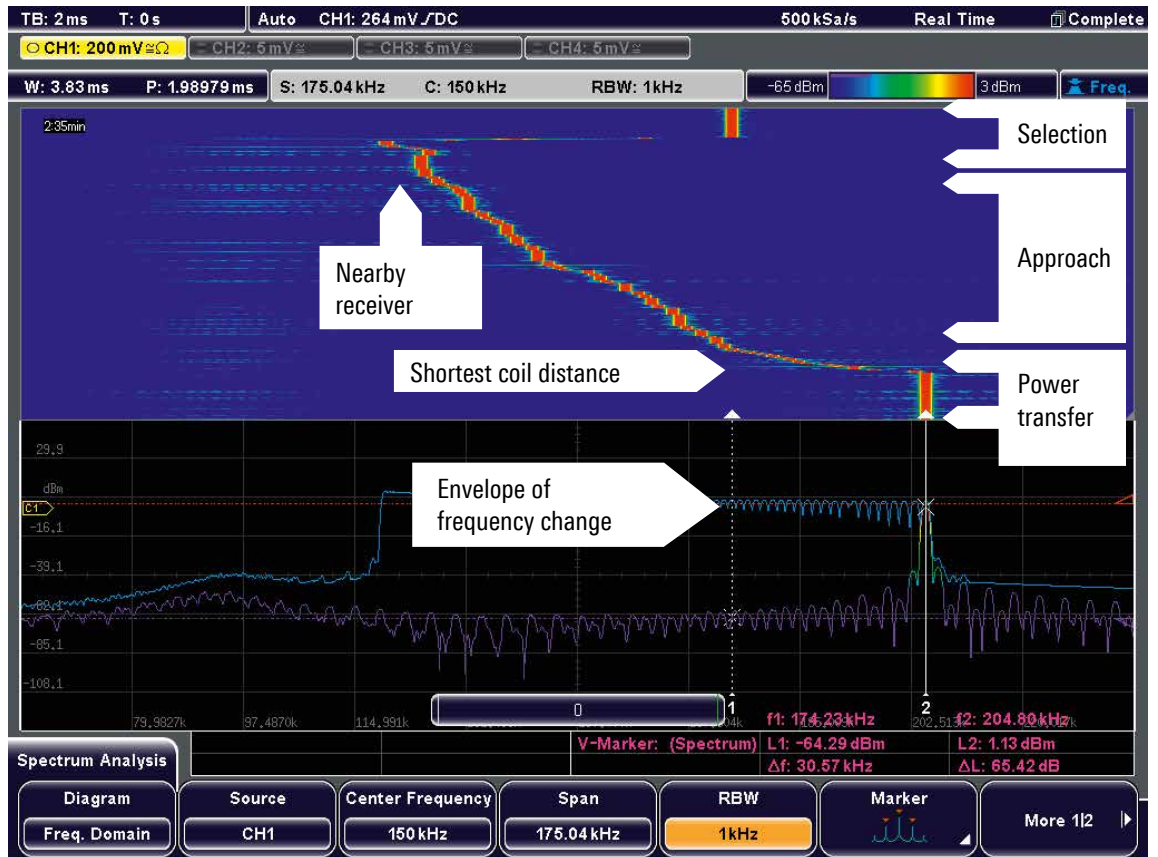

Fig. 5: Scanning of a Qi controller with an H near-field probe (left). Low (center) and high (right) electromagnetic disturbance when components are switched off or on.

Well-equipped for field and lab – the R&S®Spectrum Rider

The new R&S®Spectrum Rider makes spectrum analysis in the field and lab easier, faster and more affordable. The instrument has been designed for the installation and maintenance of RF transmitters as well as troubleshooting in repair and development labs.

The frequency range of the base unit extends from 5 kHz to 2 GHz and covers a multitude of lab and education applications. A software keycode makes it easy to increase the range of the R&S®Spectrum Rider to 3 GHz or 4 GHz for applications above 2 GHz or in the LTE bands above 3 GHz.

Large buttons and a multifunction rotary knob allow users to keep their gloves on when working in the field. The illuminated keypad is easy to use in the dark, and the nonreflective display clearly shows the measurement results and not a mirror image of the user.

The R&S®Spectrum Rider (Fig. 1) is highly ruggedized in line with the specifications of MIL-PRF-28800F class 2. It is protected against dripping water and dust in line with IP51 and features a fanless design thanks to its low power consumption (approx. 8 W). This increases the analyzer's lifetime and provides silent operation. The instrument takes just seconds to power up, can operate for almost eight hours without recharging the battery and weighs a total of just 2.5 kg (with battery).

Despite its small size, the R&S®Spectrum Rider offers numerous capabilities and a solid RF performance:
▮ Phase noise of –105 dBc (1 Hz) at 100 kHz offset from carrier
▮ Total measurement uncertainty of 0.5 dB
▮ High sensitivity (DANL) of typ. < –163 dBm up to 3 GHz)

Typical measurements for RF diagnostics in service and development labs:
▮ Frequency and amplitude measurements of any RF source

EDN, the well-known media house for professional electronics, selected the R&S®Spectrum Rider as one of its Hot 100 products of 2015.

▮ Accurate frequency readings with the frequency counter, e. g. for frequency reference alignment
▮ Measurement of spurious emissions
▮ Measurement of harmonics and intermodulation products
▮ Measurement of pulsed signals in the time domain

An 18 cm capacitive touchscreen and a keypad make the R&S®Spectrum Rider easy to operate. The analyzer's touchscreen enables users to adjust the most common settings, such as center frequency, span and reference level, and manage markers with intuitive gestures as with a smartphone.

Fig. 1: Well-prepared for use in the field: the R&S®Spectrum Rider is protected against dripping water and dust in line with IP51 an meets MIL-PRF-28800F class 2 specifications.

Touching or clicking the configuration overview menu icon opens a simplified version of the menu found in Rohde & Schwarz high-end signal and spectrum analyzers (Fig. 2). It provides a quick overview for checking and changing measurement settings such as frequency, amplitude, bandwidth etc.

The R&S®Spectrum Rider offers a broad range of standard features used in everyday spectrum analysis such as two spectrum traces, AM/FM audio demodulation, remote control and a frequency counter.

Field engineers and repair labs in various industries will find optional measurement applications for their daily work, e.g. peak and average power measurements. All options can be easily enabled using a software keycode, eliminating extra installation costs and downtime caused by shipping the instrument.

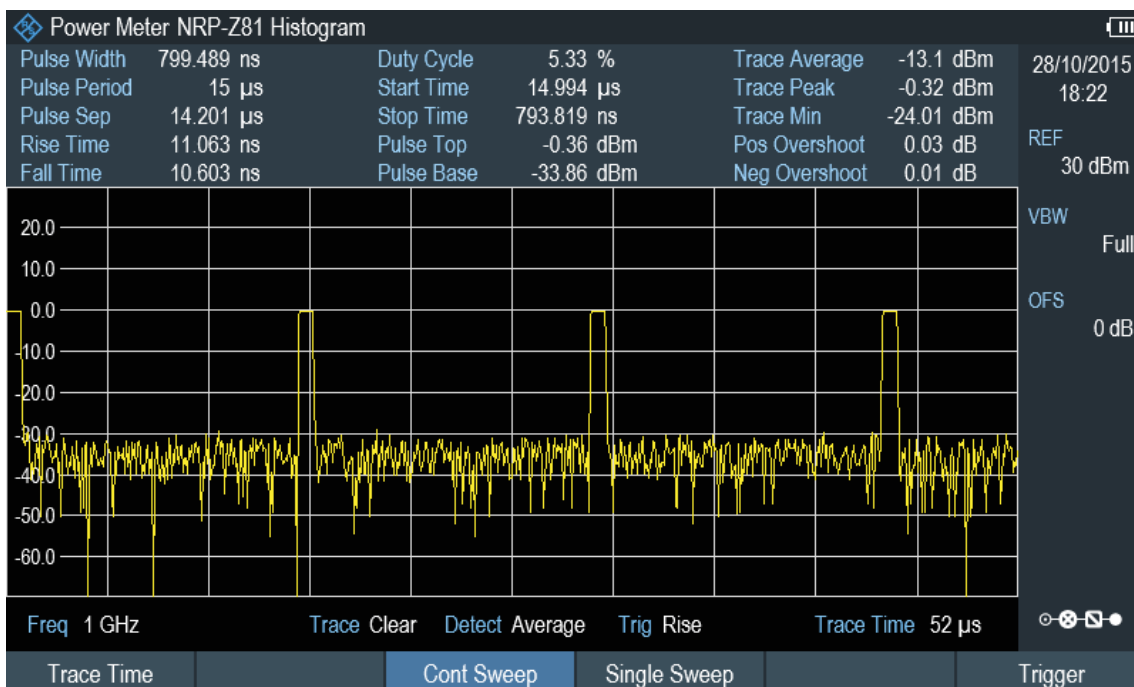Fig. 2: Menu with configuration overview.

Fig. 3: Pulse analysis with the R&S®FPH-K29 option and the R&S®NRP-Z8x power sensors.

Field use example: pulse measurements with a power sensor

The R&S®FPH-K29 option enables precise pulse and peak power measurements when used with the R&S®NRP-Z8x wideband power sensors. These sensors measure pulses with a resolution of up to 50 ns at frequencies up to 44 GHz (Fig. 3). The main pulse parameters such as pulse width, rise / fall time and duty cycle are displayed automatically. Trigger functions and markers are available, and increasing the time resolution makes it possible to zoom in on the pulses. This is convenient for installing and maintaining radar systems, for example.
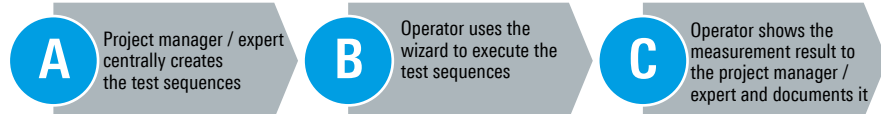
Lab use example: EMI debugging with optional near-field probes

The R&S®HZ-15 near-field probes are used as diagnostic tools for EMI debugging, e.g. on circuit boards, integrated circuits, cables and shielding. The probes are ideal for emission measurements between 30 MHz and 3 GHz. The R&S®HZ-16 preamplifier improves measurement sensitivity up to 3 GHz, with approx. 20 dB gain and a noise figure of 4.5 dB. In combination with the R&S®Spectrum Rider, the near-field probes and the preamplifier are a cost-effective means of analyzing and locating disturbance sources during development (Fig. 4).
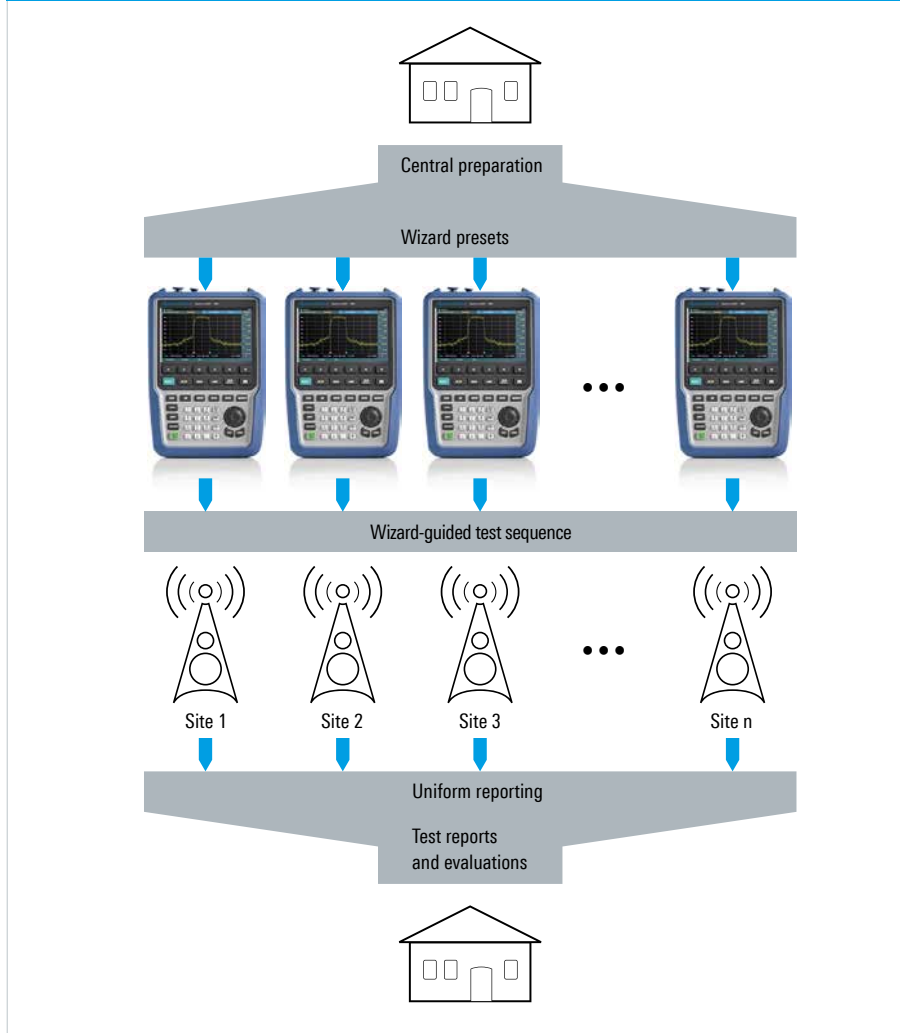
Fig. 4: The R&S®Spectrum Rider is combined with EMI probes for measurements on circuit boards, integrated circuits, cables and shielding.

Three simple steps needed to work with the measurement wizard

A Project manager / expert centrally creates the test sequences

B Operator uses the wizard to execute the test sequences

C Operator shows the measurement result to the project manager / expert and documents it

Typical test scenario

Central preparation

Wizard presets

Wizard-guided test sequence

Site 1   Site 2   Site 3   Site n

Uniform reporting

Test reports and evaluations

Wizard for easier and faster measurements

Site surveys or the installation and maintenance of transmitter sites often require a standard set of spectrum measurements. The wizard makes it easy to perform standardized and recurring measurements (Fig. 5).

First, a measurement expert uses the free R&S®Instrument View software to create the test sequences on a PC. Pictures and written instructions can be added to each measurement step. After the measurement sequences have been configured, they can be transferred to the instruments via LAN. The operator in the field only needs to start the wizard, select the measurement sequence and follow the instructions on the touchscreen. The instrument is correctly configured for each test step, so there is no need to spend time on configuration on site.

When all measurements have been carried out, they can be transferred to a Windows tablet or a PC to generate a measurement report in a few seconds using the R&S®Instrument View software.

Laura Sanchez

Fig. 5: Typical scenario for preparing measurements and postprocessing results. The operator in the field only needs to start the wizard and follow the instructions on the touchscreen.

Fig. 1: R&S®FSWP phase noise analyzer and VCO tester.

Measuring phase noise from high-end signal sources for radar systems

The new R&S®FSWP phase noise analyzer and VCO tester features internal signal sources with very low phase noise. Combining these sources with cross-correlation technology produces such high sensitivity that the instrument can carry out phase noise measurements on highly stable sources (such as those used in radar systems) in a matter of seconds.

Signal source quality is a primary driver of performance in advanced radar systems. Lower phase noise in signal sources means better spatial resolution and more accurate velocity measurements of moving objects. Developers have to be able to measure phase noise, even in pulsed mode, in order to minimize it. These measurements have previously required

complex systems consisting of phase detectors, FFT spectrum analyzers and extremely low-noise reference signal sources. These sources have to deliver significantly better quality than those of the DUT in order to ensure accurate measurement results. If the reference signal sources are too noisy, developers can also use cross-correlation based on two

parallel receive paths, two different reference signal sources and two phase detectors. Engineers can then suppress the inherent noise of the sources and measurement path components by averaging the I/Q data of the noise that results from the two measurement paths. This makes the test setup extremely complex, but significantly increases sensitivity as shown in the following equation:

$$\Delta L = 5 \cdot \log(n)$$

ΔL: improvement in sensitivity through cross-correlation in dB
n: number of correlations / averages

Increasing the number of correlations by a factor of 10, for example, increases the sensitivity of the phase noise test setup by 5 dB.

Fig. 2: Trace of a high-end OCXO with –190 dBc (1 Hz) phase noise at a frequency offset of 1 MHz.
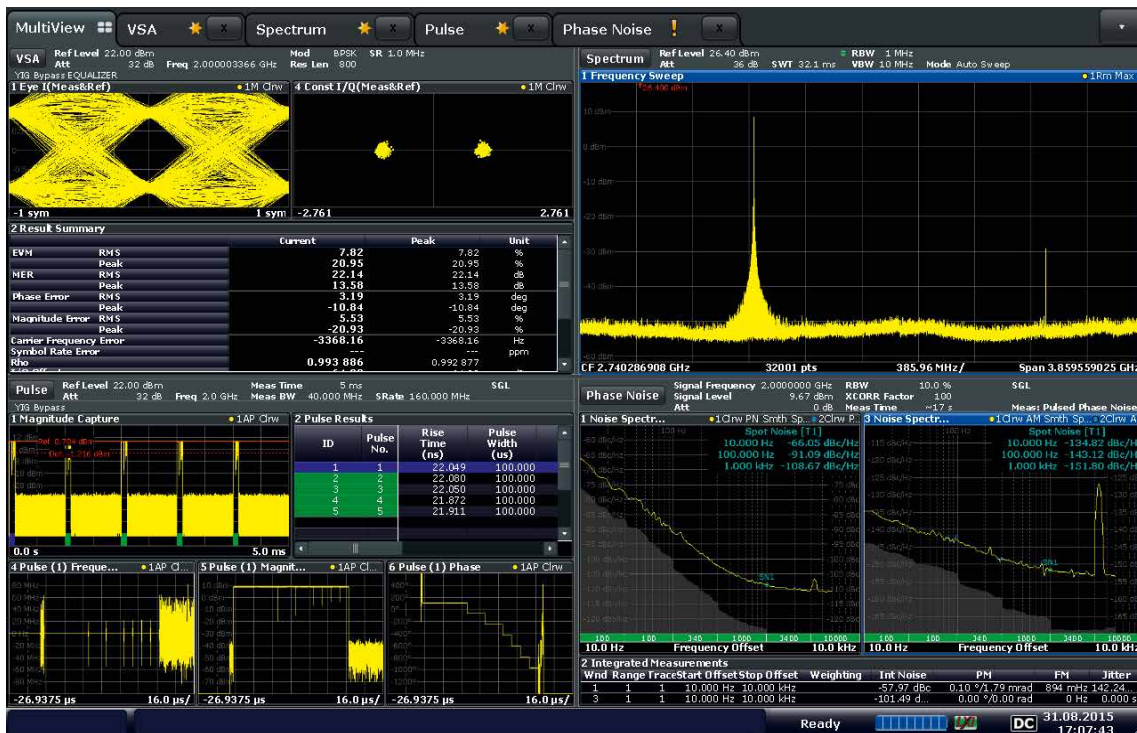

Fig. 3: Vector signal analysis, pulsed signal analysis, measurement of higher harmonics, sensitive phase noise measurements – the R&S®FSWP does it all. It switches easily between measurement channels and displays results simultaneously.

Phase noise is a key parameter for more than just radar applications. Developers must use these complex systems to carry out highly sensitive measurements on high-end oscillators such as OCXOs, DROs and synthesizers used for scientific and communications applications.

The R&S®FSWP phase noise analyzer and VCO tester (Fig. 1) offers all necessary measurements in a single instrument at the push of a button, enabling developers to concentrate on improving their system instead of dealing with complex test setups. Extremely good internal reference signal sources, cross-correlation capability and additional options such as phase noise measurement on pulsed sources and additive phase noise characterization of components make the R&S®FSWP unique for radar applications (Fig. 2).
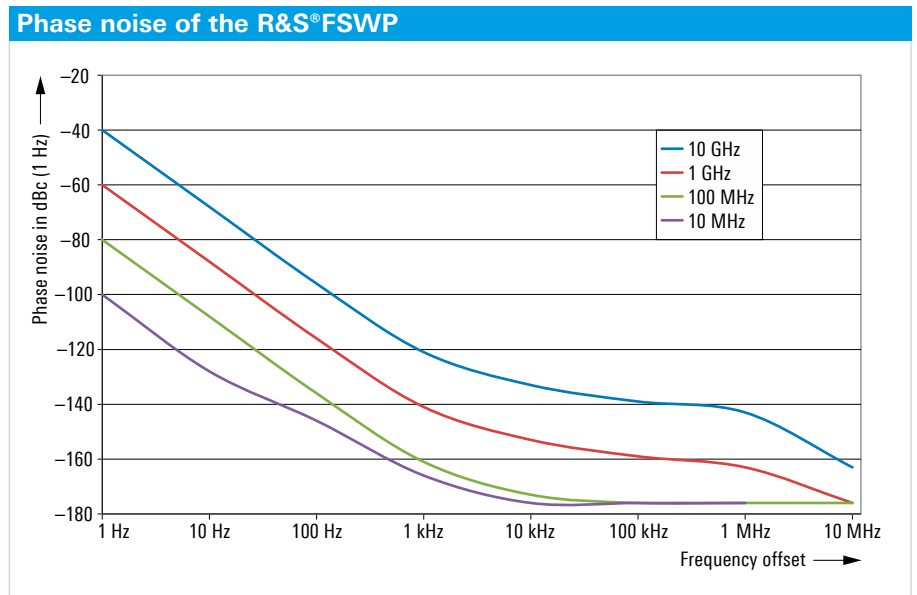
The R&S®FSWP can also be operated as a signal and spectrum analyzer to verify if signals under test meet expectations. The R&S®FSWP is an all-in-one solution that enables developers to easily switch between various measurement channels (Fig. 3). A quick glance at the spectrum and then on with phase noise measurements – it's that easy.

Measuring phase and amplitude noise with high sensitivity

The R&S®FSWP requires no external reference sources or other complex setups to measure the phase noise of radar system oscillators, for example. Its internal local oscillator outperforms nearly all generators and sources on the market in terms of phase noise performance (Fig. 4). If even better sensitivity is required, cross-correlation can improve the sensitivity by up to 25 dB. The R&S®FSWP uses a second internal local oscillator (R&S®FSWP-B60 option) for this purpose. A gray area below the trace shows the achievable level of sensitivity for a particular measurement for the selected number of correlations (Fig. 5). The correlation process can be aborted automatically if adding more correlations will not improve sensitivity. Measurements on high-end oscillators often require just a few correlations thanks to the extremely low noise of the internal sources. These high-sensitivity measurements deliver extremely fast, reliable results (up to 100 times faster than comparable systems).

The R&S®FSWP mixes the signal into the baseband and then digitizes and demodulates it. In addition to phase noise, it can measure amplitude noise – a parameter of increasing importance especially for digital modulation methods. Users can take advantage of cross-correlation in this case as well to measure with over 20 dB more sensitivity than is possible

Fig. 4: Phase noise of the internal local oscillator of the R&S®FSWP at various frequencies.

Phase noise of the R&S®FSWP

Legend: 10 GHz, 1 GHz, 100 MHz, 10 MHz

Y-axis: Phase noise in dBc (1 Hz)
X-axis: Frequency offset

Typical phase noise values of the internal local oscillator								
	1 Hz	10 Hz	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
1 GHz	−60 dBc	−88 dBc	−116 dBc	−141 dBc	−153 dBc	−159 dBc	−163 dBc	−176 dBc

with diode detectors (currently most common method). Phase and amplitude noise can be displayed simultaneously in a diagram or in two windows (Fig. 5).

Phase noise measurements on pulsed sources at the push of a button

Signals from radar systems in the A&D sector are almost always pulsed. In the past, phase noise measurements on these signal sources required extremely costly, complex set-ups, as the necessary pulsed sources had to be synchronized with the DUT. Accurate pulse parameter information and a great deal of patience were also needed to achieve stable measurements. This is all history. Equipped with the R&S®FSWP-K4 option, the R&S®FSWP carries out these measurements at the push of a button. It records the signal, automatically calculates all parameters such as pulse repetition

rate and pulse width (Fig. 5), demodulates the signal and displays the phase and amplitude noise. The instrument automatically sets maximum usable offset ranges and calibrates measurements, but users still have the freedom to define gates in order to suppress transients or improve sensitivity, for example (Fig. 6). Cross-correlation is available for all these instances involving measurements on very good sources and compensation for desensitization (a reduction of the dynamic range), as longer pulse off times produce significantly lower average signal power with pulsed signals.

As a signal analyzer, the R&S®FSWP does more than measure the phase noise of pulsed signals. Equipped with the R&S®FSWP-K6 option, it also automatically identifies all the additional parameters required for characterizing of pulsed sources, e.g. pulse rise and fall times, phase and frequency response and parameter trends.

Fig. 5: Measuring a pulsed signal in the time and frequency domain with the spectrum analyzer (below) and with the phase noise analyzer (above). The upper left window shows the phase noise of the pulsed source; the upper right window displays the amplitude noise. The distance between the noise measurement traces and the gray area below represents the sensitivity improvement by cross-correlation. The segments where there is no distance between trace and gray area indicate that additional cross-correlations are required to achieve an unambiguous measurement result.
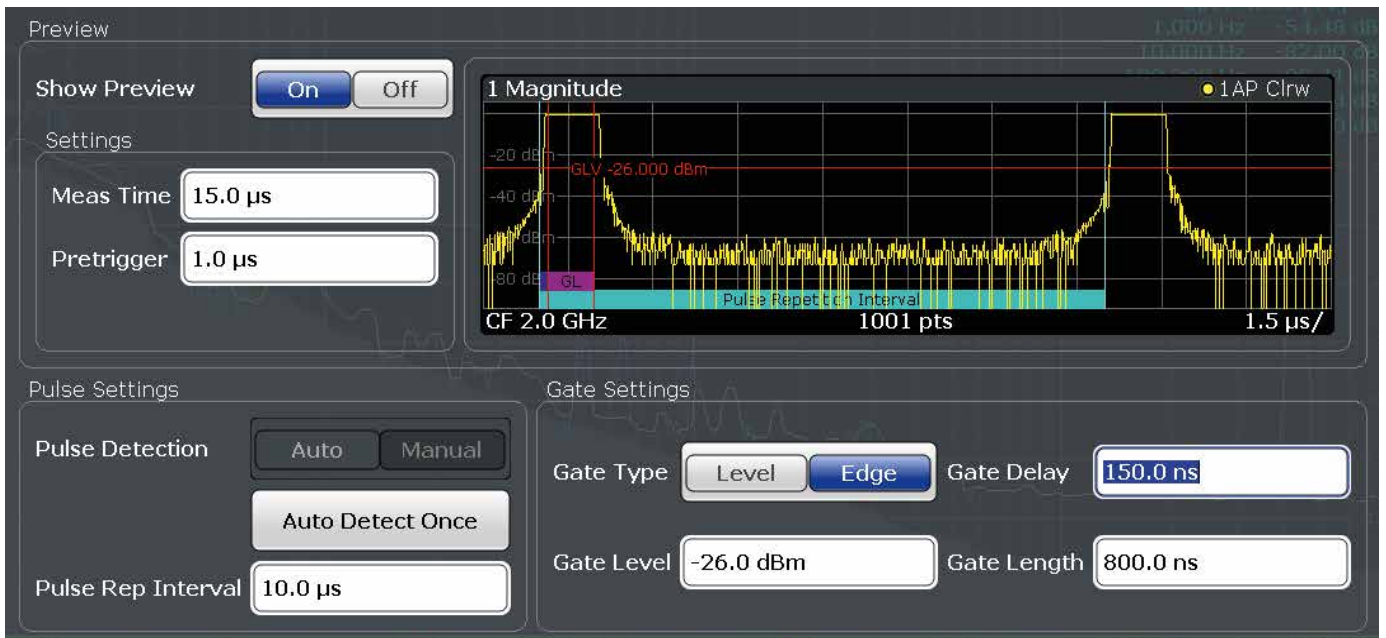
Fig. 6: The instrument measures pulse parameters automatically, yet users still have the freedom to define gates.

Measuring additive phase noise – even on pulsed signals

The R&S®FSWP can be equipped with an internal signal source (R&S®FSWP-B64) to determine additive phase noise. These measurements are essential for developing high-end radar applications, for example. Developers must know how much phase noise individual components in the signal path such as amplifies add to the overall phase noise of the local oscillator. Two-port components can have a negative impact on the phase noise of a signal and add noise (additive phase noise), even though they do not generate a signal. The R&S®FSWP carries out this previously complex measurement requiring extremely good signal sources and phase shifters at the push of a button. Users simply connect the internal signal source to the input of the DUT and the DUT output back to the R&S®FSWP. The additive phase noise of the DUT is then available. The R&S®FSWP uses cross-correlation for this operating mode as well to suppress the additive phase noise of the internal frequency converters.

When equipped with the R&S®FSWP-K4 option, the R&S®FSWP can also measure additive phase noise on pulsed signals. These measurements are required for characterizing and optimizing the components of radar transmitters under real-world conditions (i. e. with pulsed signals), as they behave differently with continuous signals.

Summary

The new R&S®FSWP phase noise analyzer and VCO tester offers more than unique sensitivity for phase noise measurements. It delivers unparalleled user friendliness and a broad range of measurement options. In addition to measuring the phase and amplitude noise of continuous and pulsed signals as well as additive phase noise, it can be used as a signal and spectrum analyzer.

Dr. Wolfgang Wendler

R&S®FSWP in brief

Frequency range	R&S®FSWP8	1 MHz to 8 GHz
	R&S®FSWP26	1 MHz to 26.5 GHz
	R&S®FSWP50	1 MHz to 50 GHz
Offset frequency range		
Input signal ≤ 1 GHz		10 mHz to 30 % of carrier frequency
Input signal > 1 GHz		10 mHz to 300 MHz
Phase noise		see Fig. 4
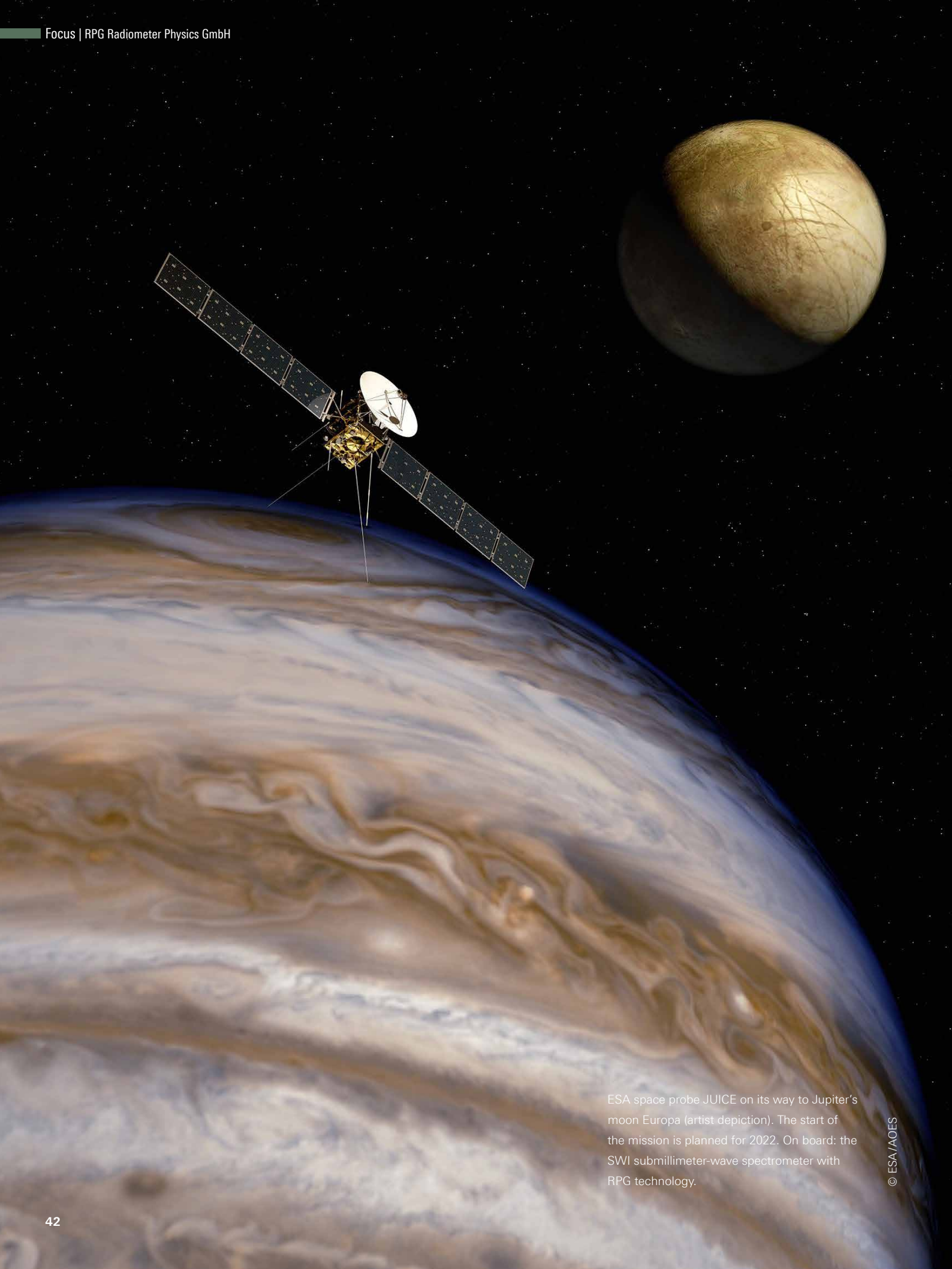
ESA space probe JUICE on its way to Jupiter's moon Europa (artist depiction). The start of the mission is planned for 2022. On board: the SWI submillimeter-wave spectrometer with RPG technology.

© ESA/AOES

High up, far away

The research objects typically associated with products from Rohde & Schwarz subsidiary RPG Radiometer Physics can be found by looking up into the sky; however, a telescope is often required.

Committed to R&D

The roots of the company residing in a new building in Meckenheim near Bonn are, one might say, extraterrestrial. The fact that the company is located in Bonn is no coincidence. It logically follows from the proximity to the Max Planck Institute for Radio Astronomy, where RPG founder Dr. Peter Zimmermann worked for over 20 years. Working on the Microwave Limb Sounder Project at NASA's Jet Propulsion Laboratory in subsequent years brought him in close contact with technology for researching the earth's atmosphere using submillimeter waves, and laid the foundation for starting his own company in 1991. In the early years, the company concentrated on developing mixers and local oscillators up to 1 THz and integrating them into receiver systems. The soon-to-come transition to building entire radiometers (see box) was obvious and consistent with RPG's technological focus. The company and its product line grew with the increasing market demand for further applications in the exotic and difficult-to-master frequency range, to which RPG had dedicated itself. Meteorological measuring instruments are still a mainstay of the company's portfolio today. In addition to passive solutions (radiometers and scintillometers), RPG now also offers active weather scanners such as cloud radar systems. A second business field has carried on the company founder's passion for space exploration since he passed the baton to his successor in 2002. RPG subsystems were and are installed on important satellites and probes operated by ESA, NASA and other national space agencies. R&D efforts for key upcoming projects

such as ESA's (large photo) Jupiter Icy Moons Explorer (JUICE) mission are well underway. The company's third pillar brings the focus back to earth – and to Rohde & Schwarz. Those who have committed themselves to mastering the entire radio spectrum must think beyond 100 GHz. They have to rise to the Terahertz challenge. Considering the physical and technical pitfalls that this frequency range represents for developers, however, it made sense to cooperate with a company that feels at home with the subject matter. Initial joint test and measurement projects extended the frequency range of Rohde & Schwarz network analyzers and signal generators into the triple-digit Gigahertz range. To secure the know-how of the RPG experts for the future, Rohde & Schwarz started purchasing company shares in 2006 and ultimately became its majority holder in 2010. The two companies have cooperated intensively on test and measurement projects ever since.

There are various reasons why the Terahertz range will never have the widebase market significance of microwave technology. It does, however, cover exclusive R&D niches and offer

concepts for applications in medicine, materials science, industrial sensor technology, security and communications technology that make a thorough exploration of this range appear an attractive option.

What is a radiometer?

Radiometers are instruments for measuring the radiance of electromagnetic waves. At the core of RPG instruments are ultrasensitive receiver modules that measure sky radiation in the microwave range (~3 GHz to 660 GHz). The power of the radiation emitted in this range must be amplified significantly (60 dB) before it can be detected in separate receive channels. These channels are positioned so that the absorption spectrum of the air components water and oxygen is captured. This information enables researchers to derive temperature and moisture distribution data along the measurement path.

The electromagnetic spectrum
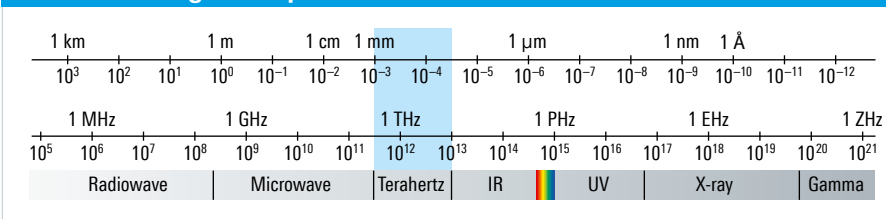
The Terahertz (or submillimeter-wave) range between the microwave and infrared regions of the spectrum marks the transition from electronics to optics.

Weather reconnaissance from the ground

Microwave remote sensing instruments is a key business field for RPG. The company focuses on developing ground-based measuring instruments for remote atmospheric sensing. In contrast to balloon-based measurements, remote sensing means measurements are not taken on site. Instead, researchers analyze radiation emitted by items under test, in this case, the atmosphere. This could be naturally occurring thermal emission from air molecules, for example. Radiometers are based on this passive principle of measurement. Alternatively, active radar can also be used to measure the radiation reflected by rain and clouds. Both product groups work in the high microwave range, as the atmosphere is partially transparent in this range. This means the entire atmospheric column can generally be observed, even in cloudy or rainy conditions. The microwave radiometer is the most widely used instrument for this purpose. It can determine vertical temperature and humidity distribution from the ground up to an altitude of 10 km. This atmospheric layer, the troposphere, is where weather is made. Vertical temperature and humidity profiles are of great importance to weather prediction. Weather services around the world use weather balloons to collect this data. However, the cost of sending up such balloons is so high that usually only two can be launched each day. This is where radiometers can help. They provide temperature and humidity profiles once a minute, enabling meteorologists to reliably capture atmospheric changes, especially in the layers close to the ground. The data collected can be used as input parameters for weather forecasting models. Radiometers are increasingly being combined into networks for this purpose. The objective is to do away with weather balloons for numerical weather prediction and improve forecasting quality.

A great deal of uncertainty in weather forecasting, however, comes from poor registration of clouds and precipitation. This is the point where passive radiometry reaches its limits and the reason why RPG developed a cloud radar system that measures cloud distribution with high accuracy. Besides applications for numerical weather prediction, the instrument also provides valuable findings for cloud research. Only by understanding the processes taking place inside clouds is it possible to predict how they will form and develop.

RPG's portfolio in the remote sensing sector covers more than the earth's atmosphere. Microwave radiometers can also be used for observations of the solid earth, e.g. for soil moisture measurements. Another instrument that comes into play here is the scintillometer. It measures the heat flux between the ground and atmosphere. A portion of this heat flux is directly linked to the transfer of moisture between the ground and atmosphere. This makes these measurements useful, especially for water management experts. Such data is helpful for tasks such as optimizing irrigation strategies, assessing forest fire hazards and monitoring water reservoirs.

Beyond the atmosphere

The RPG space activities division is responsible for exploration from the sky. For years, this division has developed microwave and millimeter-wave frontends and components for ultrasensitive T&M equipment on satellites and space probes. Once more, the focus lies on atmospheric research instruments, be they for earth or other planets and moons. The above-mentioned JUICE mission is an example of an extraterrestrial program. It is the first large-class mission in ESA's Cosmic Vision 2015 – 2025 planning period. The probe is expected to reach Jupiter in 2030 and will use the most powerful analysis tools ever sent to the outer solar system to dissect the planet and three of its four large (Galilean) moons over the course of many years. The SWI submillimeter-wave spectrometer will be one of the ten instruments employed on this mission. Its task will be to record the atmospheric temperature profile of Jupiter, determine the composition and dynamics of the planet's stratosphere and troposphere and analyze the exospheres and surfaces of its icy moons. The SWI uses a 30 cm antenna for this purpose and operates in the frequency ranges between 1080 GHz and 1275 GHz as well as 530 GHz and 601 GHz. RPG has completed preliminary studies for the instrument and is currently developing RF component prototypes.

The meteorological operational satellite (MetOp) program is an important satellite project with RPG involvement. ESA is implementing this programm on behalf of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). The MetOp satellites are the first European weather satellites in polar orbit. They fly at low altitude (800 km) to deliver high-resolution measurement data on air and water temperature, humidity, wind speed and ozone concentration. This information enhances data provided by the very high flying European Meteosat satellites in geostationary orbit. The program includes multiple phases extending out to 2030. The first satellites are already in orbit (MetOp-A and -B), and MetOp-C is expected to follow in 2017. RPG is already working on the second generation of these satellites (MetOp-SG), which will carry instruments that are significantly more powerful. Three instruments will be distributed between two satellites and are expected to provide a significantly more broadband examination of the microwave and millimeter-wave ranges in particular (18 GHz to 229 GHz and 183 GHz to 664 GHz). The MetOp-SG orbiters will operate in pairs, flying the same orbit in short succession with different equipment on each. RPG has carried out preliminary studies for all three instruments (microwave sounder, microwave imager and ice cloud imager) and is now developing and manufacturing key components such as downconverters, mixers,

frequency multipliers and complete frontends. The company is currently beginning to produce prototypes of the instrument qualification models.

On this project and others, ESA, as a European organization, attaches great importance to key components coming from Europe and being developed

The RPG remote sensing product line:
Radiometers in the French-Italian Dome Concordia Antarctic station (center left), in the climate observation station of the Italian energy and environmental agency ENEA on Lampedusa (bottom left), at the European Southern Observatory in Chile's Atacama Desert (top right); cloud radar (center right) and scintillometer.

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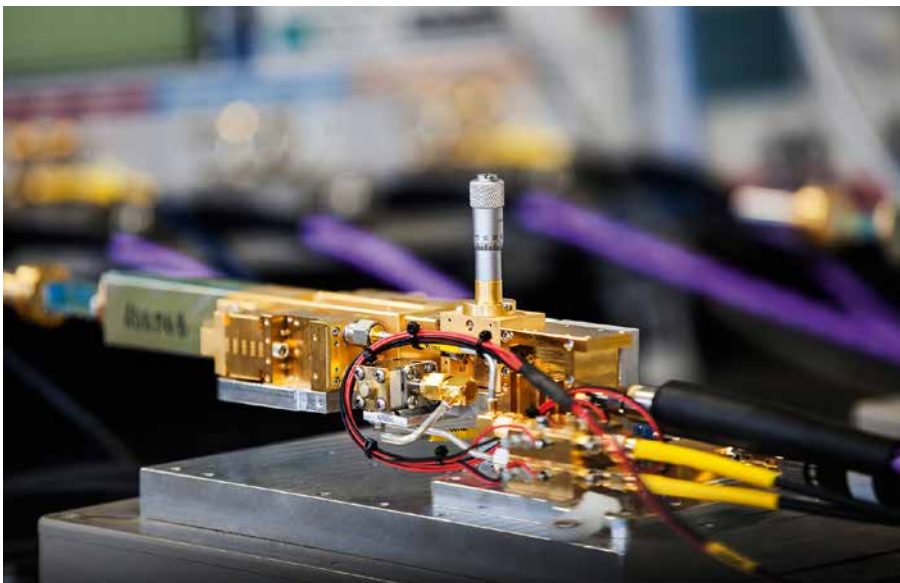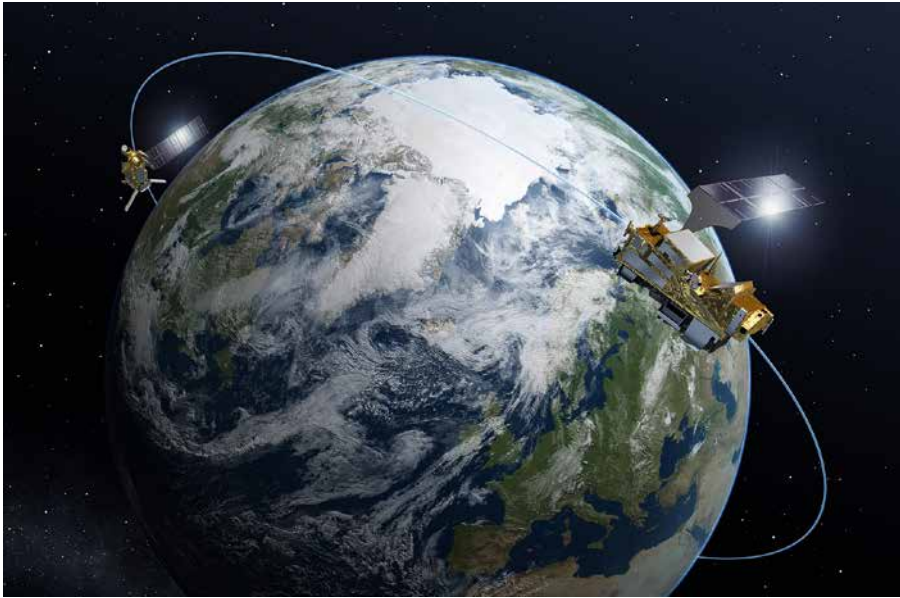
with European expertise. Until recently, this would have been possible only to a limited extent in the field of millimeter-wave technology. European companies lacked the ability to produce the semiconductor devices needed to generate millimeter waves of sufficient power. However, initiatives such as the EU-sponsored Millimetre-wave Integrated Diode and Amplifier Sources (MIDAS) project and a similar ESA program have meanwhile borne fruit. Several European semiconductor manufacturers now have the capability to produce the required circuits based on GaAs Schottky technology. The main advantage of the European solution is the close interlinking of system developers and technology experts, which has now become possible (US manufacturers were not able to enter into such close partnerships for technology policy reasons). This provides RPG with deep insight into the process data of its partners. The company can use this information to draft its own highly precise circuit layouts.

Top: The MetOp-SG weather satellites are expected to replace the current MetOp-A/B/C generation starting in 2020 (photo: ESA). Center and bottom: The new R&S®ZCx frequency converters developed and produced by RPG enable users to conduct network analysis in the millimeter-wave range with unprecedented operating convenience.

Back to earth

The advances in millimeter-wave semi-conductor technology also have a productive impact on the third pillar of RPG's portfolio. This focuses on the development and manufacturing of millimeter-wave components in general as are required for a diverse range of tasks in research and industry. These components typically include mixers, frequency multipliers, antennas and connection elements but also amplifiers and entire spectrometers and, last but not least, T&M equipment accessories produced by RPG for Rohde & Schwarz. The most recent product in the last category is a new generation of network analysis frequency converters that deliver 10 dB to 15 dB higher output power than previous models (power being the critical issue in this frequency range, as mentioned above) and offer new possibilities for characterizing active components.

RPG manufactures all its products at its own facilities, as this is the only way to ensure the desired level of quality. The use of RPG instruments at renowned scientific institutions is proof that this quality is well known and valued throughout the demanding research community (as shown by the small selection of photographs on page 45).

Volker Bach

One of the prime addresses for millimeter and submillimeter-wave technology in Europe: RPG Radiometer Physics GmbH, Meckenheim near Bonn, Werner-von-Siemens-Strasse 4, http://www.radiometer-physics.de.

Color explosion on the screen – HDMI 2.0a transmits HDR video

To create an even more intense home movie experience, various technical developments have taken place in recent years. High dynamic range (HDR) is the latest and probably the most spectacular innovation in terms of picture quality. A new module for the R&S®VTC / VTE / VTS video tester family is the appropriate T&M solution.

To improve the video quality, three main points are taken into consideration: resolution, frame rate and pixel quality. The introduction of the first UHD TV sets several years ago quadrupled the number of pixels in comparison to FullHD – especially to do justice to bigger and bigger displays. Newer UHD standards also define a higher frame rate (HFR), so that the picture remains clear even during fast movements. The pixel quality can be improved by an extension of the color space and a higher dynamic range (HDR) for luminance. These extensions aim to approximate the picture image to the perception of the human eye as closely as possible. For this to succeed, the dynamic range must be increased to achieve the necessary color saturation, which significantly impacts the color quality, even in very bright and very dark picture areas. This is where HDR comes into play.

High dynamic range

The dynamic range within a picture is defined as the difference in brightness between the darkest and brightest areas. The physical quantity to capture brightness is called luminance, which is measured in cd/m² or nits. Fig. 1 shows the luminance spectrum measurable on the earth and the part of it that the human eye masters. Up to now, television technologies with standard dynamic range (SDR) have a very limited minimum and maximum brightness. As a result, picture information is lost especially in dark and light areas. That is a thing of the past with HDR video.

Future HDR television displays, in contrast to the SDR devices with a value in the order of magnitude of 100 nits, will reach a maximum luminance of several thousand nits and will be able to show this value together with rich black. But how does it look on the content side?

Comparison of luminance ranges

Unit: cd/m² or nits
SDR = standard dynamic range
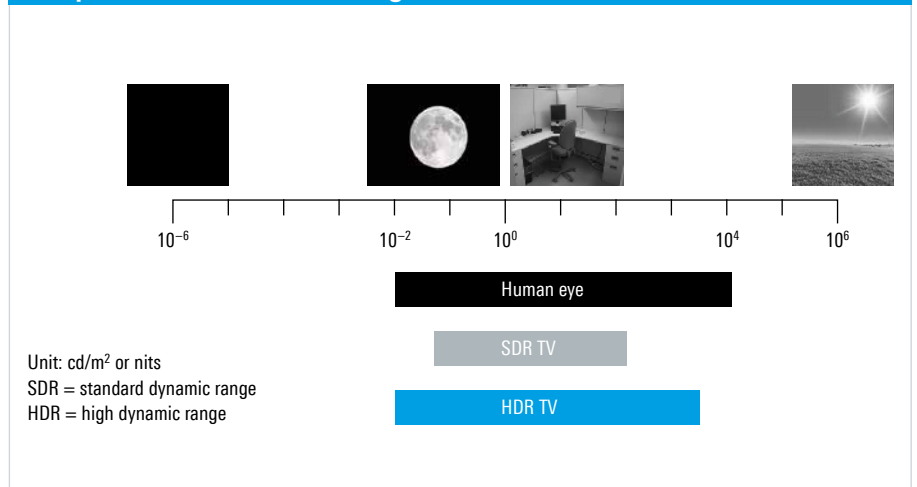HDR = high dynamic range

Fig. 1: Comparison of luminance range of the human eye with that of HDR and SDR TV sets.

Fig. 2: The R&S®VT-B2363 HDMI RX/TX 600 MHz module offers generator and analyzer functions for HDMI 2.0a including support for HDCP 2.2.

HDR can bring added value to consumers' screens only if there is suitable program material available. Currently, this is still very limited, at least for the end user. The UHD Blu-ray Disc™ to be launched shortly and large web TV providers will support the feature. HDR streams are already available through Amazon and Netflix. Classic broadcast sites will also not be able to avoid HDR in the long run. Test transmissions have already taken place (e. g. through Sky in the summer of 2015, when parts of a German soccer league match were aired in UHD/HDR via satellite using the R&S®AVHE100 headend solution). Standardization bodies have the topic on their agenda, e. g. for ATSC 3.0. The film industry has also long been on the way to HDR. For a long time now, new movies and series have been produced in high video color depth, keeping future playback capabilities in mind.

Since HDR does not depend on the resolution, this characteristic would not necessarily be limited to UHD content, but could also enhance HD videos. Whether it comes into practice is still uncertain, but conceivable. In any case, in the studio, or rather in post production, there is already footage that allows HDR playouts. For example, with 10 bits per color channel, as has been specified for the UHD Blu-ray Disc™. In the mastering process, a reference monitor is used to create the artistic interpretation, i. e. the final color scheme of the video material, for the output channels, whether it is broadcast, Blu-ray™ or Internet / video-on-demand. In order to obtain the desired picture quality as pure as possible on each HDR dis-

play, metadata is transmitted along with the picture contents. This metadata includes characteristics of the reference monitor (EOTF, color space, primary colors, etc.), which can be interpreted and implemented by HDR-capable receivers. The transfer of HDR content between consumer electronics is performed via HDMI connections in line with the new 2.0a specification.

HDMI extensions related to HDR

Above all, HDMI 2.0a brings support for HDR based on the CTA-861.3 HDR Static Metadata Extension standard. The standard revision includes a signaling function for HDMI sinks and a transmission system for HDR metadata (for sources).

Based on a newly introduced static HDR metadata block as part of the enhanced extended display identification data (E-EDID), HDMI sinks now signal their support for HDR. Non-HDR-capable sources ignore this block. With positive signaling, the source sends HDR content, including the necessary metadata. The metadata is transmitted in the data island periods (where the transmission of audio data and additional data occurs with HDMI) as a Dynamic Range and Mastering InfoFrame. An InfoFrame is sent every two pictures.

Metadata is static, which means that only a fixed metadata set is used for a specific content (broadcast, film). Dynamic metadata, i. e. data that changes depending on the scenario, is currently not part of the HDMI specification.

R&S®VTx video tester family fit for HDMI 2.0a

Fig. 2 shows the new R&S®VT-B2363 HDMI RX/TX 600 MHz module for the R&S®VTS compact video tester, R&S®VTE video tester and R&S®VTC video test center. This module allows users to conduct interoperability test for latest-generation HDMI sinks and sources at different stages in the value chain process.

In contrast to the previous R&S®VT-B360 / -2360 / -2361 modules, it supports HDMI 2.0a with data rates up to 18 Gbit/s including related innovations such as scrambling. It is backward compatible with previous HDMI versions and fully replaces the predecessors. In addition to HDCP 1.4, it also supports HDCP 2.2 and enables not only encoding and decoding, but also a status display of the HDCP connection for debugging purposes.

The analyzer and generator functions are activated independently of each other via software keycode. In addition to realtime analyzing and generating, the respective compliance test mode can be selected optionally for sources and sinks. The extent of supported compliance testing is referred to in the data sheet. Tests certified by the HDMI Forum are available as MOI documents from the HDMI LLC or HDMI Forum servers.

As for HDR, the generator function offers free editing of the Dynamic Range and Mastering InfoFrame (Fig. 3) and allows the display of the controlled sink's E-EDID including the HDR
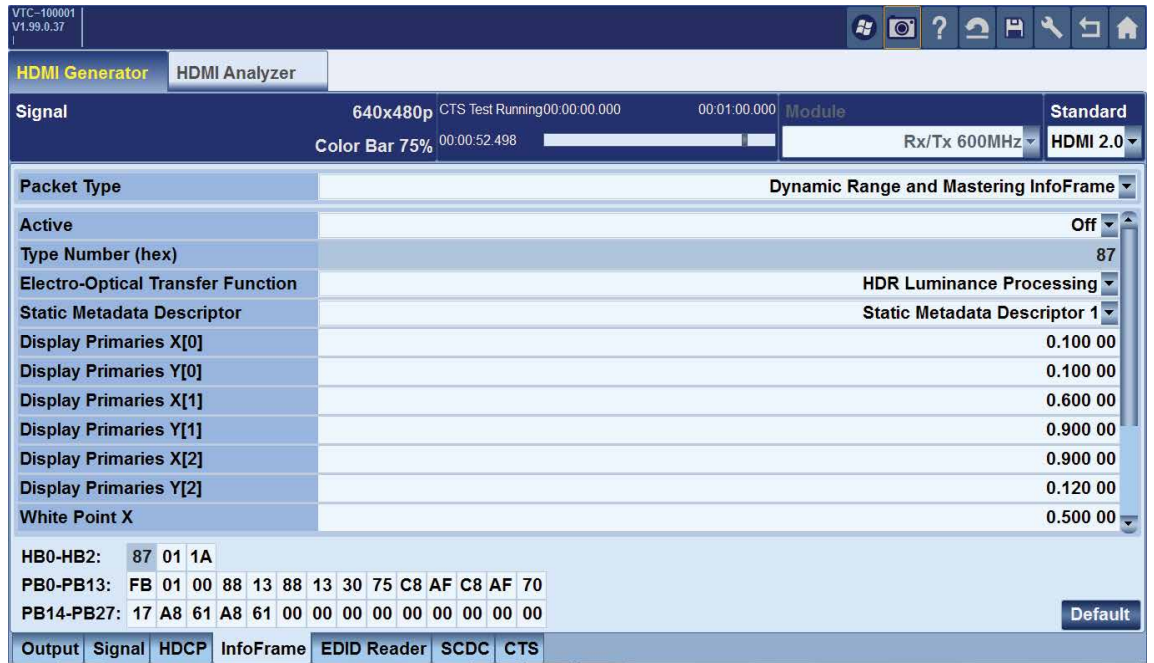
Fig. 3: The generator application makes it possible to configure the Dynamic Range and Mastering InfoFrame.

metadata block. Conversely, a suitable E-EDID is provided at the analyzer end and the Dynamic Range and Mastering InfoFrame is displayed. A specific HDR test in line with the compliance test specification (CTS) is available for both the generator and the analyzer.

The module can be used as usual together with the other analysis functions of the R&S®VTx product family to view the received A/V signal more in detail.

Summary

HDR enables an even more realistic TV experience. To ensure HDR-capable devices work together within the home, they must support the HDMI 2.0a standard. With its R&S®VTx video tester family, Rohde & Schwarz now offers a test option that enables users to test the new HDMI features in development, quality assurance and production.

Harald Gsödl

The German National Library is one of the largest libraries in the world. The late Wilhelmine main building in Leipzig has had to be expanded four times. The last expansion was in 2011 (glass facade on left in photo).

Top-proof digital backbone to safeguard the nation's heritage

The German National Library (DNB) collects all German-language publications and makes them available to the public. The DNB has two sites that regularly share large amounts of data and also have to protect personal user data. With this in mind, the library issued a nationwide call for bids to find a reliable IT security solution – Rohde & Schwarz delivered that solution.

At each of its sites in Leipzig and Frankfurt, the German National Library (DNB) maintains a complete collection of all German and German-language media (books, newspapers, magazines, maps, music, sound recordings and electronic publications) released since 1913. German law mandates that two copies of works published in Germany be sent to the DNB unrequested and free of charge. Foreign media are acquired by receiving copies, through international exchange agreements and purchases.

Both sites of the DNB maintain largely the same reference collection of German publications to ensure the integrity of Germany's cultural heritage if, for example, a fire were to occur. This mutual safeguard is also in place for the library's growing digitized collection. Better networking was needed to make data sharing between Frankfurt and Leipzig faster, secure and future-ready.

But the German National Library has to do more than simply ensure the security of its collections. It must also protect users' sensitive data. Many of the library's services are now available online, e.g. to order books and journals for the reading room. Some of these services, such as WLAN login in the reading room, book orders and book reservations, are individual-specific and require users to enter personal data. Additionally, some digital items such as electronic publications are under copyright and public access to them is restricted to the library's reading rooms. All of this data is mirrored between the data centers of both sites, and these transmissions must be encrypted. "We are not only obliged to safeguard German publications," says Peter Ratuschni, head of the network and data center at the German National Library. "We also have a duty to our users and employees to provide the best protection for their personal data."

Easy management of millions of data records

The German National Library currently has around 30,000 registered users. Its holdings include some 27.9 million media publications, which it archives and makes available to interested parties. Current projects such as transferring the CD-based content of the German Music Archive in Leipzig to the archive system in Frankfurt are also increasing data traffic volumes. "Since almost all our workflows are now IT-based, we have to ensure smooth data traffic within the German National Library," says Ratuschni. That is why redundant data links, high availability, failsafe performance and service played a decisive role when it came to selecting a supplier.

Since only the solution from Rohde & Schwarz SIT GmbH was able to fulfill the technical requirements, the company won the tender together with HL komm, a telecommunications provider in Central Germany. The R&S®SITline ETH product family will protect the data traffic traveling over the DNB's fiber-optic lines. "The solution from Rohde & Schwarz SIT is ideal, especially for very large data volumes," says Gregor Türpe from HL komm. "It provides reliable encryption without hindering data traffic. This enables us to offer our customers increased security in addition to our tried and tested carrier services."

Fast and secure data-sharing

The R&S®SITLine ETH40G Ethernet encryptor with its world-leading throughput rate of 40 Gbit/s and encryption latency of only three microseconds will safeguard critical data. The encryption solution will enable data to flow in realtime, ensuring more than just transparent integration into data transmission paths. Subscriber equipment and users will also be unaffected in terms of latency. Encryption takes place on the data link layer (OSI layer 2). This provides an additional advantage: security overhead is reduced by up to 40 % compared with IP encryption (OSI layer 3), thereby saving bandwidth. This makes the encryptor ideal for the German National Library. It offers protection against tapping and manipulation of transmission lines without negatively impacting performance.

The AES algorithm with a 256-bit key is used for encryption. Two independent connections to the fiber-optic network, each with two transfer points, provide additional security. If the primary line fails, the data is automatically transmitted via the secondary backup line, which is also protected by R&S®SITLine ETH encryptors.

The German National Library sites in Frankfurt am Main (top) and Leipzig will be able to quickly synchronize their data pools in the future thanks to high-throughput encryption. (Photos: DNB).

Investment protection for rising data volumes

The R&S®SITLine ETH40G network encryptor is based on the platform architecture developed by Rohde & Schwarz SIT. This modular hardware and software architecture combines the advantages of high-security customized encryption solutions and less expensive standard encryption solutions. State-of-the-art microelectronics reduces the space requirement to just 1 HU per encryptor, making it easy to meet the specification that the total modular package at each transfer point take up no more than 5 HU in the server rack. The innovative platform concept offers another benefit. Crypto throughput can be modified via software upgrades without replacing hardware. The 1 Gbit/s bandwidth (2 × 500 Mbit/s per line) specified in the tender can be increased to 40 Gbit/s per encryptor as needed without even taking the R&S®SITLine ETH out of the rack.

Made in Germany

Another benefit: the network encryptors from Rohde & Schwarz SIT have been approved by the German Federal Office for Information Security (BSI) for handling data classified as RESTRICTED and NATO RESTRICTED. The legal requirements for protecting personal data, including those of the German IT Security Act, are met. "With Rohde & Schwarz SIT as an IT security partner to the German Federal Government, we as a public institution are on the safe side as far as legal data protection requirements go," says Ratuschni. "That gives us security for the future as well."

Rohde & Schwarz SIT, a 100 % subsidiary of Rohde & Schwarz, develops and manufactures its products in Germany. This has two advantages. First, it ensures fast, long-term availability of platform components and the products based on them. Second, customers can rely on the high German data protection standards – an important advantage, especially when it comes to encryption equipment.

Christian Reschke

Automated oversight of complex radiomonitoring systems

Advanced radiomonitoring systems are made up of an ever increasing number of networked sensors, subsystems and IT components. This level of complexity poses the risk of failures and malfunctions going unnoticed and causing damage or critical system conditions. A new software product provides a solution.

Complex radiomonitoring and direction finding systems include a large number of components such as antennas, sensors, system devices, PCs/servers, software applications, databases, and infrastructure and network segments. Monitoring the operating states of these system elements is essential for maintaining effective monitoring / interception operations. A new member of the R&S®RAMON software family is designed for this job: the R&S®RA-CHM system status monitoring software. It monitors devices, system components and their operating parameters fully automatically, warns operators if components approach or reach critical operating states and assists maintenance personnel in fault diagnosis.

This software is typically used with radiomonitoring systems that comprise numerous subsystems and are perhaps scattered across multiple locations (Fig. 1). It is also ideal for monitoring small unattended systems and sensors at remote locations. The primary function of R&S®RA-CHM is to monitor system parameters by comparing their actual values with preset threshold values. This can include parameters such as:

❙ Operating states (door contacts, temperature, humidity, smoke detectors, air pressure, fuel gauges, power supplies, servers, workstations)
❙ Storage media and databases (data volume of external and internal storage media, virtual memory capacity, database status information)

Fig. 1: The new R&S®RA-CHM system status monitoring software records the operating parameters of all components in large distributed radiomonitoring systems, compares them with nominal values and triggers alarms when target values are not met.

❚ Processor load (utilization of control computers, system servers, database servers)
❚ Network (e. g. accessibility of system components / IP addresses, network link loads)
❚ Equipment status information (operating status of receivers, direction finders, analysis systems, analysis of built-in test [BIT] results)
❚ System software status information (operating status of drivers and processes)

R&S®RA-CHM collects these parameters and stores them uniformly (Fig. 2).

When threshold values are either not reached or exceeded, the software generates acoustic and visual alarms at operator workstations. The operators get immediate access to the dedicated management interface of the affected component, enabling them to quickly perform in-depth error analysis and initiate troubleshooting.

A central server application manages all data from LAN accessible devices and subsystems. R&S®RA-CHM accesses Rohde & Schwarz equipment via the appropriate device drivers. Third-party devices can be accessed via the standardized and widely used simple network management protocol (SNMP).

R&S®RA-CHM permits centralized startup and shutdown of entire radiomonitoring systems – a feature easily accessible via a central menu item on the operator console during normal operation. There is also a fast shutdown function for when irregularities occur in crucial components (e. g. cooling unit) and proper shutdown is not possible or advisable. The system ensures that all critical components (e. g. database server) are disconnected from the network so as to prevent damage.

Fig. 2: R&S®RA-CHM main window with total system overview. The software can monitor up to several dozen components in large systems.
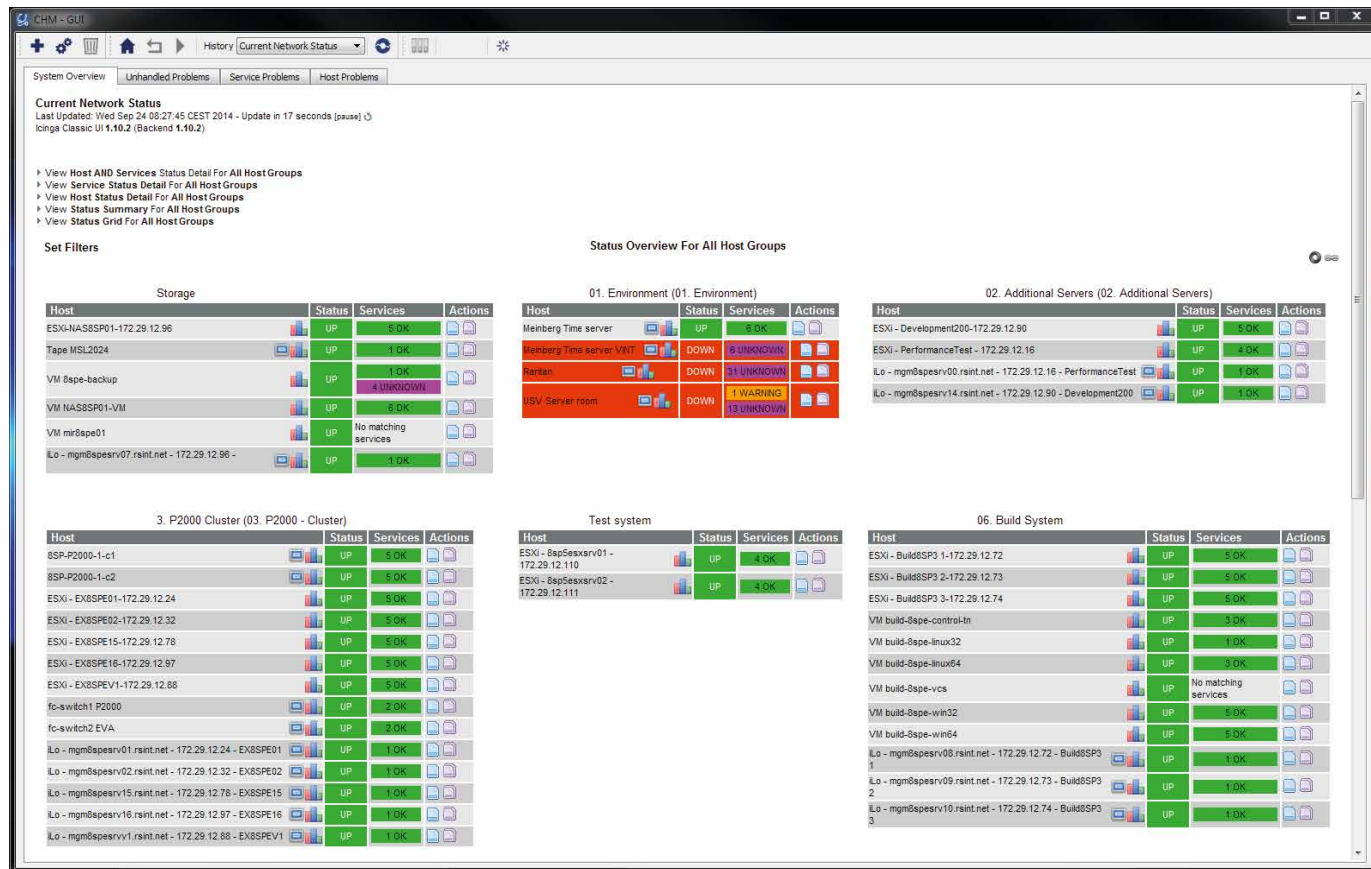
Easy system setup

Depending on setup and system requirements, R&S®RA-CHM can be used as either a virtual server or independent hardware server. Installing the software on dedicated hardware provides considerably more robust operating parameters such as temperature and contamination. This also makes it possible to start up and shut down the system independently. Configuration is equally simple and flexible for both versions. During system integration, the information required for R&S®RA-CHM is extracted from the R&S®RAMON system configuration tools and saved as a file. This system configuration file can be easily read into the R&S®RA-CHM server via the management GUI. System software updates are performed in the same way. The software also supports hierarchical system configurations in particular, so that even spatially distributed systems with unattended remote stations can be monitored effectively. If errors occur, the configuration can simply be reloaded from the original configuration file to significantly reduce downtime.

An extensive set of analysis tools, such as the visualization of measured values in time-sequence charts, helps system administrators carry out maintenance work and detect error bursts.

R&S®RA-CHM offers users different result displays. An icon on the Windows system tray provides an initial, basic indication of the system status. The various windows of the console application provide a complete overview of the individual subsystems and their components as well as a system status overview (Fig. 3). This is particularly useful for spatially distributed systems with unattended, remotely controlled stations.

R&S®RA-CHM features detailed views for hardware components such as PCs (Fig. 4). The data can be called up with restricted functionality via a web browser. This makes it possible to check the system status away from the operator workstation.

Fig. 3: System status overview. Realistic hardware views can be integrated into the software to give users fast visual orientation on system status.

Summary
Complex radiomonitoring systems require continuous monitoring to ensure proper functionality and eliminate disruptions quickly, which makes automation sensible. And this is exactly what R&S®RA-CHM system status monitoring, a new software module in the R&S®RAMON family, delivers. R&S®RA-CHM records the operating parameters of all components, compares them with nominal values and triggers alarms when target values are not met. In addition to monitoring Rohde&Schwarz equipment, R&S®RA-CHM makes it possible to monitor devices and system components from third parties using the simple network management protocol (SNMP).

Guido Schwarzer

Fig. 4: Processor load behavior of an industrial intrasystem PC versus time.
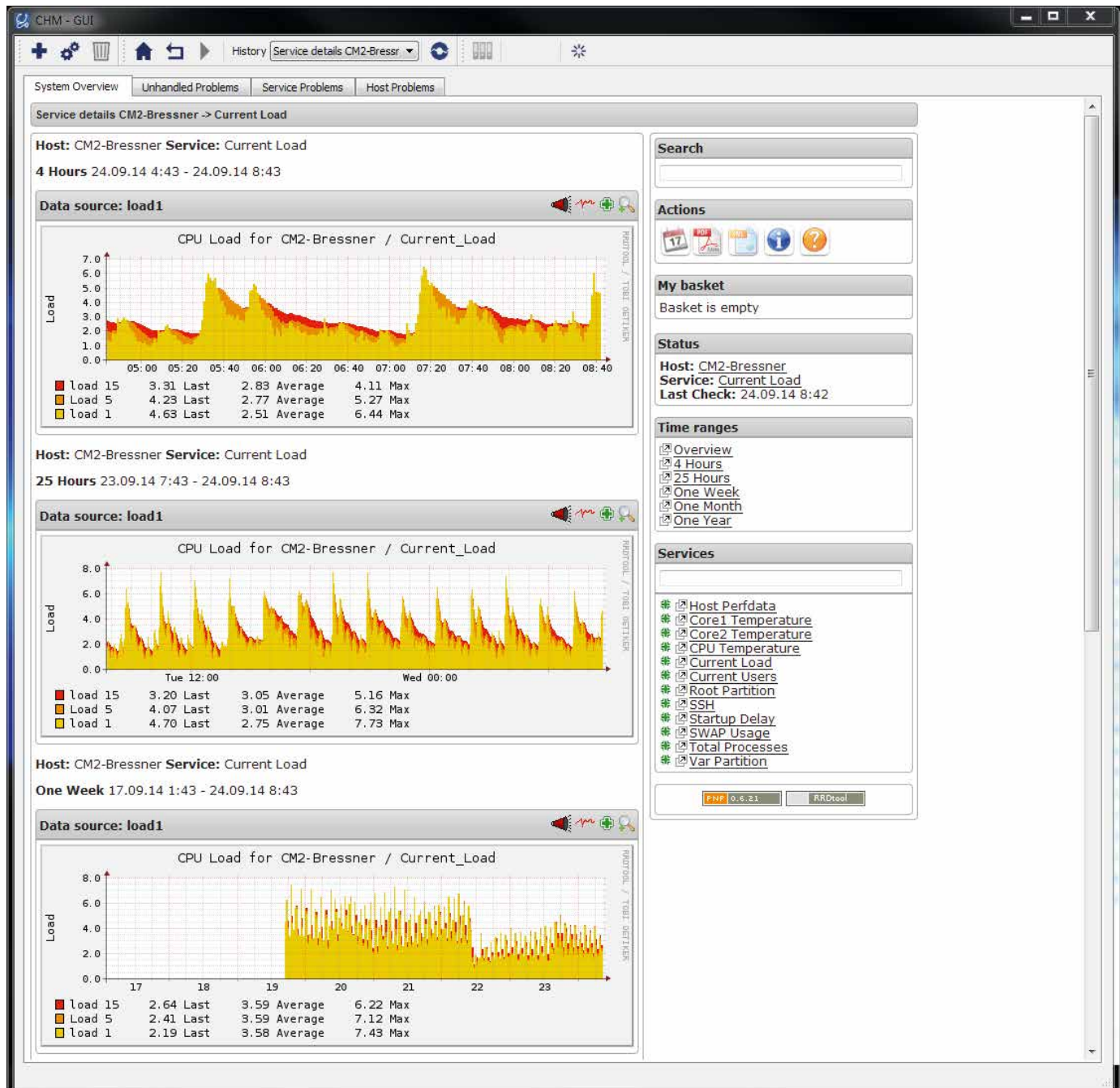
"Hello, I have a question …"

20 years of customer support

The callers on the other end of the line, or customers who write an email, can be sure that their concerns will be heard and answered in a technically well-founded, personal dialog. For 20 years, Rohde & Schwarz Customer Support has worked around the clock and around the globe to address urgent questions and problems that trouble the users of the company's products. Originally founded as a center of competency to help sales, it soon became clear that a high-quality, value-added service that the end customer would also welcome had been created. Success leaves no doubt: every year, more than 20,000 queries are answered in Europe alone; worldwide, about 100 problems are addressed on an average working day. Almost three-quarters of these are successfully resolved on the same day. It doesn't matter whether it is a measuring instrument, a TV transmitter, a radio system, another core product, or even a product from a subsidiary. The engineers in the Customer Support Center form a network of specialists who are experts in all business fields. Anything that cannot be answered personally is dealt with at the company level. The recipe for success consists of making sure that all of the information available in the company is accessible to customers' point of contact. The Customer Support Center can rely on considerable resources: in Munich alone, an inventory of demo instruments valued at about two million euros is available. This helps the engineers directly understand technical issues. The tasks are distributed over four sites around the world. The day starts with the colleagues in Beijing and Singapore. Then the Munich team takes over. At the end of the work day in Germany, the US colleagues in Columbia, Maryland, respond to customer questions from around the world, in different languages. English, of course, always works. If customers call in, they will experience a surprise: there is no computerized hotline with a call queue. The caller receives a personal greeting, even during times of high call volumes. If all employees are busy and nobody can help immediately, the caller is asked for a call-back number – and the call will be returned as fast as possible. The use of the Customer Support Center is free.

Volker Bach

Contact the Customer Support Center:

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+49 89 4129 12345
customersupport@rohde-schwarz.com

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Cutting-edge EMC anechoic chamber in the Philippines

The electronics industry in the Philippines now has the ideal conditions for product development thanks to the new Electronics Product Development Center (EPDC). At the new development center, companies can now perform EMC tests to certify conformity with CISPR standards for electronic and multimedia products as well as household appliances. Rohde & Schwarz Asia (RSAsia) was responsible for the installation of all EMC equipment, including an anechoic chamber with a measurement path of ten meters. The backdrop for the EMC project was the close collaboration between Rohde & Schwarz Asia, Rohde & Schwarz Philippines Inc. and the Albatross Projects Group, a supplier of EMC anechoic chambers and a Rohde & Schwarz partner.
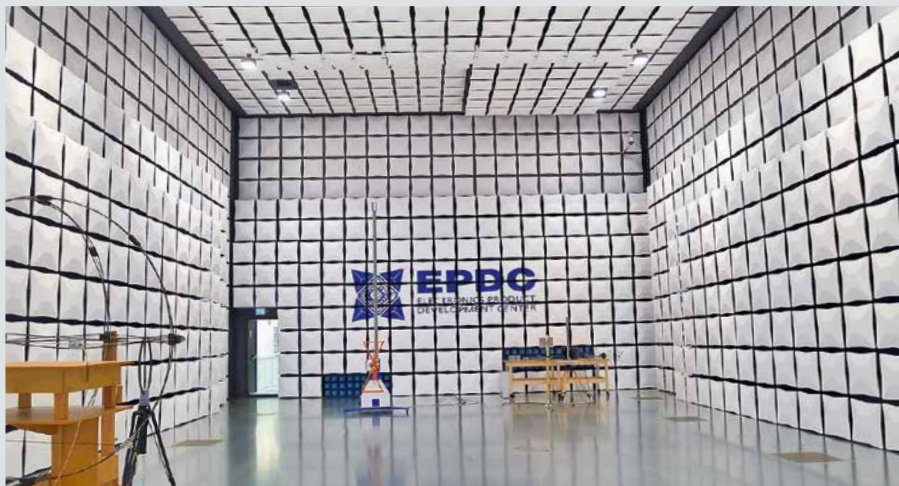
The EPDC's EMC anechoic chamber is the largest of its type in the Philippines.

Joint UHD channel with AsiaSat

Uplink of AsiaSat's UHD channel from the Tai Po Earth Station in Hong Kong.

Asia Satellite Telecommunications Co. Ltd. (AsiaSat) and Rohde & Schwarz have implemented the first free to air (FTA) UHD channel on AsiaSat 4, the new broadcast platform from AsiaSat. Rohde & Schwarz is providing a comprehensive broadcast solution that includes the R&S®CLIPSTER mastering station for editing, handling and playing out UHD data in real time. In addition, the R&S®AVHE100 headend will be used for live encoding using an HEVC encoder with 10 bit color depth. Rohde & Schwarz technology not only gives AsiaSat the best UHD TV picture quality, it also provides a future-ready solution. Operating at 122° east, the UHD channel started operation in October 2015 on AsiaSat 4. The wide coverage of AsiaSat 4 will enable broadcasters and pay TV platforms with an AsiaSat 4 C-band antenna in the Asia-Pacific region to receive the UHD channel directly.

Communications system for Type 26 global combat ships

The integrated communications system from Rohde & Schwarz has convinced the British company BAE Systems. In June 2015, the two companies concluded a contract to equip three Type 26 global combat ships each with a communications system. The ships will be deployed by the Royal Navy, and follow-up orders are in the pipeline. The key factors in the decision were the system's technical superiority, its user-friendliness and its outstanding cost-effectiveness. Its unique security concept has qualified Rohde & Schwarz as a reliable NATO partner also for future ship projects.

The core component of the communications system is R&S®NAVICS, a new IP-based switching system with a unique security concept.

5G experts at Rohde & Schwarz

In September 2015, Rohde & Schwarz hosted another high-profile event at its headquarters in Munich: 5G mmWave expert day. At this event, researchers, developers, manufacturers and test equipment users had an opportunity to discuss the challenges faced at millimeter-wave frequencies. The participants were from leading technology companies, including Ericsson, Fraunhofer HHI, Huawei, Intel, Nokia, NTT DoCoMo and Samsung. During the one-day workshop, 5G experts from various industries presented their experiences with millimeter waves that were beneficial to the wireless industry. The presentations covered subjects such as spectrum exploration, channel measurements, different 5G technologies, antenna technologies, and test equipment for 5G devices. There was also an interactive demonstration area that provided insight into Rohde & Schwarz solutions.

Among the 40 international participants were employees of leading technology companies and representatives of important 5G countries.

Big success for Mobile Network Testing Forum 2015

In June 2015, Rohde & Schwarz hosted wireless communications industry representatives for the 7th time at the Mobile Network Testing Forum. The technical presentations covered topics such as LTE-U / LTE-D, the Internet of Things, machine-to-machine communications and IP traffic analysis. The agenda included guest speakers from customers and partners. The mobile network testing product offerings from Rohde & Schwarz were set up at eight demo islands. Subsidiaries ipoque and SwissQual also showcased their latest T&M developments.
More information at www.rohde-schwarz.com/mobile-network-testing

More than 100 guests from 20 countries participated in the seventh Mobile Network Testing Forum.

Memorandum of understanding signed with Tata Power SED

Tata Power Strategic Engineering Division (SED), a part of the multinational Indian conglomerate Tata Group, and Rohde & Schwarz have signed a memorandum of understanding to cooperate in the Indian market. The signing occurred during German Chancellor Dr. Angela Merkel's visit to India. In the accompanying business delegation, Rohde & Schwarz was represented by President and CEO Manfred Fleischmann. With the memorandum of understanding, the two companies aim to develop solutions for terrestrial radiocommunications systems using software defined radios. The solutions are to be utilized in various projects of the Indian government. Moreover, the two partners also intend to cooperate in the field of T&M solutions.

Rahul Chaudhry, CEO of Tata Power SED (left), and Manfred Fleischmann, President and CEO of Rohde & Schwarz, sealing the cooperation.

First digital TV transmitter in Lesotho

At the Berea broadcasting station in Lesotho's capital Maseru, the country's first digital TV transmitters, the R&S®THU9 and R&S®TMU9, went into service in June 2015. The digital migration will provide the South African country not only with more frequencies but also faster broadband services. Khotso Elias Letsatsi, Minister of Communications, Science and Technology, put the transmitters into operation at the Lesotho National Broadcasting Service (LNBS) via touchscreen. Lesotho plans to be completely digitized and to switch the analog signal off by the end of 2015.

With a single touch, Minister Khotso Elias Letsatsi leads his country into the age of digital TV.

RF amplifier in SOLARIS particle accelerator

The new particle accelerator at the SOLARIS National Synchrotron Radiation Centre at the Jagiellonian University in Kraków, Poland – the first facility of its kind in East Central Europe – was officially opened in September 2015. Two 60 kW amplifiers based on the R&S®THR9 high-power FM transmitter family from Rohde&Schwarz are an important component of the accelerator. They are used to amplify the 100 MHz signal generated by two main cavities in the storage ring. With each cycle, the cavities provide an energy boost that compensates for energy losses of the circulating electrons. This added energy allows the electron beam to maintain a fixed orbit within the storage ring. The SOLARIS synchrotron is a universal research device. It can produce electromagnetic waves in a range from infrared to X-ray radiation, which are needed in various scientific disciplines. The opening ceremony was honored by the presence of authorities of local and central government, rectors of Kraków's universities and representatives of the world of science not only from Poland but also from abroad.

RF specialist Marek Madura from SOLARIS (left) with the Polish sales engineers Mariusz Warzywoda (center) and Robert Szutkowski from Rohde&Schwarz.

R&S®BTC for Vietnam and Thailand

The R&S®BTC test center and R&S®AVBrun compliance test software have been in use by the National Broadcast and Telecommunications Commission (NBTC) in Thailand and the Vietnam Telecommunication Authority (VNTA) since June 2015. In Thailand, the R&S®BTC is used for receiver tests and to prepare the DVB-T2 rollout.

DVB-T2 is also broadcast in Vietnam, which is why the VNTA cooperated with Rohde&Schwarz to set up a lab for testing compliance with the QCVN 63 standard. This lab will also permit the VNTA to offer the Vietnamese consumer industry compliance testing services for the most important European receiver standards. In both countries, Rohde&Schwarz cooperated with StreamSpark, the company that provided the test suites for PSI/SI and audio/video as well as reporting tools.

Headends transmit HDR quality for the first time

During the UltraHD (UHD) live transmission of the Supercup match between VfL Wolfsburg and FC Bayern Munich in early August 2015, the responsible program provider used high dynamic range (HDR), a method that uses an extension of the color space and luminance range, for the first time (see article on page 48). The HDR format spanned the entire production chain: from the camera in the stadium to the satellite transmission to the display on a TV that was tested as a prototype. The live encoding of the signal was performed by SES Platform Services GmbH, using the R&S®AVHE100 headend from Rohde&Schwarz. The headend handled HEVC encoding as well as processing and multiplexing of coding the 4K/UHD program data into a transmittable transport stream while also transmitting special data relating to the color space via the Astra satellite. The match could be viewed on HDR-capable TV set prototypes in impressive quality. Since September SES Platform Services GmbH, as first service provider, has been transmitting UHD programs regularly. Coding and multiplexing solutions from Rohde&Schwarz are also used in these transmissions.

Awards

Airbus presents Rohde & Schwarz with award

Airbus Defence & Space presented Rohde & Schwarz with the Best Performer Award at the 2015 Supplier Awards ceremony, which took place at the Airbus site in Bremen, on Supplier Day in mid-September 2015. The prize is given to suppliers who have distinguished themselves in the past 12 months with their performance, innovation and optimization. Rohde & Schwarz received the award for its innovative test and measurement equipment and technological excellence.

At the same time, Airbus acknowledged the specialized partnering solutions for aerospace and defense, the competitive on-time delivery and the long mean time between failures.

An award for an outstanding supplier: Martin Weichhardt, Senior Vice President, Head of Procurement, Supply Chain & Logistics at Airbus, congratulates President and CEO Manfred Fleischmann.

Memmingen plant is "Factory of the Year 2015"

The German business newspaper "Produktion", in cooperation with the consulting firm A.T. Kearney, selected the Memmingen plant as "Factory of the Year 2015" in the category "Excellence in Small Series Production". In the second year of participation, Memmingen was already able to impress the jury with its quality. On the way to becoming a "one-day TAT plant", which can execute a customer order within 24 hours, the plant went through the next development phase. Led by its production model, Rohde & Schwarz has provided even more transparency in production and has more closely synchronized the processes along the value stream. The result: very flexible small series production of high-tech products. The "Factory of the Year" prize has been awarded since 1992. The competition is considered the toughest and most tradition-rich benchmark for manufacturers in Germany and other European countries. In 2014, the Rohde & Schwarz Teisnach plant received the award.

Rohde & Schwarz China awarded for excellent service

A special honor was bestowed upon Rohde & Schwarz China at the Lenovo Global Supplier Conference: The world's largest PC manufacturer awarded the company the MBG Award for Outstanding Serviceability. More than 2000 representatives from 600 suppliers worldwide met at the event, which was held at the China National Convention Center in Beijing.

President Jürgen Steigmüller (left) and Achim Müller, project manager for benchmark competition, did it: Memmingen is "Factory of the Year".